Pulmonary Rehabilitation in a Community Hospital

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Pulmonary rehabilitation programs seem to have come into vogue along with the national craze for exercise. This paper will discuss the feasibility of a rehabilitation program in a community hospital. In order to do that, we will first address several questions: "Does pulmonary rehabilitation really work?"; "If so, how?"; and "Is it safe?" Having answered those questions, we will discuss some of the details of setting up a rehabilitation program.

"Does Pulmonary Rehabilitation Really Work?"

Several investigators have shown significant improvement in exercise tolerance following pulmonary rehabilitation programs consisting of a number of treatment modalities which include bronchodilator therapy, antibiotic therapy, oxygen, postural drainage, somatic (exercise) reconditioning, and breathing retraining.[1-4] Petty et al[5] showed not only an increased exercise tolerance but also improved survival, reduction in hospital days and improved psychological status in patients completing a rehabilitation program. Pierce and associates[6] have shown that, following exercise training, maximal oxygen consumption was higher and, at any given level of exercise, minute ventilation, oxygen consumption and heart rate were lower even though there was no improvement in ventilatory function or lung volumes. Others have confirmed the beneficial effects of reconditioning without breathing retraining.[7-11]

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Although there is general agreement that exercise reconditioning is effective, even in patients with severe chronic obstructive pulmonary disease, there is no consensus regarding the value of breathing retraining. The studies appearing in the literature consist of several treatment modalities applied simultaneously; thus it is impossible to separate the relative effects of breathing retraining. Pursed lip breathing and abdominal augmentation can affect a decrease in minute ventilation and respiratory rate and an increase in tidal volume as well as an improvement in blood gas tensions.[12-14] Motley[15] found that slow deep breathing led to a reduction in the ratio of dead space to tidal volume and an increase in the oxygen saturation in most patients with emphysema. Following a program of breathing retraining, Sinclair reported a reduction of inefficient spinal and shoulder girdle movement during respiration.[16]

At the University of California at Irvine we have recently completed a study that was designed to separate the relative effects of somatic reconditioning and breathing retraining. Results of this study have been submitted elsewhere for publication. Our program was divided into four phases: selection of patients, optimizing medical therapy, somatic reconditioning, and breathing retraining. Eleven patients with severe type A chronic obstructive pulmonary disease were selected for this study. Optimal medical management using bronchodilators, oxygen, diuretics and ionotropics where appropriate was achieved and stabilized prior to entering the study. The patients were then exercised on a treadmill on an outpatient basis three times weekly in pairs with one patient resting

