Regular Walking and Long-term Maintenance of Outcomes After Pulmonary Rehabilitation

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■ BACKGROUND: Empirical evidence supports the role of exercise as part of pulmonary rehabilitation in improving symptoms of breathlessness (dyspnea), health-related quality of life, and exercise tolerance among patients with chronic lung disease. However, many studies show that these initial benefits tend to diminish 12 to 18 months after rehabilitation. Given the importance of exercise (ie, walking) during rehabilitation, we examined whether patient adherence to regular walking enhanced the long-term maintenance of functional benefits gained from an 8-week pulmonary rehabilitation program.

■ METHODS: One hundred twenty-three patients with moderate to severe chronic lung disease completed an 8-week pulmonary rehabilitation program and participated in a 12-month maintenance intervention trial. Measures of weekly walking, lung function, self-efficacy for walking, dyspnea during activities of daily living, exercise capacity (6-minute walk test, 6MW), perceived breathlessness after the 6MW, and health-related quality of life were obtained at postrehabilitation, and at 6, 12, and 24 months after completing pulmonary rehabilitation. Regular walkers were defined as those active on most days or every single day of the week on the average throughout the 24-month period, whereas irregular walkers walked on some days, rarely, or not at all.

■ RESULTS: The effects of the maintenance program on average frequency of walking were nonsignificant, with 44% of the maintenance patients and 38% of the standard care patients classified as regular walkers. There were no significant differences between walking groups on gender, healthcare utilization over the 24-month follow-up period, and postrehabilitation measures of lung function, 6MW distance, perceived breathlessness after 6MW, health-related quality of life, dyspnea, or age. Repeated measures analyses of variance using a 2×4 mixed model approach were applied to examine group differences and changes in outcomes over time. Overall, participants decreased in 6MW distance ($P < .001$), reported increases in perceived breathlessness after the 6MW ($P < .05$), and decreased in overall health-related quality of life ($P < .001$) from postrehabilitation to 24 months. Regular walkers reported significantly better health-related quality of life ($P < .05$) as compared to irregular walkers, averaging across time points. Irregular walkers declined significantly more than regular walkers on measures of shortness of breath during activities of daily living ($P < .01$) and walking self-efficacy ($P < .001$) from postrehabilitation to 24 months.

■ CONCLUSIONS: Findings suggest that participation in regular exercise such as walking after completing pulmonary rehabilitation is associated with slower declines in overall health-related quality of life and walking self-efficacy as well as less progression of dyspnea during activities of daily living. Regular exercise after rehabilitation may be protective against increases in dyspnea symptoms and perceived limitations in walking which are both characteristic of progressing chronic lung disease.

KEY WORDS

adherence

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INTRODUCTION

Pulmonary rehabilitation has been empirically established as a standard mode of care for patients with chronic obstructive pulmonary disease and has been shown to result in improvements in health-related quality of life, symptoms, and functional status.[1] The primary goal of pulmonary rehabilitation is to reverse disability from disease by optimizing the functional capacity, controlling and alleviating symptoms, and reducing the economic and medical burdens of disease. Pulmonary rehabilitation is a comprehensive, multidisciplinary program typically consisting of exercise, breathing retraining, psychosocial support, and education about the disease process and management of symptoms.[1]

Exercise training is well recognized as a fundamental component of pulmonary rehabilitation. Randomized controlled trials comparing pulmonary rehabilitation programs with exercise training to education or usual care consistently support the efficacy of exercise training in improving maximum exercise tolerance and endurance without improvement in measures of lung function.[1] Although the short-term benefits of pulmonary rehabilitation including exercise training are well documented, many studies including follow-up periods of up to 2 years suggest that initial functional gains tend to diminish 12 to 18 months later.[2–8] If exercise training is important during rehabilitation in improving functional outcomes, maintenance of exercise may play a protective role against functional decline after pulmonary rehabilitation.

In a prospective, observational study, Garcia-Aymerich et al[9] found that higher levels of physical activity were associated with a lowered risk for hospital readmission for a chronic obstructive pulmonary disease exacerbation independent of age, lung function, use of anticholinergic medications, and prior hospital admission. These findings suggest that the relationship between regular physical activity and long-term functional outcomes warrants closer investigation. Therefore, we analyzed data from a randomized trial of maintenance after pulmonary rehabilitation to evaluate the effects of regular walking on dyspnea, exercise tolerance, health-related quality of life, and walking self-efficacy over 24 months. The main findings of the completed trial focused on group differences (maintenance vs. usual standard care) on short- and long-term outcomes of exercise tolerance, health status, pulmonary function, health-related quality of life, dyspnea, and healthcare use.[10] The current study combined the 2 groups of maintenance and standard care together and reports on frequency of walking in the study sample and its relationship to 6-, 12-, and 24-month outcomes of walking self-efficacy, dyspnea, health-related quality of life (disease-specific and general), pulmonary function, and exercise tolerance. We hypothesized that patients who walked regularly after pulmonary rehabilitation would better maintain the beneficial health and psychosocial outcomes following successful rehabilitation.

METHODS

Study Design

Three hundred forty (340) patients were recruited from the University of California, San Diego Pulmonary Rehabilitation Program over a 4-year period. One hundred sixty-four (164) patients who completed the 8-week pulmonary rehabilitation program agreed to participate and were randomized to 12 months of either standard care or to a maintenance program. The UCSD Human Subjects Program approved the protocol and consent form used to obtain written informed consent from all subjects.

The standard care condition consisted of a referral back to the patient's primary care provider with a letter outlining a home care program. Patients were also invited to monthly alumni meetings.

