Exercise for Patients With COPD: An Integral Yet Underutilized Intervention

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Jessica Favero Butts, MD[1]
Mark H. Belfer, DO, FAAFP[2,3]
Kevin B. Gebke, MD[4]

[1]Department of Family Medicine and Sports Medicine, Indiana University, Indianapolis, IN; [2]Professor of Family Medicine, Northeast Ohio Medical University, Rootstown, OH; [3]Chief Medical Officer, Greater Rochester Independent Practice Association, Rochester, NY; [4]Chairman, Department of Family Medicine and Director of the Sports Medicine Fellowship, Indiana University, Indianapolis, IN

Abstract: Chronic obstructive pulmonary disease (COPD) was the third leading cause of mortality in the United States in 2009 and accounts for millions of dollars in health care expenses annually. It is characterized by slow declines in functional ability and exercise tolerance, which are strongly predictive of poor health-related quality of life and survival. The cycle of physical, social, and psychosocial consequences of COPD is more easily prevented than remedied; therefore, maintaining baseline respiratory function is a key goal of early treatment. Although medical management of COPD is generally well understood and implemented by most primary care physicians, multidisciplinary approaches that include nonpharmacologic modalities (eg, exercise training) are not often used. Exercise training can alleviate dyspnea and improve exercise tolerance and health-related quality of life in patients with mild-to-severe COPD. Pulmonary rehabilitation, which includes exercise training, nutritional and psychological counseling, and patient education, is an important component of COPD treatment and management programs, and is currently underutilized in the United States. This article addresses the role of exercise as part of a multidisciplinary approach to the management of COPD, especially with regard to pulmonary rehabilitation.

Keywords: chronic obstructive pulmonary disease; exercise; management; pulmonary rehabilitation

Introduction

Chronic lower respiratory diseases were the third leading cause of mortality in the United States in 2009[1]; chronic obstructive pulmonary disease (COPD), a disease of the lower respiratory tract, is expected to become the third leading cause of mortality worldwide by 2030.[2] According to the Centers for Disease Control and Prevention, COPD was an underlying cause in 718 077 deaths from 2000 to 2005, and the prevalence of COPD is thought to be even higher due to the likely number of undiagnosed cases.[3,4] Chronic obstructive pulmonary disease was initially considered a disease primarily manifesting in older men; however, it is increasingly seen in younger patients, and the annual number of deaths among women increased by 11% from 2000 to 2005.[4]

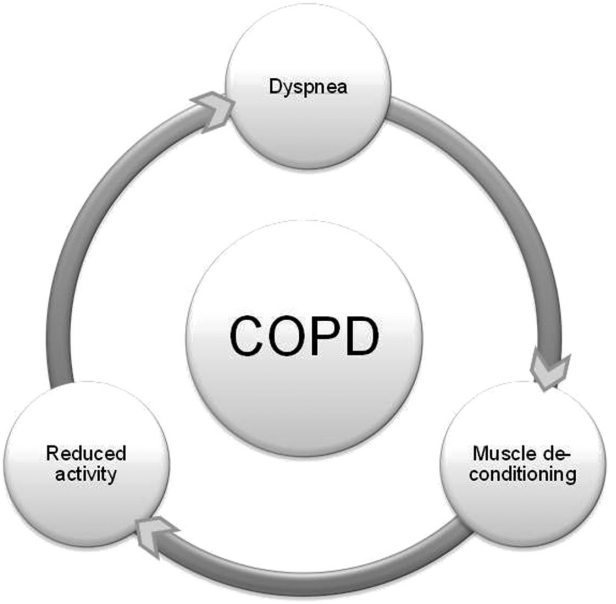
Chronic obstructive pulmonary disease is characterized by chronic inflammation throughout the lung parenchyma, airways, and vascular tissue, resulting in hypersecretion of mucus, constriction of airway smooth muscle, hyperinflation, airflow restriction, and, ultimately, dyspnea-induced impairment.[5] An estimated 85% to 90% of cases in industrialized countries are associated with tobacco smoking,[6] although a small percentage of patients with COPD have no history of smoking.

