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Abstract

Although the rehabilitation of patients with chronic obstructive pulmonary disease (COPD) improves both exercise capacity and quality of life, a standard protocol for COPD patients has not been established. To clarify whether physiologic and quality-of-life improvements can be achieved by an inpatient pulmonary rehabilitation program 5 days per week for 3 weeks, 18 patients with COPD were enrolled in a rehabilitation program. The physical exercise training regimen consisted of respiratory muscle stretch gymnastics and cycle ergometer exercise training. Pulmonary function tests, an incremental ergometer exercise test, a 6-min walking test, and a quality of life assessment by the Chronic Respiratory Questionnaire were administered before and after the program. The peak VO2, an indicator of maximal exercise capacity, did not increase, although the 6-min walking distance, an indicator of functional exercise capacity, increased significantly after rehabilitation. There was a significant improvement in the quality of life in terms of dyspnea, fatigue, and emotional state. These findings suggest that even a 3-week program may be beneficial for COPD patients. Increases in functional exercise capacity, even without an increase in maximal exercise capacity, are helpful for reducing dyspnea and improving quality of life parameters in patients with COPD.

KEYWORDS: exercise tolerance, stretch gymnastic, dyspnea

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Effects of Short-Term Pulmonary Rehabilitation on Exercise Capacity and Quality of Life in Patients with Chronic Obstructive Pulmonary Disease

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Although the rehabilitation of patients with chronic obstructive pulmonary disease (COPD) improves both exercise capacity and quality of life, a standard protocol for COPD patients has not been established. To clarify whether physiologic and quality-of-life improvements can be achieved by an inpatient pulmonary rehabilitation program 5 days per week for 3 weeks, 18 patients with COPD were enrolled in a rehabilitation program. The physical exercise training regimen consisted of respiratory muscle stretch gymnastics and cycle ergometer exercise training. Pulmonary function tests, an incremental ergometer exercise test, a 6-min walking test, and a quality of life assessment by the Chronic Respiratory Questionnaire were administered before and after the program. The peak $\dot{V}O_2$, an indicator of maximal exercise capacity, did not increase, although the 6-min walking distance, an indicator of functional exercise capacity, increased significantly after rehabilitation. There was a significant improvement in the quality of life in terms of dyspnea, fatigue, and emotional state. These findings suggest that even a 3-week program may be beneficial for COPD patients. Increases in functional exercise capacity, even without an increase in maximal exercise capacity, are helpful for reducing dyspnea and improving quality of life parameters in patients with COPD.

Key words: exercise tolerance, stretch gymnastics, dyspnea

The rehabilitation of patients with chronic obstructive pulmonary disease (COPD) is known to improve quality of life and exercise capacity (1-3). Although exercise training of the lower limbs is an important element of a rehabilitation program, a standard protocol for exercise training, including appropriate program duration and appropriate intensity for COPD patients, has not been established (1). In many studies, the program duration has been more than 6 weeks (2-11). Only a few investigators have studied exercise programs of less than 1 month, and the question remains as to whether a 3- or 4-week rehabilitation program is beneficial for quality of life and physiologic function (12-14).

Pulmonary rehabilitation conventionally includes elements of physical therapy, exercise conditioning, and education. In addition, respiratory muscle stretch gymnastics (RMSG) has recently been used (15). RMSG stretches chest wall respiratory muscles during contraction and is considered to be a safe and effective physical conditioning method.

To determine whether physiologic and quality of life improvements can be achieved by following a 3-week training program comprising RMSG and cycle ergometer exercise training, a pulmonary rehabilitation program was tested on inpatients with stable COPD.

Subjects and Methods

Subjects. Twenty-one patients with stable COPD were entered into this study after giving informed consent. The diagnosis of COPD was made according to the standards of the American Thoracic Society (1). The

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entry criteria included a forced expiratory volume in 1 sec (FEV1.0) of less than 80% of that predicted and a FEV1.0 / forced vital capacity of less than 70%. The predicted normal values for FEV1.0 were determined according to the method of Berglund *et al.* (16). The dosages of all medications were unchanged for at least 4 weeks before study entry and were not altered during the course of the program. Patients with evidence of ischemic heart disease, intermittent claudication, musculoskeletal disorders, or other disabling diseases were excluded.