The maintenance program consisted of weekly telephone calls and monthly supervised reinforcement sessions. The objectives of the 12-month maintenance intervention were to: (1) maintain social support, (2) enhance self-efficacy, (3) encourage compliance with the home care program which includes daily exercise, and (4) assist with adjustments necessary due to intervening medical illnesses or other barriers to compliance.

Participants

Among the 164 patients who completed rehabilitation, 12 patients withdrew from participation and 20 patients died during the 24-month trial. An additional 9 patients were excluded from the present analyses due to missing data, yielding a sample of 123 patients (64 males and 59 females) who completed the study up to 24 months with no missing data. Mean age was 66.7 ± 8.0 years. The sample was 95% white. Patients had moderate to severe pulmonary dysfunction with mean FEV_1 of 47% ± 18% of predicted values. One hundred seven (107) patients had obstructive lung disease and 16 had either restrictive or mixed (obstructive and restrictive) lung disease.

Measures

Assessments were obtained prior to randomization into maintenance or standard care (postrehabilitation), and at 6, 12, and 24 months after completing pulmonary rehabilitation.

Primary Outcomes

Weekly walking was assessed using a 1-item question asking patients to indicate how often they walked for exercise during the past week using a 5-point Likert scale (0 = no days, 1 = rarely, 2 = some days, 3 = most days, and 4 = every single day).

Health-related quality of life was assessed using the interview-administered Quality of Well-Being (QWB) scale.[11] The QWB assesses symptoms, self-care, mobility, and usual activity as impacted by health. Using preferences weights, an overall QWB score places each case on a continuum ranging from 0 (dead) to 1.0 (optimal health).

Dyspnea was assessed using 2 measures: UCSD Shortness of Breath Questionnaire (SOBQ) and the Dyspnea Scale of the Chronic Respiratory Questionnaire (CRQ).

The SOBQ lists 21 activities of daily living and requires the participant to rate his/her level of dyspnea while performing each of the activities using a 6-point Likert scale (0 = Not at all, … 4 = Severely, 5 = Maximally or unable to do because of breathlessness). An additional 3 items requires the participant to rate how shortness of breath, fear of "hurting myself" or overexertion, and fear of shortness of breath limit him/her in daily life. The Dyspnea scale of the CRQ[12] consists of 5 activities of daily living identified by the patient to be impacted by breathlessness. The patient rates his/her level of breathlessness while performing each activity on a scale of 1 to 7 (1 = "extremely short of breath" to 7 = "not at all short of breath"). A total Dyspnea score is obtained by summing the ratings for each of the 5 activities.

Maximum exercise tolerance was measured with the 6-minute walk test (6MW) following standardized instructions and encouragement during the test to walk the maximum distance over level ground over 6 minutes.[13,14] Perceived symptoms of breathlessness and muscle fatigue were obtained at the end of the 6MW with a 10-point modified Borg scale.[15]

Self-efficacy for walking was evaluated with a questionnaire adapted by Toshima et al[16] and Kaplan et al.[17] Subjects were asked to rate the level of walking duration they are 100% confident they can perform using 9 statements of increasing intensity (eg, walk 1 block in approximately 5 minutes, walk 2 blocks in 10 minutes, walk 3 blocks in 15 minutes… up to walk 3 miles in 90 minutes). The score reflects the highest level at which the patient indicated 100% confidence he or she could complete.

Secondary Outcomes

Healthcare utilization in the most recent 3 months was obtained from a self-reported questionnaire including information on number of hospital days and emergency room (ER) visits.

Pulmonary function was assessed with spirometry performed after administration of an inhaled bronchodilator following current recommended practice guidelines.[18] The forced expiratory volume in 1 second (FEV_1) was used as an indicator of disease severity using recommended guidelines.[19]

Walking Groups

Walking groups were derived by averaging the reported frequency of walking during the past week at postrehabilitation, 6-, 12-, and 24-month follow-up for each participant. Patients whose average walking frequency was less than 3 were classified as irregular walkers, whereas those whose average walking frequency was 3 or more were classified as regular walkers. Therefore, patients who reported walking on most days or every single day of the week were considered regular walkers, whereas irregular walkers were those who reported walking on no days, rarely, or only some days of the week.

Statistical Analysis

Data representing primary outcomes of health-related quality of life, dyspnea, walking self-efficacy, 6MW distance, and perceived breathlessness after the 6MW for regular and irregular walkers at postrehabilitation and 24-month follow-up were evaluated with descriptive statistics and repeated measures analyses of variance using a 2 × 4 mixed model. Significant Time by Group interactions were followed up by independent-samples t tests comparing walking groups on change scores from postrehabilitation to 24 months. Walking groups were compared on postrehabilitation data using independent t tests for continuous variables and χ^2 tests for discrete variables. Type I error rate was set at a level of .05 for all statistical analyses.

RESULTS

Overall, 51 patients were classified as regular walkers and 72 patients as irregular walkers. Of the 2 study groups, 44% of the maintenance group (n = 68) were regular walkers as compared to 38% of the standard care group (n = 55). Using a χ^2 test, we found no significant effect of the maintenance intervention on outcome of walking classification (χ^2 = 0.44, NS), such that control patients were as likely as maintenance patients to be regular walkers, allowing us to pool the standard care and maintenance groups together to focus solely on differences between walking groups. Characteristics of the 51 regular and 72 irregular walkers are described in Table 1. There were no significant differences at postrehabilitation between regular and irregular walkers on any of the measures analyzed.