Correspondence: Jessica Favero Butts, MD, Department of Family Medicine and Sports Medicine, Indiana University Health Physicians, One American Square, Suite 185, Indianapolis, IN 46282.
Tel: 317-948-6161
Fax: 317-638-0678
E-mail: jessicabuttsmd@gmail.com

Healthy lungs have reserve capacity for ventilation and oxygenation beyond that required for daily living, which means that patients with COPD have typically lost a significant portion of their lung function before they become symptomatic.[7] The onset of COPD symptoms is insidious and is characterized by slow declines in functional ability and exercise tolerance,[8] which are strongly predictive of poor health-related quality of life (HRQoL) and survival independent of the patient's airflow limitation or age.[9] Functional capacity for exercise is limited not only by pulmonary symptoms but also by cellular-level changes caused directly by COPD. Patients with airway disease have been shown to have lower muscle strength, mass, quality, and mobility compared with healthy individuals.[10] This loss of strength and muscle mass likely contributes to early fatigue during activity. Elevated numbers of inflammatory cells and consequent increases in apoptosis, and decreases in the activity levels of aerobic enzymes have been identified in muscle studies of patients with COPD.[11] These changes decrease muscular aerobic capacity, which leads to early fatigue. The combination of muscular and pulmonary changes directly causes some of the most troublesome symptoms of COPD. Once a patient has become symptomatic, the idea of implementing an exercise regimen can be overwhelming and frightening; however, exercise is suspected to have a direct effect on the outcomes of patients with COPD, with lower activity levels being directly associated with worse outcomes. Maintaining activity levels is integral to improving the long-term prognosis for patients with COPD.

The progression of COPD is often characterized by a slow decline in lung function punctuated by periodic exacerbations and accompanied by progressively decreasing exercise capacity and levels of physical activity.[12] In response to the distressing symptoms of dyspnea and fatigue, the patient often subconsciously limits or eliminates some of his or her more strenuous physical activities, which results in further deconditioning. A vicious cycle develops in which exertional dyspnea leads to inactivity, which further worsens exertional dyspnea (Figure 1).[13] In a survey performed by the American Lung Association, 51% of patients with COPD stated that their condition limited their ability to work. Limitations were also perceived in normal physical exertion (70%), household chores (56%), sleeping (50%), social activities (53%), and family activities (46%).[6] In addition to these symptoms, patients with COPD may frequently experience acute exacerbations,[14,15] which lead to further decreases in lung function[16] and more dyspnea. Perceived functional limitations and the resulting limitation of activity may necessitate lifestyle changes, including job changes, limitation of leisure activities, and, sometimes, inability to comfortably perform activities of daily living (ADL) or instrumental ADL.[6,17]

Figure 1. Cycle of activity and dyspnea in patients with COPD.



Abbreviation: COPD, chronic obstructive pulmonary disease.

Furthermore, depression, anxiety, and similar emotional problems are often comorbid with COPD.[18] Depression or anxiety can often result from impairment of the ability to perform even basic ADL or from the dyspnea associated with performing such activities. Exercise intolerance and dyspnea may also lead patients to limit leisure activities that they once enjoyed. This isolation and limitation of pleasurable activities contributes to depression in patients with COPD.[19] Depression and anxiety in patients with COPD are often detrimental to the overall course of the disease and contribute further to the vicious cycle of fatigue, increased subjective dyspnea, and exercise intolerance, all of which further exacerbate the patient's depression and anxiety.

In the authors' experience, the cycle of physical, social, and psychosocial consequences of COPD is more easily prevented than remedied, and the maintenance of baseline respiratory function is a key goal of early treatment. This article discusses the role of exercise as part of a multidisciplinary approach to the management of COPD, especially pulmonary rehabilitation.

