The Effects of Short-term and Long-term Pulmonary Rehabilitation on Functional Capacity, Perceived Dyspnea, and Quality of Life*

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Study objectives: The purposes of this study were as follows: (1) to determine whether physical performance, quality of life, and dyspnea with activities of daily living improved following both short-term and long-term pulmonary rehabilitation (PR) across multiple hospital outpatient programs; (2) to examine the differences in these parameters between men and women; and (3) to determine what relationships existed between the psychosocial parameters and the results of the 6-min walk (6MW) test performance across programs.

Design: Nonexperimental, prospective, and comparative.

Setting: Seven outpatient hospital PR programs from urban and rural settings across North Carolina.

Participants: Three hundred nine women and 281 men who were 20 to 93 years of age (mean [± SD] age, 66.7 ± 11.1 years) with chronic lung disease.

Interventions: All 6MW tests and health surveys were administered prior to and immediately following 12 and 24 weeks of supervised PR participation. Scores from the 6MW tests, the Ferrans and Powers quality of life index-pulmonary version III (QLI), the Medical Outcomes Study 36-item short form (SF-36), and the University of California at San Diego shortness of breath questionnaire (SOBQ) were compared at PR entry, at 12 weeks, and at 24 weeks for differences by gender with repeated-measures analysis of variance. The study entry and follow-up SF-36 physical and mental component summary scores, the QLI health/function and overall scores, and the SOBQ scores were also compared to the 6MW test scores with Pearson correlation coefficient analysis.

Results: The mean summary scores on the SF-36 and the QLI increased after 12 weeks of PR (p < 0.05), and improvements were maintained by 24 weeks of PR participation (p < 0.05). Scores on the SOBQ improved after 12 weeks (p < 0.001) among the short-term participants, but not until after 24 weeks among the long-term participants (p = 0.009). The 6MW test performance improved after 12 weeks (p < 0.001) and again from 12 to 24 weeks (p = 0.002) in the long-term participants. No relevant correlational relationships were found between 6MW scores and the summary scores of the administered surveys (r = −0.43 to 0.36).

Conclusions: Physical performance, as measured by the 6MW test, continued to improve with up to 24 weeks of PR participation. Quality-of-life measures and the perception of dyspnea improved after 12 weeks of PR participation, with improvements maintained by 24 weeks of PR participation. It is recommended that PR patients participate in supervised PR for at least 24 weeks to gain and maintain optimal health benefits.

Key words: Ferrans and Powers quality of life index-pulmonary version III; Medical Outcomes Study short-form health survey; pulmonary rehabilitation; quality of life; 6-min walk test; University of California at San Diego shortness of breath questionnaire

Abbreviations: ADLs = activities of daily living; 6MW = 6-min walk; NCCRA = North Carolina Cardiopulmonary Rehabilitation Association; PR = pulmonary rehabilitation; QLI = Ferrans and Powers quality of life index-pulmonary version III; QOL = quality of life; SF-36 = Medical Outcomes Study 36-item short form; SOBQ = University of California, San Diego shortness of breath questionnaire

COPD is the fourth leading cause of death in the United States. Disability from lung disease is second only to disability caused by heart disease. Pulmonary rehabilitation (PR) is a scientifically proven and efficacious technique for improving the overall health of the patient with chronic pulmonary disease. Randomized controlled trials have shown that short-term PR (ie, 4 to 12 weeks) can reduce the number of hospitalizations, improve quality of life (QOL), reduce respiratory symptoms, improve exer-
cise tolerance, increase self-efficacy, and improve exercise activities of daily living (ADLs). However, only a few studies have looked at the benefits of long-term (ie, > 12 weeks) supervised PR. Berry et al found that an 18-month PR program resulted in greater improvements in self-reported disability and physical functioning in patients with COPD when compared with a 3-month exercise program. Other investigators have shown a gradual decline over time in the positive gains made in both physical and psychosocial progress seen during the early phase of PR. Some of this decline reflects the progression of the underlying respiratory disease and other comorbidities. However, we do not currently know to what extent this decline in overall health status may be attenuated with long-term PR intervention.

One way to address this problem is to perform clinical outcome studies that are focused on cardio-pulmonary rehabilitation intervention from multiple sites, providing “real-life” evidence of the health benefits across programs. Participants in PR programs now participate in structured, medically supervised programs for extended periods, sometimes up to many years. Unfortunately, long-term compliance with exercise therapy is poor in both the cardiac and pulmonary populations.

To accurately assess both the short-term and long-term improvements in physical and psychosocial health parameters following PR, a systematic measurement of treatment outcomes is required. Timed walking tests such as the 6-min walk (6MW) test have gained popularity for use in clinical practice and research settings to assess changes in functional capacity following PR intervention. Validated surveys are also commonly used to assess psychosocial improvement and changes in perceived dyspnea in pulmonary patients following PR. Interrelationships found between 6MW performance and measures such as self-efficacy, dyspnea with ADLs, and QOL have been mixed in patients with chronic pulmonary disease.