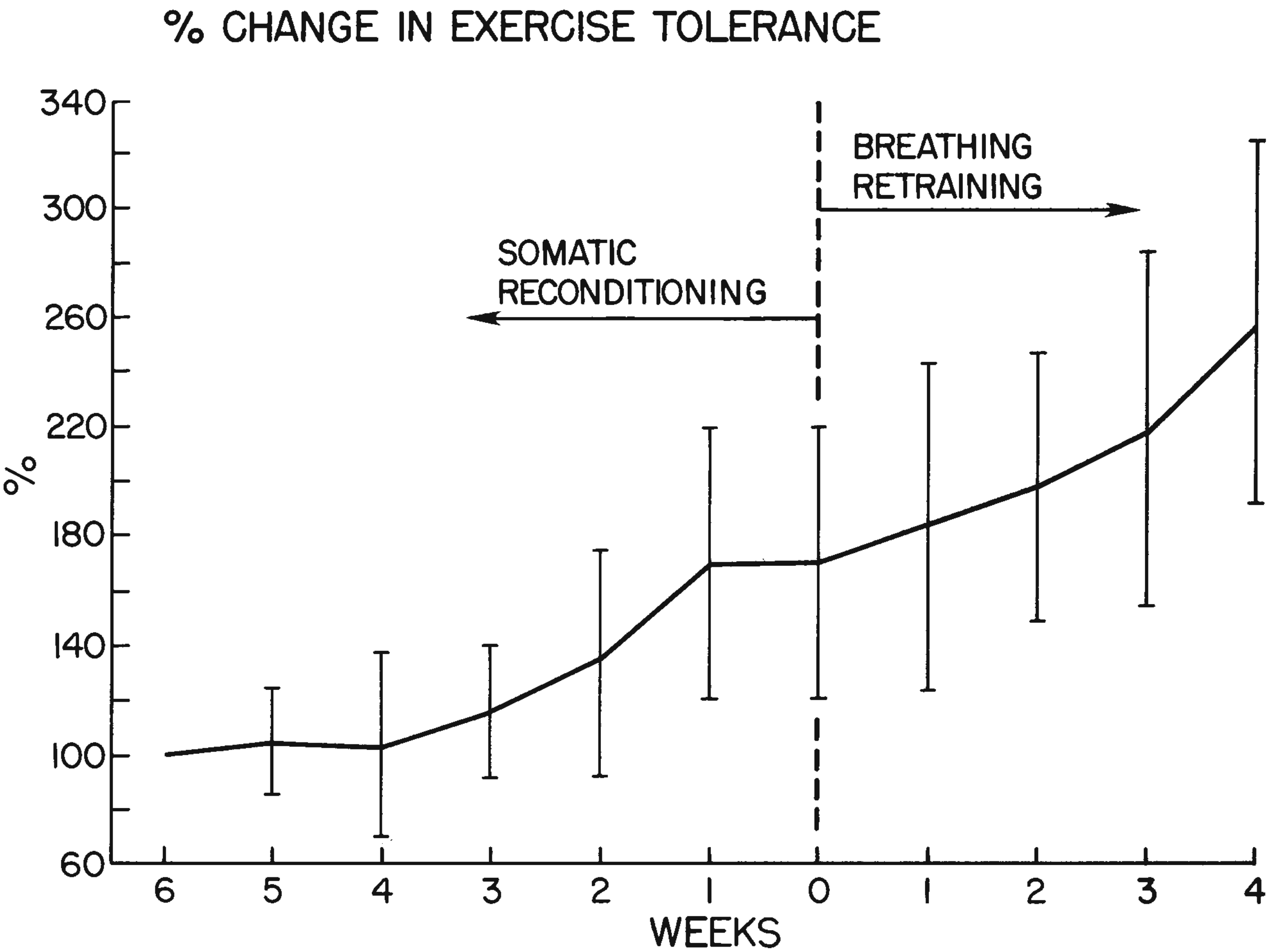

Fig 1—Mean percent change in maximal exercise tolerance for all 11 patients over the entire study period. Time O is determined to be the point at which breathing retraining has begun.

while the other was exercising. The total exercise session for two men would last one hour with each man exercising for approximately 25 minutes. Each exercise session consisted of a warm-up period at slow speeds, a stress period during which the patient would be encouraged to top his previous maximal tolerance, rest, and then several longer exercise periods at lower workloads. The rest periods were long enough to let the patient's pulse and respiratory rate return to baseline levels. The patients continued exercising until their maximal exercise tolerance was stable for at least four consecutive sessions.

After the somatic reconditioning phase of the program was completed, a program of breathing retraining was begun. Breathing retraining consisted of education about chronic obstructive lung disease, pursed lip breathing,[12,13] expiratory abdominal augmentation,[14] synchronization of movement of the abdomen and thorax using magnetometry and biofeedback, relaxation techniques for the accessory muscles[17] using electromyography and biofeedback, and psychological reassurance. Attempts were made to teach the patients to integrate these breathing retraining techniques into their activities of daily living. Breathing retraining was continued until all the techniques were well learned and were used without prompting during exercise as well as at rest.