Materials and Methods

A critical review of the literature and guidelines on the role of exercise in COPD management was performed using

PubMed. Search terms included *COPD*, *exercise*, *exercise prescription*, *management*, *pulmonary rehabilitation*, and *treatment*. Randomized and nonrandomized clinical trials, observational studies, and review articles that focused on the relationship between exercise and COPD were included in this article. Studies were also identified from the references of original research articles and review articles.

Exercise and COPD

Exercise intolerance results from many contributing factors. A subjective feeling of breathlessness is 1 of the major components of exercise intolerance; however, mechanical and physiologic factors can also contribute. One of the mechanical factors involved is peripheral muscle deconditioning.[17] Peripheral muscle deconditioning can begin within 1 week after the onset of reduced physical activity. Typically, patients with COPD subconsciously limit their activity for many months or years before they are diagnosed, which can lead to insidious muscle wasting.[13,20] These patients' deconditioned peripheral muscles tire very quickly, contributing heavily to their exercise intolerance.[21]

Ventilatory and respiratory mechanics also contribute to exercise intolerance. Physiologically, COPD results in air trapping and hyperinflation; this shift in lung volume decreases inspiratory capacity. Patients with lower inspiratory capacities are less able to regulate their tidal volumes to accommodate exercise, resulting in exercise intolerance. In addition, exercise directly exacerbates hyperinflation and air trapping, a phenomenon known as dynamic hyperinflation.[12] Dynamic hyperinflation further reduces inspiratory capacity by impairing the ability of the lungs to accommodate exercise either mechanically or physiologically. The severity of exertional dyspnea has been shown to correlate directly with the degree of dynamic hyperinflation.[17,22]

Diagnosis and Treatment of COPD

For all of the reasons discussed, COPD significantly impacts the HRQoL of both the patients and their loved ones. The trends in the morbidity and mortality from this disease portend significant social and economic consequences. Therefore, early diagnosis and treatment of COPD are paramount not only for improving the patient's HRQoL but also for limiting the social and economic ramifications of this disease.

Chronic obstructive pulmonary disease is often misdiagnosed early in its course as asthma, which delays the correct diagnosis and treatment of COPD.[23] Early diagnosis is critical to the treatment of COPD because it enables the earlier initiation of interventions and thereby affects the perceived declines in pulmonary function and exercise tolerance.

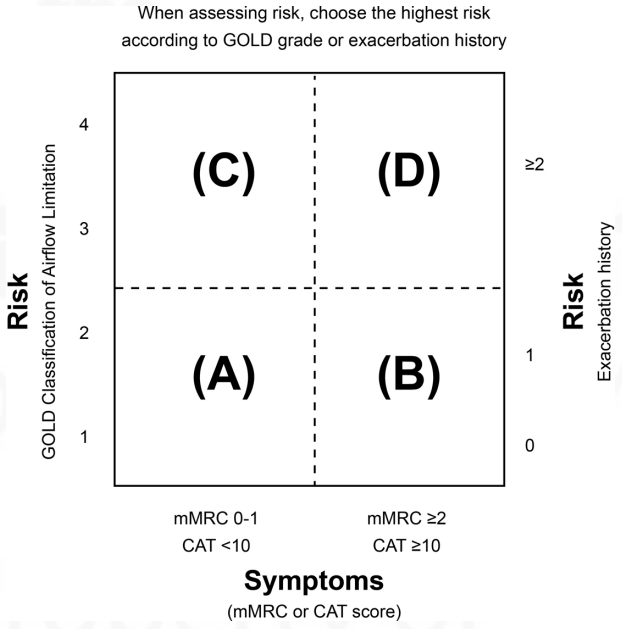
Chronic obstructive pulmonary disease should be suspected in any current or former smoker who is aged $\geq$ 40 years and has $\geq$ 1 of the key diagnostic criteria outlined by the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines.[12] These criteria include dyspnea, chronic cough or sputum production, and/or a history of exposure to risk factors for the disease. The GOLD document is an evidence-based publication outlining a global strategy for diagnosis, management, and prevention of COPD. It is one of the foremost resources for health care providers for the diagnosis, treatment, and prevention of COPD. As discussed in the document, early and appropriate treatment can significantly decrease morbidity from COPD.[12]

