

Effects of pulmonary rehabilitation on quality of life in chronic obstructive pulmonary disease patients

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Purpose of review

Pulmonary rehabilitation plays a key role in the management of chronic obstructive pulmonary disease (COPD). Although the American Thoracic Society recently provided a grade of 1A for evidence of health-related quality of life (HRQoL) benefits related to pulmonary rehabilitation, knowledge about the psychological and behavioral processes explaining the impact of pulmonary rehabilitation on HRQoL in COPD patients remains limited. This review describes the state of knowledge over the past year concerning HRQoL benefits after pulmonary rehabilitation and suggests avenues for future research.

Recent findings

HRQoL outcomes related to pulmonary rehabilitation explores five themes: optimizing pulmonary rehabilitation components to improve HRQoL; characterization of a responder phenotype; suitability of pulmonary rehabilitation following acute exacerbations; exploration of psychological and behavioral mechanisms explaining pulmonary rehabilitation benefits; and long-term maintenance of HRQoL benefits after pulmonary rehabilitation.

Summary

Evidence supports the use of pulmonary rehabilitation to improve HRQoL in patients with moderate-to-severe COPD. However, it is unclear how pulmonary rehabilitation improves HRQoL and which characteristics confer the greatest HRQoL benefits. Moreover, most studies failed to provide a compelling theoretical rationale for the intervention employed. Future research should focus on improving the understanding of the psychological mechanisms implicated in the adoption and maintenance of healthy behavior.

Keywords

chronic obstructive pulmonary disease, epidemiologic studies, follow-up studies, pulmonary rehabilitation, quality of life

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Introduction

Chronic obstructive pulmonary disease (COPD) is an important cause of global morbidity and mortality. Its burden is expected to increase with the aging population [1]. The World Health Organisation has estimated COPD as the future third leading cause of death worldwide by 2030 [1]. Current treatments for COPD have been unable to improve survival or prevent decline in lung function. Recent studies showed systemic outcomes of several types of COPD phenotypes [2], suggesting that COPD is a complex disease [3]. This emphasizes the importance of patient-focused outcomes that include symptom relief, functional status, and overall health-related quality of life (HRQoL) [4,5]. Pulmonary rehabilitation programs – defined as ‘evidence-based,

multidisciplinary, and comprehensive interventions’ [6] – play an essential role in the management of COPD and in decreasing the systemic impacts of COPD. The aims of pulmonary rehabilitation are to reduce symptoms and disability with the overall goal of optimizing patient HRQoL [4,6]. Typical pulmonary rehabilitation programs involve patient assessment, education, exercise training, nutritional counselling, and psychosocial support [6]. The recently up-dated *Cochrane Review* of Lacasse *et al.* [7] showed that pulmonary rehabilitation leads to clinically significant improvements in patient-reported dyspnea, fatigue, perceptions of control over their condition, and both disease-specific and generic HRQoL. A grade of 1A (i.e. the highest grade of evidence) was also recently provided by the American Thoracic Society for the HRQoL benefits related to

pulmonary rehabilitation [5], attesting to the empirical relevance and clinical importance of pulmonary rehabilitation.

Knowledge remains limited, however, about the psychological and behavioral processes explaining the acute and long-term impact of pulmonary rehabilitation on HRQoL. In order to guide future research, the purpose of this report was two-fold: to critically review the current advances in the field, highlighting the most interesting original publications, and to suggest perspectives for future research. This review presents studies published over the past year which focused on the optimization of pulmonary rehabilitation components to improve HRQoL, the characterizing the phenotype of patients who benefitted more than others from the pulmonary rehabilitation in terms of HRQoL, the suitability of a pulmonary rehabilitation program following acute exacerbations, the exploration of the psychological and behavioral mechanisms explaining the pulmonary rehabilitation benefits on HRQoL, and the maintenance of the acute effects of pulmonary rehabilitation on HRQoL using follow-up programs.

Methods

This section will describe the criteria of inclusion for considering studies in this review, the search methods, and the definition of constructs surrounding quality of life.

Study eligibility and literature search

This review included all English-language peer-reviewed research that was published in the last year dating back from 19 October 2010 when the last literature search was performed. All longitudinal studies (retrospective or prospective) evaluating the acute or long-term effects of pulmonary rehabilitation on HRQoL in patients with COPD were included. Study samples must have comprised COPD patients of any age or severity, either exclusively or in combination with other disease populations (e.g. asthma). In studies including combined samples, data must have been available on COPD patients separately from other subgroups. This review used pertinent MeSH search terms in the *PubMed* portal for *Medline* including: 'COPD', 'quality of life', and 'rehabilitation'. The *PubMed* search yielded 88 publications, and a final sample of 24 original studies was included in the report after study exclusion. In general, studies were excluded for not having strictly evaluated the effectiveness of a pulmonary rehabilitation program.