In 2000, the North Carolina Cardiopulmonary Rehabilitation Association (NCCRA) developed a Web-based registry to assess the physical, behavioral, and psychosocial outcomes following PR participation. The purposes of this investigation were as follows: (1) to determine whether, and to what extent, physical performance, QOL, and perceived dyspnea with ADLs improved following both short-term and long-term PR participation across multiple hospital outpatient programs; (2) to determine what differences existed, if any, between these parameters in men and women; and (3) to determine whether any relationships existed between 6MW performance and the physical component measures of the health surveys administered.

Materials and Methods

Participants

The subjects for this investigation consisted of 309 women and 281 men aged 20 to 93 years (mean ± SD age, 66.7 ± 11.1 years) from seven North Carolina PR programs. The greatest number of subjects in this study came from hospitals in the greater Charlotte and Greensboro metropolitan areas. All patients had some form of restrictive, obstructive, or mixed lung disease. A majority of patients had COPD (92%), consisting primarily of emphysema, asthma, chronic bronchitis, or combinations of the three. Patients with restrictive lung diseases such as sarcoidosis and pulmonary fibrosis comprised approximately 8% of the study population. Two patients had received double-lung transplants, and two patients had previously undergone lung volume reduction surgery. The FVC values for the entire cohort ranged from 0.29 to 5.26 L (X = 1.9 ± 0.95 L). FEV1 values ranged from 0.13 to 3.21 L (X = 1.05 ± 0.60 L).

All patients were tested between January 1, 2000, and January 1, 2003. Only those patients who completed both the initial and follow-up tests were included in this study. The majority of patients were white, with African-Americans comprising < 10% of patients and either Asian-Americans or Hispanics comprising < 1%. For each patient, basic information was provided, including age, gender, weight, height, and race. Supplemental oxygen use and pulmonary function were reported but were not formally assessed across programs in this investigation.

Outcome Measures

Participating centers agreed to use the same set of outcome measures, following the same instructions for all participants who were enrolled in their programs. Each program performed 6MW tests for all participants. The University of California at San Diego shortness of breath questionnaire (SOBQ) was used by four of seven programs to assess dyspnea with ADLs. For QOL assessment, PR programs were allowed to use either the quality of life index-pulmonary version III by Ferrans and Powers (QLI), which is a survey that has been validated in many illness groups, or the Medical Outcomes Study 36-item short form (SF-36). Some centers utilized both surveys. Thus, the number of patients reported varied by the survey administered.

PR Programs

Patients exercised 2 to 3 days per week across programs. All programs provided aerobic exercise therapy, consisting of a...
combination of track or treadmill walking, upright or recumbent cycling, rowing, stair-stepping, elliptical trainer exercise, and arm ergometer training. The intensity of exercise varied by program but followed established exercise training guidelines for pulmonary patients. Most programs incorporated resistive exercise training that included the use of weight machines, hand weights, and/or elastic bands or tubes. All programs offered nutritional and psychosocial assessment and counseling. Education modules were offered throughout programs covering obstructive and restrictive lung diseases, pulmonary hygiene, breathing retraining, risk factor modification, dietary modification, pulmonary medications and apparatus, stress management/relaxation, exercise benefits, smoking cessation, musculoskeletal injury prevention, and overall pulmonary disease intervention. Staff varied by the program, but generally included the medical director, program director or coordinator, respiratory therapist, clinical exercise physiologist, nurse, dietitian, psychologist, clinical social worker, and/or physical therapist. All participating PR programs offered supervised maintenance exercise programs.

6MW Test

Each initial, or “entry,” 6MW test was performed within the first week of admission to the PR program. Follow-up testing was performed again after 8 to 12 weeks and after 24 weeks of supervised participation. The first follow-up test was allowed from 8 to 12 weeks after PR entry due to the fact that some programs varied slightly in their patient discharge or advancement criteria. Most patients were tested immediately following 12 weeks of PR participation. Standardized instructions for the administration of the 6MW test were sent to all PR program directors. A one-trial 6MW protocol was utilized in this investigation. Patients were instructed to walk as far as possible in a 6-min time period, taking rest periods if necessary. The time elapsed and statements of encouragement were provided at standardized intervals during tests in accordance with instructions sent to each director, which were condensed from established testing procedures. Before each test, the patient’s resting heart rate, blood pressure (BP), and arterial oxygen saturation level were monitored at rest in a sitting position. Immediately after completion of the 6MW test, a PR staff member measured the peak exercise data, which included heart rate, BP, rating of perceived exertion, rating of dyspnea, and arterial oxygen saturation. These measures were taken primarily for patient monitoring and safety purposes, and were not formally collected or analyzed. The total distance walked was measured to the nearest foot and recorded. Patients who became symptomatic (e.g., severe dyspnea or chest pain) were instructed to stop walking, and the test was discontinued. There were no reported cardiopulmonary complications requiring physician intervention or medical follow-up with testing throughout the programs.

