Home-based Physical Activity Coaching, Physical Activity, and Health Care Utilization in Chronic Obstructive Pulmonary Disease

Chronic Obstructive Pulmonary Disease Self-Management Activation Research Trial Secondary Outcomes

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Abstract

Rationale: Physical inactivity among patients with chronic obstructive pulmonary disease is associated with exacerbations requiring high-cost health care utilization including urgent, emergent, and hospital care.

Objectives: To examine the effectiveness of a behavioral lifestyle physical activity intervention combined with chronic obstructive pulmonary disease self-management education to prevent high-cost health care utilization.

Methods: This was an analysis of secondary outcomes of the Chronic Obstructive Pulmonary Disease Self-Management Activation Research Trial, a two-arm randomized trial of stable adult outpatients with chronic obstructive pulmonary disease recruited from primary care and pulmonary clinics. Following a 6-week self-management education run-in period, participants were randomized to usual care or to a telephone-delivered home-based health coaching intervention over 20 weeks. Secondary outcomes of physical activity and health care utilization were determined by self-report 6, 12, and 18 months after randomization. Associations between treatment allocation arm and these secondary outcomes were examined using log-binomial and Poisson regression models.

Results: A total of 325 outpatients with stable chronic obstructive pulmonary disease were enrolled in the trial. Their average age was 70.3 years (standard deviation, 9.5), and 50.5% were female; 156 were randomized to usual care and 149 to the intervention. A greater proportion of participants reported being persistently active over the 18-month follow-up period in the intervention group (73.6%) compared with the usual care group (57.8%) (mean difference, 15.8%; 95% confidence interval, 4.0–27.7%). This association varied by severity of forced expiratory volume in 1 second impairment (P for interaction = 0.09). Those in the intervention group with moderate impairment (forced expiratory volume in 1 second, 50–70% predicted), more frequently reported being persistently active compared with the usual care (86.0 vs. 65.1%; mean difference, 20.9%; 95% confidence interval, 5.7–36.1%). Patients with severe and very severe forced expiratory volume in 1 second impairment (forced expiratory volume in 1 second $<$ 50% predicted) in the intervention group also reported being persistently active more frequently compared with usual care (63.3 vs. 50.8%; mean difference, 12.6%; 95% confidence interval, –4.7 to 29.8). The intervention was associated with a lower rate of lung-related utilization (adjusted rate ratio, 0.38; 95% confidence interval, 0.23–0.63) only among participants with severe spirometric impairment.

Conclusions: Our results demonstrate that a feasible and generalizable home-based coaching intervention may decrease sedentary behavior and increase physical activity levels. In those with severe chronic obstructive pulmonary disease, this intervention may reduce lung disease–related health care utilization.

Clinical trial registered with www.clinicaltrials.gov (NCT01108991).

Keywords: physical inactivity; self-management; behavior change; health care utilization

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Severe exacerbations of chronic obstructive pulmonary disease (COPD) resulting in high-cost emergency department visits and hospitalizations have been increasing (1) and are associated with an increased risk of mortality (2). Over the past decade these observations have contributed to a growing body of evidence on methods for the prevention of COPD exacerbations (2). From these observations evidence-based guidelines have been developed by Criner and colleagues (2), who conducted a comprehensive review of available research on pharmacological and nonpharmacological interventions. Although many research questions remain, the strongest evidence for prevention is the use of inhaled long-acting controller medications among patients with moderate to severe COPD. Among nonpharmacological interventions, influenza vaccination, regardless of severity of COPD, is also highly recommended (2). Recommendations for other nonpharmacological interventions are limited to pulmonary rehabilitation within 4 weeks of a severe exacerbation and patient education with case management and monthly follow-up (2). However, few patients ever access rehabilitation programs (3), the benefits are often not sustained long-term, and its effect on reducing physical inactivity has been inconsistent (4).

Although there is consistent evidence from observational studies that physical inactivity is associated with hospitalizations for COPD (4), scant evidence is available on whether interventions to increase physical activity prevent hospitalization (5, 6). In a randomized clinical trial, we found no effect of a lifestyle physical activity behavioral intervention on dyspnea or the 6-minute walk distance overall (7). During the trial, we also collected data on self-reported physical activity and health care utilization as secondary outcomes (8). Our hypothesis in this secondary analysis of the clinical trial data was that allocation to the behavioral intervention would increase physical activity and be associated with fewer urgent, emergency, and hospital visits compared with those allocated to receive usual care. Some of the results of this analysis were previously reported in the form of an abstract (9).