Definitions and measures of quality of life

For the purposes of this review, and according to a recent study [8], it seems important to clarify the constructs surrounding quality of life (i.e. health status, functional

Key points

- It is unclear how pulmonary rehabilitation improves HRQoL and which characteristics (i.e. intensity, duration, or ingredients) confer the greatest HRQoL benefits.
- Most studies failed to provide a compelling theoretical rationale for the intervention employed.
- HRQoL, currently explored as a uni-dimensional and global concept, needs to be regarded as an aggregation of a set of distinct self-perceptions with their own dynamics over time.
- Newer brief multidimensional measures of HRQoL – using an EMA approach – might offer the opportunity to capture a more detailed picture of the dynamic and multifaceted nature of HRQoL in COPD patients.
- The combination of domain-specific and global quality of life indicators is recommended as being more informative than the use of either type of measure alone.

status, global quality of life and HRQoL), and to make a distinction between subjective and objective, global and specific quality of life indicators.

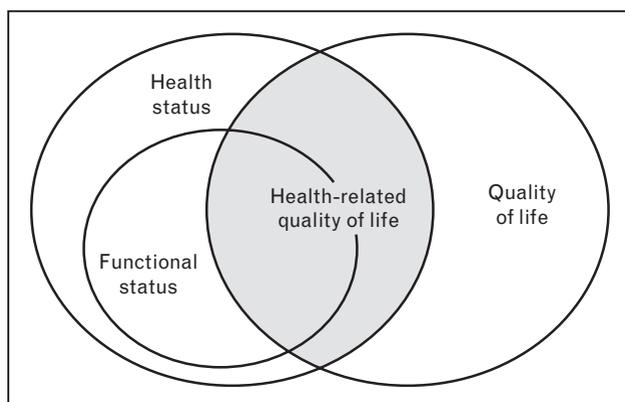
Quality of life constructs

Conceptually, health status and quality of life are very similar (Fig. 1). The measurement of health status assesses the impact of health on an individual's ability to perform daily life activities and to benefit from them [9]. Functional status corresponds to the ability of the individual to function physically, emotionally and socially [9]. An individual's degree of satisfaction with his/her daily life more directly refers to the concept of quality of life. Global quality of life comprises two large domains: health domains (i.e. HRQoL) and nonhealth domains, including financial, cultural, spiritual, occupational, environmental and social domains, among others. Unfortunately, some tools fail to distinguish between these quality of life concepts [10,11].

When investigators evaluate quality of life during the course of pulmonary rehabilitation, they must decide which quality of life indicators to measure – subjective or objective, domain-specific or global, or some combination of these measures. To make these choices, it is important to be aware of the theory and evidence underlying the use of these different types of quality of life indicators.

Subjective vs. objective

Although they are based on the perception of the respondent, some items can be characterized as subjective whereas others may be considered more objective evaluations. Objective quality of life indicators take into

Figure 1 Concepts of quality of life, health-related quality of life and functional status

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account the tangible aspects of life (e.g. income, work status, physical health, frequency of social relations, etc.). Conversely, subjective quality of life indicators attempt to measure how people feel about their lives. These measures encompass several related constructs including 'life satisfaction', 'well being' and 'mental health'. It has been shown that items that require less subjective appraisal and address objective situations or events are less likely to be biased by mood congruence response bias [12,13]. The potential confound of mood on pulmonary rehabilitation programs' quality of life outcomes is an important point to consider, given the known high prevalence of depressive disorders in COPD populations [14].

Global vs. specific

The second decision regarding quality of life measures is the choice between global or domain-specific indicators. Domain-specific indicators refer to experiences in specific areas of life such as work, family, finances, social relations or health. They contrast with global indicators, which have 'life in general' as the referent. Moreover, the domain-specific indicators are distinct from psychological distress measures than are global quality of life measures. This supports the notion that global quality of life indicators measure a construct more closely related to mental health, and that domain-specific quality of life indicators may provide more discrete measures of satisfaction resulting from specific life conditions. The combination of domain-specific and global quality of life indicators is recommended as being more informative than the use of either type of measure alone [15].

In sum, quality of life is a multifactorial, personal concept and depends on the individual's social and financial situation, their conception of happiness, and their health status. Despite its complexity, quality of life is an excellent marker of health status and is often shown to be a

better predictor of hospitalization and mortality in COPD patients than physiological parameters [16,17]. Consequently, quality of life measurements are very important outcomes to assess following participation in pulmonary rehabilitation [10].

Results

The next sections will present the five themes explored by the current body of literature about HRQoL outcomes related to pulmonary rehabilitation.

