ORIGINAL ARTICLE

Pulmonary Rehabilitation:
A Retrospective Study in Eastern North Carolina

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BACKGROUND Pulmonary rehabilitation (PR) is an evidence-based measure to benefit chronic obstructive pulmonary disease (COPD) patients. Many patients have benefitted from our robust university hospital–based PR program. We have objectively assessed the benefit of our PR program for COPD patients in Eastern North Carolina.

METHODS We used retrospective chart review to collect data from all the patients who completed PR from January 1, 2012 through December 31, 2013. Data collection included quality-of-life scores using short-form 36 (SF-36) and 6-minute walk distance (6MWD) to measure exercise capacity before and after PR. We also collected data on COPD exacerbation frequency 1 year before and 1 year after PR. The data were analyzed using the statistical software Statistical Package for the Social Sciences version 22.0.

RESULTS We analyzed data from 51 patients with 4 categories of COPD: mild (n = 2), moderate (n = 12), severe (n = 23), and very severe (n = 14). The PR program resulted in improvement in 6MWD of an average of 263.8 feet ($P < .01$) and a decrease in COPD exacerbation frequency by 0.3 events per year ($P < .05$). There were mixed results for quality-of-life scores.

LIMITATIONS Our study was conducted at 1 center and thus involved a single COPD patient population with limited sample size. We did not follow patients long term to see whether the benefits were sustained.

CONCLUSIONS Our PR program resulted in a positive impact on exercise capacity, COPD exacerbation rate, and some aspects of quality of life.

Chronic obstructive pulmonary disease (COPD) is defined by the American Thoracic Society (ATS)/European Respiratory Society (ERS) as "a preventable and treatable disease state characterized by airflow limitation that is not fully reversible" [1]. Chronic bronchitis and emphysema fall under COPD. According to the Centers for Disease Control and Prevention (CDC), COPD is the 3rd leading cause of death in the United States after heart disease and cancer. Many evidence-based medications are known to help qualified COPD patients, including bronchodilators, inhaled steroids, and oxygen inhalation. In addition, there is growing interest in structured, supervised pulmonary rehabilitation (PR) programs. PR comprises supervised exercise training along with education and psychological support. PR aims to improve the physical and psychological condition of patients as well as their long-term adherence to health-enhancing behaviors [2, 3].

According to 2011 vital statistics data, Eastern North Carolina has higher death rates from chronic medical illnesses like stroke (0.8%), heart disease (12%), diabetes (30%), and cancer (3%), but a lower COPD mortality rate (6.3%) compared to the rest of the state. PR has proven to be effective in treating COPD patients in multiple studies [4-6].

Our university-based hospital has a robust PR program. Many patients who complete PR at our center feel that they benefit from this program; however, PR has not previously been studied in Eastern North Carolina. The purpose of this study was to determine if there was objective improvement in health-related quality of life (HRQOL), 6-minute walk distance (6MWD), and frequency of COPD exacerbations in our patient population.

Methods

Description of the Pulmonary Rehabilitation Program

The PR staff consists of nurses, exercise physiologists, respiratory therapists, a dietician, and a supervising physician. Each patient's exercise goals are identified during the initial patient interview. The duration, intensity, and progression of the exercise program depend on the patient's medical history, clinical status, risk stratification, and results of a 6MWD test. The patient participates in PR 2–3 days per week. Generally, each session lasts 40–85 minutes. We used a combination of different modes of exercise depending on the patient's goals and physical and orthopedic limitations: treadmill or track walking, arm ergometer, flexibility exercise, NuStep (recumbent stepper), strength training, arc or elliptical trainer, and rowing machine. Patients are monitored during the sessions, and they are encouraged to continue specified exercises at home.

In addition to exercise, patients are educated weekly on psychosocial issues including smoking cessation, compliance with medications, and coping with chronic medical illness. Rehabilitation staff also screen patients for depression

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and report symptoms to the referring physician. Although we do not have a formal smoking cessation program, the rehabilitation staff educates patients about the health benefits of cessation and the hazards of continuing to smoke. If patients are ready to quit, staff recommend and make referrals to the North Carolina Quitline.