Methods

This is a secondary analysis of data from the Chronic Obstructive Pulmonary Disease Self-Management Activation Research Trial (COPD-SMART) (7, 8, 10). The design was a single-site, parallel randomized-controlled trial, which compared usual care and COPD self-management education with these same components plus a behavioral intervention to promote lifestyle physical activity. Previous publications, which adhered to the Consolidated Standards of Reporting Trials (CONSORT) checklist for reporting randomized trials (11) described in detail the research methods (8, 10). Results of coprimary outcomes of health-related quality of life and 6-minute walk distance have been reported previously (7). The study was approved by the University of Texas Health Northeast Institutional Review Board, and all participants provided written informed consent.

Patient Recruitment and Eligibility

Patients were recruited from primary and specialty care clinics of University of Texas Health Northeast (8, 10). Briefly, the target population was outpatients with physician-diagnosed and spirometry-confirmed COPD ($FEV_1/FVC < 70\%$ and $FEV_1 < 70\%$ predicted) and who were eligible for, but not participating in, pulmonary rehabilitation (8).

Intervention

The intervention was composed of two components including COPD self-management education and a behavioral intervention to promote lifestyle physical activity (8). After enrollment, all participants were provided COPD self-management education delivered by a trained health coach telephonically during a 6-week run-in period. Participants were then randomized to usual care or the physical activity intervention with the goal of accumulating at least 30 minutes of moderate intensity physical activity per day. The theoretical foundations of the intervention included social cognitive theory and the transtheoretical model. The intervention was delivered using a 25-chapter structured workbook intended to activate participants in accumulating and maintaining moderate intensity lifestyle physical activity (e.g., walking, gardening, etc.). The workbook was supported by telephone health coaching tailored to each participant's stage of change for physical activity and pedometer self-monitoring. Two major phases of the intervention included activation and maintenance. During the activation phase the health coach used standardized scripts to determine the participant's understanding, self-efficacy, goal setting, pedometer self-monitoring, barrier identification, and problem solving to tailor messages to promote adherence to their physical activity goals. The health coach calls were conducted every other week over 20 weeks. Standardized automated telephone health coach messages were made on alternate weeks to reinforce the workbook activity for that week. The 10-month maintenance phase included five workbook assignments, with health coach calls initiated every other month to promote adherence to physical activity goals by addressing common challenges and to assist with techniques to sustain their physical activity.

Data Collection

Participant characteristics, self-reported physical activity, and health outcome and health care utilization data were collected at baseline and approximately 6, 12, and 18 months after enrollment. The methods and standardized instruments used for data collection have been described in detail previously (7, 8). For the current analysis, we evaluated prespecified process and secondary outcomes of physical activity and health care utilization, respectively.

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Physical activity level was self-reported using the Rapid Assessment of Physical Activity (RAPA) questionnaire (sedentary, underactive, and active) (12). This is a nine-item questionnaire used to rate the amount of weekly physical activity relative to the Centers for Disease Control and Prevention physical activity goal of accumulating at least 30 minutes of moderate-intensity physical activity five or more days per week.

Health care utilization during the prior 6 months was assessed at each data collection point using standardized questions separately for physician office visits, urgent care/emergency room visits, and hospitalizations (*see* METHODS in the online supplement). The measurement periods were the 6 months before baseline and the follow-up periods of baseline to 6 months, 6–12 months, and 12–18 months. In addition to the location, the reason (i.e., lung-related vs. other conditions), frequency, and length of stay for hospitalizations were collected (*see* Table E1 and Figure E3 in the online supplement).

Data were collected on participants' characteristics associated with the risk of hospitalization (2, 4). These factors included age, sex, smoking status, previous lung-related health care utilization, COPD severity (moderate, FEV_1 50–70% predicted; severe, $FEV_1 < 50\%$ predicted), pharmacological treatment, oxygen use, heart/vascular disease, diabetes, potential alcohol problems, and physical activity levels. Previous lung-related health care utilization was defined as any urgent care visit, emergency room visit, and hospitalization during the 6 months before baseline. The composite BODE index (body mass index, degree of airflow obstruction, functional dyspnea, and exercise capacity) (13) was used to define severity of COPD. Pharmacological treatment was characterized by the number of COPD controller medications and total COPD medications reported. COPD controller medications included inhaled long-acting β-agonists and anticholinergic agent; corticosteroids; and long-acting β-agonist/corticosteroid combinations. In addition to controller medications the total number of COPD medications included inhaled short-acting β-agonists, anticholinergic, and short-acting β-agonist/anticholinergic combination. Current oxygen use was determined at baseline. Cardiovascular disease was defined as a composite measure of self-reported congestive heart failure, myocardial infarction, cerebrovascular disease, peripheral vascular disease, and hypertension. Self-reported diabetes was used as a proxy for metabolic syndrome. Comorbid depression was measured with the Geriatric Depression Scale (no depressive symptoms vs. depressive symptoms) (14). A potential alcohol problem was characterized by the four-question CAGE (cut down, annoyed, guilty, eye-opener) screening tool (no risk vs. some risk) (15).

