



Exercise and chronic obstructive pulmonary disease
by Jacqueline Lamphier

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Nursing
Montana State University

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Abstract:

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Thirty-seven individuals with a diagnosis of moderate to severe COPD participated in the study. The sample included 19 females, 9 who exercised on room air and 10 who exercised with an O₂ supplement, and 18 males, 9 who exercised on room air and 9 who exercised with an O₂ supplement. All participants were Caucasian; their ages ranged from 55 to 82 with a mean age of 70.3 years.

Participants with moderate COPD enhanced their physiological functions in five of the physiologic parameters measured. The five categories considered statistically significant when using single factor Analysis of Variance (ANOVA) were systolic blood pressure, diastolic blood pressure, oxygen saturation, duration of exercise, and MET level. In comparison, participants who were considered to have severe COPD (requiring oxygen during exercise) demonstrated improvement in only two physiologic parameters. Statistical significant measures for oxygen dependent participants included duration of time exercised and MET level.

These study results support the hypothesis that exercise does enhance physiologic functioning in patients with COPD. However, participants with moderate COPD demonstrated greater improvement. Nursing plays a key role in providing care for the patient with COPD. Patient education can facilitate behavior change to improve functional capacity and decrease hospital admission rates, creating a direct lower cost of health care.

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This thesis has been read by each member of the graduate committee and has been found to be satisfactory regarding content, English usage, format, citations, bibliographic style, and consistency, and is ready for submission to the College of Graduate Studies.

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VITA

Jacqueline Lamphier, the daughter of Jack and Mary Hubbard, was born October 8, 1940, in Lewistown, Montana. She received her secondary education from St. Leo's High School at Lewistown. In 1977, she graduated with a Bachelor of Arts degree in Nursing from Carroll College, Helena, Montana.

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ABSTRACT

This correlational descriptive study examined change in physiological functioning in older adults with chronic obstructive pulmonary disease (COPD) who participated in a 12-week exercise program. Variables examined included cardiovascular function measured by blood pressure and heart rate, oxygen saturation measured by pulse oximetry, work capacity measured by duration of time and metabolic equivalent table (MET) levels, and perceived symptoms of exertion measured by the Borg (1982) Scale of Perceived Exertion.

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These study results support the hypothesis that exercise does enhance physiologic functioning in patients with COPD. However, participants with moderate COPD demonstrated greater improvement. Nursing plays a key role in providing care for the patient with COPD. Patient education can facilitate behavior change to improve functional capacity and decrease hospital admission rates, creating a direct lower cost of health care.

CHAPTER 1

INTRODUCTION

Few people today would argue the notion that an active life style, which includes a regular plan of exercise, produces a high quality of living in both a physiological and a psychological sense. With the prevalence of chronic disease and an aging society, the consequences of regular exercise are potentially profound for both the individual and society (Bruce & Larson, 1987).

Currently, in the United States there are 33.9 million people between the age of 65 and 85. By the year 2020, the U.S. Census Bureau predicts 44.3 million older adults between the age of 65 and 85 (Bureau of the Census, 1994). If accurate, these demographics predict a 30.6% increase in the number of people at advanced ages in this country. The health of this population will be the unknown variable. If the health of the population in the future does not differ considerably from the health of current society, a huge proportion of the population will suffer from one or more disabling chronic diseases.

Today's limited resources constrain health care delivery, thus federal entitlement programs affecting this matter have become a major issue (Samuelson, 1993).

Increased pressure on the already limited resources of the U.S. society will require difficult decisions in terms of life expectancy and availability of health care for older Americans. The health care debate launched by President Clinton balances between ethics and economics. In the end, controlling health costs may mean denying some treatment to the very sick because the very sick account for most health spending (Samuelson, 1993). This ethical and economic dilemma may be partially alleviated by introducing preventive and maintenance health care strategies. These strategies can assist the elderly in adhering to therapies designed to slow disease progression, prevent complications and minimize morbidity.

Purpose

Considering these realities, the purpose of this study is to examine the physiological response to an exercise program in older adults with moderate to severe chronic obstructive pulmonary disease (COPD). The study will determine if exercise participation enhances cardiovascular function, increases arterial oxygen saturation, improves physical work capacity, and lowers perception of exertion.

