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**PHYSICAL FITNESS AND QUALITY OF LIFE OUTCOMES IN A PULMONARY
REHABILITATION PROGRAM UTILIZING SYMPTOM LIMITED INTERVAL TRAINING
AND RESISTANCE TRAINING.**

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ABSTRACT

M.E. KAELIN, A.M. SWANK, K.L. BARNARD, K.J. ADAMS, P. BEACH, AND J. NEWMAN **Physical Fitness And Quality Of Life Outcomes In A Pulmonary Rehabilitation Program Utilizing Symptom Limited Interval Training And Resistance Training.** JEPonline. 2001;4(3):30-37. This investigation examined the efficacy of a program utilizing symptom-limited interval training (IT) combined with strength training (ST) on 6-minute walk distances, increases in exercise capacity (METs), and quality of life. Outcome Data for 50 patients enrolled in outpatient pulmonary rehabilitation with a Mean Forced Expiratory Volume in One Second (FEV1) of 39.45±11.51 and an average age of 68.34±6.94 were analyzed using dependent t-tests to compare admit and discharge values (mean±SD). Values collected were 6-minute walk results 931.20 feet±305.00 to 1131.9 feet±226.32 ($p < 0.0001$), peak exercise tolerance with symptom limited interval training 2.55±0.52 METs to 4.78±1.22 METs ($p < 0.0001$). Quality of life scores on the Health Status Questionnaire 2.0 increased significantly ($p < 0.0001$) in the areas of physical function, health role limits, emotional role limits, social function, mental health, and energy levels. There was no significant change in patients' perception of overall health and body pain. Results suggest that IT combined with ST can be tolerated by individuals with severe COPD and results in significant increases in 6-minute walk results, peak exercise tolerance, and quality of life.

Key Words: COPD; Exercise Training

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) results in impairment of ventilatory function and dyspnea leading to a sedentary lifestyle, limited physical function, and diminished quality of life (1). As recently as the 1960's exercise limitations were viewed as natural consequences of COPD (1). Assumptions were that an individual's level of function was limited solely by abnormal mechanics of ventilation and poor alveolar gas exchange (1). However, decreases in functional capacity associated with COPD cannot be explained solely by the natural progression of the disease. Often, the increasing level of disability is a combination of the disease and a consequence of a sedentary lifestyle. Thus comprehensive pulmonary rehabilitation programs comprised of exercise training and education have proven effective in the treatment of COPD. However, the specific exercise dosage necessary to optimize outcomes for individuals with COPD remains elusive (2,3,4).

Due to de-conditioning and a disproportionate energy requirement for respiratory muscle function during exercise, individuals with COPD rely on anaerobic metabolism at lower exercise intensities than their apparently healthy counterparts (5). The associated acidosis produced by anaerobic metabolism contributes to excess CO₂ production and a concomitant increase in ventilation (5). Given excess ventilation during exercise, symptom-limited interval training has been suggested as an exercise regimen for this population. Interval training has the ability to increase aerobic power, increase lactate threshold and enhance acid buffering thus addressing a limiting factor for exercise in COPD (6). Furthermore, symptom-limited interval training may have the ability to mimic everyday life activity for the individual with COPD more so than continuous training (2). Limited research suggests that symptom-limited interval training can achieve significant improvement in aerobic power, lactic acid tolerance and ventilatory capacity with this special population (2,3,4).

Also contributing to reduced functional capacity for individuals with COPD is peripheral muscle weakness. The American College of Sports Medicine, American Association of Cardiovascular and Pulmonary Rehabilitation and American Heart Association support the addition of strength training to aerobic conditioning for a comprehensive exercise program that maximizes outcomes. (8,15) Benefits of strength training and aerobic conditioning complement each other, thus optimizing outcomes. Several studies have found an increase in muscular strength and endurance consequent to peripheral muscle training for individuals with COPD (9,10,11). However, it remains unclear whether endurance muscle training, strength training or a combination of the two will maximize outcomes associated with pulmonary rehabilitation (12).