Rehabilitation program. Patients participated in an inpatient pulmonary rehabilitation program 5 days per week for 3 weeks. The physical exercise training regimen consisted of a respiratory muscles stretching program, termed RMSG, designed to stretch inspiratory muscles during inspiration and expiratory muscles during expiration, followed by exercise on a calibrated cycle ergometer under the supervision of a physical therapist. Monitoring during exercise sessions involved measurement of the pulse, oxygen saturation, and blood pressure and Borg's scale of dyspnea (17).

The exercise level for the cycle ergometer was based on an initial cycle ergometer exercise test and allowed patients to exercise initially at up to 50% of their maximal cycle ergometer wattage for 20 min as tolerated by symptomatic and physiologic end points. If patients could not exercise at the prescribed work level for 20 min, the work level was decreased by 25%, and this level was continued. The exercise prescription was revised on a weekly basis. Once the patient could exercise at the prescribed work level for 20 min, the work level was increased by 25%, and this level was continued as long as the level was tolerable for 20 min. Supplemental oxygen was administered during exercise sessions to patients who demonstrated significant desaturation with exercise or those who were using home oxygen therapy.

The 8 educational sessions covered such topics as pulmonary pathophysiology, pharmacology of medications, relaxation and stress-management techniques, and breathing retraining (pursed-lip breathing, expiratory abdominal augmentation, and synchronization of thoracic and abdominal movement) (18).

Testing. Parameters were assessed at baseline, and evaluated before and within 1 week after completing the rehabilitation program. Pulmonary function tests were performed using a rolling seal spirometer (Chestac-55V, CHEST, Tokyo). Lung volumes were determined by the helium dilution method, and the single-breath diffusing capacity was measured with a single-breath diffusion technique.

Following the pulmonary function tests, an incremental ergometer test was carried out using a ramp slope of 10 watts/min. Breath-by-breath online gas analysis was performed using a respiratory gas analysis system (Aero Monitor AE-280, Minato Medical Science, Osaka) with incremental data (tidal volume, respiratory rate, $\dot{V}O_2$, $\dot{V}CO_2$ and $\dot{V}E$) collected every 15 sec. The anaerobic threshold was determined by the V-slope method (19). Patients were exercised to a symptom-limited end point, to their predicted heart rate, or until arterial oxygen saturation (SpO_2) fell below 85% according to pulse oximetry (PULSOX-7, Minolta, Tokyo).

The patients underwent a 6-min walking test before and after pulmonary rehabilitation. They walked indoors as far as possible for 6 min with standardized encouragement (20). Immediately after completion of the walking test, the patients were questioned to estimate the intensity of dyspnea on the Borg category scale (17).

Quality of life and its components were assessed using the Chronic Respiratory Questionnaire (CRQ) (21), which was translated into Japanese. Dyspnea, fatigue, emotional function, and mastery were measured during self-selected day-to-day activities. The CRQ measures both physical function and emotional function. Physical function was investigated by 5 items related to dyspnea and 4 items related to fatigue. Assessment of emotional function addressed both the emotional state and self-perception of mastery, including questions about frustration, depression, anxiety, panic, and fear of dyspnea. The patients were asked to rate their physical and emotional function on a 7-point scale. Higher scores represented better function. Questionnaires were administered at entry and at approximately 2 weeks after completion of the program.

Data analysis. Statistical analysis was performed using StatView-J4.11 software, and the data are presented as the mean ± SD. Parameters before and after the pulmonary rehabilitation program were compared using the paired t-test. Differences were considered as significant at $P < 0.05$.

Results

Three patients dropped out of the rehabilitation group due to an acute exacerbation of respiratory symptoms. The rehabilitation group, therefore, included 18 patients, 17 men and 1 woman. The patient characteristics are shown in Table 1. The mean FEV1 was 42.3% of that predicted, and the mean residual volume/total lung capacity ratio was 52.2%.

The values for pulmonary function before and after rehabilitation are presented in Table 2. The maximal voluntary ventilation (MVV) increased significantly after pulmonary rehabilitation. Although the vital capacity increased by 7.3% with respect to the initial value, the change was not statistically significant. In addition, there was no significant change in forced vital capacity, residual volume, or total lung capacity.

Table 3 shows the change in the incremental ergometer test. There was no significant increase in peak $\dot{V}O_2$, the maximal minute ventilation, or the maximal work rate. AT values were determined in 17 patients before and after rehabilitation and did not increase significantly.

