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Prescribing and Monitoring Exercise Intensity in Pulmonary Rehabilitation: Review

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Abstract

This review intends to explore the impact of various levels of exercise intensity on physiological performance in a group of participants undergoing pulmonary rehabilitation. Specifically, this study aims to determine prescribing and monitoring exercise intensity in pulmonary rehabilitation. Although numerous studies have emerged in the past decade revealing the advantages of different aerobic exercise for pulmonary rehabilitation, this review has examined the nature of exercise training as part of a pulmonary rehabilitation programme in patients with Chronic Obstructive Pulmonary Disease. This review will allow for greater confidence in any observed treatment effects, and will also provide novel information related to physiological and quality of life outcomes in patients with pulmonary disease. Information gained from this review is believed to allow for more individualised and appropriate exercise prescription for pulmonary rehabilitation programmes, as well as promote greater consistency and clarity related to the psychological and social impacts of varying levels of exercise intensity.

Key Words:

Physiotherapy; Exercise Intensity; Pulmonary rehabilitation; COPD

Introduction and Background

Chronic obstructive pulmonary disease (COPD) is characterised by a chronic process of impaired respiratory function, characterised by both emphysematous and bronchitic changes in lung tissue [1]. Consequently, patients experience a gradual reduction in effective airflow in the lungs, which is largely irreversible, resulting in dyspnoea and an increased risk of infection [2]. COPD is ranked as the fourth major cause of mortality in the Western world and thus effective management is a significant health priority [3]. Current therapeutic approaches involve the administration of bronchodilators, steroids and antibiotics, when appropriate, while the oxygen administration is often used in patients when oxygen saturation levels drop [4]. However, none of these management options reverse the disease process and often patients experience severe dyspnoea and exercise intolerance, resulting in reduced mobility and psychological sequelae in many cases [5,6]. Indeed, exercise intolerance, while related to the severity of disease in most cases, may also be a significant feature in mild disease, suggesting that interventions to improve exercise tolerance may be beneficial at an early stage [7].

A recognised approach to tackling dyspnoea and exercise intolerance in patients with COPD is pulmonary rehabilitation (PR) [8,9]. The aim of PR is not to improve gas exchange or lung function, but rather to improve the function of other systems in the body, minimising the impact of poor lung function [10]. The pathophysiology of COPD explains this phenomenon: although the primary pathological processes are pulmonary in nature, extra-pulmonary features include skeletal muscle dysfunction, characterised by changes in aerobic metabolism, capillary density and increased inflammation [1]. These features reduce aerobic capacity, especially in leg musculature, leading to early onset lactic acidosis and muscle fatigue. Indeed, many patients with exercise intolerance associated with COPD find muscle fatigue, as opposed to dyspnoea, as the major limiting factor [10,11]. These changes may be the result of COPD-specific pathology, but it is also likely that due to the sedentary nature of many patients with the condition, that muscle deconditioning is responsible. Therefore, the theoretical basis for PR is to restore skeletal muscle condition, enhance aerobic capacity of muscles and therefore reduce exercise intolerance and dyspnoea [4].

In addition to the above, PR is thought to work by lowering ventilatory demand, leading to a reduced ventilator demand leading to a reduced sensation of breathlessness. During exercise where the ventilatory demand is increased, dynamic hyperinflation occurs in the lungs, reducing time for expiration and causing a build-up of end-inspiratory lung volume: when this reaches a maximum value, dyspnoea increases considerably [4]. Therefore, a reduction in ventilatory demand leads to longer expiratory times, lower end-inspiratory volume and a reduction in hyperinflation and dyspnoea. In addition to these mechanisms, it is thought that PR may exert effects through other mechanisms, such as increased social interaction, distraction from dyspnoeic sensations and the fact that PR often involves educational components and self-management strategies, leading to enhanced management of COPD [12]. Therefore, PR has the potential to improve symptoms and quality of life for COPD patients with exercise intolerance, based on a variety of mechanisms.