Data Analysis

Two outcome measures of health care utilization were examined: *1*) a dichotomous composite indicator of health care utilization defined as any urgent care visit, emergency room visit, or hospitalization; and *2*) the rate of health care utilization defined as the cumulative count of urgent care visits, emergency room visits, and hospitalizations during the 18 months postrandomization relative to the amount of time they were in the study.

Cumulative physical activity level scores were calculated by comparing self-reported physical activity at each time point with their baseline. Scores were summed across time points and categorized into three persistent activity groups: *1*) inactive, *2*) underactive, and *3*) active corresponding to changes over time. χ^2 tests were performed to assess between-group differences in cumulative self-reported physical activity.

Health care utilization data were analyzed in the participant's original group assignment. Data are presented as mean and standard deviation, or as frequency and percent for continuous and categorical variables, respectively. *Post-hoc* comparisons were made across FEV_1 severity to evaluate whether between-group differences could be observed across strata of airflow obstruction. Pairwise interactions were assessed using generalized linear models based on the Wald test statistic; we considered interaction between FEV_1 and allocation arm present for P values less than 0.1. Log-binomial regression analysis was used to estimate unadjusted and adjusted risk ratios (RRs) and 95% confidence intervals (95% CIs) for the association between allocation arm and health care utilization with and without adjustment for potential confounding variables. For the rate of health care utilization, we used generalized estimating equations with a Poisson distribution and log link function to estimate unadjusted and adjusted incidence rate ratios (IRRs) for the association between treatment allocation arm and health care utilization. For estimating the IRR of health care utilization, log-transformed values of the contributing time at risk in the study were used as the regression model offset, and overdispersion was accounted for by incorporating a scale parameter based on the deviance. For both outcome models, we estimated the unadjusted measures of association, as well as two multivariable adjusted models. The first included variables with statistically significant unadjusted associations, and the second included variables, which have been identified as factors associated with increased health care utilization in the literature. The multicollinearity of predictor variables in both log-binomial and Poisson models was assessed using the variance inflation factor, with a threshold of five. All data management and analyses were performed with SAS version 9.4 (SAS Institute).

Results

Details of patient recruitment, enrollment, and randomization (10), and results of coprimary outcomes, health-related quality of life, and 6-minute walk distance, have been described previously (7). Briefly, patient enrollment was conducted from April 2010 through September 2012, and the 18-month follow-up was completed in April 2014; a total of 325 patients were enrolled and 305 were randomized (156 to usual care and 149 to the intervention group) (Figure 1). At baseline, there were no differences between the usual care and intervention groups for age (69.8 vs. 70.8 yr), female sex (50.6 vs. 50.3%), FEV_1% predicted (47.3 vs. 45.5%), total composite health care utilization (31.4 vs. 34.9%), non–lung-related health care utilization (17.3 vs. 20.8%), or lung-related utilization (17.3 vs. 18.1%) (Table 1). Moreover, there were no differences overall, or when stratified by severity of FEV_1 impairment, in baseline physical activity (Table 2), or in health care utilization during the 6 months before enrollment (Figures E1A and E2A).

Results of Intervention on Physical Activity

Baseline and cumulative physical activity over the 18 months of the trial, overall and stratified by severity of FEV_1 impairment,