The 6-min walking distance increased significantly after pulmonary rehabilitation, as shown in Table 4. The maximal Borg score during the walking test decreased

Table 1 Characteristics of 18 patients with chronic obstructive pulmonary disease before pulmonary rehabilitation

Age (years)	69.2 ± 7.3
Height (cm)	162.5 ± 5.7
Weight (kg)	50.8 ± 7.7
VC[a] (L)	2.75 ± 0.62
FEV1.0[b] (L)	0.96 ± 0.34
%FEV1.0[c] (%)	42.3 ± 14.6

Data shown are mean ± SD, *a*, vital capacity; *b*, forced expiratory volume in 1 sec; *c*, percent of predicted forced expiratory volume in 1 sec.

Table 2 Pulmonary function before and after pulmonary rehabilitation of 18 patients with chronic obstructive pulmonary disease

	Before	After	*P* value
VC (L)	2.75 ± 0.62	2.92 ± 0.58	NS[a]
FEV 1.0 (L)	0.96 ± 0.34	1.00 ± 0.36	NS
RV (L)[b]	3.10 ± 0.89	3.03 ± 0.78	NS
TLC (L)[c]	5.88 ± 1.28	6.00 ± 1.11	NS
DLCO/VA (ml/m/torr/L)[d]	2.52 ± 1.19	2.66 ± 1.15	NS
MVV (L/min)[e]	36.1 ± 14.4	40.2 ± 16.4	$P < 0.05$

Data shown are mean ± SD, *a*, not significant; *b*, residual volume; *c*, total lung capacity; *d*, ratio of diffusing capacity, carbon monoxide, single-breath method, to alveolar volume; *e*, maximal voluntary ventilation.

Table 3 Incremental exercise test results before and after pulmonary rehabilitation of 18 patients with chronic obstructive pulmonary disease

	Before	After	*P* value
Peak $\dot{V}O_2$ (ml/min/kg)[a]	12.23 ± 2.63	13.04 ± 2.53	NS
Peak $\dot{V}E$ (L/min)[b]	26.4 ± 8.1	27.7 ± 7.2	NS
Peak WR (watt)[c]	49.1 ± 15.6	53.2 ± 16.0	NS
AT (ml/min/kg)[d] n=17	9.49 ± 1.91	10.59 ± 1.88	NS

Data shown are mean ± SD, *a*, oxygen uptake at maximal load; *b*, minute ventilation at maximal load; *c*, work rate at maximal load; *d*, anaerobic threshold.

Table 4 Six-min walking test results before and after pulmonary rehabilitation of 18 patients with chronic obstructive pulmonary disease

	Before	After	*P* value
Distance (m)	384.7 ± 124.5	456.6 ± 80.0	$P < 0.05$
Max Borg scale[a]	5.5 ± 2.3	3.9 ± 1.5	$P < 0.05$
Min SpO_2(%)[b]	89.6 ± 5.2	90.1 ± 3.7	NS

Data shown are mean ± SD, *a*, maximal Borg scale score during the test; *b*, minimal SpO_2 during the test.

Table 5 CRQ[a] score before and after pulmonary rehabilitation of 18 patients with chronic obstructive pulmonary disease

	Before	After	P value
Dyspnea	16.6 ± 6.2	21.6 ± 7.7	$P < 0.05$
Fatigue	18.0 ± 5.5	21.5 ± 3.4	$P < 0.01$
Emotion	35.4 ± 7.2	39.1 ± 6.0	$P < 0.05$
Mastery	19.8 ± 4.2	20.9 ± 3.9	NS

Data shown are mean ± SD, *a*, chronic respiratory disease questionnaire; NS, not significance.

significantly after pulmonary rehabilitation. The minimum SpO_2 during the walking test did not change.

Values for the CRQ score before and after rehabilitation are presented in Table 5. Dyspnea, fatigue, and emotion improved significantly after pulmonary rehabilitation. Items concerning dimension mastery, however, showed no significant improvement after completion of the program.

Discussion

In most previous studies, the duration of pulmonary rehabilitation has been more than 6 weeks based on the training effect in normal subjects (22, 23). A few studies have demonstrated the effects of a 3-4 week rehabilitation period, but the exact exercise programs used have been unclear (12-14). In addition, these studies did not evaluate the effect on quality of life. To clarify the effect of a pulmonary rehabilitation program lasting less than 1 month, we conducted a training program 5 times per week for 3 weeks, including RMSG and cycle ergometer exercise training at half the maximal work rate.