However, despite the recognition that PR is effective in patients with COPD, there are specific factors that remain inconsistent or poorly defined in practice, including the intensity of the exercise component and how this should be monitored in practice. These factors need to be optimised to ensure that patients receive maximum benefit from intervention, while minimising the risk of adverse effects

or exacerbation of respiratory problems [13-15]. Therefore, the aim of this paper is to review the monitoring and intensity of exercise as part of a PR programme from the perspective of a physiotherapist. This will lead to identification of research, appraisal of data and formulation of recommendations, pertinent to physiotherapy practice.

Exercise Intensity

A number of guidelines have been produced relating to the use of PR in COPD and it is agreed that PR is beneficial intervention, with few recognised adverse effects [3,16]. A recent analysis of the literature indicates that there is significant disparity in the evidence base for specific components of the PR programme. For instance, strong evidence supports exercise training in ambulatory muscles as a mandatory component of PR, while evidence is poor for maintenance strategies resulting in long-term benefits for patients [12]. The nature of exercise is also analysed in Ries review, with the conclusion that strong evidence favours both low and high intensity training as part of a PR programme. However, it is clear that these forms of exercise therapy differ significantly and therefore it is important to determine the most effective approach for patients with COPD, particularly as there are concerns that patients with COPD may find it difficult to adhere to a high intensity regimen [17].

The American College of Sports Medicine (ACSM) have published a position paper where they state that an effective exercise training stimulus needs to be applied three times per week for at least eight weeks and that the intensity of training should be tailored towards the exercise tolerance of the person [13,18]. Specifically, training should be set at 55-85% of the heart rate reserve. However, the use of this marker alone has been questioned as COPD is associated with a complex musculoskeletal pathology and other markers may be more useful in setting exercise intensity [13]. Recent guidance has reinforced this figure, however, with Nici et al. [1] noting that exercise should be at a level of 60% or greater than the heart rate reserve in patients with COPD. Therefore, while it is clear that there is a consensus on this figure, it is uncertain if this applies only to individuals undergoing high intensity training, And if the targets actually reflect clinically measurable changes in patient function or quality of life [19]. As such, it is necessary to review evidence for low and high intensity training regimens in achieving these aims in patients with COPD.

High intensity training

Studies have supported a role for high intensity training in COPD management. Varga et al. [20] assessed 71 patients who underwent two high intensity regimens for eight weeks and compared the findings to patients who underwent self-directed exercise over the same period of time. High intensity exercises were designed to be at 80 and 90% of the pre-training peak work rate. The results indicated that in both high intensity groups, there were significant changes in the test peak rates and a reduction in lactic acidosis associated with increased oxygen uptake. These changes did not occur in the control group and therefore this study demonstrates that high intensity training can be more effective than normal activity in improving biochemical and physiological function. A similar study has shown that high intensity training performed through either continuous or interval regimens can result in significant changes in quality of life and performance during exercise compared with patients who do not participate in such intense training [21]. Both studies represent good approaches to the problem, focusing on a clearly defined COPD population, adopting a randomised approach and utilising standard outcome measures. Therefore, this data is of good quality, indicating that high intensity training may be beneficial in COPD.

It has been noted that patients who are engaged in high intensity PR programmes may not actually achieve high intensity training by definition due to the nature of the exercise programme or patient health status. As a result high intensity training studies may not be reviewing maximal training programmes. Hsieh et al. [22] conducted a high intensity training study in patients with COPD and ensured training was optimized through a minimum of 75% maximal oxygen uptake training. The results demonstrated that both lung function (FVC) and exercise tolerance (maximal exercise capacity, measured through peak VO_2) improved significantly in these patients compared to those receiving standard care. However of 34 patients enrolled in the high intensity group only 14 were able to complete the study, indicating that this form of training may be excessive in this population. Furthermore, although improvements in physiological function were noted, the quality of life was not assessed and therefore it is difficult to attribute these improvements with changes in daily activities of patients.