In addition to reduced exercise capacity, individuals with COPD demonstrate an inability to perform activities of daily living, diminished social interaction, and reduced quality of life. Several recent studies have demonstrated increased quality of life associated with participation in moderate intensity exercise programs (12,13,14). The purpose of this study was to determine if the combination of symptom-limited interval training and strength training increases exercise capacity for individuals with severe COPD as measured by 6-minute walk distance, peak exercise tolerance, and quality of life changes consequent to this combined exercise regimen. It is our hypothesis that combining symptom-limited interval training with strength training will result in significant improvements in 6-minute walk distance, peak exercise capacity, as well as quality of life for individuals with severe COPD.

METHODS

Subjects

The subjects consisted of 50 patients (females = 14, males = 36) enrolled in pulmonary rehabilitation at Southern Indiana Rehab Hospital in New Albany, Indiana. This practice includes individuals whose primary diagnosis is COPD (chronic bronchitis and emphysema). Additionally, many of the subjects had co-morbidities including

osteoarthritis, peripheral vascular disease, osteoporosis, hypertension, and coronary artery disease. All subjects signed informed consent to participate in pulmonary rehabilitation prior to beginning the program.

Preliminary Evaluation

All subjects were referred to this program by their physician and were interviewed by an exercise physiologist, nurse, and a physical therapist prior to beginning pulmonary rehabilitation. Subjects with acute orthopedic injuries, uncontrolled hypertension, acute congestive heart failure, uncontrolled metabolic disease, or uncontrolled atrial or ventricular dysrhythmias at rest or during exercise were withheld from pulmonary rehabilitation and therefore, excluded from participating in rehab until medical intervention brought these conditions under control.

6-Minute Walk Test

6-minute walk tests for distance were performed before and after exercise training in all subjects according to standards described by guidelines of the American Association of Cardiovascular and Pulmonary Rehabilitation (14). Subjects walked in the same section of the hospital both times and were instructed to walk as far as they could in a 6-minute time period.

Pulmonary Rehabilitation Program

Subjects reported to the training facility three times a week for 2.5 hours each session. The mean number of sessions attended by subjects was 16.4 with a range of 7 to 24. Individuals were enrolled in the program as long as they continued to progress and their physical condition required participation in a medically supervised exercises program. Each training session was conducted by the principal investigator who is Advanced Cardiac Life Support certified. The exercise program consisted of strength training, aerobic training and active and static stretching to enhance flexibility.

Strength training was performed using the subjects own body weight, dumbbells or ankle weights. The specific lifts utilized were sit to stand, seated rows, wall squats with a Swiss ball, military press, lateral raise, bicep curls, hip flexion, knee extension, and calisthenics to increase strength of the abdominal and back extensor muscles. Subjects began with one set of 10 repetitions of each exercise. Resistance was increased when the subject could perform 15 repetitions of each exercise with a rating of 4 (out of 10) on the RPE scale. Subjects exercised on both a motorized treadmill (Trotter Model 685) and a NU-STEP recumbent stepper (NUSTEP-Inc, Ann Arbor, MI) for a total of 30 minutes. Initial aerobic workloads were determined by dividing the total feet walked by 0.1 to determine walking pace in miles per hour (MPH) and the corresponding MET values for that speed. (16) Initial interval workloads were set at 65-85% of MET levels achieved during 6-minute walk. Patients whose ambulation results were too small calculate walking pace in MPH and a corresponding MET value were increased to 1.5 MPH on the treadmill as quickly as possible. As soon as the patient could tolerate this workload, hill intervals were initiated at 3% inclines. Workloads were increased weekly by 1-2 METs. After a two-minute warm up, subjects began symptom-limited interval training with a 1:1 active rest to work ratio. Speed in miles per hour or stepping rate in steps per minute remained constant throughout the training sessions

Exercise intensity was increased by raising grade on the treadmill or increasing pedaling resistance on the NU-STEP recumbent stepper. Ratings of perceived exertion and dyspnea were used as indicators of exercise intensity. Intensity was increased until the subject rated perceived exertion and dyspnea higher than a 5 (strong) for either scale. Heart rate, blood pressure, and oxygen saturation were monitored in all subjects throughout their exercise session. Blood pressure was assessed using the auscultation method while heart rate and oxygen saturation were measured using the NELLCOR/N-20 P heart rate and oxygen saturation monitor.