Optimization of pulmonary rehabilitation to improve HRQoL

The main components of most typical pulmonary rehabilitation programs are education, physiotherapy, exercise training, nutritional counselling, and psychosocial support [6]. Nevertheless, it should be noted that not all pulmonary rehabilitation components, which may be delivered using various combinations and emphases, produce the same benefits [6]. Furthermore, in practice, there is no internationally recognized standard formula for the design of a pulmonary rehabilitation program, because designs or structures may reflect local health policies, available financial support, healthcare delivery structures, and healthcare provider skills and abilities [18]. There may therefore be significant differences in pulmonary rehabilitation design depending on whether an individual or population approach is taken. The process may be patient-focused, seeking to optimize patient benefits. Conversely, especially where resources are limited, pulmonary rehabilitation may be designed to optimize benefits for the population by offering the minimum amount of rehabilitation components necessary to obtain a satisfactory result (i.e. a minimal clinically important difference, MCID). Using this perspective, it is interesting to note that the last year's articles emphasized optimizing individual patient benefits of pulmonary rehabilitation on HRQoL, regardless of the system implications.

Optimizing benefits for patients

Three studies recently looked at optimizing the HRQoL benefits related to pulmonary rehabilitation by adding new components to traditional programs. One 3-month prospective randomized controlled trial (RCT) from Japan [19] evaluated the effects of nutritional supplementation (i.e. 400 kcal/days for 12 weeks) as part of a home-based pulmonary rehabilitation program ($n=17$) compared to a control group ($n=15$) who benefitted from a monthly education. Eligibility for nutritional supplementation was defined as a body mass index of less than 19 kg/m^2 . This combination was successful in improving HRQoL (i.e. measured by the Chronic Respiratory Questionnaire, CRQ) in pulmonary rehabilitation patients vs. controls after 3 months. This suggests the potential role for the combination of nutritional support

and home-based pulmonary rehabilitation for the management of malnourished patients with COPD. These results are interesting given recent evidence on the significant relationship between low BMI in COPD patients and a greater risk for future exacerbations [20,21].

One other RCT from the USA [22] prospectively examined whether adding a psychosocial intervention, that is a written disclosure therapy (WDT), in COPD patients participating in an 8-week outpatient pulmonary rehabilitation program produced additional HRQoL benefits. At the weekly group support session, which was repeated for 3 consecutive weeks, the WDT group ($n = 29$) wrote for 20 min about their traumatic or upsetting life experiences, compared to a control group ($n = 37$) who wrote about an emotionally neutral subject. Contrary to expectations, the authors found no evidence of additional benefit in HRQoL in patients who underwent WDT (as measured by St George's Respiratory Questionnaire, SGRQ, and CRQ) relative to controls.

Aspiration of food and liquid has been shown to increase the risk for recurrent COPD exacerbations and complications [23]. Therefore, in a noncontrolled study, an Australian team looked the impact of different components of dysphagia education, screening, and management within an 8-week pulmonary rehabilitation program [24]. As part of the education sessions, participants attended a 1-h education session on identification and management of dysphagia. An additional education booklet about dysphagia in COPD was provided to all participants. The prepost results, obtained in 55 patients, showed after 3 months a significant within-group change in the subscale scores of a specific HRQoL questionnaire (i.e. SWAL-QOL). Dysphagia management and education of patients in pulmonary rehabilitation may contribute toward early identification and self-management of dysphagia, and may enhance HRQoL.

Optimizing benefits for the population

In the current healthcare economy, with demand exceeding capacity and the need to be more responsive to individual patient preferences, several studies have looked at determining whether less-frequent supervised exercise could achieve the expected benefits of a more structured, intensive pulmonary rehabilitation program [7]. In a RCT from the UK, Liddell and Webber [25] evaluated the effect of a once-weekly outpatient supervised exercise program ($n = 15$) compared to a standard twice-weekly format ($n = 15$) on SGRQ scores. Results suggested that once-weekly supervised exercise was not sufficient to improve HRQoL. The reported between-group difference in HRQoL scores may reflect the cumulative effect of the opportunities in the twice-weekly program for reinforcement and clarification of the infor-

mation and group discussion. Successful pulmonary rehabilitation may therefore require patients to adapt their thought processes to give them confidence that they can manage their chronic conditions. Such change may require more time for reinforcement and encouragement than that allowed by the once-weekly home-based format.

Pulmonary rehabilitation programs are most commonly provided within hospital outpatient departments. In the hospital setting, immediate medical support is available making this the most appropriate modality for patients with severe disease and complex comorbidities [26]. There is also evidence of benefits from inpatient programs for patients with stable COPD – especially in Europe (e.g. France, Italy), and even though these are costly, they provide an option for patients who live in isolated areas without access to a local program [18]. However, if pulmonary rehabilitation could be delivered effectively at home [27] or in community settings, this could substantially increase the number of patients receiving these programs [28]. In the past year, two prospective studies with large samples focused on the effectiveness of community-based pulmonary rehabilitation on HRQoL outcomes [29^{••},30^{••}].