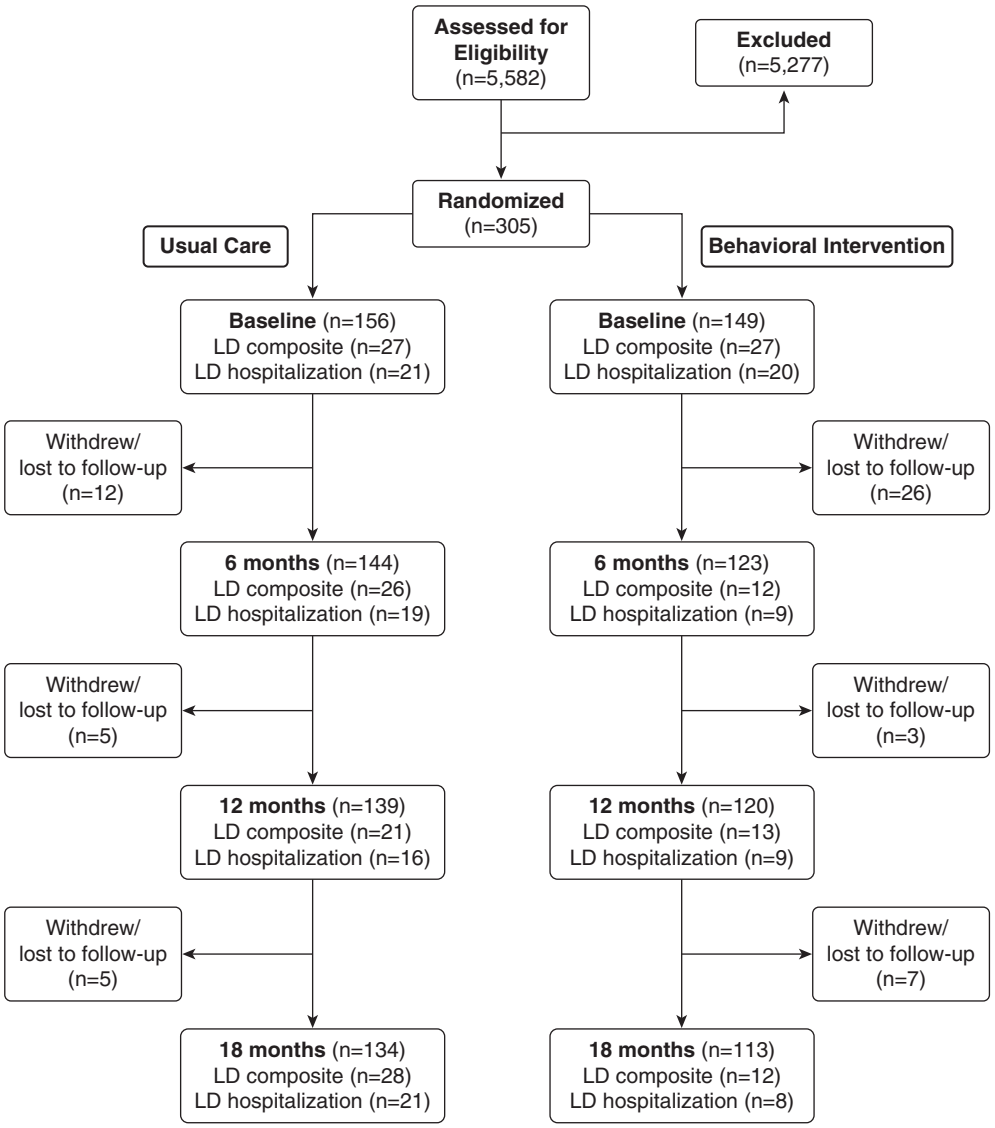

Figure 1. Patient flow and occurrence of self-reported lung disease (LD)–related hospitalizations and composite health care utilization composed of lung-related urgent and emergency care visits, and hospitalizations during 18-month trial.

are shown in Table 2. In the overall sample, of participants who completed the 18-month follow-up, 73.6% in the intervention group reported being persistently active during the trial compared with 57.8% in the usual care group (absolute mean difference, 15.8%; 95% CI, 4.0–27.7%). In stratified analyses, we observed the largest difference in cumulative physical activity among participants in the intervention group, with moderate impairment (FEV_1 50–70%) at 86.0 versus 65.1% among usual care (absolute mean difference, 20.9%; 95% CI, 5.7–36.1%). Among participants with severe FEV_1 impairment (<50%), 63.3% of the intervention group reported being persistently active compared with 50.8% among usual care (absolute mean difference, 12.6%; 95% CI, −4.7 to 29.8%). Moreover, effect modification of the treatment group by FEV_1 impairment is suggested (P for interaction = 0.09) (Table 2).