The sample of 123 patients used in this study excluded patients who died, dropped out, or had missing data. We applied a Kruskal-Wallis test to compare baseline characteristics of patients in the study sample (n = 123) to those who died by 24 months (n = 20), dropped out (n = 12), and had missing data (n = 9). Patients in this study tended to have less baseline breathlessness during activities of daily living as measured by the UCSD SOBQ ($\chi^2 = 13.33$, $P < .005$) and covered more distance during the 6MW test ($\chi^2 = 8.80$, $P < .05$) at postrehabilitation. In addition, patients who died by 24 months had more severe lung disease ($\chi^2 = 8.00$, $P < .05$) compared to the other groups. There were no baseline differences between those included in this study and those who dropped out, had missing data, or died on measures of age, weight, general health-related quality of life, dyspnea as measured by the CRQ, perceived breathlessness after the 6MW, self-efficacy for walking, and walking frequency.

Walking group differences in QWB scores (excluding deaths) over the 24 months following rehabilitation are depicted graphically in Figure 1. Repeated measures analysis of variance showed a significant main effect of group such that regular walkers had significantly higher quality of life than irregular walkers ($F_{1,121} = 6.21$, $P < .05$). Analyses also indicate a significant main effect of time, suggesting that both groups declined significantly from postrehabilitation to 24-month follow-up ($F_{3,363} = 6.65$, $P < .001$). Although irregular walkers appeared to decline steadily from 0.651 at postrehabilitation to 0.612 at 24-month follow-up, regular walkers appeared to maintain postrehabilitation levels of QWB (>0.680) up to 12 months, but declined to 0.639 by 24 months. At 12 months, regular walkers had significantly higher levels of health-related quality of life than irregular walkers ($t_{121} = -2.82$, $P < .01$).

For measures of dyspnea, there was a significant Group × Time interaction for both the UCSD SOBQ ($F_{3,362} = 4.58$, $P < .005$) and the CRQ Dyspnea scale ($F_{3,356} = 3.46$, $P < .05$) (Figures 2 and 3), suggesting a different rate of change in dyspnea during activities of daily living between regular and irregular walkers over time. Higher scores on the UCSD SOBQ represent increasing levels of breathlessness, whereas higher scores on the CRQ Dyspnea scale indicate less breathlessness. Follow-up independent-samples t test on the Group × Time interaction effect for the UCSD SOBQ indicates that the mean increase of 13.0 units on the UCSD SOBQ among the irregular walkers from postrehabilitation to 24-month follow-up is significantly greater than the mean increase of 2.9 units among the regular walkers ($t_{121} = 3.06$, $P < .005$). Similarly, the mean decrease of 3.8 units on the CRQ Dyspnea scale for the irregular walkers is significantly greater than the mean decrease of 0.6 for regular walkers ($t_{119} = 2.65$, $P < .01$).

Figure 4 shows that 6MW distance declined significantly over time from postrehabilitation to 24-month follow-up with no observable differences between walking groups ($F_{3,321} = 18.19$, $P < .001$).

In addition, perceived breathlessness after the 6MW also increased significantly over time from postrehabilitation to 24-month follow-up with no differences between regular and irregular walkers ($F_{3,243} = 2.83$, $P < .05$; Figure 5).

As with measures of dyspnea during activities of daily living, repeated measures analysis of variance examining group differences on self-efficacy for walking over time show a significant Group × Time interaction ($F_{3,361} = 4.35$, $P < .01$), indicating different rates of change from postrehabilitation to 24 months between regular and irregular walkers. Figure 6 shows that although regular and irregular walkers had similar levels of self-efficacy at postrehabilitation, those who walked regularly maintained postrehabilitation levels of self-efficacy by 24 months (4.6), whereas irregular walkers reported a significantly greater mean decrease

Table 1 · WALKING GROUP CHARACTERISTICS AT POSTREHABILITATION

	Regular Walkers (n = 51)	Irregular Walkers (n = 72)	*P*
Age (years)*	66.9 (8.7)	66.6 (7.7)	NS
Gender	27 M, 24 F	37 M, 35 F	NS
Diagnosis (COPD vs. non-COPD)	46 C, 5 NC	61 C, 11 NC	NS
Treatment group (maintenance vs. control)	30 M, 21 C	38 M, 34 C	NS
Total number of hospital days	2.9 (6.1)	2.2 (6.0)	NS
Total number of ER visits	1.2 (1.7)	0.9 (1.4)	NS
FEV_1, % predicted*	46.3 (15.8)	48.1 (20.2)	NS
QWB score*	0.682 (0.12)	0.651 (0.10)	NS
CRQ Dyspnea Scale*	22.1 (5.9)	22.6 (5.5)	NS
UCSD SOBQ*	44.6 (20.9)	40.9 (19.6)	NS
6MW distance (meters)*	473.9 (85.0)	455.3 (103.9)	NS
Perceived breathlessness after 6MW	3.74 (1.89)	4.11 (1.92)	NS
SEW*	4.7 (2.8)	4.8 (2.7)	NS

COPD indicates Chronic obstructive pulmonary disease; FEV_1, forced expiratory volume in 1 second; QWB, Quality of Well-Being Scale; CRQ, Chronic Respiratory Questionnaire; UCSD SOBQ, UCSD Shortness of Breath Questionnaire; 6MW, 6-minute walk test; SEW, Self-Efficacy for Walking.
Values are mean (SD).
*Measurement at postrehabilitation.