One well designed 2-year study from the Netherlands [29^{••}] compared the efficacy of community-based pulmonary rehabilitation with usual care in patients with moderate COPD. One hundred ninety-nine moderate COPD patients were randomized to usual-care ($n = 91$) or the INTERCOM ($n = 102$; INTERdisciplinary COMMunity-based COPD management) program. They delivered a 4-month intensive pulmonary rehabilitation program in which patients visited the local physiotherapist twice weekly for endurance and strength training, and were instructed to perform daily exercise including walking and cycling outside. During pulmonary rehabilitation, patients also received an individualized education program using a booklet. Pulmonary rehabilitation was followed by a 20-month maintenance program where patients visited the local physiotherapist monthly to monitor exercise capacity and adherence to the training. In addition, nutritionally depleted patients visited a dietician four times (i.e. after 6, 9, 12 and 24 months). This study demonstrated that community-based pulmonary rehabilitation is feasible and effective, as it showed some acute improvements in HRQoL at discharge – in particular, significant adjusted between-group difference in SGRQ-activity and SGRQ-impact subscores. However, the mean changes from baseline to 12 and 24 months in SGRQ subscores did not remain significantly different between or within the two groups.

A second large prospective study from the UK [30^{••}] goes further in determining whether pulmonary rehabilitation delivered in a community setting is more effective than

that carried out in a standard hospital setting. Two hundred forty patients were randomized to hospital-based pulmonary rehabilitation ($n = 129$) or to community-based rehabilitation ($n = 111$). Pulmonary rehabilitation delivered in a community setting has similar efficacy to that produced in a more traditional hospital-based setting, both settings producing clinically important benefits in terms of exercise capacity and HRQoL acutely and after long-term follow-up. Cost-effectiveness analysis showed that neither hospital nor community programs were greatly favored; this, as expected, was also observed during follow-up.

Despite the positive outcomes and the novel approach to delivering pulmonary rehabilitation, these programs require community resources and healthcare providers not readily available in all countries. Where resources are scarce and COPD prevalences are high, clinicians, researchers and policy makers must think innovatively about cost-effective ways to deliver care [28].

Characterization of patients who benefit the most from pulmonary rehabilitation: is there an optimal responder phenotype?

Improvements following pulmonary rehabilitation have been well proven in patients with COPD, irrespective of the severity of their disease or level of functional impairment. However, the characteristics of patients who show the greatest improvements in HRQoL following pulmonary rehabilitation have not been extensively studied.

Therefore, one recent prospective trial from Italy [31^{*}] evaluated whether baseline characteristics of patients, specific comorbidities, and increasing numbers of comorbidities may independently predict a poorer response to outpatient pulmonary rehabilitation in terms of HRQoL. After adjustment for significant covariates (i.e. PaO₂, SGRQ baseline scores and comorbid diseases including kidney, liver, digestive system, cerebral or peripheral vascular diseases), their results did not show any significant predictors for demonstrating a MCID (i.e. 4 units) in composite SRQO-total scores. However, the authors did not present the results according to SGRQ sub-domains, in which improved sensitivity would be expected with individual scores (i.e. especially the SGRQ-impact domain, see rationale in the study by Moullec and Ninot [32^{*}]). Similarly, one Norwegian study [33^{*}] examined the prospective association between the level of self-efficacy at pulmonary rehabilitation admission and quality of life (i.e. QoL Scale) and HRQoL (i.e. SGRQ) benefits after a 6-week outpatient pulmonary rehabilitation program. They showed that patients with higher levels of self-efficacy at pulmonary rehabilitation admission reported a significantly higher change in QoL and HRQoL (i.e. SGRQ-activity, SGRQ-impact and SGRQ-

total scores). This suggests that COPD patients with higher levels of self-efficacy also demonstrate greater capabilities and more confidence to perform physical and psychosocial activities during pulmonary rehabilitation and over the follow-up period. This study emphasizes the fact that pulmonary rehabilitation should not only focus on improving HRQoL, but also on enhancing predictors of HRQoL such as perceptions of self-efficacy.

