Impact of Brief or Extended Exercise Training on the Benefit of a Dyspnea Self-management Program in COPD

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- PURPOSE: To evaluate the differences in the long-term outcomes of dyspnea, exercise performance, health-related quality of life, and health resource utilization following a dyspnea self-management program with 3 different ''doses'' of supervised exercise.
- PATIENTS AND METHODS: In a prospective, randomized, single-blind, 1-year trial, patients with stable chronic obstructive pulmonary disease (N = 103; age 66 ± 8, females 57; FEV_1 44.8% ± 14% predicted) were randomly assigned to either: (1) Dyspnea self-management program (DM); (2) DM plus 4 supervised exercise sessions (DM-exposure); or (3) DM plus 24 supervised exercise sessions (DM-training). The dyspnea self-management program included individualized education and demonstration of dyspnea self-management strategies, an individualized home walking prescription, and biweekly nurse telephone calls. Outcomes were measured at baseline and every 2 months for 1 year.
- RESULTS: The DM-training group had significantly greater improvements in dyspnea during incremental treadmill test and in exercise performance on the incremental and endurance treadmill tests at 6 and 12 months compared with the other 2 groups. Dyspnea with activities of daily living and self-reported physical functioning significantly improved for all groups over time. The dose-response relationship between supervised exercise and improvement in dyspnea present at 2 months was not sustained over the year.
- CONCLUSION: Consistent with previous findings from evaluation studies of pulmonary rehabilitation programs, the greater number of supervised exercise training sessions improved laboratory dyspnea and performance more than the other two doses of exercise. In the long term, the improvement in dyspnea with activities of daily living and physical functioning was similar for all 3 groups.

KEY WORDS

COPD

dyspnea

exercise

health-related quality of life

physical functioning

self-management

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INTRODUCTION

Dyspnea, or shortness of breath, is the most common complaint of patients with chronic obstructive pulmonary disease (COPD). Optimal medical treatment does not always provide complete relief and, with the exception of acute exacerbations, patients with COPD must rely on themselves to control their shortness of breath and the suffering it causes.[1,2] Recent studies of comprehensive outpatient and home-based pulmonary rehabilitation as treatments for patients with COPD have been shown to improve dyspnea, exercise performance, and health-related quality of life in both the short[3–9] and long term.[10–17] However, outpatient programs are available for only a small percentage of patients with COPD because they are expensive and often not accessible to those living outside metropolitan areas.[18,19] For patients who are unable to attend structured pulmonary rehabilitation programs, more readily available interventions that enhance patients' self-management of dyspnea and ultimately improve their quality of life across the continuum of their illness are needed.

Self-management programs have shown promising results in a number of chronic diseases including heart failure, diabetes, arthritis, and asthma.[20–24] By increasing knowledge and mastery of self-management skills, these programs place the day-to-day responsibility for managing the disease on the patient with only intermittent collaboration with the healthcare provider.[25] There has been relatively little study of self-management programs for dyspnea in patients with COPD. Self-management programs for COPD that have included only education and limited skills training have not been shown to significantly or consistently reduce symptoms,[26–28] although recent programs have shown improvement in health resource utilization.[26,29] Unlike other chronic conditions such as asthma, prior studies affirm that if symptom and quality-of-life outcomes are to be improved for patients with COPD, self-management programs need to incorporate some form of regular exercise.[27,28] However, the most appropriate "dose" of supervised or nonsupervised exercise to achieve a reasonable reduction in dyspnea remains unclear.

The purpose of this analysis was to evaluate the long-term outcomes of 3 versions of a dyspnea self-management program: (1) Dyspnea self-management program (DM) alone; (2) DM with 4 supervised exercise sessions (DM-exposure); and (3) DM with 24 supervised exercise sessions (DM-training). The primary outcomes were dyspnea with laboratory exercise as well as activities of daily living. We also compared the effects of these programs on exercise performance, health-related quality of life, and health resource utilization.