Clinical Database

A multisite registry was established in voluntary cooperation with participating North Carolina PR program coordinators. This database contained information from participants who were enrolled in seven hospital-based outpatient PR programs between January 1, 2000, and January 1, 2003. All collected data were electronically submitted to the NCCRA outcomes registry for data storage. The NorthEast Medical Center Health and Fitness Institute in Concord, NC, served as the coordinating center for data storage, and statistical support was given by the Psychology Department at Davidson College (Davidson, NC). Once entry and follow-up data were received from each program, the 6MW distance (in feet), QLI scores in each health domain (including the overall score), the SF-36 physical and mental component summary scores, and the overall SOBQ score were entered into a statistical software package (SPSS for Windows, version 10.0; SPSS Inc. Chicago, IL) for analysis. For participating in this investigation, PR programs received summary reports that included data for their program compared to state and population norms for each outcome measure.

Statistical Analysis

Scores for each parameter were analyzed for differences by gender with repeated-measures analysis of variance. Two analysis of variance tests were typically run for each measure; one that compared the patients who completed 12 weeks and one that compared those who completed 12 and 24 weeks with analysis of time, treatment, and the interaction effects. Analysis of variance was also used to test for interaction effects between individual clinics. Changes were considered to be statistically meaningful at the 0.05 level of significance. Entry, 12-week, and 24-week follow-up 6MW test scores for each gender were also compared to the five domains of the QLI, the SF-36 physical and mental component summary scores, and the overall SOBQ scores with Pearson correlation coefficient analysis to assess any correlational relationships.

Clinically meaningful changes for 6MW test, QLI, SF-36, and SOBQ scores have not been firmly established in pulmonary patients. One method of assessing the magnitude of change in one’s health status is the effect size, which is a standardized measure of change within a group. The effect size is calculated by dividing the mean change from the initial score to the follow-up score by the SD of the change, as follows: (Mean Initial Scores – Mean Follow-up Scores)/SD of Initial Scores. While the magnitude of the effect size that is clinically relevant for specific health parameters has yet to be established, Cohen and others have suggested that an effect size of 0.20 is small, 0.50 is moderate, and 0.80 is large. Thus, the greater the effect size, the stronger the evidence that a change represents a minimal clinically meaningful difference in a particular variable, such as 6MW distance or QOL survey scores. Benzo et al have suggested an effect size of ≥ 0.40 as a benchmark for minimal clinical relevance in pulmonary patients, although further study is needed on this issue.

RESULTS

6MW Test

The 6MW distance (in feet) increased in men and women across programs (p < 0.001) following 12 weeks of PR (Table 1). While men walked further than women on both the initial and 12-week follow-up tests (p < 0.05), there were no interaction effects (p = 0.304) between genders as both improved similarly. The effect sizes for men and women were 0.47 and 0.54, respectively, indicating moderate clinical improvements in 6MW test performance after 12 weeks (men, 15%; women, 18%).

In the patients who completed 24-week follow-up tests (Table 1), improvements in 6MW performance were seen at both 12 and 24 weeks following PR entry (p < 0.001). Mild-to-moderate effect sizes were observed at 12 weeks (men, 0.32; women, 0.54), becoming greater when analyzed from PR
entry to 24 weeks (men, 0.46; women, 0.74). Statistical improvements in 6MW scores were also observed from 12 to 24 weeks in the long-term participants (p = 0.002). However, little clinical improvement was apparent, as indicated by the minimal effect sizes of 0.21 (men) and 0.23 (women). The participants who did not complete 24 weeks of PR (n = 439) were either discharged from PR at 12 weeks or had not had enough time to complete 24 weeks of PR at the time of these analyses.

SF-36

Physical component summary scores from the SF-36 survey (Table 2) improved both statistically (p < 0.001) and clinically, with effect sizes of 0.56 (men) and 0.99 (women) following 12 weeks of PR participation. Scores improved by 16% in men and by 26% in women. The SF-36 surveys were routinely administered by three of seven programs, hence the smaller numbers of patient responses analyzed.

In patients who participated in PR for 24 weeks and completed the SF-36 surveys, improvements in physical component summary scores were seen from PR entry to 12 weeks (p < 0.001) and from PR entry to 24 weeks (p = 0.001) [Table 2]. The large effect sizes observed from PR entry to both 12 and 24 weeks, and the degree of increase (i.e., > 5 points) indicates strong clinical improvements in both men and women. Physical component summary scores did not improve in men and women between 12 and 24 weeks of PR participation (p > 0.05; effect size: men, 0.18; women, 0.07) among the long-term participants.