Beyond the magnitude of short-term improvements, others studies looked at identifying factors that may influence pulmonary rehabilitation adherence and completion. To this end, a recent Norwegian study [34] reversed the question, choosing HRQoL as independent variable, and investigated whether the level of HRQoL prior to beginning the program was a good predictor of participation. They compared the level of HRQoL among patients who chose either to participate in a 4-week inpatient pulmonary rehabilitation program ($n = 161$) or usual outpatient consultations with their pneumologists ($n = 44$). All patients had been encouraged to participate in pulmonary rehabilitation prior to the study. The significant between-group differences in SGRQ-activity, SGRQ-impacts and SGRQ-total scores indicated lower HRQoL among patients in the inpatient pulmonary rehabilitation group compared with those who chose to continue their outpatient consultations. Patients' perceptions of low HRQoL may make them feel that participating in a pulmonary rehabilitation is necessary. Interestingly, this study suggests that COPD patients are conscious of their overall health status and need for treatment.

In sum, to date it is difficult to identify an optimal phenotype of patients who are more likely to demonstrate greatest benefits from pulmonary rehabilitation in terms of HRQoL. Therefore, considering HRQoL as a key outcome related to pulmonary rehabilitation, all patients with COPD who meet the referral criteria for pulmonary rehabilitation should be referred to a program.

Pulmonary rehabilitation after exacerbations to improve HRQoL

The recent Cochrane meta-analysis of Puhan *et al.* [35], including only three studies in their pooled analyses relative to HRQoL outcomes, reported that participating in pulmonary rehabilitation following acute COPD exacerbations resulted in significant improvements. Furthermore, adverse effects of pulmonary rehabilitation following an acute exacerbation of COPD were not found. However, the likely significance or magnitude of change in HRQoL at the end of pulmonary rehabilitation following exacerbation is still poorly evaluated in COPD patients. There is an evident need for more RCTs to achieve more clarity about the safety and effectiveness of pulmonary rehabilitation across different modalities

(i.e. home, outpatient and inpatient settings) shortly after exacerbations.

Therefore, one Egyptian RCT [36] evaluated the feasibility and safety of early (i.e. 2 months postexacerbation) home-based pulmonary rehabilitation with outpatient supervision every 2 weeks including exercise training and education on exercise capacity and HRQoL in 39 COPD patients. They demonstrated that participating in a 2-month pulmonary rehabilitation early in the recovery period after hospital discharge led to significant improvements in functional capacity and HRQoL (i.e. CRQ and SF-36). In a prospective study from the UK, Seymour *et al.* [37^{*}] tested the effectiveness of an 8-week outpatient pulmonary rehabilitation program following a COPD exacerbation (i.e. within a week of the hospital discharge) to improve HRQoL (measured by the EQ5D, CRQ and SGRQ). Measurements were made within 72 h of hospital discharge and after 3 months. The authors demonstrated that hospital-based pulmonary rehabilitation administered shortly after an acute exacerbation of COPD was associated with a reduced frequency of rehospitalization in the subsequent 3 months. Compared with the usual care ($n=23$) condition, patients who benefitted from pulmonary rehabilitation ($n=26$) also showed improved SGRQ-total and SGRQ-activity scores as well as increased CRQ-dyspnea and CRQ-emotion scores. The long-term nature of these effects remains to be determined, as does the minimum duration postexacerbation at which pulmonary rehabilitation should be initiated. Longer term studies could evaluate whether posthospitalization 'rescue rehabilitation' can better maintain or prolong the benefits of pulmonary rehabilitation administered during a stable period of the disease.

Since inpatient pulmonary rehabilitation is more the modality of choice in several European countries, such as Italy, Clini *et al.* [38] assessed, in a retrospective cohort study, the effectiveness of early inpatient pulmonary rehabilitation following an exacerbation on exercise tolerance, dyspnea and HRQoL. They compared the percentage of changes across the Medical Research Council (MRC) categories in a large cohort of 1826 patients. Changes in 6-minute walk test (6MWT) distance, but not in dyspnea and HRQoL, significantly differed according to the MRC grade. The lack of improvement observed after pulmonary rehabilitation in dyspnea and HRQoL across MRC grades reinforces findings related to 6MWD change in favor of the sickest patients. Indeed, this particular effect might favor those individuals with lower exercise tolerance and higher risk of developing new exacerbations. This study demonstrates that early inpatient pulmonary rehabilitation is feasible and provides clinically relevant changes in exercise tolerance, dyspnea, and HRQoL across all the MRC grades following an exacerbation.

In sum, the results obtained among different modalities of pulmonary rehabilitation (i.e. home-based, outpatient or inpatient settings) would alert clinicians to prompt pulmonary rehabilitation after exacerbation whatever the degree of severity, and to consider the most deconditioned patients as those who may be most likely to benefit from it.

Finally, one original American study [39] determined the impact of COPD-related exacerbations on pulmonary rehabilitation participation and completion, and on HRQoL outcomes. Steele *et al.* found that exacerbations contributed significantly to attrition from outpatient pulmonary rehabilitation, accounting for a third of those who failed to complete the overall program. Interestingly, they noted that patients who experienced exacerbations during pulmonary rehabilitation and continued in the program performed at least as well on the 6MWT, and with respect to HRQoL (i.e. SF-36) and quality of life (i.e. SOLDQ) scores.