PATIENTS AND METHODS

This was a longitudinal, randomized, clinical trial with repeated measures every 2 months over 1 year. Research personnel who performed these measurements were blinded to patients' treatment group assignments. Entry criteria included the following: age older than 40 years, clinically stable for at least 1 month, persistent moderate to severe airflow obstruction after inhaling 2 puffs of albuterol, absence of exercise training or pulmonary rehabilitation for at least 1 year, absence of other diseases which would interfere with exercise, and ability to complete an incremental treadmill test (ITT) with appropriate use of the modified Borg scale for rating dyspnea.[30] The methods and 2-month outcomes for this study have been previously reported.[31]

Interventions

Dyspnea Self-management (DM) Program

Patients in this group received the DM program only that included 3 components:

Individualized education: Four 1-hour individualized educational sessions over the first 8 weeks and half-hour reinforcement sessions at 4 and 8 months included discussion of: (1) the sensations and precipitants of dyspnea; (2) early recognition of exacerbations; (3) reinforcement of the patient's own self-care strategies for dyspnea and discussion of those used by others; (4) benefits of home walking and integration of home walking into the patients' lifestyle with discussion of specific ways to overcome barriers to walking.

Home walking prescription and daily log: Patients were instructed to walk at least 4 times per week for a minimum of 20 minutes per session at their maximum pace so that they felt at the end of the walk that they could not have gone farther. They completed a daily log of time and distance walked, and the level of dyspnea at the end of the walk rated on a modified Borg scale.

Biweekly nurse telephone calls were used to monitor progress, answer questions and provide encouragement, discuss barriers to exercise, and provide personalized feedback.[32]

Dyspnea Self-management Program Plus Exposure (DM-exposure)

Patients in this group received all of the components of the DM program described above and 4 supervised treadmill exercise sessions once every other week for 2 months. Compliance with the 4 exercise sessions was 100% for this group. In our earlier work, we showed that exposure to dyspnea in 12 supervised exercise sessions significantly decreased the anxiety associated with dyspnea and dyspnea intensity.[33] Analysis of the

patterns of change in dyspnea and anxiety associated with dyspnea during 12 exercise training sessions showed that anxiety related to dyspnea decreased significantly after only 4 treatment sessions. This finding was the primary rationale for the choice of 4 supervised exercise sessions.

Dyspnea Self-management Program Plus Training (DM-training)

Patients in this group received all of the components of the DM program and 24 supervised treadmill exercise sessions 3 times per week over 2 months. Compliance with exercise sessions in this group was 93.3%.

Supervised treadmill exercise sessions: This intervention was based on the behavior modification techniques of exercise desensitization and guided mastery. These techniques of graduated exposure to a fearful stimulus (dyspnea) in a safe environment accompanied by expert modeling and reinforcement of coping strategies have decreased anxiety associated with a phobia or fearful stimulus.[34] The goal of training was steady-state exercise consisting of continuous walking for as long as 30 minutes at a level 1 workload lower than the maximum completed during the ITT. The protocol for coaching during exercise included feedback, demonstration, distraction, and encouragement as previously described.[35]

Outcome Measures

Pulmonary Status

Patients performed spirometry according to American Thoracic Society criteria.[36] Baseline lung volumes (helium dilution method), maximum voluntary ventilation, and single-breath diffusion capacity for carbon monoxide were measured using a body plethysmograph (Collins Plus Body Plethysmography System; Collins Medical, Braintree, Mass).

Dyspnea With Laboratory Exercise

Patients rated dyspnea on a modified Borg scale[30] before and at the end of the 6-minute walk in response to the question, "How short of breath are you?" During the incremental (ITTs) and endurance treadmill tests (ETTs), dyspnea was rated at rest, every 40 seconds for the first 160 seconds, and then every 80 seconds until the patient signaled to stop the test.

The slope expressing the linear relationship between dyspnea and time during the ITTs change and ETTs was determined for each patient using the dyspnea rating at the end of every stage from rest to end of exercise. The individual slopes were averaged to determine an overall mean slope, dyspnea/time. Dyspnea at isotime was measured separately for both ITTs and ETTs and defined as the dyspnea rating during each treadmill test that occurred at the highest stage reached during all tests.

Dyspnea With Activities of Daily Living

The *Chronic Respiratory Disease Questionnaire (CRQ) Dyspnea subscale* is described below as part of the CRQ.