Mental component summary scores of the SF-36 (Table 3) improved only slightly (men, 5%; women, 5%) from PR entry to 12 weeks (p = 0.001). Clinical improvements were also minimal, with effect sizes of 0.05 in women and 0.28 in men. In patients who completed 24 weeks of follow-up tests (Table 3), improvements in the mental component summary scores were observed from PR entry to 12 weeks (p = 0.035) and from PR entry to 24 weeks (p = 0.004). Minimal to mild effect sizes were seen from PR entry to 12 weeks (men, 0.43; women, 0.19), becoming slightly stronger from PR entry to 24 weeks (men, 0.49; women, 0.30). The mental component summary scores did not improve from 12 to 24 weeks of PR participation (p > 0.05) in the long-term patients, with associated minimal clinical effect sizes (men, 0.09; women, 0.18).

### Table 2—Improvement in SF-36 Physical Component Summary Scores*

<table>
<thead>
<tr>
<th>Improvement</th>
<th>Entry</th>
<th>12-wk</th>
<th>Gain, Effect Size</th>
<th>24-wk</th>
<th>Gain From Entry, Effect Size</th>
<th>12-24 wk</th>
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<tbody>
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<td></td>
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<tr>
<td>12 weeks</td>
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<td></td>
</tr>
<tr>
<td>Men (n = 86)</td>
<td>30.8 ± 8.8</td>
<td>35.7 ± 12.8</td>
<td>16</td>
<td>0.56</td>
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<tr>
<td>Women (n = 106)</td>
<td>28.6 ± 7.6</td>
<td>36.1 ± 12.4</td>
<td>26</td>
<td>0.99</td>
<td></td>
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</tr>
<tr>
<td>Total (n = 192)</td>
<td>29.6 ± 8.2</td>
<td>35.9 ± 12.5</td>
<td>21</td>
<td>0.77</td>
<td></td>
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<tr>
<td>24 weeks</td>
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<td></td>
</tr>
<tr>
<td>Men (n = 27)</td>
<td>29.2 ± 8.5</td>
<td>39.3 ± 15.3</td>
<td>35</td>
<td>36.6 ± 15.5</td>
<td>25</td>
<td>1.0</td>
</tr>
<tr>
<td>Women (n = 43)</td>
<td>27.0 ± 8.1</td>
<td>35.7 ± 13.0</td>
<td>32</td>
<td>35.7 ± 12.7</td>
<td>32</td>
<td>1.0</td>
</tr>
<tr>
<td>Total (n = 70)</td>
<td>27.9 ± 8.3</td>
<td>37.1 ± 13.9</td>
<td>33</td>
<td>36.1 ± 13.7</td>
<td>29</td>
<td>&gt; 1.0</td>
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</tbody>
</table>

*Values given as mean ± SD, unless otherwise indicated.*
Table 3—Improvement in SF-36 Mental Component Summary Scores*

<table>
<thead>
<tr>
<th>Improvement</th>
<th>Entry</th>
<th>12-wk</th>
<th>Gain, %</th>
<th>Effect Size</th>
<th>24-wk</th>
<th>Gain From Entry, %</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 weeks</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Men (n = 86)</td>
<td>51.2 ± 9.8</td>
<td>53.9 ± 10.6</td>
<td>5</td>
<td>0.28</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women (n = 106)</td>
<td>50.1 ± 11.2</td>
<td>52.8 ± 10.9</td>
<td>5</td>
<td>0.05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total (n = 192)</td>
<td>50.6 ± 10.6</td>
<td>53.3 ± 10.7</td>
<td>5</td>
<td>0.25</td>
<td></td>
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<tr>
<td>24 weeks</td>
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</tr>
<tr>
<td>Men (n = 27)</td>
<td>53.4 ± 9.1</td>
<td>57.3 ± 6.3</td>
<td>7</td>
<td></td>
<td>57.9 ± 6.5</td>
<td>7</td>
<td>0.43</td>
</tr>
<tr>
<td>Women (n = 43)</td>
<td>53.8 ± 11.2</td>
<td>55.5 ± 9.4</td>
<td>3</td>
<td></td>
<td>57.2 ± 8.6</td>
<td>6</td>
<td>0.19</td>
</tr>
<tr>
<td>Total (n = 70)</td>
<td>53.7 ± 10.4</td>
<td>56.2 ± 8.3</td>
<td>5</td>
<td></td>
<td>57.2 ± 7.8</td>
<td>6.5</td>
<td>0.24</td>
</tr>
</tbody>
</table>

*Values given as mean ± SD, unless otherwise indicated.