There was significant improvement in exercise tolerance with somatic reconditioning alone (Fig 1). The average percent improvement in estimated oxygen consumption, which is a measure of work tolerance, after somatic reconditioning was 71% [0.97 ± 0.41 liters/min to 1.52 ± 0.43 liters/min ($p < 0.005$)]. What was surprising, however, was that there was an additional 39% increase in exercise tolerance after breathing retraining [1.52 ± 0.43 liters/min to 2.12 ± 0.61 liters/min ($p < 0.025$)]. The patients differed in their response to the program. Some improved minimally after exercise reconditioning but markedly after breathing retraining. Others improved more after exercise reconditioning. The mean improvement from baseline levels after completion of the program was 126%. These results indicate that somatic reconditioning and breathing retraining are beneficial aspects of a program of pulmonary rehabilitation.

"If So, How?"

Based upon earlier work, the improvement after exercise reconditioning was expected. It is generally accepted that this improvement is due to a combination of improved neuromuscular coordination and acclimatization to walking on a treadmill, improved utilization and distribution of delivered oxygen, and improved effort due to motivational factors.[1,6,7,9]

The improvement after breathing retraining is more difficult to explain and has not been previously reported in the literature; it could not be attributed to any improvement in resting pulmonary function since none was found. Most previous workers have not found any change in resting pulmonary function[1,6-8] following a program of pulmonary rehabilitation, and our study substantiated these findings.

Arterial blood gas studies showed that the PaO_2 did increase significantly from the reconditioning to the retraining phase. This indicates better ventilation-perfusion relationships following breathing retraining. We could not, however, attribute the improvement observed in exercise tolerance to this increase in PaO_2 alone, since the improvement in oxygen content would not be great enough to account for the improvement in exercise tolerance. Arterial blood gas studies also showed that there was a significant decrease in the base excess after breathing retraining compared to both the baseline period and the reconditioning period. This indicates that the patients were willing to exercise beyond their anaerobic threshold following breathing retraining. This would increase exercise tolerance; however, it is again unlikely that this would account for all the improvement we observed.

The heart rate did not change significantly during the study (Fig 2). However, the respiratory rate decreased significantly following breathing retraining both at rest and after maximal exercise. When examined further it became apparent that the decrease in respiratory rate

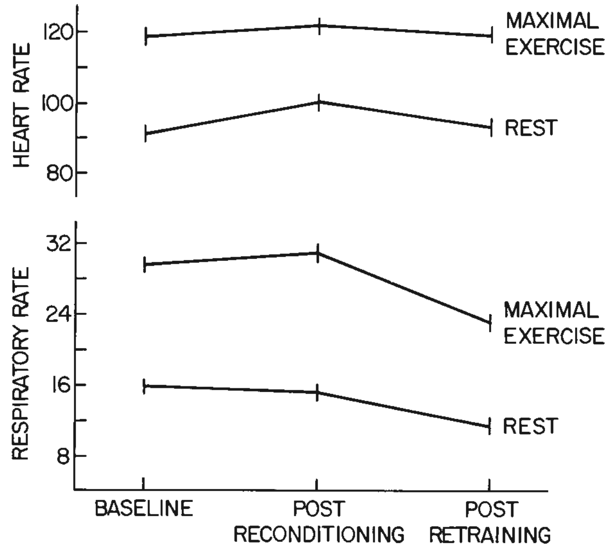

Fig 2—Heart rate and respiratory rate at rest and after maximal exercise measured at the beginning of the study, after somatic reconditioning and after breathing retraining.

was due to an increase in tidal volume, because minute ventilation did not change significantly. Cherniack[18] has shown that there is a decreased efficiency of the respiratory muscles and a high oxygen cost of increased ventilation in patients with emphysema. It has been suggested that breathing retraining may decrease the work of breathing by lowering the respiratory rate and relaxing accessory muscles.[1,16] The most likely explanation for the improvement demonstrated by our study after breathing retraining is increased efficiency of the respiratory muscles so that there is less relative increase in the oxygen cost of increasing ventilation during exercise, thereby freeing more oxygen for distribution to the peripheral tissues.

This study also showed that sophisticated and expensive magnetometry monitoring is not necessary for the purpose of synchronizing chest and abdominal movement. We found that patients corrected their own phase lag following somatic reconditioning and that the magnetometry and biofeedback techniques were not needed.