A detailed discussion of the treatment of COPD is beyond the scope of this article; however, a brief review of some pharmaceutical interventions may be useful. The categories of medications used for the treatment of COPD include bronchodilators (categorized as long- or short-acting β_2-agonists, long- or short-acting inhaled anticholinergics, or methylxanthines, such as theophylline), inhaled corticosteroids, systemic corticosteroids, combination medications, and phosphodiesterase-4 inhibitors. The recommended implementation of these medications is based on the patient's disease category (Figure 2, A–D), which is derived from the patient's symptoms and future risk for exacerbations. Patients in categories A, B, C, and D are those with low risk for exacerbations and few symptoms, those with low risk and more symptoms, those with high risk for exacerbations and few symptoms, and those with high risk and more symptoms, respectively.[12] Pharmaceutical interventions for patients in category A include short-acting bronchodilators (taken as needed) as the first choice and a combination of short-acting bronchodilators or a long-acting bronchodilator as the second choice. Long-acting bronchodilators should be introduced for patients in category B or higher. Inhaled corticosteroids should be added to the existing medication regimen for patients in category C (Figure 3).[12]

The Exercise Prescription

Pharmaceutical management of COPD is well recognized by primary care physicians (PCPs); however, another critical and often-overlooked intervention is the implementation of an exercise program. As discussed, activity levels correlate

Figure 2. Associations between symptoms, spirometric classification, and future risk of exacerbations.[12]



Abbreviations: CAT, Chronic Obstructive Pulmonary Disease Assessment Test; GOLD, Global Initiative for Chronic Obstructive Lung Disease; mMRC, modified British Medical Research Council.
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inversely with morbidity and mortality. Exercise training, specifically aerobic exercise and resistance training, alleviate dyspnea and improve exercise tolerance and HRQoL in patients with mild-to-severe COPD.[24,25] In fact, the minimal clinically important change in HRQoL from exercise training can be comparable with or greater than that gained through pharmaceutical interventions.[26] Formal exercise prescriptions have been shown to increase patient compliance with exercise plans.[27,28] One commonly accepted and proven way of writing an exercise prescription that may be appropriate for patients with stage I or II COPD is the FITT format, which comprises 4 components: Frequency (of exercise sessions), Intensity (rate of energy expenditure), Time (duration of a session), and Type of activity.[29]

Frequency

The benefits of exercise are dose dependent, meaning that the benefit increases as the amount of exercise performed increases, especially for those who lead sedentary or near-sedentary lives. The American College of Sports Medicine and the American Heart Association recommendation for individuals aged 18 to 65 years is moderate-intensity physical activity 5 times per week for 30 minutes, vigorous-intensity exercise 3 times per week for 20 minutes, or a combination of moderate- and vigorous-intensity exercise.[30]

Intensity

Because fitness levels vary markedly among adults, intensity is a subjective measure for each patient. On a 10-point scale, moderate intensity is rated as a 5 or 6. However, this rating is based on patient-perceived exertion during certain activities, which means that a 5 or 6 on a scale of 10 for 1 patient could vary significantly from a 5 or 6 for another, more physically fit patient. This is where the FITT plan becomes individualized and dynamic. As a patient's fitness level improves, the exercise prescription needs to change to meet the intensity criteria. Moderate-intensity activity should noticeably increase the heart and respiratory rates. One good way to measure the subjective intensity level in healthy patients and patients in the earlier stages of COPD is the talk test. During moderate-intensity exercise, the patient should still be able to hold a conversation despite increases in his or her heart and breathing rates. Some examples of moderate-intensity exercise include walking ($\geq$ 3 mph, but not race walking), general gardening, ballroom dancing, household cleaning, leisurely biking (at $<$ 10 mph), and water aerobics.[31] Because many patients with chronic disease—especially those with more advanced chronic lung disease—may not reach the desired level of intensity because of self-limitation, a few episodes of supervised activity or sessions of pulmonary rehabilitation may help patients feel more comfortable identifying and exercising at a moderate-intensity level.[32] For patients with significant activity limitations, a personalized exercise plan may be necessary. The plan should be based on direct evaluation of the individual's ability, with exercise goals and limits typically based on more objective values, such as the maximum work rate or maximum oxygen consumption.[33]