Educational topics covered included: anatomy and physiology of respiratory system, overview of COPD, energy conservation and activities of daily living, overview of metered dose inhalers and other medications, relaxation techniques to controlling anxiety and stress management, dietary requirements exercise and COPD, utilizing pursed lip breathing and diaphragmatic breathing, oxygen therapy and caring for equipment, and advanced

directives. Quality of life was measured during preliminary evaluation and at discharge using the Health Status Questionnaire 2.0 (Health Outcomes Institute).

Statistical Analyses

All data was analyzed with SPSS using dependent t-tests to compare before and after response to training for all outcome measures. T-values were considered significant at $p < 0.001$. to insure a Type I error was not committed. All values are presented as mean \pm standard deviation (SD).

RESULTS

Patient demographics are listed in Table 1. According to %predicted forced expiratory volume in one second (FEV₁) values, patients had a diagnosis of severe COPD (FEV₁ < 40%) and significant smoking histories (pack years 65.31 \pm 31.38). Patients were also asked to rate their shortness of breath utilizing a 0-4 scale. This information is not used as an outcome; however, it does provide valuable insight to the patient's level of functional mobility.

Table 1. Demographic Data of Patients

<i>Item</i>	<i>Subject Values</i>
<i>Age (Years)</i>	68.37 \pm 6.94
<i>Height (cm)</i>	169.66 \pm 11.53
<i>Weight (kgr)</i>	73.21 \pm 20.43
<i>Body Mass Index (BMI)</i>	25.18 \pm 5.34
<i>% FEV1 (predicted)*</i>	39.45 \pm 11.51
<i>Pack Years</i>	65.35 \pm 31.38
<i>Ability to perform ADL's**</i>	
<i>Grooming</i>	2.5 \pm 0.65
<i>Shopping</i>	2.8 \pm 0.75
<i>Driving</i>	1. \pm 0.7
<i>Light Housework</i>	2.8 \pm 0.6
<i>Walking</i>	3.0 \pm 1.2

*FEV1 = forced expiratory volume in one second

**Scale for performance of ADL's

1= able to perform with no shortness of air

2=able to perform with slight to moderate shortness of air

3= able to perform with severe shortness of air

4= unable to do because of shortness of air

Table 2 shows average heart rate, blood pressure, oxygen saturation, and rating of perceived exertion and dyspnea for all subjects. No abnormal cardiopulmonary responses were noted in any subjects undergoing symptom-limited interval training throughout the study. Appropriate oxygen saturation levels were maintained at all times with a mean of 93.5%.

Table 3 shows fitness and quality of life outcomes for all subjects before and after 8-weeks of combined symptom-limited interval training and strength training. Significant improvements in 6-minute walk distance, exercise tolerance and several areas of quality of life. Furthermore by discharge, subjects were performing two to three sets of 10 repetitions for each exercise of resistance training with an RPE of 5 (strong) – 7 (very strong).

Table 2. Cardiovascular and Subjective Response to Interval Training (Mean \pm SD, n=50).

	<i>Resting</i>	<i>Peak Exercise</i>
<i>Heart Rate (b/min)</i>	89.6 \pm 16.0	115.1 \pm 16.8
<i>Systolic Blood Pressure (mmHg)</i>	122.0 \pm 18.2	150.2 \pm 16.9
<i>Diastolic Blood Pressure (mmHg)</i>	71.9 \pm 12.2	79.0 \pm 14.0
<i>Rating Of Perceived Exertion*</i>	-----	3.5 \pm 1.3

*Modified Borg Scale Range 0-10 (16)

Table 3. Pre and Post Results of Fitness and Quality of Life Outcome Measures (Mean \pm SD)