The Baseline Dyspnea Index has 3 subscales: (1) functional impairment, (2) magnitude of task, and (3) magnitude of effort, and the *Transitional Dyspnea Index* is used on subsequent visits to assess change. The focal Transitional Dyspnea Index score, which sums the 3 scores, can range from −9 (*worsening*) to +9 (*improvement*).[37] A change of 1 point on the Transitional Dyspnea Index is the minimal clinically significant improvement.

Exercise Performance

Six-minute walk: Two 6-minute walk (6MW) tests were performed approximately 30 minutes apart. Encouragement was given before, but not during, the walk.[38] If the walk distances did not agree within 10%, a third walk was performed.

Incremental and endurance treadmill exercise tests: Patients inhaled 2 puffs of a bronchodilator and received standardized verbal instruction before exercise testing. After a demonstration, patients briefly practiced walking on the treadmill (Quinton 55: Seattle, Washington) with and without a mouthpiece. After a short rest period, patients performed a symptom-limited ITT according to the following protocol.[35] The speed of the treadmill began at 1 mph and increased to a new stage every 80 seconds at the following speeds: 1.4, 1.7, 2.0, 2.5, and 3.0 mph. After walking at 3.0 mph for 80 seconds, the grade was then increased by 2% every 80 seconds until the patient signaled the need to stop; at that point the patient completed a "cool-down" at 1 mph. After pulse and dyspnea ratings had returned to baseline (at least 30 minutes after the ITT), a symptom-limited constant workload ETT was performed. After an 80-second warm-up at 1 mph, each patient performed the ETT at a workload one level below the maximum workload completed during the baseline ITT. Patients performed the ITT and ETT while breathing room air. Physiologic measurements during both tests included 12-lead electrocardiogram, heart rate (HR), oxygen saturation (SaO_2) by pulse oximeter, respiratory rate, minute ventilation (VE), oxygen consumption (VO_2), and carbon dioxide production (VCO_2) during the last 20 seconds of each stage during the ITT or last 20 seconds of every 80 seconds of the ETT (Sensormedics 2900, Yorba Linda, Calif). All equipment were calibrated immediately before each test.

Health-related Quality of Life

Chronic Respiratory Disease Questionnaire. The CRQ is a validated disease-specific health status instrument that includes 20 interview questions in 4 domains: dyspnea, fatigue, emotional function, and mastery (perception of control of breathing).[39–41] The criteria for minimal clinically important difference are met with a 10-unit

Table 1 • BASELINE PATIENT CHARACTERISTICS

Variable	All Patients (N = 103)	Complete (n = 79)	Missing* (n = 24)
Gender, (F/M)	57/46	46/33	11/13
Age, years	66 ± 0.8	67 ± 0.8	64 ± 1.7
FEV_1, L	1.09 ± 0.03	1.11 ± 0.04	0.99 ± 0.05
FEV_1, % predicted†	44.8 ± 1.4	46.9 ± 1.6	38.2 ± 2.3
FEV_1/FVC %	42.2 ± 1.1	43.1 ± 1.3	39.1 ± 2.5
$D_L$co % predicted†	64.8 ± 2.0	67.5 ± 2.4	56.3 ± 2.7
MVV % predicted†	41.9 ± 1.4	43.6 ± 1.7	36.5 ± 2.7
Pao_2, mm Hg‡ (n = 99)	74.2 ± 0.9	74.9 ± 1.1	72.3 ± 1.7
$Paco_2$, mm Hg‡ (n = 99)	39.4 ± 0.5	39.0 ± 0.5	40.9 ± 1.0
ITT Duration (minutes)†	9.1 ± 0.4	9.6 ± 0.4	7.4 ± 0.6
ITT Isostage SOB (**0**–10)	4.3 ± 0.2	4.3 ± 0.2	4.2 ± 0.5
ETT Duration (minutes)	6.9 ± 0.5	7.2 ± 0.6	5.9 ± 0.8
ETT Isostage SOB (**0**–10)	4.0 ± 0.2	4.1 ± 0.3	3.8 ± 0.3
6MW Distance (feet)†	1398.8 ± 351.3	1438.1 ± 259.5	1333.8 ± 303.9
BDI (0–**12**)	5.1 ± 0.2	5.4 ± 0.2	4.4 ± 0.3
CRQ Dyspnea (0–**35**)	16.3 ± 0.5	16.7 ± 0.5	15.0 ± 1.1
CRQ Fatigue (0–**28**)	15.2 ± 0.5	15.7 ± 0.5	13.5 ± 1.0
CRQ Emotional Functioning (0–**49**)	31.9 ± 0.7	32.4 ± 0.8	30.4 ± 1.6
CRQ Mastery (0–**28**)*	18.7 ± 0.5	19.4 ± 0.5	16.5 ± 1.1
SF-36 Physical Functioning (0–**100**)†	34.6 ± 1.7	37.0 ± 2.1	26.9 ± 2.3
SF-36 Social Functioning (0–**100**)†	65.2 ± 2.6	68.8 ± 2.8	53.1 ± 5.4