Recently, meta-analyses study conducted by Kristin Osterling et al. [23] shows that people with moderate to severe, stable COPD were able to perform high intensity exercise, which was associated with positive changes in ventilatory parameters and dyspnea, but these finding cannot be generalized due to a number of factors that limited it.

Therefore, one must bear in mind that the management of COPD is a multidisciplinary process and that optimisation of exercise intensity training during PR may involve additional measures, rather than just modification of exercise protocols.

Low intensity training

Baumann et al. [24] recently completed a randomized controlled study of 100 patients with COPD in order to compare standard PR with a long term, low intensity programme of exercise, where trainers guided participants' level of exertion according to the Borg scale, where submaximal exertion was preferred. Key outcome measures included functional pulmonary tests and quality of life indicators. The findings suggested that improvements in both areas could be achieved with low intensity training at 26 weeks. It pointed significant differences were seen in 6-minute walking tests and respiratory questionnaire scores, with greater improvement in the low intensity group. Therefore the authors suggest that low intensity training may be a preferable approach in light of patient acceptance and outcomes. However, of 100 patients only 81 completed the study indicating that both forms of training may not be suitable for all patients with COPD.

These findings are supported by several studies that have utilised a long-term approach to assessing the effectiveness of low-intensity training in COPD. Troosters et al. [25] performed a randomised study of 100 patients, where 50 underwent rehabilitation and 50 usual medical care. Exercise training involved cycling, walking and strength training in combination. The authors noted that at 6 months following the intervention numerous physiological characteristics, including maximal work load, 6-minute walking distance and maximal oxygen uptake were significantly improved compared with patients who did not undergo low intensity training. Similar dropout rates were reported however, although results tended to persist for 18 months in patients who completed the PR programme. Guell et al. [19] performed a similar randomised study in 60 patients with COPD, but

the low intensity group involved greater emphasis on breathing exercises, chest physiotherapy and non-technical equipment, and found that dyspnoea, walking intolerance, fatigue and poor emotional function improved in patients undergoing training compared to the control group. The number of patients needed to treat for a significant health benefit over a 2 years period was three, suggesting that the intervention may be effective in a significant proportion of COPD patients.

Comparison and summary

Direct comparison of low and high intensity exercise training has been noted in the literature [26]. A prospective randomized trial was completed comparing these aspects of PR with low intensity training facilitated through twice weekly session of 30 minutes of classroom exercises, while the high intensity group performed at least 80% maximal oxygen capacity running or cycling for 30 minutes twice per week. After 8 weeks the groups were compared and significant differences were noted. The high intensity group showed greater improvements in exertion dyspnoea and treadmill endurance while the low intensity group showed increased upper limb endurance. Upper limb endurance was likely enhanced as a result of the specific nature of exercise undertaken by the low intensity group, which involved basic calisthenics and upper limb exercises. Both groups scored similarly on other outcomes, including quality of life and overall dyspnoea. Therefore the authors conclude that both types of training may confer benefits to the COPD population and should be utilised according to patient functional capacity and preference [27]. However, the exercise completed in this study fails to meet the recommendations for training, which should encompass at least three sessions per week. As improvements were noted in this study despite this, remains to be seen if additional sessions can increase the benefit associated with training.

Researchers have noted that markers for improvement in functional outcome should not necessarily be pursued at all costs [28,29]. While higher intensity training may confer additional physiological benefits, improvements in quality of life are not increased any more than with low intensity training, indicating that training should be delivered according to patient capacity and preference, rather than for improvement in physiological function which may not benefit the patient.

Interval v/s Continuous Training

At present, there is a move towards increasing the level of interval training in patients with COPD, based on recent studies that demonstrate beneficial effects and the practical understanding that patients with varying levels of COPD severity may find interval training more acceptable [17]. A number of studies have sought to compare interval training with continuous exercise in patients with COPD and utilise numerous outcome measures to justify the type of exercise, including walking test, performance, peak oxygen uptake and quality of life. In general results have been contradictory, with some studies noting similar improvements in function over an 8-week interval/continuous regimen [4].