	<i>Pre-Training</i>	<i>Post-Training</i>
<i>Exercise Tolerance</i>		
<i>6 minute walk distance (ft)</i>	931.20 \pm 305.0	1131.9 \pm 226.32*
<i>METs</i>	2.55 \pm 0.52	4.78 \pm 1.22*
<i>ml/kg/min</i>	8.92 \pm 1.82	16.73 \pm 4.27*
<i>Health Status Questionnaire 2.0</i>		
<i>Health Perception</i>	36.94 \pm 18.54	35.13 \pm 18.64
<i>Physical Function</i>	30.7 \pm 18.95	45.24 \pm 20.62*
<i>Health Role Limitations</i>	15.5 \pm 29.40	46.16 \pm 37.51*
<i>Emotional Role Limits</i>	47.21 \pm 44.28	72.31 \pm 35.76*
<i>Social Function</i>	55.37 \pm 32.22	74.98 \pm 23.93*
<i>Mental Health</i>	60.36 \pm 22.15	72.92 \pm 19.13*
<i>Body Pain</i>	65.95 \pm 26.68	69.51 \pm 21.63
<i>Energy/Fatigue</i>	29.72 \pm 19.49	48.20 \pm 20.21*

*p<0.00001

DISCUSSION

The purpose of this study was to examine the functional outcomes of a pulmonary rehab program utilizing symptom limited interval training and resistance training on 6-minute walk distances, sub-maximal exercise capacity, and self-reported quality of life in individuals with severe COPD. Results suggest that the combined exercise regimen provided sufficient stimulus to increase 6-minute walk distance, exercise capacity, and several indicators of quality of life. Additionally, no abnormal cardiovascular responses were reported and no subject dropped out of the program due to injury. However, ten subjects were discharged from the program and results were not used in the outcomes due to patient compliance or illness.

Direct comparisons between previous studies evaluating outcomes of exercise training for individuals with COPD are difficult due to different subject characteristics (severe disease versus moderate disease), and exercise dosage (bike versus treadmill, high versus low intensity). However, our findings of a 20% increase in 6-minutes walk distance is consistent with other studies (2,3,4,). Berry and associates (17) using a combination of aerobic training and resistance training, found a 10% increase in 6-minute walk distance for individuals with severe disease while Engstrom and co-workers (18) found a 12.1% increase. Recently, Bernard and co-workers added strength training to the exercise regimen of COPD subjects and found a modest increase in muscle strength and mass, however both aerobic trained and resistance trained groups increased 6-minute walk distance in a similar manner (12).

Coppoolse and associates (2) recently compared the physiological responses of male subjects with severe COPD using continuous or interval training. The continuous training group significantly increased VO₂max and reduced

ventilation at peak exercise, adaptations indicative of changes in oxidative pathways. The interval-training group only demonstrated significant differences in peak work output and a decrease in leg pain for a given workload, adaptations indicative of changes in anaerobic power. The authors concluded that optimal exercise dosage for subjects with severe COPD might lie in a combination of continuous and high intensity interval training (2).

The current investigation used a combination of continuous training with interval training, involving 30 minutes of exercise with 1:1 active rest to work ratios (15 minutes of low intensity and 15 minutes of high intensity). Performing aerobic exercise in this manner employs the principle of specificity of training or performing a mechanical activity that is similar to that performed in a sport or in this case the performance of ADL's. Utilizing this combination, patients gain experience working at the higher end of their $\dot{V}O_2$ peak and the breathlessness associated with it.

The training regime utilized in this study resulted in an average increase in 6 min walk distance of 200.7 feet. According to research by Reldelmeir and associates, the degree of change seen in this study would result in a perceived benefit by the subjects. These researchers found that the threshold for perceived improvement in 6-minute walk distance is an increase of 177.17 feet (24). However, one of the limitations of a 6-minute walk test is that it is not an incremental test (23). Independence with ambulation in the community requires the ability to walk at a continuous pace and handle terrain changes (anaerobic challenges). The author's rationale for using tolerance of sub-maximal intervals as one of the primary outcomes in this study was to address this limitation. It is the author's contention that programs need to utilize 6-minute walk results and METs or ml/kg/min to have a greater understanding of a patient's ability to function at home and in the community. These results suggest that aerobic interval training coupled with resistance training increased ability to handle aerobic and anaerobic challenges resulting in significant increases in quality of life.