Ten of the 11 patients responded to a questionaire that was sent to them at the conclusion of the study. All felt that they had benefited from the study (8 answered "very much" and 2 answered "a lot"). Their comments regarding how they benefited are interesting. In response to the question "What can you do now that you could not do before the program?" two persons said that they could resume work, two said they were able to travel (one having completed a cross-country trip), one began to play golf again, one reported the ability to shop for himself, and one related he was able to walk up a small hill to a recreation center that he had not been able to climb for the previous three years. Four patients suggested that the most important benefit of the program was learning that they could recover from a stressful situation, thereby decreasing their sense of panic. These findings, suggestive of subjective improvement, are similar to almost every study of pulmonary rehabilitation that has appeared in the literature.[1,4,7,10] This improvement may be secondary to the physiologic changes already described, or it may represent benefits obtained by the patients from the amount of attention rendered to them by members of the rehabilitation team. In any event, it seems to be a real and consistent finding following programs of pulmonary rehabilitation.

TABLE
Comprehensive Respiratory Care: Factors to Consider

I. General
  A. Environmental factors
    1. avoid inhalation of pollutants, including cigarette smoke
    2. avoid occupational hazards
    3. consider climate (altitude, temperature, humidity, smog)
  B. High fluid intake, unless contraindicated by presence of cardiac disease
  C. Yearly influenza shot
  D. Pneumococcal vaccine shot
II. Medications
  A. Bronchodilators
    1. sympathomimetics (prefer beta$_2$ stimulators)
    2. theophylline types
  B. Expectorants
    1. water
    2. glyceryl guaiacolate
    3. other
  C. Antimicrobials (early antibiotic therapy for pulmonary infections)
  D. Corticosteroids
  E. Digitalis
  F. Diuretics
  G. Cromolyn sodium
  H. Other
III. Respiratory Therapy
  A. Aerosol devices
    1. cartridge inhaler
    2. hand-held nebulizer
    3. compressor-driven nebulizer
    4. Intermittent positive pressure breathing
  B. Humidification devices
    1. vaporizer/humidifier
    2. all-purpose nebulizer (heated or cool mist)
    3. ultrasonic nebulizer
  C. Oxygen systems
    1. high-pressure gas cylinders (stationary or portable)
    2. low-pressure liquid systems (stationary or portable)
    3. concentrators
  D. Air purifiers
IV. Physical Therapy
  A. Somatic (exercise) reconditioning
  B. Breathing retraining
  C. Percussion and postural drainage
V. Occupational Therapy
  A. Activities of daily living
  B. Energy conservation
  C. Adaptive equipment
VI. Nutrition
VII. Psychosocial Evaluation and Recommendations for Vocational Rehabilitation
VIII. Patient and Family Education

"Is It Safe?"

No complications of exercise were observed in our study; indeed, not a single study has reported deterioration of cardiopulmonary function following a program of pulmonary rehabilitation. There has been no precipitation of right cardiac failure; to the contrary, a fall in mean resting pulmonary artery pressure along with a rise in arterial oxygen partial pressure has been reported.[19]

How to Set Up a Program in a Community Hospital

Equipment and Physical Plan

Approximately 400 sq ft is needed to house a rehabilitation program, one easily accessible from a hospital entrance or the parking area. The room should be divided so that there is an area where patients can exercise and an area where the physician can examine prospective patients. Since patients will be exercising rather strenuously, the room must be well ventilated.

We elected to use a treadmill to recondition our patients. We chose this because treadmill walking more closely approximates day to day activity than bicycle ergometry. A cardiac monitoring system, complete with recorder, is mandatory, as is a fully equipped resuscitation cart. Oxygen is, of course, available and we try to have several different types on hand to instruct the patients in their use. A Hewlett-Packard ear oximeter is an excellent way of measuring oxygen saturation noninvasively.[20] This essentially negates the need for arterial line monitoring. The ear oximeter attaches to the patient's ear and gives continuous saturation readouts at rest, while exercising and during recovery. All of the equipment described above can be obtained for less than $15,000.