QLI

Men and women across programs who completed QLI surveys showed both statistical improvement (p = 0.001) and moderate clinical improvement (effect size, 0.45 in men and women) in QLI overall scores following 12 weeks of participation in PR (Table 4). Both genders improved by 11% and exceeded the 2-point clinically meaningful threshold of improvement on the overall QLI scores.30–32 Patients who completed 24 weeks of PR (Table 4) showed statistical improvement, but only mild clinical improvement, in QLI overall scores after 12 weeks of PR (p = 0.008). By 24 weeks of PR participation, statistical and moderate clinical improvements in QLI overall scores were observed in both genders (p = 0.001; effect size, 0.50 in men and women), with women showing a 2.2-point mean overall increase in scores. As with the SF-36 summary scores, no statistical or clinical improvements were seen from 12 to 24 w of PR participation (p > 0.05).

SOBQ

The men and women who completed the SOBQ surveys (three programs) showed statistical improvements (p < 0.001) in scores following 12 weeks of PR participation, with minimal clinical changes (Table 5). Both genders demonstrated a mean significant improvement over time, with women showing a greater, but not statistically significant, drop in scores than men. Neither gender differences (p = 0.408) nor interaction effects (p = 0.623) were present. The mean decrease in the scores of women exceeded the level considered to represent a minimal clinically important difference (ie, 5 points), although minimal effect sizes were seen in both genders from PR entry to 12 weeks of participation.

Only a small number of men (n = 14) and women (n = 25) completed the 24-week follow-up SOBQ surveys due primarily to the later initiation date of this survey into the NCCRA registry. This subgroup of patients showed no decrease in SOBQ scores after 12 weeks of PR participation (p = 0.191) but did show a decrease in SOBQ scores after 24 weeks of PR participation (p = 0.009) [Table 5]. Women showed a greater 24-week drop when compared to men (−10.4 vs −5.3 points, respectively), with a greater clinical effect size (0.41 vs 0.20, respectively).

Correlational Relationships

To determine whether any relationships existed between the mean entry, 12-week, and 24-week 6MW test scores, and the mean of the entry, 12-

Table 4—Improvement in QOL Index Overall Scores*

<table>
<thead>
<tr>
<th>Improvement</th>
<th>Entry</th>
<th>12-wk</th>
<th>Gain, %</th>
<th>Effect Size</th>
<th>24-wk</th>
<th>Gain From Entry, %</th>
<th>Effect Size</th>
</tr>
</thead>
<tbody>
<tr>
<td>12 weeks</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Men (n = 204)</td>
<td>19.3 ± 4.7</td>
<td>21.4 ± 4.4</td>
<td>11</td>
<td>0.45</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Women (n = 225)</td>
<td>19.6 ± 4.9</td>
<td>21.8 ± 4.5</td>
<td>11</td>
<td>0.45</td>
<td></td>
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<tr>
<td>Total (n = 429)</td>
<td>19.4 ± 4.8</td>
<td>21.6 ± 4.4</td>
<td>11</td>
<td>0.46</td>
<td></td>
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<tr>
<td>24 weeks</td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Men (n = 31)</td>
<td>21.1 ± 3.2</td>
<td>22.0 ± 3.1</td>
<td>4</td>
<td></td>
<td>22.7 ± 3.2</td>
<td>8</td>
<td>0.28</td>
</tr>
<tr>
<td>Women (n = 47)</td>
<td>20.4 ± 4.4</td>
<td>22.0 ± 3.9</td>
<td>8</td>
<td></td>
<td>22.6 ± 3.9</td>
<td>11</td>
<td>0.36</td>
</tr>
<tr>
<td>Total (n = 78)</td>
<td>20.7 ± 4.0</td>
<td>22.0 ± 3.6</td>
<td>6</td>
<td></td>
<td>22.6 ± 3.6</td>
<td>9</td>
<td>0.33</td>
</tr>
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</table>

*Values given as mean ± SD, unless otherwise indicated.
This multiple-site study was designed to evaluate functional status and health-related QOL relationships in patients with chronic lung disease following both short-term and long-term supervised PR intervention. While the participating PR programs may have differed in staff and structure, their assessment measures were standardized for uniform outcome data tracking. Analyzing data in this fashion from several hospital outpatient facilities may offer a better look at the “real-life” benefits of PR and may contribute to the establishment of normative values for PR patients.