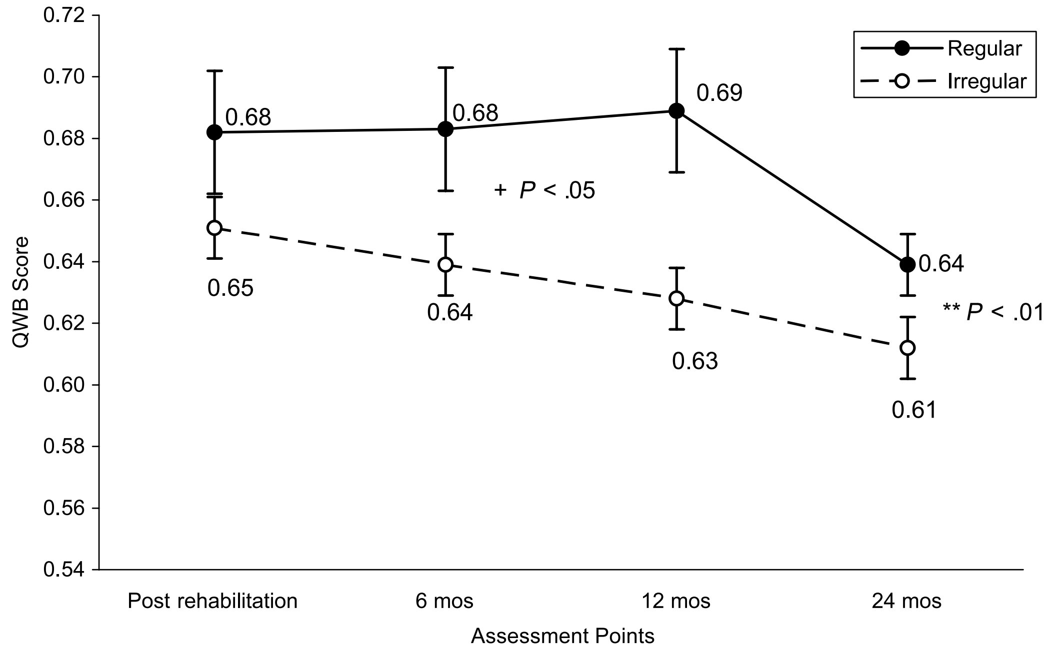

Figure 1. Changes in the Quality of Well-Being Scale (QWB) - excluding deaths for regular and irregular walkers at post rehabilitation and 6-, 12-, and 24-month follow-ups. Higher scores indicate better overall health-related quality life. + Regular walkers had significantly higher overall QWB scores across time points as compared to irregular walkers. **Both groups declined significantly in health-related quality of life from post rehabilitation to 24 months regardless of walking status.

in self-efficacy of 1.7 units by 24 months ($t_{120} = -3.76$, $P < .001$).

DISCUSSION

Overall, the results of this study indicate that among patients with chronic lung disease, regular walking is associated with better long-term maintenance of functional benefits from participation in an 8-week pulmonary rehabilitation program. In spite of the chronic and progressive course of deterioration and debilitation among patients with chronic lung disease, over the course of the 24-month follow-up period, about 41% of our patient sample reportedly walked on most or all days.

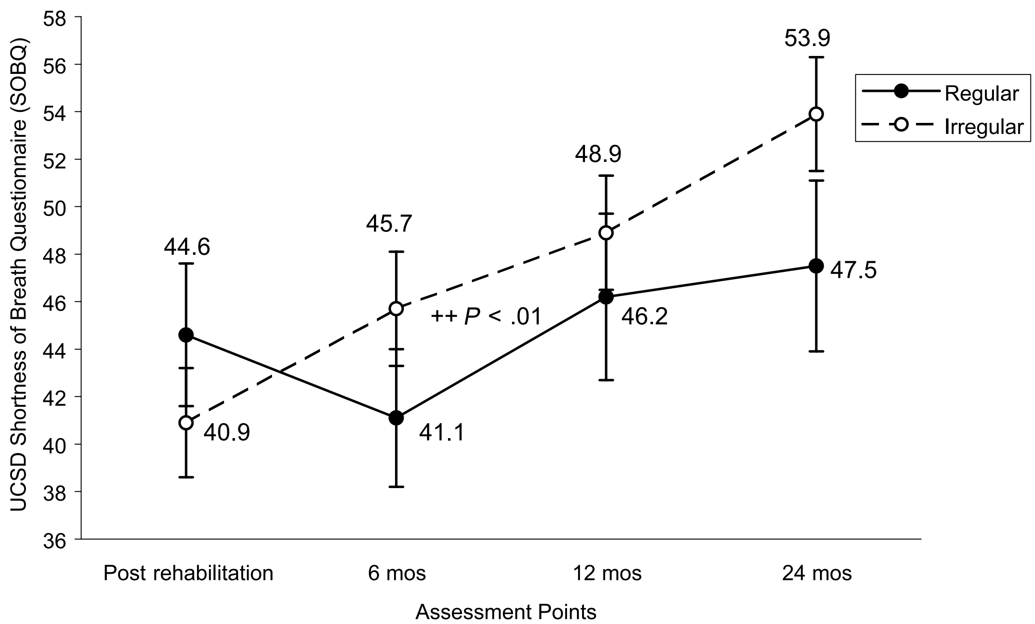

Figure 2. Changes in the UCSD Shortness of Breath Questionnaire (UCSD SOBQ) for regular and irregular walkers at post rehabilitation and 6-, 12-, and 24-month follow-ups. Higher scores indicate more dyspnea during activities of daily living. ++ Irregular walkers had significantly larger increases in dyspnea during activities of daily living from post rehabilitation to 24 months as compared to regular walkers.