The evolution of treatment for COPD over the last quarter century reflects a changing view of health needs and health care for patients with lung diseases. Beginning with standard medical treatment, many health care

professionals now recognize the benefits of a regular exercise program as a physiologic and psychologic enhancement, as well as a cost effective means for producing significant benefits for older adults with COPD (Hodgkin, 1987).

Background and Significance of Study

With the declining importance of acute infectious diseases and the progressively aging population, Western medicine has increasingly focused on chronic conditions and their associated disabilities (Williams, 1989). Chronic obstructive pulmonary diseases (COPD), including emphysema and chronic bronchitis, are characterized by chronic airway obstruction and reduction in expiratory airflow. These diseases represent major causes of death and disability and have dramatically increased in prevalence during the 20th century. In the United States during the 1980s these diseases ranked as the fifth leading cause of death and accounted for approximately four percent of all deaths (Higgins, 1989; Lenfant, 1982).

In contrast to other major diseases, the death rate from COPD in the United States has increased rapidly in recent years. For instance, from 1970 to 1980, death rates from coronary heart disease, the number one cause of death, decreased nearly 30%, while deaths from COPD increased more than 60% (The Surgeon General's Report, 1984). Since 1980

these trends have continued, particularly among men older than 75 years and in women older than 55 years of age (Higgins, 1988).

Chronic obstructive pulmonary disease is a progressive disease leading to disability and death (Carter et al., 1988). In the evolution of this disease process individuals enter into what may be termed a disability spiral (Schwartzstein & Zadai, 1992). Gradually, as the disease progresses, individuals cope with the functional loss of ventilation capacity and gas exchange by becoming increasingly sedentary. A sedentary life style further erodes the individual's functional capacity and the physiologic reserve necessary to perform even the simplest tasks of daily living (Carter et al., 1988). Despite this evolving pattern, the disability spiral can be interrupted. Even with severe airway obstruction many older adults who feel limited by dyspnea (shortness of breath) do not actually have a purely respiratory limit to exercise. In fact, the majority of these older adults can return to a more active lifestyle. Determining the precise factors that contribute to a client's exercise limitation, modifying these factors to reduce the discomfort of dyspnea, and developing an exercise program can help the older adult break the spiral of disability (Schwartzstein & Zadai, 1992).

Statement of Problem and Research Question

The research problem for this study will answer this question: Is there a relationship between a 12-week structured exercise program for older adults with moderate to severe COPD and their degree of physiologic functioning? The 12-week exercise prescription is individualized and monitored to ensure the subjects do not exceed the maximum prescribed intensity, duration and frequency. Improvement in physical health and the ability to perform activities of daily living is a desirable outcome at any age. Data gathered for this study evaluated physiological responses and the significance of exercise and physical fitness.

Conceptual Framework

Being physically fit to maintain a quality life and carry out the activities of the day dates back as far as 3.5-3.8 million years (Malina, 1988). The earliest hominids were scavengers. Hunting and gathering characterized the mode of existence for many early human beings. A hunting and gathering lifestyle involved high energy expenditure for several days a week, with peak bouts of strenuous physical activity (Eaton, Shostak, & Konner, 1988; Park, 1988).

The next major change in human socio-culture development took place with the domestication of plants and

animals and the rise of agriculture 10,000 years ago. Advances in industrialization over the past 200 years led to further urbanization and the rise of the middle class. Even during this period most individuals still had relatively high energy expenditures compared with individuals at the end of the 20th century (Blair, Kohl, Gorden, & Paffenbarger, 1992).

Human energy expenditure requirements have declined through the 20th century. This trend accelerated during the technological era following World War II (Park, 1989). Increased automotive transportation, widespread adoption of sedentary activities, and labor saving devices all contributed to the decline in energy expenditure for individuals. The metabolic energy demands of previously strenuous jobs, such as working as a homemaker, miner, or farmer, are much lower today than in the past because of containerization, mechanization, and automation (Blair et al., 1992).

Humans evolved to be active animals and may not be able to adapt well to modern, sedentary lifestyle. "From a genetic standpoint, humans living today are Stone Age hunter-gatherers displaced through time to a world that differs from that for which our genetic constitution was selected" (Eaton et al., 1988, p. 256). This teleological argument suggests that human genetic selection and the need for physical activity is necessary for health (Blair et al.,

1992); it also serves as a useful launching point for a review of the scientific discussion of exercise.