To screen for depression, we used the Center for Epidemiologic Studies Depression Scale (CES-D) [7]. We recommend referrals to local support as needed (psychologists, primary care providers, and psychiatrists), and we also offer participation in stress management sessions within the PR program. The stress management classes are facilitated by the rehabilitation staff and include guided imagery, breathing retraining techniques, and progressive muscle relaxation. The psychosocial classes are taught in the rehabilitation facility by representatives from the East Carolina University Department of Psychology .

Patients graduate from the program after completing 24–32 sessions, achieving the goals specified in their individualized treatment plan, and adopting a home exercise program.

Study Design

Our study was approved by the East Carolina University institutional review board, and need for subject consent was waived. Patients were identified by reviewing the PR records. We accessed each chart to confirm the diagnosis of COPD, attendance at PR, and outcome variables. Data were collected retrospectively by reviewing the electronic medical records of all patients who completed PR during the period from January 1, 2012 to December 31, 2013. 6MWD was measured in feet, and HRQOL scores were assessed by short-form 36 (SF-36) before and after completing PR [8]. Patients completed these forms before beginning and after completing rehabilitation. SF-36 consists of multiple components, 3 of which we checked in our PR program: social functioning, role evaluation, and mental health. Each component was scored from 0 (high disability) to 100 (no disability). The score was calculated by a proprietary algorithm that assigned equal weights to all of the questions [8]. We also collected data on the frequency of COPD exacerbations during the period 1 year before and 1 year after the completion of PR. For the purpose of our study, a COPD exacerbation was defined as worsening of COPD symptoms requiring treatment with steroids and antibiotics or steroids alone. We did not distinguish between COPD exacerbations treated in the outpatient setting versus those requiring hospitalization.

Selection of Patients

Patients were eligible to participate in the study if they were 18 years of age or older, had a COPD diagnosis based on clinical criteria and pulmonary function tests, and completed the PR program. Patients were excluded from the study if they did not have pulmonary function tests for the diagnosis of COPD or they failed to perform PR exercises because of other medical conditions such as severe osteoarthritis, severe heart failure, or stroke.

Intervention

The intervention for this study was participation in an outpatient PR program. We collected data on the same patients before they entered the rehabilitation program and again after they graduated. 6MWD and HRQOL were assessed before starting the program and after finishing the program. COPD exacerbation frequency was calculated 1 year before and 1 year after completion of the PR program.

Statistical Analysis

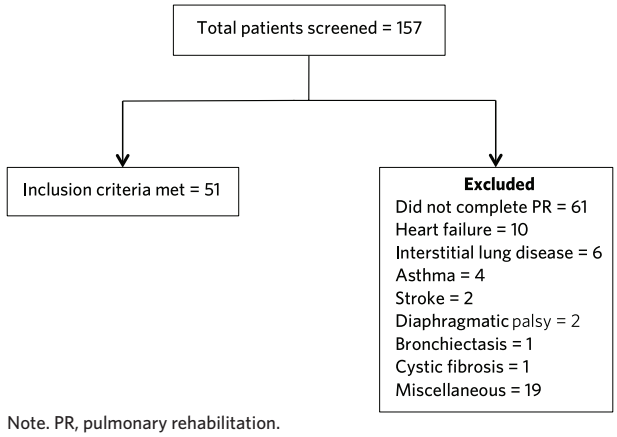
The statistical software Statistical Package for the Social Sciences version 22.0 was used for the analysis of data. Descriptive statistics were computed using the frequency, cross tables, and comparison of the means procedures of that software package. Changes in scores were computed as the post-intervention value minus the pre-intervention value. A Wilcoxon signed-rank test was used for assessing the changes. Based on forced expiratory volume at the end of 1 second (FEV1), we used the Global Initiative for Chronic Obstructive Lung Disease (GOLD) criteria to divide COPD into the following categories: mild (FEV1 80% predicted or more), moderate (FEV1 50%–79% predicted), severe (FEV1 30%–49% predicted), and very severe (FEV1 29% or less predicted) [9]. The comparison of change scores among these subgroups was computed using the Kruskal-Wallis test. The level for statistical significance was set at 0.05.

Results

We screened a total of 157 patients who completed PR from January 2012 to December 2013. Of this group, 51 patients met all of the inclusion criteria. Most of the excluded patients did not complete the rehabilitation program (See Figure 1).