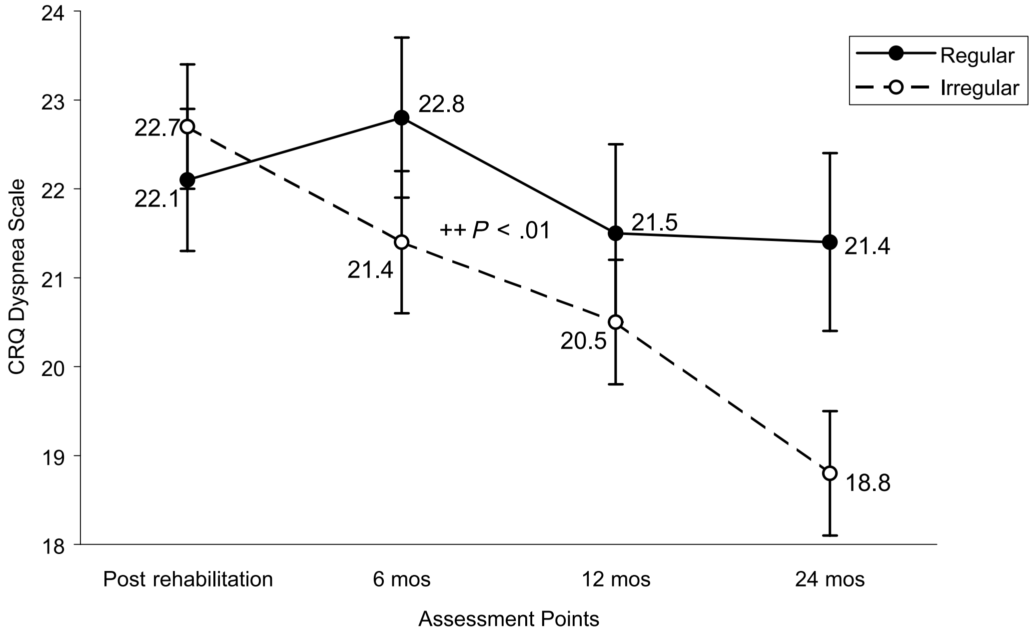

Figure 3. Changes in the Dyspnea Scale of the Chronic Respiratory Questionnaire (CRQ) for regular and irregular walkers at post rehabilitation and 6-, 12-, and 24-month follow-ups. Higher scores indicate less dyspnea during activities of daily living. ++ Irregular walkers declined significantly more with increasing dyspnea during activities of daily living from post rehabilitation to 24-months as compared to regular walkers.

As a whole, patients in the study sample declined on measures of dyspnea during activities of daily living and after a maximal exercise tolerance test, health-related quality of life, exercise tolerance, and self-efficacy for walking by 24 months after pulmonary rehabilitation. However, when examining these outcomes in the context of walking behavior, regular walkers had better health-related quality of life (averaging across all time points) and sustained less increases in impairment from dyspnea over time compared to irregular walkers. Self-efficacy for walking declined significantly among irregular walkers, whereas regular walkers maintained postrehabilitation levels of self-efficacy for walking over 24 months of follow-up. These group differences in rate

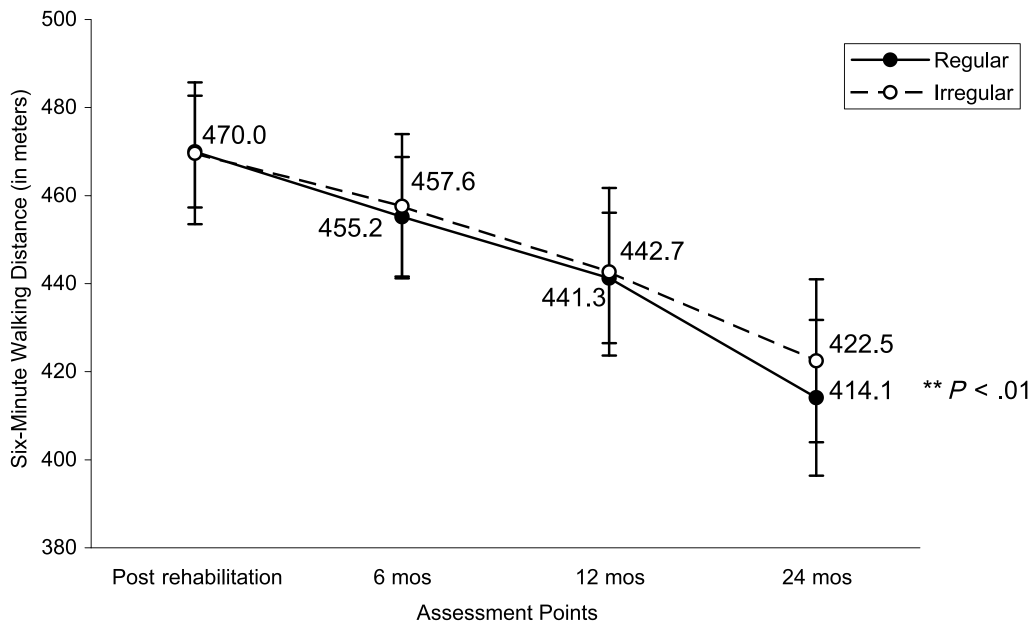

Figure 4. Changes in 6MW distance (in meters) for regular and irregular walkers at post rehabilitation and 6-, 12-, and 24-month follow-ups. Higher scores indicate longer distance walked during 6MW. **Both groups declined significantly on 6MW distance from post rehabilitation to 24 months regardless of walking status.