The scientific study of exercise is a recent development (Koplan & Powell, 1984). Physiologists in the latter part of the 19th century began to use exercise to "stress" body systems to understand physiological functioning better. Three exercise physiologists, Hill (1921, physiology of exercise) and Meyerhof and Krogh (1922, muscle metabolism) received the Nobel prize for their research in theory and application of the physiology of exercise (Montoye, in press; Powers & Howley, 1990).

Life has changed dramatically in the past 50 years. Individuals have become more sedentary and subjected to increased strain; the lack of sufficient exercise leads to reduced muscular strength and flexibility, and decreased cardiovascular and pulmonary function. Physical fitness is not only beneficial to cardiovascular and endocrine function, but it also provides a psychological benefit related to the fundamental unity of the mind and body. Most observers agree that exercise improves the self-image and provides a more positive approach towards life (Council on Scientific Affairs, 1984). Nearly 2,000 years ago, Juvenal, a Roman writer of satire, recognized the many benefits and positive interactions of a healthy body and a healthy mind when he said, "A sound mind in a sound body is a thing to be prayed for" (p. 545).

Freidrich (1977) indicates that "stress causes biochemical changes within the body, and undue stress on the unconditioned body may eventually cause failure of the endocrine gland system" (p. 330). Failure to keep the pituitary-adrenal axis conditioned, that is, ready and able to react to stresses, is one of the main reasons older people may not continue to function effectively. Lack of physical stimulation tends to cause endocrine glands to atrophy and become less responsive. Exercise can have a prophylactic value, because the mild stress that it provides to the adrenal system conditions a person to handle severe stress more effectively (Council on Scientific Affairs, 1984). The physiologic and psychologic benefits of exercise are not new concepts. In the third century B.C. Hippocrates (Webster, 1988) said:

All parts of the body which have function, if used in moderation and exercised in labors to which each is accustomed, become thereby well-developed and age slowly; but if unused and left idle, they become liable to disease, defective in growth and age quickly. (p. 9)

Strength and flexibility decrease with aging, but if they decrease from a high level obtained by proper physical fitness during childhood and youth, they will not drop so readily to the abysmally low level so often seen in relatively young people and particularly in middle age and older adults. It is commonly accepted that an otherwise "healthy" 50-year-old or even a 40-year-old may experience

trouble climbing a couple flights of stairs because of a lack of cardiovascular and muscular fitness, but this response is by no means natural or inevitable. The fact that one's heart is unable to cope with a relatively small strain like climbing stairs may explain why this same heart may fail under excessive mental or physical stress. The physically inactive individual will show signs of aging earlier in life and exist physiologically at a lower potential. Additionally, such individuals do not maintain homeostasis or meet the daily stresses of life as well. Such low levels of function combined with forced suppression of "fight or flight" response enhance the incidence of chronic diseases (Bortz, 1982).

Hypotheses

Considering the history and theory of exercise, it is hypothesized that a 12-week structured exercise program for older adults with moderate to severe COPD will improve physiological functioning. The expected outcomes include (a) enhanced cardiovascular function as evidenced by decreased systolic and diastolic blood pressure and decreased heart rate; (b) increased arterial oxygen saturation as measured by pulse oximetry; (c) improved physical work capacity, evaluated by duration of time exercised and metabolic equivalent table (MET) levels; and

(d) decreased symptoms of perceived exertion, measured by the Borg (1982) Scale of Perceived Exertion.

Definitions of Terms

Chronic Obstructive Pulmonary Disease: COPD is an all-inclusive, non-specific term that refers to obstructive and restrictive disorders of the lungs (Hammon, 1987).

Older Adults: Older adults are defined as those individuals who are 55 years of age or older.

Pulmonary Rehabilitation: Pulmonary rehabilitation is an art of medical practice wherein an individually tailored multi-disciplinary program is formulated through an accurate diagnosis, therapy, emotional support, and education which stabilizes or reverses both the physiological and psychopathology of pulmonary diseases. Pulmonary rehabilitation also attempts to return the patient to the highest possible functional capacity allowed by his pulmonary handicap and overall life situation (Hodgkin, Farrell, & Gibson, 1981).