Our results demonstrate that this program improves some pulmonary function parameter of MVV, improves exercise capacity as determined by the walking test, reduces dyspnea on effort, and improves the quality of life in patients with COPD. In most previous studies, no changes in spirometric values have been reported (2-5, 7, 8, 12, 13). Because lower-limb training may not help to improve spirometric values, the significant increase in MVV observed in the present study may have been due to the effect of RMSG. RMSG was primarily designed to stretch the respiratory muscles during the contraction phase. It has been reported that RMSG increases FVC and PEFR (15). We think that respiratory muscle stretching affects chest-wall compliance and decreases chest-wall stiffness. Although the increases in FVC and PEFR were insignificant in our study (data not shown), the increase in MVV might be explained by this mechanism.

The training effect in COPD patients is usually evaluated by a timed walking test or peak $\dot{V}O_2$. In our study, the 6-min walking distance significantly increased, although the increase in peak oxygen uptake was insignificant. Needleman *et al.* have reported that cycle ergometer training at half the maximal work rate 3 times a week for 8 weeks significantly improves the 6-min walking distance (6). We trained our patients 5 times a week at almost the same intensity as in this previous study, which may explain the improvement in the 6-min walking distance. Most reports of exercise training describe improvements in the timed walking distance (2, 4-6, 9-11). A walking test may be a good measure of "functional exercise capacity," defined as a patient's ability to undertake physically taxing activities encountered in everyday life that are difficult to measure by a conventional exercise testing. Therefore, we assume that an increase in functional exercise capacity is necessary for improvements in dyspnea and quality of life in COPD patients.

In most studies, the improvement in peak $\dot{V}O_2$ is controversial (4-6, 8, 10, 14). Peak $\dot{V}O_2$ is considered to be a measurement of maximal exercise capacity. Carter *et al.* (14) have reported an increase in peak $\dot{V}O_2$ after a pulmonary rehabilitation program lasting only 12 days. However, in some studies, an increase in peak $\dot{V}O_2$ has not been seen, even after 6 weeks of rehabilitation. In healthy subjects, decisions about the intensity of exercise are based on the supposition that there is a threshold value beyond which a training effect will be perceived, and that above this threshold the amount of work done will affect outcome measures (24). The anaerobic threshold (25) has been used to ascertain this threshold, but the anaerobic threshold is close to the peak $\dot{V}O_2$ in most elderly patients with COPD, and it is difficult for these patients to maintain training at this intensity (26). For these reasons, elderly patients with COPD might have difficulty in increasing their maximal exercise capacity. To establish an appropriate exercise intensity to accomplish an increase in the peak $\dot{V}O_2$ in COPD, further investigation is necessary.

Although the effect on our patients was due to a multidisciplinary pulmonary rehabilitation program including not only ergometer exercise but also RMSG and education, we suggest that the prescribed exercise intensity, session duration, and overall duration of our ergometer exercise protocol may improve the quality of life for COPD patients. However, we only investigated the exercise capacity and quality of life immediately after rehabilitation. It is not clear how long this improvement will last. Further long-term rehabilitation program studies, including an assessment of physical function, quality of life, and prognosis, are necessary.

In summary, our 3-week pulmonary rehabilitation program, comprising cycle ergometer exercise and RMSG, improved MVV and the 6-min walking distance (an indicator of functional exercise capacity), and improved quality of life. These findings suggest that even if the program duration does not exceed 1 month, it can still benefit patients with COPD. The increase in functional exercise capacity, even without an increase in maximal exercise capacity, should reduce dyspnea and improve the quality of life in patients with COPD.