Psychological and behavioral mechanisms explaining the HRQoL benefits

Several studies recently looked at better understanding the processes involved in HRQoL improvements over the pulmonary rehabilitation period. According to a recent Dutch theoretical model, developed to structurally design and evaluate disease-management programs for patients with chronic disease [40], a distinction should be made between process indicators (what is done, i.e. here the pulmonary rehabilitation components), intermediate indicators (procedural end point, i.e. patient behavioral change) and final outcome indicators (end results of care, i.e. change in HRQoL). Changes in intermediate and final outcomes are expected to result from program implementation (e.g. optimal combinations of pulmonary rehabilitation components). On the basis of this theory-driven model, validated recently on a sample of COPD patients [41^{*}], patient-related interventions such as pulmonary rehabilitation aim to change patient behavior through mechanisms such as gained knowledge, skills and/or self-efficacy. Finally, the supposed patient behavioral change – due to improved knowledge, psychosocial beliefs and self-efficacy – should contribute to the achievement of expected outcomes (e.g. HRQoL). In light of this model, we report the results of recent papers that explored the relationship between these different procedural indicators and HRQoL outcomes.

Psychosocial beliefs

In a prospective noncontrolled study from the Netherlands [42], Fischer and colleagues investigated the contributions of patients' appraisals of participating in a pulmonary rehabilitation program to changes in their illness representations. They showed, in a sample of 87 COPD patients, that the perceived outcomes of the

pulmonary rehabilitation were positively associated with improvements in HRQoL scores (i.e. CRQ-fatigue and CRQ-dyspnea sub-scores) and in 6MWT distances. Their results also indicated that successful participation in pulmonary rehabilitation is associated with more optimistic post-treatment illness perceptions. Patient's evaluations of treatment goal achievement were correlated with an increase in HRQoL (i.e. change of CRQ scores from baseline) for the CRQ-dyspnea, CRQ-fatigue, and CRQ-mastery domains, but not for the CRQ-emotional functioning domain. Furthermore, the results showed that greater length of time since diagnosis was related to lower posttreatment perceptions of personal control over the illness. Interestingly, this study suggests that managing patient motivation throughout the pulmonary rehabilitation program requires patients to expect they can achieve personally relevant outcomes. In the same way, one Norwegian qualitative study explored the COPD patient's experiences during the pulmonary rehabilitation period [43]. The authors revealed that social relationships in pulmonary rehabilitation groups may be of great significance for patients in terms of coping and well being. Qualitative interviews were conducted twice with each of the 18 COPD patients within 2 months of completing pulmonary rehabilitation and again 1 year later, to capture changes over time in participants' experience of pulmonary rehabilitation in everyday life. Participants experienced social integration and support as an important and positive part of pulmonary rehabilitation that enhanced their perceptions of quality of life. The pulmonary rehabilitation groups represented new social networks of limited duration, providing opportunities for integration with engagement, commonality and role identification, as well as resources to enhance their ability to cope with the stress of chronic illness.

Behavioral change

In a prospective noncontrolled study from the USA, Mador *et al.* [44] looked at whether COPD patients increase their daily physical activity (i.e. time spent walking and doing activities of daily living, measured by an accelerometer) after an 8-week pulmonary rehabilitation program. Activity was monitored over a 7-day period before and after completion of pulmonary rehabilitation in 24 patients. Despite significant and clinically relevant improvements in exercise capacity (i.e. measured by 6MWT) and HRQoL (i.e. CRQ) after pulmonary rehabilitation, there were no significant changes in daily physical activity monitored by the accelerometer. The authors suggest that this negative result and those of previous studies may reflect the fact that improvements in exercise capacity and dyspnea may not always translate into actual lifestyle changes. Patients habituated to a sedentary lifestyle may not transition to a more active one, even though they have the capacity to do so. The dissociation between HRQoL scores and the objective repeated measure of daily physical

activity is very interesting. It suggests that global assessments of HRQoL with traditional questionnaires – often too long for idiographic protocols in which they have to be completed repeatedly – can obscure the observation of dynamic changes over time and across situations. Ecological Momentary Assessment (i.e. EMA) approaches may therefore be a useful alternative to static retrospective self-reports among COPD patients post-pulmonary rehabilitation. The repeated measure of HRQoL allowed by this approach may reveal the vulnerability of the dynamics of self-reports or perceptions [45]. This could be an original explanation of the discrepancy between the results of follow-up studies that show maintenance of HRQoL scores at least 6 months after pulmonary rehabilitation, and the early withdrawal of healthy behavior reported here and by clinicians a few weeks after pulmonary rehabilitation discharge.