Time

Timing is another fixed variable. Although 30 minutes per day is recommended,[30] this 30-minute exercise may be completed all at once or divided into separate sessions (eg, three 10-minute sessions). While division of the 30 minutes into $>$ 3 sessions is not recommended, it is ultimately better to exercise for a total of 30 minutes, however possible, than not at all. If a patient is new to exercise or has more severe limitations, it is appropriate to take a gradual or stepwise approach to reaching the target of 30 minutes per day. For these patients, breaking the exercise into short sessions may make the difference in their abilities to reach their exercise goals. Such

Figure 3. Pharmacologic management of COPD.[12]

Initial Pharmacologic Management of COPD*

Patient Group	First Choice	Second Choice	Alternative Choice**
A	Short-acting anticholinergic prn *or* Short-acting $beta_2$-agonist prn	Long-acting anticholinergic *or* Long-acting $beta_2$-agonist *or* Short-acting $beta_2$-agonist and short-acting anticholinergic	Theophylline
B	Long-acting anticholinergic *or* Long-acting $beta_2$-agonist	Long-acting anticholinergic and long-acting $beta_2$-agonist	Short-acting $beta_2$-agonist *and/or* Short-acting anticholinergic Theophylline
C	Inhaled corticosteroid + long-acting $beta_2$-agonist *or* Long-acting anticholinergic	Long-acting anticholinergic and long-acting $beta_2$-agonist	Phosphodiesterase-4 inhibitor Short-acting $beta_2$-agonist *and/or* Short-acting anticholinergic Theophylline
D	Inhaled corticosteroid + long-acting $beta_2$-agonist *or* Long-acting anticholinergic	Inhaled corticosteroid and long-acting anticholinergic *or* Inhaled corticosteroid + long-acting $beta_2$-agonist and long-acting anticholinergic *or* Inhaled corticosteroid + long-acting $beta_2$-agonist and phosphodiesterase-4 inhibitor *or* Long-acting anticholinergic and long-acting $beta_2$-agonist *or* Long-acting anticholinergic and phosphodiesterase-4 inhibitor	Carbocysteine Short-acting $beta_2$-agonist *and/or* Short-acting anticholinergic Theophylline

*Medications in each box are mentioned in alphabetical order, and therefore not necessarily in order of preference.
**Medications in this column can be used alone or in combination with other options in the First and Second columns.
Abbreviations: COPD, chronic obstructive pulmonary disease; prn, taken as needed.
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incremental approaches also make increasing activity more pleasant, minimize the risk for overuse injuries, and provide positive reinforcement as patients achieve each small goal.[32]

Type

Finally, type relates to the type of exercise training that is performed (ie, aerobic activity or muscle strengthening).[34] Ideally, a patient should get some of each type of exercise training each week. Aerobic exercise is important for patients with chronic lung disease because it contributes to muscular reconditioning and increases exercise tolerance. Muscle strengthening through resistance exercise, which may be implemented in a supervised setting or individually, is equally important, as it helps to combat the loss of muscle strength.[25,35,36] A patient may execute a muscular strengthening regimen using machines or equipment or by simply using his or her own body weight. Flexibility or balance training can also be considered, especially in elderly patients, to increase the ease of performing ADL and decrease the incidence of falls.[32]

Individuals with conditions that render exercise unsafe should not be prescribed an exercise rehabilitation program. Such conditions include severe pulmonary hypertension with dizziness or syncope on exertion, severe congestive heart failure refractory to medical management, unstable coronary syndromes, and malignancy with bone instability or refractory fatigue.[19]