Table 1 shows the baseline characteristics by COPD severity groups. In our population of 51 patients, 2 had mild

FIGURE 1.
Number of Patients Screened, Included, and Excluded



Note. PR, pulmonary rehabilitation.

TABLE 1.
Baseline Demographic Characteristics, by COPD Severity

	Mild (n = 2)	Moderate (n = 12)	Severe (n = 23)	Very severe (n = 14)	Total (N = 51)
Age, years	83.5 (0.7)	67.7 (12.1)	69.2 (7.4)	63.7 (7.9)	68.0 (9.4)
Female (%)	0	26.1	52.2	21.7	45.1
FEV1[a]	91.5 (10.6)	57.3 (7.8)	39.6 (5.5)	23.0 (4.1)	41.3 (17.1)

Note. COPD, chronic obstructive pulmonary disease.
Data for age and FEV1 are given as mean (standard deviation).
[a]FEV1 is the forced expiratory volume at the end of 1 second, in terms of percent predicted.

disease, 12 had moderate disease, 23 had severe disease, and 14 had very severe disease. The majority of patients were in the severe group. Only 2 patients were in the mild group, both of whom were older than 83 years of age. The mean age of all patients included in the study was 68.0 years. Males predominated except in the severe group, which had slightly more females than males. The range of FEV1 percent predicted was from 16% to 99%, and the mean was 41.3%.

Table 2 shows the outcome variables (and their statistical significance) for the different groups before and after PR. All the numbers shown are means with standard deviations in parentheses. This table shows that, when we combine data from all subjects except those with mild COPD, PR benefits patients in terms of 6MWD, HRQOL, and COPD exacerbation frequency. The patients with mild COPD were dropped from this analysis because there were only 2 patients in that group. All the variables were statistically significant except the role evaluation component of the SF-36.

Further, we compared the moderate, severe, and very severe groups to see if any group benefitted more from PR than the other groups. This comparison revealed no statistically significant differences in improvement, meaning that all groups benefitted equally.

Discussion

COPD is primarily a disease of the lungs, but it also affects other parts of the body including skeletal muscles, thus resulting in deconditioning [10]. Although PR does not

TABLE 2.
Outcome Variables Before and After Pulmonary Rehabilitation, by COPD Severity

	Mild (n = 2)	Moderate (n = 12)	Severe (n = 23)	Very severe (n = 14)	Total (N = 51)
HRQOL: social functioning					
Pre-PR	29.5 (7.8)	36.0 (10.3)	37.7 (9.9)	43.9 (14.0)	38.7 (11.5)
Post-PR	40.5 (7.8)	46.7 (8.0)	43.3 (9.5)	50.7 (10.3)	46.0 (9.7)
Difference	11.0 (15.6)	10.7 (9.2)	5.7 (9.1)	6.9 (14.1)	7.4 (10.8)†
HRQOL: role evaluation					
Pre-PR	27.0 (8.5)	38.8 (15.9)	37.1 (14.9)	42.1 (15.1)	38.5 (15.0)
Post-PR	31.0 (2.8)	44.3 (12.3)	40.4 (13.3)	46.2 (11.8)	45.6 (12.6)
Difference	4.0 (5.7)	5.5 (18.2)	3.3 (15.9)	4.1 (13.1)	4.1 (15.1)
HRQOL: mental health					
Pre-PR	47.0 (4.2)	49.3 (10.0)	44.5 (8.8)	49.0 (8.6)	47.0 (9.0)
Post-PR	43.0 (9.9)	52.7 (8.4)	49.0 (10.0)	54.4 (8.3)	51.1 (9.4)
Difference	−4.0 (14.1)	3.3 (7.0)	4.4 (8.7)	5.4 (6.5)	4.1 (7.9)†
6MWD					
Pre-PR	861.0 (220.6)	1,070.5 (372.3)	1,135.8 (401.4)	894.7 (234.9)	1,040.6 (359.5)
Post-PR	1,137.0 (94.8)	1,321.0 (324.8)	1,393.9 (324.8)	1,167.1 (258.3)	1,304.4 (307.3)
Difference	276.0 (125.9)	250.5 (215.2)	258.1 (256.6)	283.0 (154.9)	263.8 (214.2)†
COPD exacerbations					
Pre-PR	0 (0)	0.4 (0.7)	0.6 (0.7)	1.1 (0.9)	0.7 (0.8)
Post-PR	0.5 (0.7)	0.3 (0.7)	0.4 (0.7)	0.4 (0.6)	0.4 (0.6)
Difference	0.5 (0.7)	−0.1 (1.1)	−0.2 (0.9)	−0.8 (1.3)	−0.33 (1.1)*