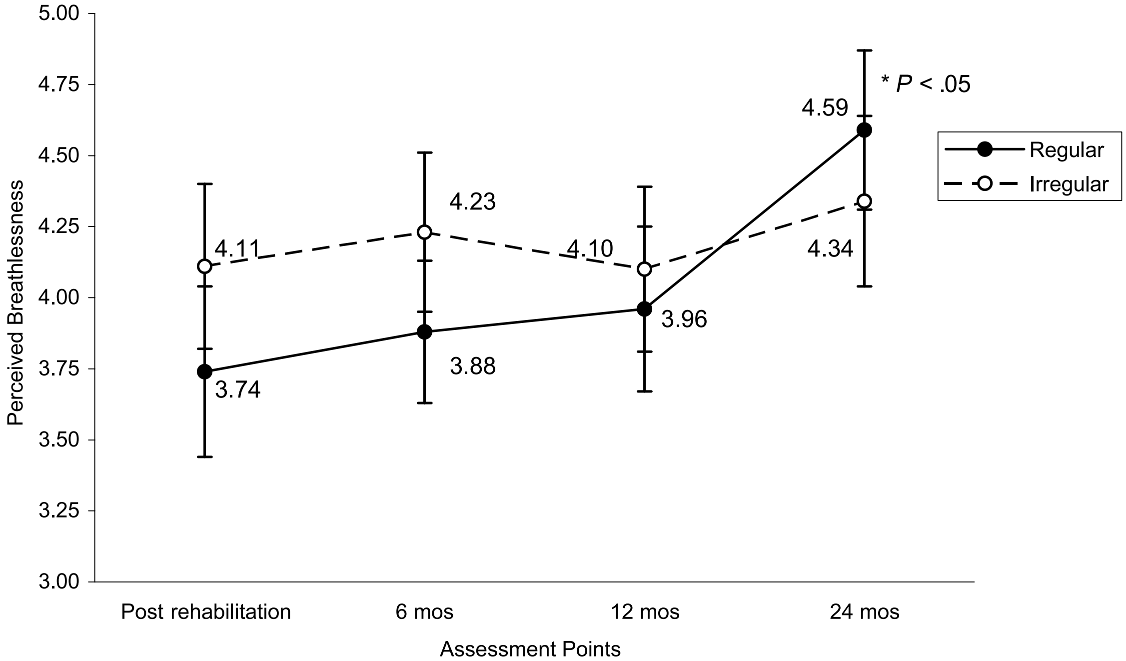

Figure 5. Changes in Perceived Breathlessness after the 6MW for regular and irregular walkers at post rehabilitation and 6-, 12-, 24-month follow-ups. Higher scores indicate more breathlessness after the 6MW. *Both groups increased significantly in perceived breathlessness after the 6MW from post rehabilitation to 24 months regardless of walking status.

of decline from postrehabilitation to 24 months on measures of dyspnea during activities of daily living and walking self-efficacy suggest that regular walking may provide some protection against the progression of chronic lung disease with respect to the impact of disease course. Without regular participation in exercise, participants showed continued decline as evidenced by increases in dyspnea and decreases in walking self-efficacy.

However, is it possible that there were factors present at postrehabilitation that predisposed patients to be regular or irregular walkers? Given the comparability

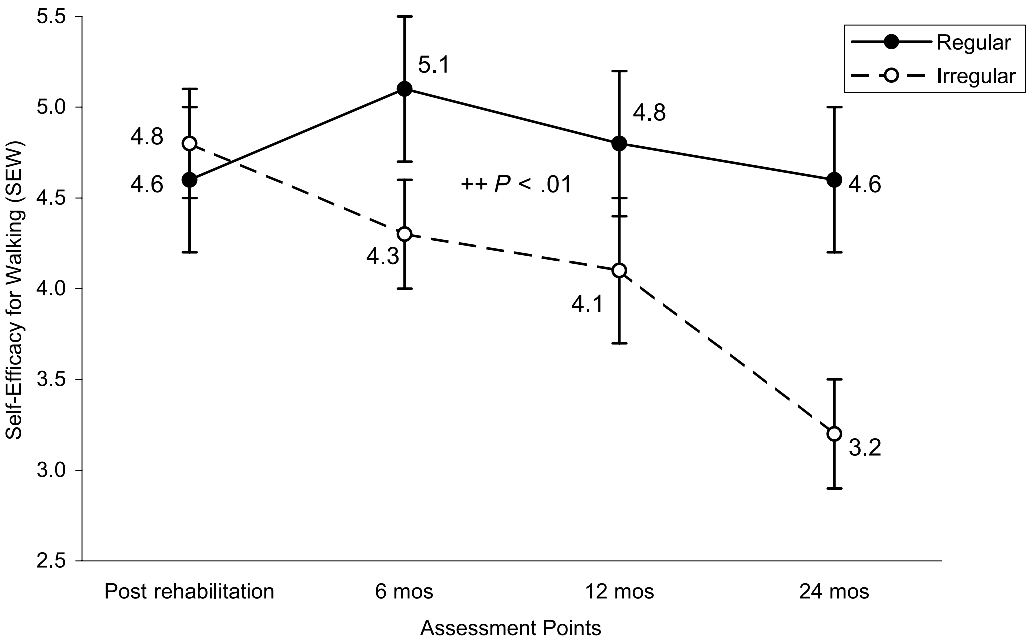

Figure 6. Changes in Self-Efficacy for Walking (SEW) for regular and irregular walkers at post rehabilitation and 6-, 12-, 24-month follow-ups. Higher scores indicate more breathlessness after the 6MW. ++ Irregular walkers had significantly larger decreases in walking self-efficacy from post rehabilitation to 24 months as compared to regular walkers.

of the regular and irregular walkers on postrehabilitation measures (see Table 1), it appears that these differences in outcomes over time cannot be attributed to preexisting differences in health status. Furthermore, regular and irregular walkers had comparable rates of healthcare utilization as represented by total number of hospital days and ER visits over 24 months after rehabilitation, suggesting that exercise behavior is independent of healthcare utilization (a reasonable proxy for decrements in health status over time). No group differences were observed for exercise tolerance as measured by the 6MW. In fact, Figure 4 shows that the groups were essentially equivalent.