Values presented are mean ± SE. Range values presented in bold indicate better score.

FEV_1 indicates forced expiratory volume in 1 second; FVC, forced vital capacity; $D_L$co, diffusion capacity of carbon monoxide; MVV, maximum voluntary ventilation; Pao_2, arterial oxygen tension; $Paco_2$, arterial carbon dioxide tension; ITT, incremental treadmill test; ETT, endurance treadmill test; 6MW, 6-minute walk distance; BDI, Baseline Dyspnea Index; CRQ, Chronic Respiratory Questionnaire; SF-36, Medical Outcomes Study, Short-Form 36.

*Patients with missing data had at least one missing score on CRQ—Dyspnea.

†Significant difference ($P < .05$) between patients with complete data compared with patients missing CRQ—Dyspnea.

‡Resting, room air arterial blood gas value.

change for the total score and a 2.5-unit change in the dyspnea, a 3.5-unit change for the emotion, and a 2-unit change for the fatigue and mastery components.[42]

Medical Outcomes Study 36-Item Short-Form Health Survey (SF-36): The SF-36 is a valid and reliable measure of quality of life in both general and specific medical populations, including patients with COPD.[43–45] The questionnaire consists of 36 items relating to 9 distinct components of overall health.

Health Resource Utilization

The number of hospitalizations for breathing problems and exacerbations were reported by patients every 2 months on a written questionnaire in which they were asked whether they had been hospitalized or had taken either antibiotics or oral steroids for an exacerbation of their COPD.

Data Analysis

Continuous dyspnea-related outcomes were analyzed using linear mixed-effects models.[46–48] These models included terms for time and treatment group and their interaction and were fit using the method of maximum likelihood and an unstructured covariance matrix. We fit the mixed-effects models using Proc Mixed in SAS version 8.0 (SAS Institute, Cary, NC). The focus of this mixed models analysis is on the pattern of change over time rather than the comparison of group means at each measurement time. This approach provides accurate estimates of all parameters of interest and does not require the same number of repeated measures for each patient.

RESULTS

Previously, we reported that at 2 months, immediately following the supervised exercise sessions, the DM-training group had significantly greater improvements than the DM-exposure and the DM groups in dyspnea at isotime during ITT, exercise performance during ITT, ETT, and 6MW; SF-36 Vitality; and CRQ mastery. There was a dose-dependent improvement in CRQ dyspnea scores with significant improvements only in the DM-training and the DM-exposure groups.[31]

Patients

A total of 115 patients were randomized and 4 patients from each group dropped out before the first

evaluation at 2 months; therefore, this analysis includes 36 DM, 33 DM-exposure, and 34 DM-training patients. There were no significant differences between the 3 treatment groups in any of the baseline characteristics. Scores were missing at one or more time points on the CRQ—Dyspnea subscale, a primary outcome, due

