Effects of Home-Based Pulmonary Rehabilitation with a Metronome-Guided Walking Pace in Chronic Obstructive Pulmonary Disease

Despite documented efficacy and recommendations, pulmonary rehabilitation (PR) in chronic obstructive pulmonary disease (COPD) has been underutilized. Home-based PR was proposed as an alternative, but there were limited data. The adequate exercise intensity was also a crucial issue. The aim of this study was to investigate the effects of home-based PR with a metronome-guided walking pace on functional exercise capacity and health-related quality of life (HRQOL) in COPD. The subjects participated in a 12-week home-based PR program. Exercise intensity was initially determined by cardiopulmonary exercise test, and was readjusted (the interval of metronome beeps was reset) according to sub-maximal endurance test. Six-minute walk test, pulmonary function test, cardiopulmonary exercise test, and St. George's Respiratory Questionnaire (SGRQ) were done before and after the 12-week program, and at 6 months after completion of rehabilitation. Thirty-three patients participated in the program. Six-minute walking distance was significantly increased (48.8 m; \( P = 0.017 \)) and the SGRQ score was also improved (-15; \( P < 0.001 \)) over the six-month follow-up period after rehabilitation. There were no significant differences in pulmonary function and peak exercise parameters. We developed an effective home-based PR program with a metronome-guided walking pace for COPD patients. This rehabilitation program may improve functional exercise capacity and HRQOL.

Key Words: Pulmonary Disease, Chronic Obstructive; Rehabilitation; Exercise Test; Quality of Life
have been carried out on an inpatient or outpatient basis (12). Inpatient programs are expensive, and in outpatient programs the subject must go to the hospital several days a week. Another problem is the long-term maintenance of benefits once the hospital-based PR program has been completed, since gains achieved diminish progressively if training is abandoned (13). For these reasons, home-based PR was proposed as an alternative to outpatient rehabilitation. However, there were limited data on the effectiveness of home-based PR (14-18). There was also a concern about determination and adjustment of the exercise intensity during conducting a home-based PR program (17, 19).

Thus, the aim of the present study was to investigate the effects of a 12-week home-based PR program with a metronome-guided walking pace on functional exercise capacity and HRQOL in patients with COPD of 3 university hospital-based centers.

MATERIALS AND METHODS

Study design and patient selection
This study was a multicenter, prospective, observational clinical trial. The subjects participated in a 12 weeks home-based PR program. The following evaluations were carried out at enrollment (initial visit), 12 weeks (immediately after the program), and 6 months after completion of rehabilitation: 1) pulmonary function tests; 2) cardiopulmonary exercise test; 3) six-minute walking test; 4) St. George’s Respiratory Questionnaire (SGRQ) (Fig. 1).

We recruited patients from the pulmonary clinics of three university hospital-based centers. Patients were eligible for participation if they had stable COPD, that is, no change in medication and symptoms for 3 months before the study; were 40 yr or older; were current or former smokers of at least 10 pack-years; and had an FEV1 less than 80% of the predicted value and FEV1/FVC ratio less than 0.70. Those with cardiovascular instability, musculoskeletal or neurologic disorders that would inhibit exercise, or previous attendance at pulmonary rehabilitation were excluded.

Because all patients were diagnosed with COPD ranging from moderate to very severe according to the Global Initiative for Chronic Obstructive Lung Disease (GOLD) guidelines, they received optimal pharmacologic therapy including one or more long-acting inhaled bronchodilator in accordance with recommendations of the treatment guidelines.

Home-based exercise program
The home-based PR program was composed of aerobic exercise (walking), muscle strength training, education, respiratory muscle training, and stretching. Exercise intensity (walking speed) was determined by cardiopulmonary exercise test, and target intensity was 60% of the maximum work rate achieved during the test. To guarantee walking speed, we gave each patient a metronome that beeped at preset intervals, individualized to each patient’s target intensity. Patient was instructed to walk with metronome in hands and synchronize steps with metronome beep.

Patients visited each clinic every 2 weeks for 12 weeks. At each visit, the exercise intensity was readjusted according to repeated sub-maximal endurance tests. Muscle strength training was done with elastic bands, and ‘Threshold®’ (Respironics, Parsippany, NJ, USA) inspiratory muscle trainer was used for respiratory muscle training. Compliance was assessed by daily exercise diary.

Outcomes and measurements
One of our primary outcomes for effectiveness was the differences from baseline in HRQOL after 12-week home-based rehabilitation as measured by SGRQ. We used the Korean version of the questionnaire which was validated in a Korean research (20). The total score range from 0 to 100, with a lower score representing a better HRQOL. A change in score of 4 units is consistent with a clinically relevant change in the patient.

To examine changes of functional exercise capacity, the other primary outcome of our study, six-minute walking distance was measured twice at the beginning and once at the end of 12-week rehabilitation and 6 months according to established criteria (21). We used the better of the first two six-minute walking distances as the baseline value.