The Role of Pulmonary Rehabilitation

While the FITT method of exercise prescription writing is a good starting point for patients with early or moderate COPD, it may not be appropriate or manageable for patients with more severe disease. All patients with COPD can benefit from structured physical training and pulmonary reconditioning

with disease-specific goals. Pulmonary rehabilitation is 1 resource for structured exercise training[12]; however, it is underutilized and poorly understood by most PCPs in the United States.[3,37,38]

Pulmonary rehabilitation is designed to increase HRQoL and functional performance in patients with chronic respiratory diseases, including COPD, through a comprehensive, multidisciplinary approach.[39,40] This multidisciplinary approach addresses both the pathophysiologic and psychological aspects of COPD.[12] The rehabilitation team consists of physicians, nurses, occupational, physical, and respiratory therapists, psychologists, dieticians, exercise specialists, and other trained medical professionals.[39] The GOLD guidelines recommend comprehensive pulmonary rehabilitation as an integral part of the COPD treatment plan for patients in categories B through D.[12] This recommendation is supported by guidelines from the American College of Physicians, the American College of Chest Physicians, the American Thoracic Society, and the European Respiratory Society, all of which advocate pulmonary rehabilitation for symptomatic patients with a forced expiratory volume in the first second of expiration (FEV_1) of $< 50\%$ of the predicted value and symptomatic or exercise-limited patients with an FEV_1 of $> 50\%$ of the predicted value.[41] A comprehensive program uses multiple strategies, including education in medication compliance, awareness of changes in disease severity, self-adjustment of medications during exacerbations, and coping skills.[12] This comprehensive approach, which is not a finite course but aims for long-term lifestyle change, reduces symptoms of breathlessness and improves overall functioning and HRQoL in many ways.[17] A meta-analysis performed by Lacasse et al[25] strongly supports the implementation of pulmonary rehabilitation, as it produces consistent improvement in 4 areas of HRQoL (ie, dyspnea, fatigue, emotional function, and mastery)—more so than the use of medical interventions alone. In addition, pulmonary rehabilitation also results in consistent improvements in functional capacity.[25] Furthermore, Golmohammadi et al[42] have demonstrated that the use of pulmonary rehabilitation as part of the treatment of COPD decreases hospitalizations and emergency department visits.

Pulmonary rehabilitation should be prescribed in conjunction with comprehensive pharmacologic management. Patients who improve their compliance with medication achieve better medical management of their symptoms. Although the literature is inconsistent regarding the effects of long-acting β_2-agonists and/or inhaled corticosteroids, the use of inhaled anticholinergics clearly improves exercise performance and tolerance.[43–47]

The emphasis of pulmonary rehabilitation programs on exercise, activity, fitness, and weight loss (or gain) has been shown to alter the pathophysiologic process of COPD.[48] On average, pulmonary rehabilitation has been shown to increase maximum workload by 18%, maximum oxygen consumption by 11%, and endurance time by 87%, which translates to a 49 m improvement in 6-minute walking distance.[12,26] Pulmonary rehabilitation reduces the perceived breathlessness on exertion, the length of hospital stay, and the total number of hospitalizations.[12,25] It also improves exercise capacity and HRQoL.[12,25]

Pulmonary rehabilitation has been shown to have significant psychosocial benefits and to alleviate mood disorders associated with COPD, specifically depression and anxiety. Because depression and anxiety can contribute directly to functional impairment in patients with COPD,[25,49] pulmonary rehabilitation also includes a psychologic counseling component. Combined with improvement in the subjective symptom of breathlessness, this reduces the symptoms of anxiety and depression in patients with COPD.[50] One study even indicated that a pulmonary rehabilitation program that did not include direct psychological counseling still decreased anxiety and depression, suggesting a positive effect of exercise alone on the psychologic comorbidities associated with chronic lung disease.[51] Improvements in these symptoms contribute to reversing the vicious cycle of dyspnea and activity limitation (Figure 1). As the symptoms of depression and anxiety abate, patients have more energy and fewer symptoms.[17,52,53] Because of this, they are better able to participate in the physical component of pulmonary rehabilitation and more likely to maintain the exercise regimen, further improving outcomes.[17,52,53]