Table 2 • CHANGE IN MAJOR OUTCOMES OVER 12 MONTHS

		Means ± SE (95% CI)			Likelihood Ratio Test
	Time	DM	DM-Exposure	DM-Training	Group × Time (*P*)
Incremental treadmill test					
Dyspnea/time	Baseline	0.5 ± 0.1	0.5 ± 0.1	0.6 ± 0.1	
	2-month change	0.0 (−0.1, 0.1)	0.0 (−0.1, 0.2)	−0.2* (−0.3, −0.1)	.004†
	6-month change	0.0 (−0.1, 0.1)	0.0 (−0.1, 0.2)	− 0.1* (−0.3, −0.1)	
	12-month change	− 0.1 (−0.2, 0.1)	0.1 (−0.1, 0.2)	− 0.2* (−0.3, 0.0)	
Stages	Baseline	6.6 ± 0.5	7.5 ± 0.5	6.4 ± 0.5	
	2-month change	0.4 (−0.1, 1.0)	0.2 (−0.3, 0.8)	1.2* (0.7, 1.8)	.02‡
	6-month change	0.1 (−0.6, 0.8)	−0.2 (−1.0, 0.6)	1.1* (0.3, 1.8)	
	12-month change	−0.3 (−1.1, 0.5)	−0.3 (−1.1, 0.5)	0.7 (−0.2, 1.5)	
Endurance treadmill test					
Dyspnea/time	Baseline	1.1 ± 0.2	0.9 ± 0.2	0.9 ± 0.2	
	2-month change	−0.3 (−0.7, 0.1)	−0.2 (−0.6, 0.3)	−0.5* (−0.9, −0.1)	NS
	6-month change	−0.3 (−1.0, 0.5)	0.7 (−0.1, 1.4)	−0.2 (−0.9, 0.6)	
	12-month change	0.0 (−0.6, 0.6)	0.2 (−0.4, 0.9)	−0.2 (−0.9, 0.4)	
Minutes	Baseline	7.4 ± 0.8	6.7 ± 0.8	6.6 ± 0.8	
	2-month change	1.7 (−2.0, 5.4)	3.7 (−0.2, 7.6)	8.9* (5.1, 12.7)	.02‡
	6-month change	1.9 (−2.7, 6.6)	0.7 (−4.4, 5.8)	7.4* (2.4, 12.3)	
	12-month change	1.9 (−2.8, 6.5)	1.1 (−3.9, 6.1)	8.1* (3.2, 13.0)	
CRQ					
Dyspnea	Baseline	16.0 ± 0.8	17.2 ± 0.8	15.8 ± 0.8	
	2-month change	1.7 (−0.3, 3.8)	3.7* (1.6, 5.9)	5.0* (2.9, 7.1)	.02§
	4-month change	3.9* (1.5, 6.3)	3.8* (1.2, 6.3)	4.8* (2.4, 7.2)	
	8-month change	3.9* (1.4, 6.5)	2.7 (−0.1, 5.5)	2.6 (−0.04, 5.1)	
	12-month change	4.5* (1.8, 7.3)	4.2* (1.2, 7.2)	3.2* (0.3, 6.1)	
Mastery	Baseline	18.4 ± 0.8	19.9 ± 0.8	17.9 ± 0.8	
	2-month change	1.8 (−0.1, 3.7)	1.9 (−0.1, 3.9)	4.7* (2.7, 6.6)	.004‖
	4-month change	2.3* (0.2, 4.3)	2.1 (−0.1, 4.3)	3.8* (1.7, 5.9)	
	8-month change	2.1* (0.0, 4.1)	1.0 (−1.2, 3.3)	2.2* (0.2, 4.3)	
	12-month change	2.5* (0.2, 4.7)	1.4 (−1.0, 3.7)	1.6 (−0.7, 4.0)	
SF-36					
Physical component	Baseline	32.0 ± 1.3	35.9 ± 1.3	31.3 ± 1.3	
	2-month change	1.6 (−1.5, 4.7)	1.4 (−1.8, 4.7)	4.5* (1.3, 7.6)	0.02¶
	4-month change	1.9 (−1.3, 5.2)	0.8 (−2.6, 4.3)	4.5* (1.2, 7.8)	
	8-month change	0.7 (−2.9, 4.4)	0.9 (−3.2, 4.9)	1.1 (−2.7, 4.8)	
	12-month change	3.2 (−0.4, 6.8)	−0.8 (−4.7, 3.1)	0.7 (−3.0, 4.5)	
SF-36					
Mental component	Baseline	49.1 ± 1.8	50.4 ± 1.9	50.1 ± 1.9	
	2-month change	2.4 (−1.6, 6.5)	3.3 (−0.9, 7.6)	2.8 (−1.3, 7.0)	NS
	4-month change	1.2 (−3.6, 6.0)	1.0 (−4.0, 6.1)	−0.5 (−5.3, 4.4)	
	8-month change	3.1 (−1.7, 7.9)	0.4 (−5.0, 5.7)	−1.0 (−5.9, 4.0)	
	12-month change	3.0 (−1.7, 7.5)	2.1 (−3.0, 7.1)	4.4 (−0.5, 9.4)	