It is also striking that the maintenance intervention consisting of weekly telephone follow-up from staff and monthly clinic-based booster sessions including exercise was not more effective than standard care in enhancing participation in regular walking. Of the maintenance group, 44% walked regularly on average as compared to 38% of the control group. Although suggestive of a positive effect of the maintenance intervention on walking behavior, the treatment groups were not statistically different. A possible explanation could be that regular telephone follow-up and clinic-based sessions are not sufficient in promoting the adoption and/or maintenance of independent exercise participation (ie, regular walking) for these patients with advanced chronic lung disease who are subject to progression of disease with or without periodic exacerbations. In a recent randomized controlled trial by DeBusk et al,[20] no significant differences were observed between a telephone-mediated nurse care management intervention for patients with low risk for heart failure and usual care on rates of rehospitalization, both for heart failure and for all causes. Wagner[21] suggests that telephone contact may be less effective than face-to-face patient contact in maintenance of health outcomes.

Berry et al[22] found that an intensive 15-month exercise intervention consisting of 1-hour exercise sessions implemented thrice weekly for 15 months after completion of pulmonary rehabilitation resulted in enhanced exercise performance and reduced disability from disease as compared to no follow-up treatment. However, despite the intensity of their intervention, independent exercise participation rates (outside of supervised, clinic-based sessions) did not differ between the long-term exercise and control conditions, suggesting that the functional benefits observed resulted from the clinic-based exercise sessions and not additional participation in independent exercise. If follow-up from staff and clinic-based exercise sessions do not promote the adoption and maintenance of independent exercise, what intervention can successfully achieve this goal?

It has been suggested that once formal, clinic-based treatment involving supervised exercise training ends, patients must assume greater responsibility for maintaining regular exercise participation.[23] Successful postrehabilitation maintenance interventions may need to optimize self-regulatory behavioral processes by enhancing self-efficacy.[24] One such intervention involving a modified cardiac rehabilitation protocol was evaluated by Carlson et al[25,26] in a 6-month randomized controlled trial. All patients completed 4 weeks of care consisting of 3 facility-based exercise sessions per week, including ECG monitoring and classes focusing on nutrition and cardiovascular risk factors. By week 5, patients were randomized to 21 weeks of either traditional cardiac rehabilitation or modified cardiac rehabilitation (MP). The traditional protocol was primarily a continuation of the treatment used during the first 4 weeks with gradual tapering of ECG monitoring and staff supervision by week 13. The modified protocol was based on principles from Bandura's self-efficacy theory emphasizing promotion of self-efficacy for performing health behaviors. The objective of the modified protocol was to increase independent exercise behavior through ongoing weekly education/support groups, reduction in facility-based exercise sessions with ECG monitoring, and education and counseling focused on overcoming barriers to behavioral change. Carlson et al found that patients in the modified protocol condition had higher rates of offsite exercise over 6 months and total exercise (on- and off-site) during the last 3 months of the intervention phase of the study. Furthermore, the modified cardiac rehabilitation patients had significantly higher levels of self-efficacy for independent exercise over 3 months and self-efficacy was the only significant predictor of independent exercise at 3 and 6 months. These findings further support previous observations that provision of clinic-based resources for exercise may not be sufficient in promoting adoption and maintenance of exercise and that maintenance interventions need to incorporate behavioral strategies that promote self-regulation (eg, learning how to overcome barriers to exercise).

Although the findings of the present study support the strong association between maintenance of functional outcomes (specifically, dyspnea during activities of daily living and walking self-efficacy) at 24 months and regular walking, it should be emphasized that they do not establish a cause-effect relationship between regular exercise and enhanced functional status. We cannot rule out the possibility that patients who walked regularly did so because they had better health-related quality of life and fewer symptoms to begin with. Furthermore, although regular and irregular walkers were quite comparable on measures of age and functional status after rehabilitation, those who declined over time may have been unable to maintain regular exercise participation, suggesting that the observed group differences may be an artifact of changes in health status. We partially addressed this confounding factor of decline in health status in relation to exercise by examining health-care utilization rates between regular and irregular walkers. We observed that the total number of hospitalization days and ER visits over 24 months after completing rehabilitation was not significantly different between walking groups, suggesting that declines in health status may not totally account for exercise behavior.

Another limitation of this study is that the measurement of weekly walking frequency was based on an ordinal scale. Exercise assessments based on a ratio scale [eg, (1) weekly exercise frequency of: 0 or no days per week, 1 day per week… every day of the week or (2) number of minutes walked total per week] might provide more information about level of exercise participation. Similarly, another primary limitation when assessing exercise participation is reliance on self-report measures, which may be inflated estimates of actual behavior. Other measures of exercise participation, such as triaxial accelerometers, may present more objective assessments of exercise and lifestyle physical activity than self-report.[27–29] Finally, although this study quantified weekly frequency of walking, we did not measure intensity of walking. Intensity of walking could very well moderate the effects of walking frequency on our measures, but we were unable to quantify this effect.

Results of this study must also be interpreted with caution as multiple comparisons and groupings were made for measures of exercise behavior as well as multiple comparisons of exercise group differences on measures of dyspnea during activities of daily living and after the 6MW test, health-related quality of life, exercise tolerance, self-efficacy for walking, and disease severity. These multiple comparisons increase the likelihood of a Type I error.

In summary, our findings suggest that regular exercise, such as walking, may play a role in the long-term maintenance of initial benefits of reduced disability from symptoms and enhanced health-related quality of life obtained from pulmonary rehabilitation. Future studies assessing the long-term benefits of pulmonary rehabilitation should incorporate measurement of independent exercise behavior given the association between continued exercise participation and indicators of general and disease-specific health status.