Underutilization of Pulmonary Rehabilitation

Given the literature on pulmonary rehabilitation and the emphasis on the importance of pulmonary rehabilitation in the treatment and management of COPD, it is surprising that pulmonary rehabilitation is not more widely used and accepted in the United States. It is the standard of care for COPD and yet remains the intervention most underutilized in our patients. In a recent study, Heins-Nesvold et al[3] noted that nearly two-thirds of the patients with COPD included in the study had neither heard of pulmonary rehabilitation nor had been recommended to undergo such a procedure by their physicians. There are likely many reasons for this. First, the

authors believe that most PCPs lack a clear understanding of the true nature and purpose of pulmonary rehabilitation. Pulmonary rehabilitation is often perceived to be only for the acutely ill. For example, a typical PCP might consider recommending pulmonary rehabilitation for a patient with a severe exacerbation of COPD requiring intubation as a transitional care option when the level of care required does not qualify for hospitalization but exceeds that available at a rehabilitation center or skilled nursing facility. This is an acceptable and important use for pulmonary rehabilitation, but it should not be the only situation in which a PCP considers pulmonary rehabilitation as a possible intervention. Pulmonary rehabilitation is available to patients on an outpatient basis as well and should be more frequently considered in that setting.

Another barrier to the widespread use of pulmonary rehabilitation is that it is typically not reimbursed appropriately by managed-care organizations, health insurance providers, or other medical payers.[54] However, in recent years, some coverage has been made available through Medicare. While many insurance companies consider physical therapy as part of the standard of care for rehabilitation after a musculoskeletal injury, pulmonary rehabilitation is often not seen in the same light. However, we propose that medical payers should reimburse for such care in order to be compliant with the recommendations of all pulmonary associations as well as the GOLD guidelines. The potential costs of the increased frequency of hospitalizations, length of stay per hospitalization, and numbers of emergency department and outpatient doctor visits for poorly controlled symptoms, exacerbations, and comorbid anxiety and depression are immense[38,55] and can help to justify the up-front expenditures required to establish pulmonary rehabilitation programs. Multiple studies in the United States and in other countries have shown favorable cost–benefit ratios for pulmonary rehabilitation when the outcomes and overall cost of treating COPD are considered.[42,53,56] This is an important area of focus for future research in pulmonary rehabilitation. In addition, the United States is in the midst of significant health care reform. Changes in the coverage of pulmonary rehabilitation may be more easily accomplished during this time of potentially monumental transitions in health care funding and systems. Pharmaceutical management for COPD has advanced significantly over the past decade. However, pharmaceutical management alone is insufficient. A more comprehensive approach to COPD is imperative to decrease the overall morbidity and mortality rates from COPD in the United States and worldwide.

Conclusion

Chronic obstructive pulmonary disease is a leading cause of morbidity, mortality, and high health care–related costs both domestically and throughout the world. The prevalence of COPD continues to increase each year. Primary care physicians must maintain a high level of suspicion for COPD to enable early diagnosis. Once the diagnosis has been made, early medical management and an exercise regimen should be implemented. Pulmonary rehabilitation or an exercise program should be considered early in the course of COPD, at the same time that pharmaceutical management is prescribed. When implemented in a timely manner, all of these interventions can improve outcomes for patients with COPD.

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Conflict of Interest Statement

Jessica Favero Butts, MD, discloses no conflicts of interest. Mark H. Belfer, DO, discloses conflicts of interest with Boehringer Ingelheim, Pfizer Inc, and sanofi-aventis. Kevin B. Gebke, MD, discloses conflicts of interest with Boehringer Ingelheim and Pfizer Inc.

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