Within-group effects: *$P < .05$.
CI, confidence interval; DM, dyspnea self-management.
Between-group effects:
†DM-training > DM-exposure at 2, 6, and 12 months ($P < .01$); DM-training > DM at 2 and 6 months ($P < .05$).
‡DM-training > DM-exposure at 2, 6, and 12 months ($P < .05$).
§DM-training > DM at 2 months ($P < .01$).
‖DM-training > DM-exposure and DM at 2 months ($P < .01$).
¶DM-training > DM-exposure at 4 months; DM > DM-exposure at 12 months ($P < .05$).

to death (3 patients), withdrawal from the study (7 patients), or other reasons (14 patients). Patients with at least 1 missing score had statistically significant differences in pulmonary function, exercise performance, and quality-of-life scores at baseline compared with patients with complete data (Table 1), but were not different in treatment group assignment (P = .46).

Pulmonary Function

There were no significant changes over the year for the total sample and no significant differences between the groups in forced expiratory volume in 1 second (FEV_1) and in the ratio of FEV_1 to forced vital capacity.

Dyspnea

Dyspnea With Laboratory Exercise

During the ITT, the DM-training group had a significantly greater improvement in dyspnea at isotime (P < .05) compared with the DM-exposure group at 2 and 6 months and the DM group at 2 and 12 months. The DM-training group also had a significantly greater improvement in the slope of dyspnea/time than the other 2 groups at 2 and 6 months (Table 2). There were no differences between groups for dyspnea isotime and dyspnea/time during the ETT or during the 6-minute walk. Although the DM-training group had a significant improvement in dyspnea at the end of the 6MW at 2, 4, and 10 months, there were no significant differences between the groups.

Dyspnea With Activities of Daily Living

At 4, 8, and 12 months, all 3 groups improved their mean CRQ—Dyspnea subscale scores above the minimal clinically important difference[42] of 2.5 (Table 2).

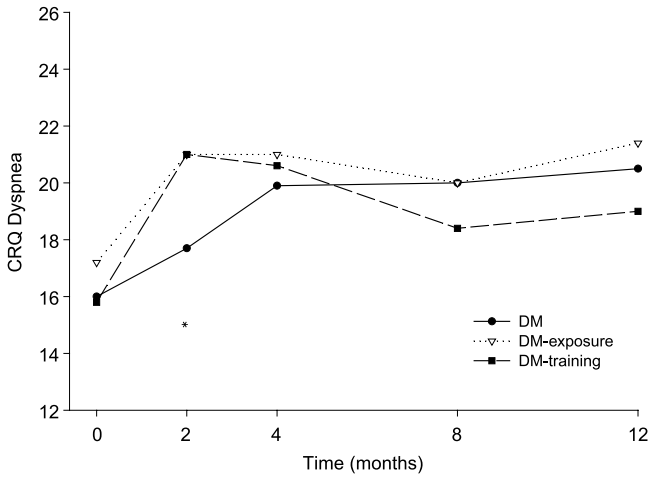

Figure 1. Chronic Respiratory Disease Questionaire—Dyspnea subscale. Minimal clinically important change = 2.5. *DM versus DM-training, P < .01.

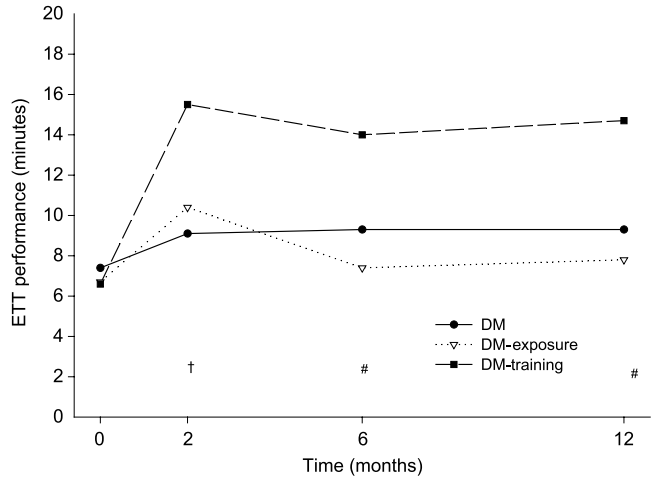

Figure 2. Endurance treadmill test exercise performance (in minutes). †DM vs. DM-training, $P \leq .01$. #DM-exposure versus DM-training, $P \leq .01$.