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References

1. 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-S121.
2. Goldstein RS, Gort EH, Stubbing D, Avendano MA and Guyatt GH: Randomised controlled trial of respiratory rehabilitation. Lancet (1994) **344**, 1394-1397.
3. Wijkstra PJ, Van Altena R, Kraan J, Otten V, Postma DS and Koeter GH: Quality of life in patients with chronic obstructive pulmonary disease improves after rehabilitation at home. Eur Respir J (1994) **7**, 269-273.
4. McGavin CR, Gupta SP, Lloyd EL and McHardy GJ: Physical rehabilitation for the chronic bronchitic: Results of a controlled trial of exercises in the home. Thorax (1977) **32**, 307-311.
5. Cockcroft AE, Saunders MJ and Berry G: Randomised controlled trial of rehabilitation in chronic respiratory disability. Thorax (1981) **36**, 200-203.
6. Niederman MS, Clemente PH, Fein AM, Feinsilver SH, Robinson DA, Ilowite JS and Bernstein MG: Benefits of a multidisciplinary pulmonary rehabilitation program. Improvements are independent of lung function. Chest (1991) **99**, 798-804.
7. Casaburi R, Patessio A, Ioli F, Zanaboni S, Donner CF and Wasserman K: Reductions in exercise lactic acidosis and ventilation as a result of exercise training in patients with obstructive lung disease. Am Rev Respir Dis (1991) **143**, 9-18.
8. Ries AL, Kaplan RM, Limberg TM and 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. Couser JI Jr, Guthmann R, Hamadeh MA and Kane CS: Pulmonary rehabilitation improves exercise capacity in older elderly patients with COPD. Chest (1995) **107**, 730-734.
10. O'Donnell DE, McGuire M, Samis L and Webb KA: The impact of exercise reconditioning on breathlessness in severe chronic airflow limitation. Am J Respir Crit Care Med (1995) **152**, 2005-2013.
11. Strijbos JH, Postma DS, van Altena R, Gimeno F and Koeter GH: A comparison between an outpatient hospital-based pulmonary rehabilitation program and a home-care pulmonary rehabilitation program in patients with COPD. A follow-up of 18 months. Chest (1996) **109**, 366-372.
12. Holten K: Training effect in patients with severe ventilatory failure. Scand J Respir Dis (1972) **53**, 65-76.
13. Chester EH, Belman MJ, Bahler RC, Baum GL, Schey G and Buch P: Multidisciplinary treatment of chronic pulmonary insufficiency. 3. The effect of physical training on cardiopulmonary performance in patients with chronic obstructive pulmonary disease. Chest (1977) **72**, 695-702.
14. Carter R, Nicotra B, Clark L, Zinkgraf S, Williams J, Peavler M, Fields S and Berry J: Exercise conditioning in the rehabilitation of patients with chronic obstructive pulmonary disease. Arch Phys Med Rehabil (1988) **69**, 118-122.
15. Yamada M, Shibuya M, Kanamaru A, Tanaka K, Suzuki H, Altose MD and Homma I: Benefits of respiratory muscle stretch gymnastics in chronic respiratory disease. Showa Univ J Med Sci (1996) **8**, 63-67.
16. Berglund E, Birath G, Bjure J, Grimby G, Kjellmer I and Sandqvist L: Spirometric studies in normal subjects: I. Forced expirograms in subjects between 7 and 70 years of age. Acta Med Scand (1963) **173**, 185-191.
17. Borg GA: Psychophysical bases of perceived exertion. Med Sci Sports Exerc (1982) **14**, 377-381.
18. Casciari RJ, Fairshter RD, Harrison A, Morrison JT, Blackburn C and Wilson AF: Effects of breathing retraining in patients with chronic obstructive pulmonary disease. Chest (1981) **79**, 393-398.
19. Sue DY, Wasserman K, Moricca RB and Casaburi R: Metabolic acidosis during exercise in patients with chronic obstructive pulmonary disease. Use of the V-slope method for anaerobic threshold determination. Chest (1988) **94**, 931-938.
20. Guyatt GH, Pugsley SO, Sullivan MJ, Thompson PJ, Berman L, Jones NL, Fallen EL and Taylor DW: Effect of encouragement on walking test performance. Thorax (1984) **39**, 818-822.
21. Guyatt GH, Berman LB, Townsend M, Pugsley SO and Chambers LW: A measure of quality of life for clinical trials in chronic lung disease. Thorax (1987) **42**, 773-778.
22. Seals DR, Hagberg JM, Hurley BF, Ehsani AA and Holloszy JO: Endurance training in older men and women. I. Cardiovascular responses to exercise. J Appl Physiol (1984) **57**, 1024-1029.
23. Yerg JE IInd, Seals DR, Hagberg JM and Holloszy JO: Effect of endurance exercise training on ventilatory function in older individuals. J Appl Physiol (1985) **58**, 791-794.

24. American College of Sports Medicine Position Stand. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness in healthy adults. Med Sci Sports Exerc (1990) **22**, 265-274.
25. Wasserman K and McIlroy MB: Detecting the threshold of anaerobic metabolism in cardiac patients during exercise. Am J Cardiol (1964) **14**, 844-852.
26. Casaburi R and Petty TL: Principles and practice of pulmonary rehabilitation. W B Saunders, Philadelphia (1993) pp204-224.

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