Therefore, to achieve HRQoL benefits in patient-centred interventions such as pulmonary rehabilitation, behavioral change and learning principles must be incorporated. According to Lemmens *et al.* [41^{*}], selection of indicators for evaluation of COPD patient-related interventions should be determined through linkage with the specific elements of the theory-driven model.

Follow-up programs to maintain HRQoL benefits obtained following pulmonary rehabilitation

The immediate aims of pulmonary rehabilitation are to reduce symptoms, improve physical functioning, and enhance HRQoL. These acute effects are well demonstrated by the within-subject studies. However, the duration of benefits of pulmonary rehabilitation seems limited. Studies suggest that improvements in HRQoL are maintained for approximately 6 months but diminish in the following 6–12 months [46]. To maintain the benefits gained following pulmonary rehabilitation, patients need to remain physically active. The optimal maintenance strategies to facilitate adherence to a regular exercise program following completion of an initial pulmonary rehabilitation are misunderstood.

Telephone support

Follow-up strategies that include telemonitoring or structured telephone support have shown limited effects on long-term HRQoL outcomes [47]. To clarify the distinction between these two follow-up options, structured telephone support consists of standardized telephone contact with patients, and relies upon reporting of symptoms alone, whereas telemonitoring consists of telephone contact for eliciting symptoms and transmission of physiological data. Regular home telemonitoring by a specialist team is likely to improve or sustain HRQoL gains after pulmonary rehabilitation [48]. Because a worsening of symptoms is usually present days before patients are admitted to hospital for an exacerbation, remote monitoring might allow

earlier outpatient-treated interventions (i.e. implementation of action plans) to manage or prevent exacerbations. A recent 6-month RCT from the UK [49] was conducted to see if this strategy was able to improve HRQoL among patients with stable COPD compared to usual care. For patients who had completed pulmonary rehabilitation and were already supported by a specialist in a community-based setting, continuous home telemonitoring was not associated with any significant difference in HRQoL scores. One other noncontrolled pilot study from Australia [50] evaluated the effectiveness of a 12-month home-based maintenance program combined with telemonitoring on HRQoL scores (i.e. SF-36 and SGRQ). The maintenance program began within 4 weeks following the completion of pulmonary rehabilitation and included: collaborative goal setting (i.e. between patient and a nurse case-manager) in relation to the maintenance program generally, which took place at the initial home visit and was revised at 6-month and 12-month visits in-hospital; weekly telephone calls from the case manager for the first month and at 2, 5, 8 and 10 months to assess and monitor progress and provide advice; and a home visit by a physiotherapist at months 1 and 3 to assess and review progress in the home environment. The authors did not find any significant change in mean SGRQ domain scores across the follow-up period. Finally, in a well designed 2×2 RCT from the UK, Waterhouse *et al.* [30**] evaluated whether structured telephone follow-up is both cost-effective and useful in prolonging the beneficial effects of either a hospital- or community-based pulmonary rehabilitation program. Their structured telephone follow-up did not significantly affect the maintenance of exercise capacity or generic HRQoL indices. Although HRQoL was significantly better maintained after telephone follow-up than after standard care, the mean effect was small and below the accepted MCID for the CRQ (i.e. 0.5 or more points). Health economic analysis favored neither telephone follow-up nor standard care. In addition, the location of pulmonary rehabilitation (i.e. hospital or community) did not influence HRQoL outcomes on the longer term (i.e. 6, 12 and 18 months post-rehabilitation).

Supervised exercise training

To maintain the benefits gained following a pulmonary rehabilitation program, others recent papers have reported the effectiveness of different supervised exercise training protocols. One Australian RCT [51*] examined if weekly, supervised, outpatient-based exercise training plus unsupervised home exercise following an 8-week pulmonary rehabilitation program would maintain functional exercise capacity and HRQoL at 12 months better than standard care. Interestingly they demonstrated that the follow-up intervention ($n = 24$) maintained HRQoL for 12 months following pulmonary rehabilitation but similar outcomes were observed in the control group ($n = 24$) in which patients were just asked to adhere to unsupervised home

exercise. Despite no supervised maintenance training in the control group, the regular retesting (i.e. 3, 6 and 12 months) may have encouraged and motivated subjects to continue the home exercise program. The regular follow-up provided by the same experienced physiotherapist may also have positively influenced adherence to the long-term unsupervised home exercise program. In a longer prospective controlled study from Denmark, Ringbaek *et al.* [52*] evaluated the effects of a comparable maintenance training program 18 months after a 7-week pulmonary rehabilitation program on HRQoL. Their program provided weekly sessions during the first 6 months and every second week during the next 6 months, and finally no supervised exercise for the last 6 months. Their maintenance program, tested in 55 participants, had no effect on HRQoL (i.e. SGRQ-total) compared to control group ($n = 41$). The literature clearly needs more RCTs to determine the optimal design of maintenance strategies, and to determine how they should be applied. Nevertheless, the accrued evidence suggests that exercise components alone are insufficient to maintain healthy behaviors over the long-term. Future studies should evaluate whether multidisciplinary approaches – key ingredients in pulmonary rehabilitation – are feasible and cost-effective for maintaining gains over the follow-up period.