Exercise: Exercise is both planned and structured physical activity with repetitive bodily movement done to improve or maintain one or more components of physical fitness (Casperson, Powell, & Christenson, 1985).

Cardiovascular Function: Cardiovascular function relates components of health and physical fitness (Powell & Paffenbarger, 1985). For this study, cardiovascular

function was measured by the resting systolic and diastolic blood pressure and resting heart rate.

Blood Pressure: The action of the heart and the forces exerted by blood against the arterial walls create blood pressure (Powers & Howley, 1990). The pulmonary rehabilitation nurse took the resting blood pressure after a five minute rest period on arrival for exercise. These blood pressure measurements determined cardiovascular function for this study.

Resting Heart Rate: Heart rate is the number of cardiac cycles per minute (Powers & Howley, 1990). Resting heart rate is measured with the pulse oximeter after a five minute rest period and before exercise begins. For this study heart rate was a measurement tool for cardiovascular function.

Arterial Oxygen Saturation (SaO₂): SaO₂ measures the binding of oxygen (O₂) to hemoglobin in the arterial blood (Powers & Howley, 1990). The pulmonary rehabilitation nurse obtained SaO₂ measurements at the beginning of each exercise session, after a five minute rest period. The cutaneous pulse oximeter was used to measure the SaO₂ or the oxygen carrying capacity of the hemoglobin.

Work Capacity: Work capacity represents the product of force (speed and grade, intensity) and the distance (duration) through which that force moves (Powers & Howley,

1990). Work capacity was measured by duration of time and MET level on the treadmill or cycle ergometer.

Duration of Time: Duration of time was measured from start to finish of exercise time on the treadmill or cycle ergometer. Each participant had a stop watch and time spent exercising was self limiting, depending on fatigue level.

Metabolic Equivalent Table (MET): A MET is a multiple of the resting rate of O₂ consumption. Thus, an individual exercising at two MET's consumes O₂ at twice the resting rate (American College of Sports Medicine, 1991). A combination of speed and grade on the treadmill or cycle ergometer was used to calculate MET level.

Rating of Perceived Exertion (RPE): The Borg (1982) scale of perceived symptoms of exertion rates subjective symptoms of breathlessness and fatigue during and after exercise. On completion of the daily exercise program the RPE is communicated to the pulmonary rehabilitation nurse by the patient.

Assumptions

An initial assessment, including an evaluation by the medical director and the pulmonary rehabilitation nurse, must be done to determine proper pulmonary diagnosis. This diagnosis is necessary to achieve optimal improvement in a patient's functional capacity. Health care providers must

know what causes the pulmonary impairment and be aware of other medical problems which could interfere, if not treated, with the patient's rehabilitation potential. Therefore, it was assumed that each patient who enters into the 12-week exercise program has been evaluated for appropriateness and educated on proper use of exercise equipment, the perceived exertion scale, and medications, including oxygen therapy. Lastly, it was assumed that all values recorded on the patient's medical record were true and accurate.

CHAPTER 2

LITERATURE REVIEW

Four specific areas of literature were reviewed for this study. They cover exercise, COPD, aging, and reported studies of exercise performance in older adults with COPD.

Exercise

The term exercise has been used interchangeably with physical fitness. In fact, both have a number of common elements. For example, exercise and physical activity involve any bodily movement produced by skeletal muscles that expends energy. Exercise, a sub-class of physical activity, represents planned, structured, and repetitive bodily movement done to improve or maintain one or more components of physical fitness. Physical fitness or conditioning correlates with a set of attributes that people have or achieve which relate to the ability to perform physical activity (Casperson et al., 1985).

Physical conditioning increases the ability to perform work. In a group of well-trained athletes, the imposition of strict bed rest or inactivity for 10 days to 2 months resulted in a deconditioned state characterized by the physiologic changes of decreased maximal oxygen uptake and

an increased heart rate and blood pressure response to exercise. Posture-dependent reduction in stroke volume and a reduction in size of the left ventricle also resulted (Convertino, Hung, Goldwater, & DeBusk, 1982; Martin, Coyle, Bloomfield, & Ehasai, 1986). Exercise intolerance sometimes forces patients with COPD to adopt a sedentary lifestyle, which in turn results in deconditioning. Depending on the degree of inactivity, physical deconditioning contributes considerably to exercise intolerance in patients with COPD (Olopade, Beck, Viggiano, & Staats, 1992).