A recent systematic review notes that there is a lack of sufficient evidence to recommend either exercise approach specifically, as peak power; peak oxygen uptake, quality of life and exercise performance do not differ significantly between the interventions [30]. This review was comprehensive, but only includes randomised studies and therefore other forms of data may be lacking, which could help contribute to the overall picture. However, in light of the nature of interval training, it may be more amenable to patients with severe COPD, or those who suffer from acute exacerbations. Consequently, pending further research, it is likely that interval training will remain a popular option in COPD management, particularly in patients who have high levels of COPD exacerbations [31].

Monitoring Exercise Intensity and Outcome

The six-minute walk tests is likely to form a part of the evaluation, although several other tests may also be used and have an equal level of support in the literature [31]. However, a key feature of facilitating an intervention is ensuring that effective outcome monitoring is conducted in order to demonstrate efficacy and improvement in the patient quality of life. Therefore, such measures should be applicable not only at the initial assessment phase, but also throughout the treatment period.

In the case of PR, outcome measures generally consist of a functional assessment, consistent with these aims. Common examples include the 6-minute walk test and the 10-m shuttle test, both of which have been demonstrated to reflect functional endurance and have a significant prognostic value [31]. However, both of these tests may also be affected by other factors, including patient arthritis, weakness or pain. Other measures have also been used in practice, including assessment of maximal cardiopulmonary exercise tests, which assess maximal capacity rather than endurance, and assessment of dyspnoea [27]. However, there is a general move towards utilising composite measures of outcome performance in order to assess improvement in numerous areas and provide a comprehensive analysis of patient benefits and physiological improvement [17].

A useful marker for determination of exercise intensity training is the level of oxidative stress experienced by the patient during exercise. One study has thus tried to determine optimal exercise strategies based on the level of oxidative stress experienced by the patient. However, these findings are difficult to relate to the clinical situation at present, where other outcomes, such as the quality of life and functional capacity should be prioritised by practitioners [17]. Therefore, outcomes should include both short and long term goals and should reflect the holistic management of the patient: education, function, quality of life and reduction in exacerbations are all achievable. The means to achieve these goals are less clear, but guidelines provide an overview of the best approach. It is recommended that intensity of training is gradually increased in patients with COPD in order to accommodate the patient's tolerance and enhance the benefits of the rehabilitation process. Incremental increases can occur every week, or after five sessions of over an hour each, according to some studies [31]. However, these studies fail to show marked improvements in patients with the long term and again focus on the physiological, rather than the quality of life and the outcomes associated with a good prognosis in COPD [32]. Therefore, care should be taken, when increasing exercise intensity, to ensure that patients are still benefitting from the increased stress and strain associated with the intervention.

Conclusion

This paper has examined the nature of exercise training as part of a PR programme in patients with COPD. Current guidance tends to favour high intensity exercise training in these patients and the evidence base generally supports this, although it is clear that low

intensity training may also be equally beneficial in some patients. However, despite the guidelines recommending high intensity training, further studies will need to be conducted in order to ensure that patient adherence to these regimens is sufficient to result in a health benefit, especially in the long term where this has not been adequately demonstrated.

From a physiotherapy perspective, it is vital that exercise training is completed in patients with COPD. The choice of low or high intensity training seems to be largely based on the patient and their specific goals. High intensity training is likely to provide greater physiological benefit to patients who can tolerate the exercise, but it is unclear if this improves the quality of life or functional outcome any more than low intensity regimens. Therefore, practice should be based on patient preference and ability and high intensity exercise favoured, provided it is cost-effective and achievable by the patient. Exercise for a period of 8 weeks or more, for three times a week minimum should be continued in order to see positive effects. Important outcomes include functional status as recorded by walking tests and treadmill endurance, but equally emotional and quality of life measures need to be factored into the recovery process to ensure holistic management is achieved. Ultimately, it is important that the intervention is tailored towards the exercise tolerance and functional capacity of the patient, in order to achieve maximum benefit. Future research should aim to support this process by determining the optimal intensity and measurements to facilitate physiotherapeutic input in patients with COPD.

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