Patients also completed pulmonary function tests and cardiopulmonary exercise tests using the bicycle ergometer (SensorMedics Corp., Yorba Linda, CA, USA) at enrollment, 12 weeks, and 6 months.

Statistical analysis
All statistical analyses were performed using the statistical software package SPSS v12.0.1 (SPSS Inc., Chicago, IL, USA). Comparison of the outcomes of each assessment moment (at enrollment, 12 weeks, and 6 months) was performed with repeated measures analysis of variance (ANOVA). The last observation carried forward method was used for missing data. A value of $P \leq 0.05$ was considered statistically significant.
**Ethics statement**
The study was approved by the Kangdong Sacred Heart Hospital institutional review board (Approval No. 06-3) and institutional review boards of other 2 hospitals. All of the patients provided written informed consent.

**RESULTS**

**General characteristics**
Thirty-three patients were enrolled from the participating centers and began the home-based PR program. However, six patients dropped out during rehabilitation due to a lack of motivation (n = 3), or COPD exacerbation (n = 3). Twenty-seven patients finally completed the home-based PR program and measurements at 12 weeks.

The general characteristics and overall measurements of twenty-seven participants are summarized in Table 1. The mean age was 66 yr, and there was only one woman included. The mean body mass index (BMI) was 21.6 ± 3.3 kg/m². In the baseline spirometry, mean FEV₁ was 1.27 ± 0.51 L/min (48.7% of predicted) and mean FVC was 2.96 ± 0.82 L/min (77.9% of predicted). The patients had moderate to very severe COPD according to the GOLD guidelines. Of these, 48.1% were classified as GOLD II (moderate COPD), 37.0% as GOLD III (severe COPD), and 14.8% as GOLD IV (very severe COPD). The mean pre-rehabilitation six-minute walking distance was 512.1 ± 197.1 meters. Initial maximal workload (Wmax) and peak oxygen uptake (VO₂ max) were measured as low as 80.8 ± 28.9 W and 17.3 ± 5.4 mL/kg/min, respectively.

**Primary outcomes**
The comparisons of measurements at enrollment, 12 weeks, and 6 months after completion of rehabilitation showed that our home-based PR strategy was associated with statistically and clinically significant improvements in six-minute walking distance \((P = 0.017)\) and total SGRQ score \((P < 0.001)\). We also observed significant differences for symptoms \((P < 0.001)\), activities \((P < 0.001)\), and impacts domain of SGRQ \((P < 0.001)\). The improvement of SGRQ scores greatly exceeded minimum clinically important difference (less than -4.0). These effects of rehabilitation on functional exercise capacity and HRQOL lasted over 6 months (Fig. 2).

**Secondary outcomes**
Pulmonary functions estimated by forced expiratory volume in 1 second and forced vital capacity were slightly increased in number after home-based pulmonary rehabilitation. Statistically, however, there were no significant differences in pulmonary functions over the six-month follow-up period (Table 2).

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**Table 1. General characteristics and baseline measurements of study patients**

| Parameters                        | Measured values |
|-----------------------------------|-----------------|
| Age (yr)                          | 66.2 ± 7.8      |
| Men : Women (No.)                 | 26 : 1          |
| BMI (kg/m²)                       | 21.6 ± 3.3      |
| Pulmonary function                |                 |
| FEV₁ (L/min)                      | 1.27 ± 0.51     |
| FEV₁ (% predicted)                | 48.7 ± 16.5     |
| FVC (L/min)                       | 2.96 ± 0.82     |
| FVC (% predicted)                 | 77.9 ± 17.2     |
| DLCO (% predicted)                | 74.4 ± 22.5     |
| SGRQ score                        |                 |
| Total                             | 44.9 ± 15.9     |
| Symptoms                          | 42.4 ± 16.8     |
| Activities                        | 69.3 ± 23.9     |
| Impacts                           | 31.8 ± 16.0     |
| 6MWD (m)                          | 512.1 ± 197.1   |
| Peak exercise parameters          |                 |
| VO₂ max (mL/kg/min)               | 17.3 ± 5.4      |
| Wmax (W)                          | 80.8 ± 28.9     |

Values are given as the mean ± SD. BMI, body mass index; FEV₁, forced expiratory volume in 1 second; FVC, forced vital capacity; DLCO, Diffusion lung capacity for carbon monoxide; 6MWD, six-minute walking distance; SGRQ, St. George Respiratory Questionnaire; VO₂, maximal oxygen uptake; Wmax, maximal workload.