Authors reviewing the available evidence on the possible benefits of exercise conditioning in patients with COPD have concluded that accepted benefits of exercise include increased endurance, maximum oxygen consumption, and increased skill in task performance (Hughes & Davison, 1983). Considerable evidence demonstrates both physiologic and psychologic improvements with exercise in patients with chronic lung disease (American Thoracic Society, 1987; Belman & Wasserman, 1981; Cotes, Bishop, & Chapel, 1981). Patients may increase their maximum capacity and/or endurance for exercise and physical activity, even though lung function does not usually change. Exercise training provides an ideal opportunity for patients to learn their capacity for physical work and to use and practice methods

for controlling dyspnea (e.g., breathing and relaxation techniques) (Ries, 1990).

In order to improve exercise tolerance there must be physiologic conditioning. The body depends on the integrated response of a number of body systems in order to perform exercise. This explanation provides a useful way to look at the physiologic requirements to perform exercise. The body must gear up to increase transport of oxygen to the exercising muscles. A number of organ systems become involved in this process. Perfusion of the muscle cells must be adequate for diffusion from the capillaries to the mitochondria, where oxidative phosphorylation produces the adenosine triphosphate (ATP) necessary for muscle contraction. Vasodilation of the muscle vasculature (and vasoconstriction of non-essential vascular beds) must direct cardiac output appropriately. Both the left and right heart must pump harder and faster and the blood pumped must be rich in oxygen (oxyhemoglobin concentration must be high). The pulmonary vasculature must dilate to accept the right heart output and the blood flow to the lung must be evenly distributed to match the distribution of the airflow. The ventilation of the lung must bring fresh air to the alveolar-capillary membrane, and carry carbon dioxide out of the lungs to increase pulmonary ventilation (Casaburi, 1992). Patients with lung

disease have distinct handicaps in meeting the increased oxygen supply requirements imposed by exercise.

Chronic Obstructive Pulmonary Disease

COPD is an all-inclusive and non-specific term that refers to a condition in patients who have chronic cough, expectoration, and various degrees of exertional dyspnea. Persons with COPD also exhibit a significant and progressive reduction in expiratory airflow, as measured by the forced expiratory volume in one second (FEV_1) (Hodgkin & Petty, 1987). This airflow abnormally does not show major reversibility in response to pharmacologic agents. Hyperinflation and a reduced diffusing capacity may be present. Both inflammatory damage to airways (bronchitis) and alveoli (emphysema) present themselves at postmortem examinations of patients with COPD (Hodgkin & Petty, 1987).

Chronic obstructive bronchitis refers to patients with cough and expectoration along with a reduced FEV_1 that does not improve significantly following bronchodilator inhalation. Simple chronic cough and expectoration with normal airflow does not fall into this definition. Simple chronic bronchitis with no airflow obstruction has a good prognosis. In essence, the social and economic impact to patients, families, and society is minimal (Hodgkin, 1987). Chronic bronchitis distinguishes itself from asthmatic bronchitis only by the degree of reversibility in response

to pharmacologic agents. Patients with chronic obstructive bronchitis do not have physiologic or roentgenographic evidence of hyperinflation. Diffusion tests are normal or near-normal (Hodgkin & Petty, 1987). The etiology of chronic bronchitis may be related to long-term irritation of the tracheobronchial tree. The most common cause of irritation is cigarette smoking. Inhaled smoke stimulates the goblet cells and mucous glands, which secrete more mucus. Cigarette smoke also inhibits ciliary action. The hypersecretion of mucous and impaired cilia lead to a chronic productive cough. The fact that smokers secrete an abnormal amount of mucous makes them more prone to respiratory infections and it generally takes longer for them to recover from an infection (Hammon, 1987).