Randomized, controlled trials from both hospital-based and home-based programs have documented the beneficial effects of short-term (ie, 4 to 12 weeks) PR on functional capacity,5,7–11,43–51 health-related QOL,5–7,11,45,46,51–53 ADLs,5,10,11,51 and exertional or overall dyspnea.7–9,45,47,51,53 It has not been established to what degree the benefits of short-term PR diminish over time, how long these benefits persist with continued supervised PR intervention, or the optimal nature of long-term PR intervention. The confounding effects of multiple study designs including varying durations of exercise, education, breathing retraining, and home exercise interventions have hindered solid conclusions about these issues. Many investigators6,10,11,50,53 have found that the physical and psychosocial benefits achieved following short-term PR plateau or diminish with continued PR participation of up to 24 months, but still remain above prehabilitation levels. In contrast to these studies, Berry et al5 found that an 18-month program of supervised PR that included both aerobic and upper body resistive exercise resulted in greater improvements in self-reported disability and physical functioning when compared with those of a 3-month program. In this randomized, single-blinded trial, 140 patients with COPD in the 18-month intervention group reported 12% less disability, walked 6% longer, climbed steps 11% faster, and completed an overhead task 8% faster than patients in the 3-month intervention group. No differences were seen in pulmonary function studies between groups after training, including peak oxygen uptake. These investigators concluded that the benefits achieved after short-term PR begin to decay once structured intervention has been terminated, despite encouragement to continue participation in a home-based or community-based program. In this same cohort of

### Table 5—Change in SOBQ Scores Across North Carolina Pulmonary Rehabilitation Programs*

<table>
<thead>
<tr>
<th>Improvement</th>
<th>Entry</th>
<th>12-wk</th>
<th>Change, %</th>
<th>Effect Size</th>
<th>24-wk</th>
<th>Change From Entry, %</th>
<th>Effect Size</th>
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<tr>
<td>12 weeks</td>
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</tr>
<tr>
<td>Men (n = 93)</td>
<td>46.8 ± 22.2</td>
<td>43.9 ± 23.8</td>
<td>−6</td>
<td>0.13</td>
<td>47.2 ± 25.2</td>
<td>−10</td>
<td>0.03</td>
</tr>
<tr>
<td>Women (n = 114)</td>
<td>48.1 ± 24.8</td>
<td>42.0 ± 24.2</td>
<td>−13</td>
<td>0.25</td>
<td>46.7 ± 20.8</td>
<td>−16</td>
<td>0.49</td>
</tr>
<tr>
<td>Total (n = 207)</td>
<td>47.5 ± 23.6</td>
<td>42.9 ± 23.9</td>
<td>−10</td>
<td>0.19</td>
<td>46.9 ± 22.1</td>
<td>−14</td>
<td>0.28</td>
</tr>
<tr>
<td>24 weeks</td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Men (n = 14)</td>
<td>52.5 ± 26.4</td>
<td>53.3 ± 27.3</td>
<td>+2</td>
<td></td>
<td>47.2 ± 25.2</td>
<td>−10</td>
<td>0.03</td>
</tr>
<tr>
<td>Women (n = 25)</td>
<td>55.4 ± 21.3</td>
<td>45.0 ± 23.7</td>
<td>−19</td>
<td></td>
<td>46.7 ± 20.8</td>
<td>−16</td>
<td>0.49</td>
</tr>
<tr>
<td>Total (n = 39)</td>
<td>54.4 ± 22.9</td>
<td>48.0 ± 25.2</td>
<td>−12</td>
<td></td>
<td>46.9 ± 22.1</td>
<td>−14</td>
<td>0.28</td>
</tr>
</tbody>
</table>

*Values given as mean ± SD, unless otherwise indicated.

**Clinical Investigations**
patients, Foy et al\textsuperscript{51} found that patients randomized to the long-term PR group had more favorable scores than those in the short-term group for dyspnea, fatigue, emotional function, and task mastery.

Ries et al\textsuperscript{29} found that improvements in physical functioning diminished once patients left an 8-week PR program that had a strong exercise component. Improvements made during the 8-week program were totally lost within 12 to 18 months. In this same cohort of patients, Ries et al\textsuperscript{10} found that weekly telephone calls and once-monthly supervised PR sessions produced only modest improvements in the maintenance of benefits gained after short-term PR. By 24 months, PR patients had returned to levels of ADLs were improved after 12 weeks of PR and were maintained over a longer time period, which is possibly attributable to the additional exercise sessions attended by the participants, a progression to a higher maintenance training intensity level, or both. Our findings suggest that moderate clinically significant improvements in 6MW test performance occur in participants from multiple PR sites following short-term participation. Further statistically relevant improvements, but not clinically relevant improvements, are then seen from 12 to 24 weeks.

**SF-36**

Men and women showed both statistically and clinically significant improvements in SF-36 physical component summary scores from PR entry to both 12 and 24 weeks of PR participation. Scores were maintained, but not improved, from 12 to 24 weeks in the long-term participants. The same relationship held true for the mental component summary scores, but with lower effect sizes. In general, a 5-point increase in SF-36 summary scores indicates a minimal clinically significant change. This was seen in the physical component summary scores after 12 weeks of PR, but not from 12 to 24 weeks. This was not seen in the mental component summary scores after either 12 or 24 weeks of PR.