In this study, indicators of quality of life increased significantly for physical function, health role limits, emotion role limits, social function and mental health, and energy levels. These improvements are similar to findings of other studies (11,12,13). Individuals with COPD report lower activity levels and quality of life than their peers (1). However, viewing the normalized quality of life data in Table 3, one can see patients reported lower than average quality of life for levels of physical function, role limitations due to health, and energy before rehab. After rehab, patients reported near average levels of physical function, health related role limitations, and energy levels. Furthermore, role limitations due to emotions and social function were rated average before rehab. After rehab, patients scored these better than average or above normal. There was no statistically significant change in Health Perception. However discharge values were numerically lower, the authors hypothesize that this is due to an increase in the patients' knowledge regarding their disease. Many times, patients under-estimate and even deny the significance of their illness. Pulmonary rehab educates individuals and helps them assess their current health and how to maintain functional mobility. Even though these individuals perception of their health decreased, patients still reported significant increases in several quality of life areas. There was no significant change in perceived body pain. While many of these subjects have mild to moderate orthopedic changes, there were no significant reports of muscle or body pain at admit, during the sessions, or after the treatment. This illustrates the safety of this type of training regime for this population.

The outcomes of the current study concur with other conducted in others evaluated quality of life in COPD patients (14,17,18). Fuchs-Climent and associates utilized the general Nottingham Health Profile questionnaire in 32 COPD patients during a 3-week intensive exercise program and found a significant increase in quality of life (14). Engstrom and associates also found an increase in quality of life related to exercise as measured by generalized questionnaire (17). Berry and co-workers evaluated quality of life using both general and disease specific questionnaires in COPD subjects with severe disease exposed to a comprehensive pulmonary rehabilitation program that included resistance training (18). The investigators found significant differences in quality of life with the disease specific questionnaire but not the general questionnaire.

While our results concur with other studies utilizing interval training for individuals with COPD there were limitations in this study. First, this study was an outcome-based investigation. However, evaluations of medically managed programs are needed to justify pulmonary rehabilitation programs and the expense to third party payers (16). Furthermore, results from this investigation will be used as pilot work to develop randomized clinical trials at our facility to evaluate training regimes that result in optimal recovery of function and mobility.

Secondly, workloads were estimated using American College of Sports Medicine's metabolic equations (8). These formulas can over or underestimate oxygen consumption in a geriatric population (19). Furthermore, Lanigan and co-workers found that individuals with COPD have a small but significant increase in resting oxygen consumption compared with normal subjects (20). It is unknown whether individuals with COPD have a higher oxygen consumption rate during exercise than their healthy counterparts.

Current research has determined that interval training is an appropriate training regime for individuals with severe COPD and it is the only way to attain physiological training effect (e.g. changes in peripheral musculature) (2,3,4). Previous studies required the analysis of expired air to determine initial workloads. Unfortunately, many clinics do not have access to the equipment needed to perform this type of testing. This paper provides a method for clinicians to prescribe interval training resulting in significant increases in exercise tolerance and quality of life. Furthermore, the results of this program would be very easy to reproduce and could be incorporated into any pulmonary rehabilitation program. Outcomes for this investigation are easily measured and provide reliable indicators of functional capacity and quality of life changes for subjects participating in pulmonary rehabilitation. In addition, both components of the exercise program, the symptom-limited interval training and strength training utilized can be adapted for home exercise programs. Therefore, the combined regimen demonstrates successful outcomes and also a program that patients can take home since most training and maintenance will be done there.

In conclusion, our research suggests individuals with severe COPD can tolerate symptom-limited interval training combined with strength training. In addition, this combined exercise regimen increased functional capacity as well as quality of life for this population. Future research efforts will be directed at quantifying the physiological changes associated with combined symptom-limited interval training and strength training and designing studies that randomly assign subjects to different training regimes to determine which results in optimal improvements in physical function and quality of life.

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