*$P \leq .05$
†$P \leq .01$
Note. 6MWD, 6-minute walk distance; COPD, chronic obstructive pulmonary disease; HRQOL, health-related quality of life; PR, pulmonary rehabilitation.
All data are represented as mean (standard deviation).

have a direct effect on lung function or gas exchange [11], it affects other body systems to help optimize lung function [2]. There are different aspects of pulmonary function tests. The most commonly used variable for research purposes is FEV1, which we used to grade severity of COPD into 4 different categories, as explained previously. PR has been linked to several health improvements: increased skeletal muscle function and exercise capacity, enhanced HRQOL, decreased dyspnea, and reduced anxiety and depression associated with COPD [5, 6]. For this study, we retrospectively analyzed several outcome variables for COPD patients who completed PR at our university hospital center.

The effects of PR on exercise capacity and HRQOL among COPD patients has been extensively studied. The results of our retrospective review are consistent with other studies that have shown that baseline severity of COPD is unrelated to the degree of improvement for the variables we measured [12-14]. PR did significantly improve 6MWD and most measures of HRQOL when data from all patients were combined (see Table 2). Our finding that there were no significant changes between groups implies that PR yields clinical benefits for all groups. Some studies have suggested that patients with less severe obstruction have greater improvements in exercise tolerance [15], but this was not the case in our study.

Data from other centers showed a mean improvement in 6MWD of 70–190 feet [5, 14, 16, 17]. Mean improvement in 6MWD among patients in our study was greater, at 263.8 feet. The reason for this greater improvement in 6MWD compared to that demonstrated by other studies is not clear. A possible explanation is that our patients had never undergone PR, and we know from the National Emphysema Treatment Trial that benefits of PR are significantly greater in patients without prior rehabilitation experience [17]. Another possible explanation is the open floor plan of our center. This means that there is not a specific class start time or stop time, which allows patients who need more rest to take breaks and still complete the prescribed exercise regimen. It is also possible that the exercise regimen in our program was different from that of other programs. This study was conducted in our university-based rehabilitation center. It would be interesting to see if the results of this study would be the same if PR were conducted at our community-based rehabilitation centers.

Of great importance is the statistically significant reduction in the frequency of COPD exacerbations in patients completing our rehabilitation program. This outcome would likely result in a reduction in health care costs, which is consistent with the findings of other studies [18-20]. In one such study by Raskin and colleagues, 128 patients received PR at 11 outpatient centers, and there were 0.25 fewer hospitalizations in the year following PR [21]. In another study, the California Pulmonary Rehabilitation Collaborative Group analyzed a total of 522 patients in 9 centers and demonstrated a significant decline in health care resource utilization 18 months after PR [22].

The improvement observed in HRQOL in our study is consistent with the findings of a prior study by Camp and colleagues. Their study performed both quantitative and qualitative analysis of HRQOL and showed that subjects had improved physical function, less dyspnea, and a heightened sense of control over their COPD, which resulted in increased confidence and improved emotional well-being [23].

There are some limitations of our study. First, an inherent limitation of this type of study is the absence of a control group. Second, we did not have long-term follow-up of patients to determine if the benefits of PR were sustained. Lastly, we had only 2 patients in the mild COPD group, which is likely due to the fact that few patients with mild COPD receive referrals to the rehabilitation center.

Conclusion

Our study is consistent with several other studies showing that COPD patients substantially benefit from PR in terms of increased exercise capacity, fewer exacerbations of disease, and improvements in some aspects of HRQOL. We recommend that every COPD patient with persistent symptoms and exercise limitations be considered for PR. Patients with mild COPD are usually not sent to PR, although they may benefit from it. Further studies targeting patients with mild COPD are needed to determine the benefit of PR in this population. It would also be useful to know which exercises are most effective in improving exercise capacity. The improvement in 6MWD shown in our study was greater than that reported by other institutions. NCMJ

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