Some investigations have noted that PR participants perceive greater impairment in the physical aspects of their health rather than in the mental aspects, and that they show greater physical improvements rather than psychosocial improvements following both short-term and long-term PR.\textsuperscript{26} Our
findings agree with those of Benzo et al,26 who found SF-36 physical and mental component summary scores to improve in 22 patients with COPD following 6 weeks of supervised outpatient PR. Our patients had baseline mental component summary scores that were much higher than those of Benzo et al,26 with mean scores in the 50s. The SF-36 mental component summary score is standardized to 50 for the general US population,40 indicating that our patients may have perceived little impairment in the psychosocial aspects of their lives on entry into the PR program. Nevertheless, we observed psychosocial improvements ranging from 4 to 7% in men and women after 12 and 24 weeks of participation. These small improvements may have been due to high mean baseline scores, similar to those seen in California PR patients (X = 47.5 ± 11.5)11 and others.5,10,45,54 Psychosocial improvements may also take longer to be appreciated than physical improvements in PR participants.

QLI

The QLI overall scores, which are a combination of physical functioning, socioeconomic factors, psychological/spiritual perception, and family interactions, improved in patients in the present study who participated in PR for both 12 and 24 weeks. In this survey, a minimal clinically significant increase has been reported to be 2 points, or 10%, in many illness groups.30–37 This was observed in the larger group of men and women who completed 12 weeks of PR and in the smaller group of women who completed 24 weeks of PR. Moderate effect sizes were observed from PR entry to 12 and to 24 weeks in both groups. As with the SF-36 physical and mental component summary scores, no statistical or clinical improvements in QLI overall scores were seen from 12 to 24 weeks of PR participation. Thus, the findings of both surveys were in relative agreement, showing that perceived physical and psychosocial factors improve clinically after 12 weeks of PR and then apparently plateau by 24 weeks of PR participation, with the perception of physical improvements being more pronounced than psychosocial improvements.

Many investigators have found little or no relationship between perceived and measured health and physical function traits in pulmonary populations.5,56–59 This finding may reflect the comprehensive nature of PR and the premise that health-related QOL depends on factors other than just exercise ability. Our findings concur with these studies, as we also found low correlations between the improvement in 6MW scores and the improvement in QOL survey scores. Specifically, the physical component summary scores of the SF-36 survey showed little relationship with 6MW scores at entry, 12 weeks, or 24 weeks, as did the QLI health and function domain scores. This finding was not unexpected, based on previous findings and the design of the QLI and SF-36 surveys. This result may have been due to the relatively varied gradations for performance of activities on the SF-36 (eg, “limited a little,” “limited a lot,” or “not limited at all”). This terminology limits the ability of the subject to describe a subtle, but possibly relevant, clinical change in physical functioning. The QLI health and function domain is also quite broad. Thus, it is likely that the SF-36 physical component summary and the QLI health and function domain measure two distinctive aspects of functional ability compared to the 6MW, which evaluates a unique domain that is not related to QOL. While showing significant gains in gross functional abilities, PR participants may not appreciate these improvements from a psychosocial perspective following both short-term and long-term PR. Moreover, health-related QOL likely depends on more than just exercise ability. The pulmonary patient may perceive that they are still functioning at a lower level, even though they have improved physically. Another possibility is that physical function improvements occur earlier in the rehabilitation process, while psychosocial adjustments take longer. In the multisite Indiana PR study,12 the greatest improvements in health status were observed in the physical function scores of the SF-36 compared to the other SF-36 subscales. Further research is needed to define the relationships between physical and psychosocial improvements in patients in PR programs, looking specifically at patient diagnosis and mental health status (eg, hostility and depression).

SOBQ

The baseline measures of perceived dyspnea in the North Carolina men and women were in the mid-40s to mid-50s, indicating a level of shortness of breath that limited basic ADLs. Both men and women decreased SOBQ scores following 12 weeks of PR, with women showing a greater drop in scores (women, 6.1 U; men, 2.9 U). This mean change in women exceeded the level considered to represent a minimal clinically important difference (ie, 5 U),11 although small effect sizes were observed in both genders from PR entry to 12 weeks. It is difficult to speculate on the long-term changes in perceived dyspnea following PR, as only a small number of patients completed 24-week follow-up SOBQ surveys due to the later initiation of this survey into the NCCRA registry. Nevertheless, this subgroup did not decrease SOBQ scores after 12 weeks but did decrease SOBQ scores following 24 weeks of PR.
participation, with women showing a greater 24-week drop in scores than men (—10.4 vs —5.3 points, respectively) and a greater clinical effect size (0.41 vs 0.20, respectively). This smaller group of long-term participants may have required additional PR sessions to achieve the beneficial perceptions of dyspnea found in the larger group who participated for only 12 weeks. Both short-term and long-term groups of women may have perceived less dyspnea with ADLs than men following PR, as indicated by the greater drop in scores. Given that the short-term group decreased SOBQ scores by 12 weeks, and the long-term group by 24 weeks, shows that perception of dyspnea with exertional activities is improved following PR of up to 24 weeks duration. However, further long-term research is needed on the SOBQ and other dyspnea measures in PR participants before any conclusions can be reached on this issue.