The significant difference between groups at 2 months was not maintained over the year (Figure 1). At 12 months, 21 (66%) of the DM group, 16 (57%) of the DM-exposure, and 18 (62%) of the DM-training group maintained gains at or above the minimal clinically important difference. The Transitional Dyspnea Index scores significantly improved for all groups with no significant differences between the groups.

Exercise Performance

Incremental Treadmill Test

The DM-training group maintained the improvements in ITT performance (stage) compared with the DM and DM-exposure groups at 6 ($P \leq .01$) and 12 months (P = .03) (Table 2). There were no significant differences between groups in end exercise VE, V_{CO_2}, V_{O_2}, HR, or RR at 2, 6, and 12 months. At isotime, there were no significant differences between the groups in any of the physiologic variables. All groups had significant changes within group in isotime VE and V_{CO_2} (P < .05).

Endurance Treadmill Test

The DM-training group had significantly greater improvement in endurance treadmill performance than the two other groups at all measurement times (Figure 2). The DM and DM-exposure groups did not change their performance significantly at any measurement time. With few exceptions, there were significant reductions in VE, VCO_2, and VO_2 at the end of the endurance test over the year (P < .05) with no significant differences in these variables between groups.

Six-Minute Walk

The changes in 6-minute walk distance were not significantly different between the groups over the year.

Although the DM-training group significantly increased their distance at 2 and 4 months, these changes fell short of the minimal clinically important difference of 177 feet.[49]

Health-related Quality of Life

Chronic Respiratory Questionnaire

The DM-training group had greater improvements compared with the other groups in mastery scores at 2 months ($P = .01$). The DM group significantly improved their score over the year, resulting in no significant differences between the groups in mastery at 12 months. There were no significant differences between groups in the fatigue and emotional function subscales at any of the measurement times.

Medical Outcomes Study SF-36

There were significant differences in the changes over time in role-physical ($P = .035$), vitality ($P = .006$), and the physical health summary scale ($P = .02$) across the 3 treatment groups. Within groups, role-physical was significantly improved for the DM-training group at 2, 4, and 12 months, and for the DM group at 12 months. Vitality was significantly improved at 2 and 12 months for the DM-training group. For the physical health summary scale, the DM-training group was significantly better than the DM-exposure group at 4 months ($P < .05$). There were no significant differences between the groups in the other subscales.

Health Resource Utilization

During the study period, there were no significant differences between the groups in number of exacerbations or hospitalizations (both $P > .05$).

DISCUSSION

The most important finding of this study is that all 3 versions of the dyspnea self-management program resulted in significant and comparable improvement in dyspnea with activities of daily living over 12 months. Confirming previous findings,[5,14,50] the DM-training group continued to maintain their improvements in both dyspnea with laboratory exercise and peak performance above baseline levels compared with the other 2 treatment groups. The dose-response relationship between supervised exercise and improvements in laboratory dyspnea and exercise performance present at 2 months[31] was not sustained. Together, these findings provide evidence that patients who receive intensive supervised exercise training will continue to demonstrate training benefits in the laboratory in both symptomatic and performance measures for at least 12 months. However, these sustained improvements in the laboratory are not reflected by a similar preservation of changes in dyspnea with activities of daily living or health-related quality of life.