Personnel

The rehabilitation team consists of a medical director, a rehabilitation specialist who may be a registered nurse, a respiratory therapist or a physical therapist, a social worker, and in some instances an occupational therapist and a psychologist. The medical director performs a complete history and physical on all candidates referred to the program. He also supervises and interprets the exercise stress test and the pulmonary function tests, and documents the degree of the patient's disability. A useful checklist illustrating the comprehensive approach to the patient with chronic obstructive pulmonary disease is shown in the Table. Various aspects of this program can be implemented by the physician directly; however, many aspects, including techniques of avoidance of cigarette smoke, nutritional information and family education, are better performed by other members of the rehabilitation team. The physician sees the patient at the conclusion of the program and at scheduled follow-up sessions at 6 weeks, 6 months, 12 months, 18 months and 24 months after completion of the program.

Pulmonary Stress Testing

Stress testing can be performed on either a bicycle ergometer or on a treadmill. Cardiac status and oxygen saturation are monitored continuously. The test consists of graded exercise with the patient walking at each level for three minutes. Since most of our patients have severe exercise limitation, we have arbitrarily elected to begin our stress testing at much lower workloads than the accepted protocols for cardiac disease. The patient is started at 1 mph and a 0% grade for three minutes. The speed is then increased by 1 mph every three minutes until the patient reaches 3 mph at a 0% grade for three minutes at which point the grade is increased to 6%. The grade is then increased by 2% increments every three minutes until the patient reaches his maximal exercise tolerance. The patient is then allowed to recover until his heart rate and respiratory rate have returned to baseline levels. If the patient's saturation falls below 88%, the test is repeated with oxygen in place administered by nasal cannula and started at 2 liters/min. The stress test is repeated, increasing the oxygen by increments of 1 liter/min, until the patient's saturation remains above 88% at maximal exercise.

The typical patient with severe chronic obstructive pulmonary disease will stop exercising at a heart rate that is well below his predicted maximum. Additionally, he will show some desaturation with respect to oxygen. If the patient stops exercising when his heart rate has reached his predicted maximum, one must consider either primary cardiac disease or extreme deconditioning as the cause of the patient's exercise limitation.

The stress test as described above is a valid indicator of the need for home oxygen. Patients who desaturate severely with maximal exercise are also likely to need oxygen during sleep and meals. An exact prescription can be written based on the oxygen saturation as observed during the treadmill stress test.

The Program

Many different types of programs exist. We feel that six weeks is a reasonable length of time to accomplish both somatic reconditioning and breathing retraining. We also favor an outpatient program as opposed to inpatient rehabilitation, as outpatient rehabilitation enables the patient to incorporate the techniques taught into his activities of daily living. In addition, there is more time in a six-week program than in a two-week inpatient program for problems of day-to-day living to become apparent to the patient and the rehabilitation team. Our patients come to the hospital three times a week for one hour sessions. Each patient has a partner, and indeed the support of a partner seems to be a very important part of the psychological reassurance. Somatic reconditioning and breathing retraining are begun simultaneously and are enforced throughout the program. Breathing retraining emphasizes primarily pursed lip breathing, accessory muscle relaxation, abdominal augmentation and psychological reassurance. The program is tailored to the individual patient utilizing the expertise of physical therapy, occupational therapy and social services as indicated by the weekly reviews of each patient's case.

In conclusion, rehabilitation has been shown to be an effective and safe art of medical practice that can return a patient to his highest possible functional capacity. Pulmonary rehabilitation programs should include careful and optimal medical management, somatic reconditioning, and breathing retraining which can be performed in a community hospital without expensive or invasive monitoring. If properly carried out, such programs will result in increased exercise tolerance, improved sense of well being, and reduced hospitalization.

Acknowledgments: We wish to thank Jackie Gardiner for her assistance in typing this manuscript.

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