Study Limitations

There are some important limitations of this investigation that warrant attention. First, this was a prospective, nonrandomized study. We did not include a control group of patients who did not participate in PR for comparative purposes. For a study of this nature, it was unrealistic to randomize participants from different programs or to develop a control group of nonparticipating PR patients, as we had no control over who entered and who did not enter PR programs from different cities and towns. It would also not have been ethical for us to deprive a PR candidate of PR therapy.

Second, we cannot imply a causal relationship between 6MW improvements and improvements in functional capacity. Direct metabolic measures before and after exercise training are needed to prove this and, indeed, have been demonstrated previously in the literature. The 6MW test also has inherent limitations, as performance has been shown to vary by protocol, the instructions given by the examiner, the parameters measured, the number of test repetitions, and the test location. However, since our finding of improved 6MW performance has been well-established and widely accepted in pulmonary patients following short-term PR, our data reinforce what we already know about short-term PR and adds to the growing body of knowledge on long-term patient outcomes. We have provided new information by showing the percentage improvement in 6MW test performance across programs for men and women after 24 weeks, and whether these gains were clinically significant from the point of view of a practitioner.

Third, the 6MW tests in this investigation were administered only once for each patient during the initial and follow-up visits. Early work with chronic heart and lung disease patients found a learning effect to be evident over the first three 6MW tests, suggesting that a minimum of two to three walks should be performed initially to establish a baseline. Due to time and staff limitations that were evident in North Carolina PR programs (and in programs nationwide), we chose to test all patients only once before and after PR. While this certainly was not ideal, it was the only feasible option for maximal program participation, given the ever-growing time and staff restraints inherent in most PR programs. Furthermore, this mirrored the protocol of Jungbauer and Fuller and other statewide cross-clinic studies, making statewide comparisons easier in the future for the establishment of “one-trial” PR 6MW test norms.

Fourth, this study involved comparisons of a larger group of patients who completed 12 weeks of PR to a smaller group of patients who completed 24 weeks of PR. While no demographic or clinical differences were apparent in these two groups of patients, the long-term patients may have had characteristics that were different than those of the short-term participants that contributed to greater long-term exercise compliance. Comparing data from short-term and long-term patients potentially provides more variability. While it would have been ideal to analyze a number of physical and psychosocial traits of the short-term vs long-term patients, we had no means of doing so due to the structure of the NCCRA registry. Many patients across programs in this study more than likely did not participate after 12 weeks of PR due to the exit criteria established by the program and/or the financial out-of-pocket costs for participating in “maintenance” PR. Future research is needed to focus on long-term compliance issues, providing insight into why some patients stick with PR intervention for many years, while others drop out only after a few sessions.

Finally, we had no control over the level of intensity of the exercise utilized at each PR center. While some centers could have incorporated higher intensity exercise for their PR patients, others may have employed lower intensity exercise regimens. However, studies have shown that both low-intensity and high-intensity exercise training improves QOL and physical performance parameters in patients in PR programs. Thus, looking at the variation in exercise prescriptions for patients from multiple sites may not have played a significant role in this respect.

Conclusions

The process of measuring outcomes, benchmarking results, and using this information to verify the
importance of PR intervention will be critical for the success of PR programs in the 21st century. This study from the NCCGRA adds to the growing body of literature showing successful health outcomes following both short-term and long-term supervised PR. Based on data from this study and previous investigations, it appears that supervised PR of up to at least 24 weeks duration can help the patient with chronic lung disease to maintain, if not improve on, the beneficial health effects achieved following short-term PR. Our findings were consistent across programs despite variations in practice, patient referral patterns, and program design. Further study of the effects of long-term PR on physical, psychosocial, and behavioral traits is needed in specific chronic respiratory disease populations (eg, lung transplant recipients or patients with restrictive lung diseases). Comparisons also need to be made with those patients who do not participate in formalized PR programs to assess the true positive effects of long-term PR interventions, in particular in groups of patients with lung disease. Research of this nature may facilitate a more thorough understanding of the many benefits of long-term supervised PR and may provide a rationale for better insurance reimbursement for the motivated maintenance participant with chronic lung disease.

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