Differences between the treatment groups in dyspnea with activities of daily living at 2 months[31] had disappeared by 4 months, primarily due to the steady improvements in the DM group and the gradual decline in the DM-training group. These findings are consistent with results of short-term studies which showed that low-intensity exercise was as beneficial as high-intensity exercise in improving dyspnea measured by the CRQ.[7,51,52] Other programs, similar to ours but that included weekly clinic visits,[51,53] home visits,[54] or a tailored exercise track at home,[53] have also shown reductions in dyspnea with activities of daily living. Two previous self-management programs consisting only of education and psychosocial support did not find significant improvements in dyspnea with activities of daily living.[55,56] Thus, it appears that exercise is a necessary component of self-management programs for patients with COPD if the goal is to reduce dyspnea with daily activities.

Nonetheless, patients must maintain a regular program of exercise to derive symptomatic relief. Preliminary analysis of our adherence data suggests that all 3 treatment groups adhered equally, although not optimally, to the home walking exercise program.[57] The sustained, albeit declining, improvements in dyspnea with activities of daily living over 12 months in the DM-training group is similar to findings by Grosbois et al,[58] who studied 4 types of self-selected exercise maintenance programs after pulmonary rehabilitation. Patients who participated in daily home exercise maintenance, similar to our home walking prescription, maintained improvements in their postrehabilitation dyspnea scores at 18 months. Strijbos et al[15] also found that patients who received home-based pulmonary rehabilitation maintained their exercise over the long term more than those who participated in an outpatient program, however, the authors did not report exercise adherence data. It appears that patients with advanced COPD will still derive symptomatic benefits from partial adherence to a home based exercise prescription, that is, endurance exercise at least twice a week for 30 minutes. Alternatively, adherence to exercise is merely a proxy for the illnesses and comorbidities that typically accompany advanced COPD.

The improvement in isotime dyspnea and the slope of dyspnea over time during laboratory testing for the DM-training group is consistent with previous studies.[10,13,15,50] The minimum number of sessions required to significantly impact dyspnea in the laboratory is still unclear. In our previous work, we showed that 12 exercise sessions were sufficient to decrease dyspnea in the laboratory for COPD patients.[35] The failure to

improve dyspnea during laboratory exercise testing with either a home walking prescription or brief supervised exercise suggests that more than 4 and less than 12 exercise sessions may be required to decrease dyspnea during laboratory exercise. The DM-training group's significant improvement in exercise performance on both the ITTs and ETTs relative to the other two groups throughout the year is consistent with many previous long-term studies of pulmonary rehabilitation that have shown that periods of training varying from 6 to 72 sessions all result in long-term benefits in exercise performance.[10,12,13,59,60]

The significant immediate improvement in mastery for the DM-training group is congruent with the theoretical proposition that greater exposure to the symptom in a safe environment may increase the individual's perception of control of the symptom.[61] However, the perception of control in the DM-training group decreased slightly over the year, while the DM group gradually increased their perception of control of their breathing, leading to no significant differences between groups in mastery at the end of the year. This convergence may reflect a dissipation of the initial intensive intervention as observed in long-term follow-up after pulmonary rehabilitation programs, and a steady positive response by all patients to the dyspnea self-management program that consisted of education, ongoing daily exercise, and biweekly nurse telephone calls.

The addition of supervised exercise to the DM program did not result in greater reductions in self-reported exacerbations or hospitalizations. Previous findings from studies of exercise training, pulmonary rehabilitation, and maintenance suggest that regular exercise reduces the frequency of pulmonary exacerbations and health resource utilization.[10,13,59,62,63] A recent study of a 12-month self-management program that did not have an emphasis on exercise was able to reduce health expenditures related to exacerbations, yet was unsuccessful in reducing exacerbation frequency compared with usual care.[29] The individual effects of each program component, especially the home visits, frequency of follow-up, home exercise, and an available prescription or supply of medications, will be important to determine in future studies of self-management programs for COPD.

In conclusion, the findings of this study reinforce previously reported research and practice guidelines that recommend that supervised exercise training within a pulmonary rehabilitation program should be the gold standard for improving exercise performance and reducing chronic dyspnea in patients with COPD. However, our findings provide evidence that, for maintenance after pulmonary rehabilitation or in the situation where a patient does not have access to a structured program, a dyspnea self-management program can affect dyspnea with activities of daily living, physical functioning, and a person's perception that they are in control of their breathing. If the patient is not able to attend a pulmonary rehabilitation program, this relatively simple and inexpensive program may help patients manage their dyspnea on a daily basis.

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