Strategies to Enhance the Benefits of Exercise Training in the Respiratory Patient

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KEYWORDS

• Chronic obstructive pulmonary disease • Exercise training • Heliox
• Neuromuscular electrical stimulation • Noninvasive ventilation • Rollators • Supplemental oxygen

KEY POINTS

- In people with chronic obstructive pulmonary disease, exercise training offered as part of pulmonary rehabilitation has strong evidence for increasing exercise capacity, reducing symptoms of dyspnea and fatigue, and improving health-related quality of life.
- Nevertheless, there is a proportion of people referred to pulmonary rehabilitation who achieve minimal gains, most likely because of profound ventilatory limitation during exercise or the presence of comorbid conditions that limit participation in exercise training.
- Several adjuncts or strategies have been explored to optimize the proportion of people referred to pulmonary rehabilitation who achieve significant and meaningful gains on program completion.

INTRODUCTION

Pulmonary rehabilitation has been defined as a comprehensive intervention that follows a thorough patient assessment and includes therapies such as exercise training and education.[1] The aim of pulmonary rehabilitation is to improve the physical and psychological condition of people with chronic respiratory disease as well as promote long-term adherence to health-enhancing behaviors.[1] Exercise training is the cornerstone of an effective pulmonary rehabilitation program. Most studies examining the effect of pulmonary rehabilitation have been conducted in people with chronic obstructive pulmonary disease (COPD).[2] In this population, there is strong

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evidence that pulmonary rehabilitation, which includes exercise training, confers significant and important improvements in exercise capacity, symptoms such as dyspnea and fatigue, and health-related quality of life as well as reductions in health care use.[2–4] These effects are seen in people with stable disease as well as during or immediately after an acute exacerbation of their condition.[2,5] The mechanism of improvement relates largely to conditioning the muscles of locomotion, namely the quadriceps.[6,7] After rehabilitation, the changes in muscle morphology and biochemistry optimize the capacity of the quadriceps to meet the demands of exercise using aerobic energy systems.[6,7] This process in turn reduces the early reliance on anaerobic energy systems, delays the onset of blood lactate accumulation, and decreases the ventilatory load and sensation of dyspnea at submaximal exercise intensities.[6,7]

Although the evidence for pulmonary rehabilitation is strong, there are a proportion of people who do not achieve meaningful gains in exercise capacity.[8,9] These so called "nonresponders" seem to be characterized by more severe airflow obstruction and profound ventilatory limitation during exercise.[8,9] This situation may preclude the person from reaching an exercise intensity that constitutes an adequate stimulus to induce a training adaptation in the peripheral muscles. Furthermore, at least half of all people referred to pulmonary rehabilitation have 1 or more comorbid conditions, including musculoskeletal disorders, which compromise the training dose that can be achieved.[10] This situation has led to an interest in the role of adjuncts or alternative strategies, implemented during an exercise training program, to increase the load borne by the muscles of locomotion. Some of these strategies are commonplace and may be perceived by clinicians as easy to implement, such as the use of (1) supplemental oxygen, (2) rollators or wheeled walkers, (3) water-based exercise modalities, and (4) inspiratory muscle training (IMT). Others are less commonly used and may be perceived by clinicians as more difficult to implement, such as the use of (1) heliox (a helium-oxygen mixture), (2) noninvasive ventilation (NIV), (3) neuromuscular electrical stimulation (NMES), and (4) partitioning the exercising muscle mass. These approaches are described in this article.

SUPPLEMENTAL OXYGEN

Exercise-induced oxyhemoglobin desaturation is common in pulmonary rehabilitation participants. In 572 people with COPD undertaking a 6-minute walk test (6MWT), most of whom were entering a pulmonary rehabilitation program, desaturation of 4% or greater to less than 90% occurred in 47% of tests.[11] Although there are no strong data regarding the adverse effects of transient oxyhemoglobin desaturation during exercise, supplemental oxygen improves exercise performance and reduces dyspnea in people with COPD.[12] This finding is primarily related to a reduction in ventilation for a given exercise workload, leading to a delay in dynamic hyperinflation and prolonged exercise time.[13] These effects have been shown both in desaturators[13] and nondesaturators.[14] The reduction in ventilation at submaximal workloads may be associated with a slower increase in blood lactate as a result of better oxygen delivery to peripheral muscle[15] or direct chemoreceptor inhibition.[14] These acute effects of supplemental oxygen may facilitate training of the locomotor muscles at a higher intensity, or for a longer duration, to enhance training benefits.

There are now 7 randomized controlled trials (RCTs) that have evaluated the impact of supplemental oxygen during exercise training in COPD (**Table 1**). Despite the good physiologic rationale underpinning this intervention, 5 of the 7 trials found no beneficial effect on pulmonary rehabilitation outcomes.[16–20] Another trial measured exercise outcomes on the assigned gas, so it was unclear whether the benefits seen in the oxygen trained participants were related to the training program or the acute effects of the gas on exercise performance.[21] One well-designed trial that included participants who did not desaturate during exercise showed significantly increased endurance time during a constant power cycle ergometry test in the group who trained on supplemental oxygen compared with the air trained group after 7 weeks.[22] The oxygen group trained at a higher work rate, which progressed more rapidly over the course of the program, consistent with the hypothesis that the benefits of supplemental oxygen are attributable to a higher training intensity. It is unclear whether application of supplemental oxygen in previous trials had facilitated higher training workloads, which may explain the lack of positive findings in these studies. A Cochrane review[23] including 5 of these trials has concluded that there are small effects of supplemental oxygen during training on endurance time at the end of the program (mean improvement in exercise time compared with room air 2.69 minutes, 95% confidence interval 0.07–5.28 minutes, 2 trials with 53 participants) and Borg dyspnea score at the end of the endurance test (mean reduction in dyspnea 1.22 points, 95%