Integrated-care

Studies [46,47,53,54] that have examined gains in HRQoL after pulmonary rehabilitation without a maintenance program have shown that benefits on emotional dimensions (e.g. mental health, emotional roles) deteriorate earlier than those on functional dimensions (e.g. physical functional, physical roles). According to a recent original paper [32*], the distinction between emotional and functional dimensions of HRQoL may be an explanation for the apparent disparity between follow-up studies on changes in HRQoL after completion of pulmonary rehabilitation, and/or an interesting way to understand the appropriate content of maintenance programs in patients with COPD. The authors referred to a theoretical model [55] which predicts that functional self-perceptions, which are more specific and cognitively based constructs, are less likely to be modified over a short period of time than emotional-based self-perceptions. This is due to the fact that emotional-based self-perceptions are more likely to be exposed to fluctuations caused by mood variations and life events. In their 1-year prospective controlled study, Moullec and Ninot [32*] demonstrated that a first-time inpatient pulmonary rehabilitation program without follow-up intervention seems to greatly influence the cognitive aspect of self-perceptions, particularly those related to concrete aspects of physical abilities, but seems not to influence the emotional perceptions which are more affected by life events. Conversely, their results indicated that an integrated care setting with patient self-help group seems to

be a feasible and efficient maintenance strategy not only for maintaining, but also for improving, functional and emotional dimensions of HRQoL 1 year after successful pulmonary rehabilitation. Their integrated follow-up intervention – targeting three levels of care (i.e. the patient, the professionals and the organization providing the care) – appears to be a promising option to respond to the current challenges facing conventional COPD pulmonary rehabilitation programs.

The application of a theoretical model on distinctive dimensions of HRQoL is interesting since it facilitates the understanding of the processes of integrated care, as well as identifying the additive value of such multiple interventions along the chronic care continuum. The specific changes in emotional and functional self-perceptions after pulmonary rehabilitation support the notion that HRQoL, currently explored as a uni-dimensional and global concept, needs to be regarded as an aggregation of a set of distinct self-perceptions with their own dynamics over time, referring to relevant emotional and functional domains.

Conclusion

Current evidence has provided support that multidisciplinary programs such as pulmonary rehabilitation are effective to improve HRQoL in patients with moderate-to-severe COPD. However, despite the growing literature on this subject, it is still not clear how pulmonary rehabilitation improves HRQoL, which specific characteristics of pulmonary rehabilitation (i.e. intensity, duration, or ingredients) bring the most HRQoL benefits to patients. Further qualitative research could elucidate this and therefore be of help in optimizing ingredients and combinations of pulmonary rehabilitation components. Additionally, the majority of the studies failed to provide a compelling rationale for the intervention employed. In the absence of theoretical models, it is difficult to provide valuable insights into why a pulmonary rehabilitation formula works or has unexpected consequences. Moreover, data on cost-effectiveness of pulmonary rehabilitation programs is scarce. Illustrations of potential cost-effectiveness is a factor that might help inform whether a program setting delivers sufficient return on investment in the short or long term. Also, changing patient behavior leading to HRQoL improvements is complex and requires time. Thus, pulmonary rehabilitation interventions targeting behavior change and its maintenance need to have longer follow-up periods (i.e. at least 18 months), need to be studied using appropriate designs (i.e. RCTs designed according to CONSORT guidelines [56], e.g. with sufficient sample sizes, appropriate control groups, using intent-to-treat analyses, etc.) to optimize the interpretability and generalizability of the results. In addition, in order to

highlight the mechanisms underlying the adoption and maintenance of healthy behaviors during and after pulmonary rehabilitation, brief HRQoL instruments could be useful by being easily incorporated in routine care. Newer brief multidimensional measures of HRQoL (e.g. VQ-11 [57]) – using an EMA approach – might offer the opportunity to capture a more detailed picture of the dynamic and multifaceted nature of HRQoL in COPD patients. Finally, since current literature has not identified phenotypic responders to HRQoL, due to its complex nature, all COPD patients who meet the criteria should be referred to a pulmonary rehabilitation program.

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There are no conflicts of interest.

References and recommended reading

Papers of particular interest, published within the annual period of review, have been highlighted as:

- of special interest
- of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (p. 127).

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