References

1. ACCP/AACVPR. Pulmonary rehabilitation: joint ACCP/AACVPR evidence-based guidelines. ACCP/AACVPR Pulmonary Rehabilitation Guidelines Panel. American College of Chest Physicians. American Association of Cardiovascular and Pulmonary Rehabilitation. *Chest*. 1997;112:1363–1396.
2. Cambach W, Wagenaar RC, Koelman TW, van Keimpema AR, Kemper HC. The long-term effects of pulmonary rehabilitation in patients with asthma and chronic obstructive pulmonary disease: a research synthesis. *Arch Phys Med Rehabil*. 1999;80:103–111.
3. Griffiths TL, Burr ML, Campbell IA, et al. Results at 1 year of outpatient multidisciplinary pulmonary rehabilitation: a randomised controlled trial. *Lancet*. 2000;355:362–368.
4. Troosters T, Gosselink R, Decramer M. Short- and long-term effects of outpatient rehabilitation in patients with chronic obstructive pulmonary disease: a randomized trial. *Am J Med*. 2000;109:207–212.
5. Engstrom CP, Persson LO, Larsson S, Sullivan M. Long-term effects of a pulmonary rehabilitation programme in outpatients with chronic obstructive pulmonary disease: a randomized controlled study. *Scand J Rehabil Med*. 1999;31:207–213.
6. Foglio K, Bianchi L, Bruletti G, Battista L, Pagani M, Ambrosino N. Long-term effectiveness of pulmonary rehabilitation in patients with chronic airway obstruction. *Eur Respir J*. 1999;13:125–132.
7. Vale F, Reardon JZ, ZuWallack RL. The long-term benefits of outpatient pulmonary rehabilitation on exercise endurance and quality of life. *Chest*. 1993;103:42–45.
8. Ries AL, Kaplan RM, Limberg TM, Prewitt LM. Effects of pulmonary rehabilitation on physiologic and psychosocial outcomes in patients with chronic obstructive pulmonary disease. *Ann Intern Med*. 1995;122:823–832.
9. Garcia-Aymerich J, Farrero E, Felez M, Izquierdo J, Marrades R, Anto J. Risk factors of readmission to hospital for a COPD exacerbation: a prospective study. *Thorax*. 2003;58:100–105.
10. Ries AL, Kaplan RM, Myers R, Prewitt LM. Maintenance after pulmonary rehabilitation in chronic lung disease: a randomized trial. *Am J Respir Crit Care Med*. 2003;167:880–888.
11. Kaplan RM, Anderson JP. The general health policy model: an integrated approach. In: Spilker B, ed. *Quality of Life and Pharmacoeconomics in Clinical Trials*. Philadelphia, Pa: Lippincott-Raven Publishers; 1996:309–322.
12. Guyatt GH, Berman LB, Townsend M, Pugsley SO, Chambers LW. A measure of quality of life for clinical trials in chronic lung disease. *Thorax*. 1987;42:773–778.
13. Steele B. Timed walking tests of exercise capacity in chronic cardiopulmonary illness. *J Cardiopulm Rehabil*. 1996;16:25–33.
14. Morgan AD. Simple exercise testing. *Respir Med*. 1989;83:383–387.
15. Borg GA. Psychophysical bases of perceived exertion. *Med Sci Sports Exerc*. 1982;14:377–381.
16. Toshima MT, Kaplan RM, Ries AL. Self-efficacy expectations in chronic obstructive pulmonary disease rehabilitation. In: Schwarzer R, ed. *Self-Efficacy: Thought Control of Action*. New York: Hemisphere; 1992:325–354.
17. Kaplan RM, Ries AL, Prewitt LM, Eakin E. Self-efficacy expectations predict survival for patients with chronic obstructive pulmonary disease. *Health Psychol*. 1994;13:366–368.
18. American Thoracic Society: Standardization of spirometry, 1994 Update. *Am J Respir Crit Care Med*. 1995;152:1107–1136.
19. American Thoracic Society: Standards for the diagnosis and care of patients with chronic obstructive pulmonary disease. *Am J Respir Crit Care Med*. 1995;152:S77–121.
20. DeBusk RF, Miller NH, Parker KM, et al. Care management for low-risk patients with heart failure: a randomized, controlled trial. *Ann Intern Med*. 2004;141:606–613.
21. Wagner EH. Deconstructing heart failure disease management. *Ann Intern Med*. 2004;141:644–646.
22. Berry MJ, Rejeski WJ, Adair NE, Ettinger Jr WH, Zaccaro DJ, Sevick MA. A randomized, controlled trial comparing long-term and short-term exercise in patients with chronic obstructive pulmonary disease. *J Cardiopulm Rehabil*. 2003;23:60–68.

23. Woodard CM, Berry MJ. Enhancing adherence to prescribed exercise: structured behavioral interventions in clinical exercise programs. *J Cardiopulm Rehabil*. 2001;21:201–209.
24. Bandura A. *Social Foundations of Thought and Action: A Social Cognitive Theory*. New Jersey: Prentice-Hall; 1986.
25. Carlson JJ, Johnson JA, Franklin BA, VanderLaan RL. Program participation, exercise adherence, cardiovascular outcomes, and program cost of traditional versus modified cardiac rehabilitation. *Am J Cardiol*. 2000;86:17–23.
26. Carlson JJ, Norman GJ, Feltz DL, Franklin BA, Johnson JA, Locke SK. Self-efficacy, psychosocial factors, and exercise behavior in traditional versus modified cardiac rehabilitation. *J Cardiopulm Rehabil*. 2001;21:363–373.
27. Belza B, Steele BG, Hunziker J, Lakshminaryan S, Holt L, Buchner DM. Correlates of physical activity in chronic obstructive pulmonary disease. *Nurs Res*. 2001;50:195–202.
28. Steele BG, Belza B, Hunziker J, et al. Monitoring daily activity during pulmonary rehabilitation using a triaxial accelerometer. *J Cardiopulm Rehabil*. 2003;23:139–142.
29. Steele BG, Holt L, Belza B, Ferris S, Lakshminaryan S, Buchner DM. Quantitating physical activity in COPD using a triaxial accelerometer. *Chest*. 2000;117:1359–1367.