Results of Intervention on Health Care Utilization

At baseline the prevalence of total health care utilization during the 6 months before enrollment, combining lung-related and non–lung-related utilization, was 33.1% with no difference between the two groups (Table 1). Over the 18 months of the trial, there were no differences in the total prevalence of both lung-related and non–lung-related health care utilization (61.1% [usual care], 60.5% [behavioral intervention]; absolute difference, 0.7%; 95% CI, −11.1 to 12.4%) (Table 3 and Figure E1A). There was significant interaction between treatment allocation arm and FEV_1 (P for interaction = 0.07). Among those with severe impairment ($FEV_1 < 50\%$) there was a borderline association between allocation to the intervention arm and a lower prevalence of total health care utilization (54.3%) during the trial compared with the usual care group (68.1%; absolute difference, 13.8%;

Table 1. Baseline characteristics of patients randomized to usual care and behavioral intervention

Characteristic	Total (*N* = 305)	Baseline Usual Care (*n* = 156)	Baseline Behavioral Intervention (*n* = 149)	Completed 18 Months of Usual Care (*n* = 128)	Completed 18 Months of Behavioral Intervention (*n* = 110)
Age, yr, mean (SD)	70.3 (9.5)	69.8 (9.5)	70.8 (9.5)	67.3 (9.2)	69.6 (9.4)
Female, *n* (%)	154 (50.5)	79 (50.6)	75 (50.3)	68 (53.1)	57 (51.8)
Ever smoker, *n* (%)	282 (92.5)	145 (93.0)	137 (92.0)	118 (92.2)	101 (91.8)
FEV_1 (%), mean (SD)	46.5 (13.1)	47.3 (13.5)	45.5 (12.6)	47.3 (13.7)	47.5 (12.3)
Current oxygen use, *n* (%)	21 (6.9)	15 (9.6)	6 (4.0)	11 (8.6)	3 (2.7)
BODE index, mean (SD)	4.4 (2.0)	4.4 (2.0)	4.4 (1.9)	4.4 (2.1)	4.1 (1.8)
COPD medications, mean (SD)					
Total	2.8 (1.5)	2.7 (1.4)	2.9 (1.6)	2.7 (1.4)	2.8 (1.6)
Controller	1.5 (0.6)	1.5 (0.6)	1.5 (0.6)	1.5 (0.5)	1.5 (0.6)
Baseline LD and non-LD composite utilization, *n* (%)	101 (33.1)	49 (31.4)	52 (34.9)	41 (32.0)	37 (33.6)
Baseline LD composite utilization, *n* (%)	54 (17.7)	27 (17.3)	27 (18.1)	21 (16.4)	20 (18.2)
Baseline non-LD utilization, *n* (%)	58 (19.0)	27 (17.3)	31 (20.8)	23 (17.9)	22 (20.0)
Alcohol risk, some/current, *n* (%)	32 (10.5)	18 (11.5)	14 (9.4)	15 (11.7)	8 (7.3)
Depressive symptoms, *n* (%)	81 (26.6)	45 (28.9)	36 (24.2)	36 (28.1)	22 (20.0)
Heart/vascular disease, *n* (%)	198 (64.9)	107 (68.6)	91 (61.1)	86 (67.2)	66 (60.0)
Diabetes, *n* (%)	62 (20.3)	25 (16.0)	37 (24.8)	21 (16.4)	26 (23.6)

Definition of abbreviations: BODE = body mass index, degree of airflow obstruction, functional dyspnea, exercise capacity; COPD = chronic obstructive pulmonary disease; FEV_1 = forced expiratory volume in 1 second; LD = lung disease; SD = standard deviation.

95% CI, –2.1 to 29.7%) (Figures E1B and E1C).

Stratification of total health care utilization as lung-related or non–lung-related showed that the reduction in utilization was limited to lung-related conditions among the intervention group (Table 3 and Figure E2A). The overall prevalence of lung-related utilization aggregated for the entire 18-month period was significantly lower among the intervention group (24.2%) compared

Table 2. Changes in cumulative self-reported physical activity* associated with physical activity coaching at 18 months: overall and stratified by FEV_1 impairment*