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![Fig. 2. Improved pulmonary and physical functions by exercise. (A) Six-minute walking distance (6MWD) and (B) St. George’s Respiratory Questionnaire (SGRQ) score differences from baseline to 6 months after completion of rehabilitation.](http://dx.doi.org/10.3346/jkms.2013.28.5.738)
or to hospital-based program to improve dyspnea and health status (15, 18). Although limited data, home-based program was not inferior to center-based program, and appeared to be superior in terms of the adherence to exercise.

This study was meaningful that we confirmed the effectiveness of home-based PR in improving functional exercise capacity and quality of life with our own rehabilitation program. Exercise intensity was determined individually using the result of cardiopulmonary exercise test, and was readjusted according to sub-maximal endurance tests at each visit. Especially, we used metronome to guarantee this exercise intensity in the actual exercise. To date, only one recent research used a metronome to maintain the prescribed walking speed during home-based PR, and better improvement of exercise capacity was shown in the group walking paced by a metronome rather than the group walking a prescribed distance in a given period of time (19). Furthermore, our rehabilitation program consisted of not only aerobic exercise (walking), but also muscle strength training, education, respiratory muscle training, and stretching. We think that we developed an effective and convenient home-based PR program for COPD patients.

Meanwhile, 18% of participants dropped out of our study. The reasons for dropping out were lack of motivation and COPD exacerbation. The rate of COPD exacerbation (9.1%) was less than or similar to that of other studies concerning home-base PR (16, 17). Three patients complained of being exhausted after cardiopulmonary exercise test and decided not to continue. These patients declined to take part in the present study because of the inappropriate perception of the necessity for exercise test and the benefits of rehabilitation program, not because of their medical conditions. Thus, although comparison cannot be made with a control group, these dropouts probably did not induce the attrition bias. Measurement of maximal oxygen uptake in COPD patients has been traditionally used to determine the exercise intensity in the pulmonary rehabilitation. Therefore, to provide home-based pulmonary rehabilitation program more easily, the development of other method that can replace the cardiopulmonary exercise test is needed. More detailed information for motivation of the patients will also be helpful to reduce the dropout rate during rehabilitation program.

The present study had several limitations. First, the number of patients was relatively small. Second, only one female patient was included. Therefore, the results cannot be generalized to female COPD patients, since a previous study suggests that gender might influence COPD manifestations (27). Third, this study was an uncontrolled, observational study. A further study in a larger patient sample with a control group is warranted to clarify the results of the present study.

In summary, our home-based PR program could improve functional exercise capacity and HRQOL, and these effects lasted over 6 months after completion of rehabilitation. The use of
a metronome for home-based rehabilitation may be an effective and convenient method to maintain the exercise intensity.

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**REFERENCES**

1. Barnes PJ. Chronic obstructive pulmonary disease. N Engl J Med 2000; 343: 289-90.
2. Skeletal muscle dysfunction in chronic obstructive pulmonary disease: a statement of the American Thoracic Society and European Respiratory Society. Am J Respir Crit Care Med 1999; 159: S1-40.
3. Landbo C, Prescott E, Lange P, Vestbo J, Almdal TP. Prognostic value of nutritional status in chronic obstructive pulmonary disease. Am J Respir Crit Care Med 1999; 160: 1656-61.
4. Agustí AG, Noguera A, Saudela J, Sala E, Pons J, Busquets X. Systemic effects of chronic obstructive pulmonary disease. Eur Respir J 2003; 21: 347-60.
5. Nici L, Donner C, Wouters E, Zuwallack R, Ambrosino N, Bourbeau J, Carone M, Celli B, Engelen M, Fahy B, et al. American Thoracic Society/European Respiratory Society statement on pulmonary rehabilitation. Am J Respir Crit Care Med 2006; 173: 1390-413.
6. 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: 207-12.
7. Ries AL, Make BJ, Lee SM, Krasna MJ, Bartels M, Crouch R, Fishman AP; National Emphysema Treatment Exercise Research Group. The effects of pulmonary rehabilitation in the national emphysema treatment trial. Chest 2005; 128: 3799-809.
8. Lacasse Y, Goldstein R, Lasserson TJ, Martin S. Pulmonary rehabilitation for chronic obstructive pulmonary disease. Cochrane Database Syst Rev 2006; (4): CD003793.
9. Bestall JC, Paul EA, Garrod R, Garnham R, Jones RW, Wedzicha AJ. Longitudinal trends in exercise capacity and health status after pulmonary rehabilitation in patients with COPD. Respir Med 2003; 97: 173-80.
26. Moullec G, Ninot G, Varray A, Desplan J, Hayot M, Prefaut C. An innovative maintenance follow-up program after a first inpatient pulmonary rehabilitation. Respir Med 2008; 102: 556-66.
27. Martinez FJ, Curtis JL, Sciurba F, Mumford J, Giardino ND, Weinmann G, Kazerooni E, Murray S, Criner GJ, Sin DD, et al. Sex differences in severe pulmonary emphysema. Am J Respir Crit Care Med 2007; 176: 243-52.