	Baseline		Evaluable at Month 18		*P* Value†	Mean Absolute Difference (%) between Groups at 18 Months	95% CI
	Usual Care (*n* = 156)	Behavioral Intervention (*n* = 149)	Usual Care (*n* = 128)	Behavioral Intervention (*n* = 110)			
Overall					0.021		
Sedentary, %	14.8	16.2	24.2	13.6		−10.6	−20.4 to –0.8
Underactive, %	28.7	27.0	18.0	12.7		−5.2	−14.4 to 3.9
Active, %	56.5	56.8	57.8	73.6		15.8	4.0 to 27.7
Missing, *n* (%)‡	—	—	28 (18.0)	39 (26.2)			
FEV_1, 50–70%					0.088		
Sedentary, %	12.0	10.2	22.2	10.0		−12.2	−25.4 to 1.0
Underactive, %	29.3	30.5	12.0	4.0		−8.7	−18.6 to 1.2
Active, %	58.7	59.3	65.1	86.0		20.9	5.7 to 36.1
Missing, *n* (%)‡	—	—	12 (16.0)	9 (15.3)			
$FEV_1 < 50\%$					0.098		
Sedentary, %	17.3	20.2	26.2	16.7		−9.5	−23.7 to 4.8
Underactive, %	28.4	24.7	23.1	20.0		−3.1	−17.5 to 11.3
Active, %	54.3	55.1	50.8	63.3		12.6	−4.7 to 29.8
Missing, *n* (%)‡	—	—	16 (19.8)	30 (33.3)			

Definition of abbreviation: CI = confidence interval; FEV_1 = forced expiratory volume in 1 second.
Note: *P* value for the interaction between FEV_1 and treatment allocation arm was 0.09.
*Assessed with the Rapid Assessment of Physical Activity (12).
†*P* value for χ^2 test of marginal homogeneity comparing groups at 18 months.
‡Missing observations are presented as frequencies and percentages of the overall sample of 156 in usual care and 149 in behavioral intervention.

Table 3. Effects of physical activity coaching and severity of FEV_1 impairment on health care utilization over the 18-month trial

	Overall Health Care Utilization		Lung-related Health Care Utilization		Non–Lung-related Health Care Utilization	
	Usual Care	Behavioral Intervention	Usual Care	Behavioral Intervention	Usual Care	Behavioral Intervention
No. of patients	88	75	51	30	66	57
No. events	282	212	129	71	153	141
Person-months of follow-up	2,514	2,148	2,514	2,148	2,514	2,148
Prevalence, % (95% CI)	61 (53–69)	60 (52–69)	35 (28–43)	24 (17–32)	46 (38–54)	46 (37–55)
Risk ratio (95% CI)						
Unadjusted	Ref	0.99 (0.82–1.20)	Ref	0.68 (0.47–1.00)	Ref	1.00 (0.77–1.30)
Adjusted I*	Ref	0.99 (0.79–1.24)	Ref	0.60 (0.39–0.91)	Ref	1.06 (0.77–1.45)
Adjusted II†						
Overall	Ref	0.99 (0.80–1.24)	Ref	0.61 (0.40–0.93)	Ref	1.01 (0.73–1.37)
FEV_1, 50–70%	Ref	1.28 (0.91–1.80)	Ref	0.70 (0.32–1.56)	Ref	1.23 (0.87–1.75)
$FEV_1 < 50\%$	Ref	0.82 (0.60–1.10)	Ref	0.61 (0.36–1.02)	Ref	0.82 (0.54–1.26)
Rate ratio (95% CI)						
Unadjusted	Ref	0.88 (0.63–1.22)	Ref	0.64 (0.42–0.99)	Ref	1.08 (0.74–1.57)
Adjusted I	Ref	0.77 (0.51–1.15)	Ref	0.38 (0.23–0.63)	Ref	1.19 (0.75–1.90)
Adjusted II						
Overall	Ref	0.80 (0.54–1.19)	Ref	0.41 (0.25–0.67)	Ref	1.18 (0.76–1.83)
FEV_1, 50–70%	Ref	0.62 (0.33–1.18)	Ref	0.43 (0.17–1.13)	Ref	0.74 (0.38–1.44)
$FEV_1 < 50\%$	Ref	0.89 (0.55–1.46)	Ref	0.38 (0.20–0.72)	Ref	1.21 (0.67–2.19)

Definition of abbreviation: BODE = body mass index, degree of airflow obstruction, functional dyspnea, exercise capacity; CI = confidence interval; COPD = chronic obstructive pulmonary disease; FEV_1 = forced expiratory volume in 1 second; Ref = reference group.
Note: *P* values for interaction between treatment allocation arm and FEV_1 were 0.07 for the risk ratio analysis and 0.01 for the rate ratio analysis in "adjusted II" models.
*Adjusted I models are adjusted for BODE index, current oxygen use, pretrial lung disease health care utilization, COPD controller medications, and total COPD medications.
†Adjusted II models are adjusted for age, sex, BODE index, smoking history, alcohol use, depressive symptoms, current oxygen use, rapid assessment of physical activity, pretrial lung disease health care utilization, COPD controller medications, and total COPD medications.

with the usual care group (35.4%) (absolute difference, 11.2%; 95% CI, 0.4–22.1%). Moreover, the difference in lung-related health care utilization was limited to participants with severe ($FEV_1 < 50\%$) spirometric impairment (Figures E2B and E2C).

There was a similar pattern for the rate of health care utilization during the trial (Table 3). The cumulative rate of total lung and non–lung-related health care utilization was not statistically different when comparing the usual care group (11.2 per 100 person-months; 95% CI, 9.9–12.5) with the intervention group (9.9 per 100 person-months; 95% CI, 8.5–11.2) (rate ratio, 0.88; 95% CI, 0.63–1.22). However, the difference in rates was greatest for lung-related health care utilization in the usual care group (5.1 per 100 person-months; 95% CI, 4.3–6.0) compared with the behavioral intervention group (3.3 per 100 person-months; 95% CI, 2.5–4.1) (rate ratio, 0.64; 95% CI, 0.43–0.99). In addition, this difference was limited to participants with severe spirometric impairment (*P* for interaction = 0.01) who received the intervention (3.0 per 100 person-months; 95% CI, 2.0–4.0) compared with usual care (7.2 per 100 person-months; 95% CI, 5.7–8.7) (rate ratio, 0.38; 95% CI, 0.20–0.72).

To determine whether the physical activity intervention was independently associated with reduction in lung-related health care utilization, we estimated risk ratios (RRs) and incidence rate ratios (IRRs), adjusting for known risk factors for COPD-related hospitalizations (Table 3). The behavioral intervention was consistently associated with a reduction in the prevalence of lung-related health care utilization in unadjusted (RR, 0.68; 95% CI, 0.47–1.00), minimally adjusted (RR, 0.60; 95% CI, 0.39–0.91), and fully adjusted models (RR, 0.61; 95% CI, 0.40–0.93) (Table 3). Similarly, the rate of lung-related utilization was reduced with the intervention in unadjusted (IRR, 0.64; 95% CI, 0.42–0.99), minimally adjusted (IRR, 0.38; 95% CI, 0.23–0.63), and fully adjusted models (IRR, 0.41; 95% CI, 0.25–0.67) (Table 3).

Discussion

Our results demonstrate that among a representative sample of stable outpatients with COPD, a lifestyle physical activity intervention plus COPD self-management education and usual care increased self-reported physical activity, decreased sedentary activity, and decreased health care utilization. Absolute increases in physical activity levels in the intervention group compared with the usual care group were seen for patients with both moderate (+20.9%; 95% CI, 5.7–36.1) and severe impairment (+12.5%; 95% CI, −4.7 to 29.8). Variations in statistical power of these comparisons may explain the lack of statistical significance among the severely impaired. However, statistically significant decreases in lung-related utilization were most consistent among patients with severe spirometric impairment. The overall risk of high-cost health care utilization requiring urgent care, emergency visits, or hospitalizations was reduced by about 40% compared with COPD self-management education plus usual care. With an overall

absolute difference in lung-related health care utilization over the 18 months of 11.2%, the estimated number of patients needed to treat to prevent one occurrence of lung-related utilization was about nine, and among patients with severe impairment the estimated number needed to treat was only five.

These results contrast with the overall negative results for the coprimary outcomes in this study of health-related quality of life and 6-minute walk distance (7). The discrepancy may be explained by a number of factors, including reliability and responsiveness of the different outcome measures (16). Moreover, the potential mechanisms for how increases in physical activity reduce lung-related health care utilization are complex and likely mediated through multiple mechanisms including psychological, social, environmental, and biological factors (17–19). Our results highlight current gaps in our understanding of how patients adapt to their illness, and how these factors influence the various outcomes used to assess COPD interventions. For example, in our study improvement of mental health-related quality of life may have partly been the result of physical activity coaching and contributed to reduced health care utilization among severely impaired patients (20).

Furthermore, a causal link between our physical activity intervention and reduced lung-related health care utilization is supported by evidence from observational studies and a limited number of experimental investigations. Sedentary activity, an independent risk factor for mortality and severe exacerbations (21, 22), was decreased in the intervention group regardless of severity of impairment compared with usual care (Table 2). Higher levels of self-reported physical activity among patients with severe COPD have been associated with reduced hospitalizations (23) and readmissions (24). Similar results have been reported with objective measure of physical activity, with statistically significant differences associated with relatively small changes of 600–1,000 steps per day (25–27).

The magnitude of reduction in lung-related health care utilization in our study is like other nonpharmacological interventions for the prevention of COPD exacerbations (2). Overall, pulmonary rehabilitation has been associated with a reduction in hospitalizations (odds ratio, 0.45; 95% CI, 0.22–0.91). In addition, when conducted shortly after a hospitalization for a COPD exacerbation there is a 76% reduction in rehospitalization (odds ratio, 0.24; 95% CI, 0.07–0.88) (2). In a meta-analysis of nine trials of pulmonary rehabilitation after hospitalizations for an exacerbation of COPD the estimated number of patients needed to treat with rehabilitation to prevent rehospitalization was four (95% CI, 3–8) (28). However, the role of pulmonary rehabilitation for increasing longer-term physical activity remains uncertain (4).

Apart from pulmonary rehabilitation few randomized trials have been conducted targeting physical inactivity to prevent severe exacerbations, and results from these studies have been inconsistent (29). Mitchell and coworkers (5) conducted a trial of a multicomponent self-management intervention, which included a walking program. However, at 6 months they did not find a reduction in utilization, but this outcome was limited by the short duration of follow-up and small number of emergency visits ($n = 3$) and hospitalizations ($n = 7$). In a small pilot study ($n = 30$) of telephone physical activity counseling and pedometer feedback among patients recently hospitalized for an exacerbation, Hornikx and coworkers (6) found no difference in hospital readmission after 1 month. The study was stopped because of difficult recruitment and negative intermediate outcomes.

In most trials of physical activity interventions among patients with COPD, health care utilization was not an outcome; instead, the focus was on objective measures or self-reports of physical activity, quality of life, and/or exercise capacity (30–35). Of these studies, objective measures of physical activity have demonstrated an increase, particularly among patients with low levels of physical activity.

Compared with the previous trials of physical activity interventions for patients with COPD our trial has several strengths. These include a larger sample size with greater generalizability, a theory- and evidence-based lifestyle behavioral intervention, evidence for fidelity and effectiveness of intervention increasing physical activity (Table 2), and an 18-month follow-up period allowing sufficient time for adoption of the behavior change and associated training effect (7, 8).

Several potential limitations need to be considered when interpreting our results, including lack of objective measurement of physical activity, use of self-reported health care utilization, lack of benefit for non–lung-related utilization, and differential attrition. Although pedometers were used as part of the intervention, we did not provide pedometers to the usual care group. Therefore, we were not able to objectively compare levels of physical activity between the groups. However, at the group level the intervention was effective at increasing self-reported physical activity (Table 2). Further evidence for the validity of self-reported physical activity has been established in previous observational studies on the association between lower risks of hospitalization and self-reports of even modest levels of physical activity (23, 24). Another potential limitation was reliance on patient self-reports of health care utilization. However, self-reports are considered an acceptable method for measuring this outcome (36–38), and the reduction in COPD exacerbations compared with non–lung-related disease hospitalizations was independently confirmed in our adverse event reporting (7). Finally, although our estimates for those with severe FEV_1 impairment may be influenced by differential attrition and missing data (Table 2), in a sensitivity analysis of physical activity we found minimal differences (Table E2).

Conclusions

The effectiveness of adding this behavioral lifestyle physical activity intervention with COPD self-management education to usual care in reducing lung-related health care utilization provides evidence of the critical need to address physical inactivity as a core component of COPD self-management programs (22, 39). Decreasing physical inactivity may be accomplished not only through increases in moderate levels of physical activity, but also by decreasing sedentary behavior, an independent determinant of morbidity and mortality (22). Large trials are in progress to examine physical activity interventions combined with exercise and inhaled bronchodilator (40) and a community-based physical activity coaching intervention in an integrated

health system (41). Moreover, a number of promising technologies have been investigated among patients with COPD including smartphones (35, 42), web-based applications (32, 43), and telehealth (44).

Results of this study add to the growing evidence on interventions to prevent exacerbations of COPD, and offers a potentially cost-effective and generalizable alternative, which addresses many of the barriers associated with pulmonary rehabilitation (3). Hospitalizations for severe exacerbations of COPD account for a substantial majority of treatment-related costs of COPD (45). And these costs emphasize the need to expand access to effective self-management behavioral interventions. Moreover, our results highlight the need to continue research to better understand how to tailor self-management interventions to improve different health-related outcomes by *1*) identifying patient-specific characteristics and goals associated with adaptation to their illness; and *2*) using this information to coach and support patients to optimally adapt to their illness. ■

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