The term emphysema refers to patients who have various degrees of dyspnea on exertion and irreversible airflow abnormalities as measured by FEV_1 . In addition, these patients demonstrate abnormalities at the air/blood interface as judged by carbon monoxide uptake tests (diffusion tests) and hyperinflation, determined clinically by physical examination, size of the lungs on x-ray films, and measurement of total lung capacity (Hodgkin & Petty, 1987). Patients with emphysema have a condition of the lungs characterized by abnormal permanent enlargement of airspace distal to the terminal bronchiole, accompanied by the destruction of alveoli walls, and without obvious

fibrosis (Hammon, 1987). Chronic bronchitis and emphysema often co-exist. Therefore, most clinicians will use the term COPD for the description of either disease (Hodgkin & Petty, 1987).

The true prevalence of COPD remains unknown, though reports indicate it exists in 10% to 30% of the adult population depending on the population studied and varying definitions of the disease (Williams, 1989; Woolcock, 1989). The natural history of COPD spans several decades and has been associated primarily with cigarette smoking as the major risk factor (Crofton & Bjartveit, 1989). Additional risk factors include air pollution (atmospheric, domestic, and occupational), childhood respiratory infections, and passive tobacco smoke (Chretien, 1989; Crofton & Bjartveit, 1989). Asthma, also an obstructive disease of the airways, overlaps considerably with COPD in its chronic forms; therefore, asthma may also be an important risk factor contributing to the development of COPD (Buist, 1989; Woolcock, 1989).

Although smoking represents the major risk factor for development of COPD, the majority of cigarette smokers do not develop clinical manifestations of obstructive lung disease until late in life (Ries, 1990). Typically, these diseases develop insidiously and, because of the large reserve in lung function, do not produce significant symptoms or come to medical attention until the disease is

at an advanced stage (Fletcher, Peto, Tinker, & Speizer, 1976). Many patients with mild to moderate COPD have few symptoms and function undiagnosed. Therefore, official health statistics significantly underreport the number of patients diagnosed with COPD. Subsequently, when the disease is recognized later in life, lung function is often severely compromised and the disease process may be largely irreversible. Survival rates for patients with diagnosed COPD are severely reduced with approximate survivals of 50% at 5 years after diagnosis and 25% at 10 years (Traver, Cline, & Burrows, 1979).

Aging Process

The effects of COPD may be confused with age related factors. Biological aging is a universal property of living things. Pescopo (1985) believes that as mammalian organisms age, bodily systems decline, and circulatory, neural, and hormonal systems lose capacity for adaptive adjustments.

Aging must be distinguished from disease. Biological changes attributable to aging are frequently referred to as normal age changes. Age changes are not disease; they are natural evolutionary transformations that are recognized by changes in hair, skin, eyes, and other similar decrements. However, the normal decrements in vital organs do produce increased vulnerability to pathological changes (Maddox, 1987).

As an individual ages the chest anterior/posterior diameter increases as respiratory muscles atrophy. The lungs lose elasticity and reduce vital capacity. In addition, pulmonary wall thickening occurs that impedes oxygen diffusion. Other age related factors include an increase in residual volume, leading to less efficient oxygen (O₂) and carbon dioxide (CO₂) exchange. Finally, fewer capillaries and thickening of alveoli lead to a decline in arterial oxygen levels (Andresen, 1990).

Age changes, coupled with cultural expectation that older adults should "slow down and take a well-deserved rest" after retirement, produce a sedentary lifestyle which further aggravates the physical decomposition of aging. The coincidence of these changes from subcellular to the whole-body, prompts the suggestion that at least a portion of the changes commonly attributed to aging in reality result from disuse and, as such, are subject to correction with moderate exercise (Blair, 1990; Bortz, 1982). Whatever the interaction between aging and disuse, changes in all physiologic systems are well documented (Webster, 1988).

Reported Studies

Several reports demonstrate improved exercise performance after exercise training in patients with COPD (Holle, Williams, Vandree, Starks, & Schoene, 1988). In

one of the earliest studies, Pierce, Taylor, Archer, & Miller (1964) reported on the results of treadmill exercise training over 3 to 16 weeks in 9 patients with severe COPD. All patients studied improved exercise endurance and maximum tolerance with an increase in maximal treadmill speed (mean of 3.5 to 5.5 mph) and a 23% increase in oxygen consumption (VO_2 max). In addition, the patients showed improved mechanical efficiency of work with a decrease in VO_2 , heart rate, and volume of air expired in one minute (V_e) and a more rapid recovery or stabilization after exercise. Similar results were reported by Paez, Phillipson, Masangkay, and Sproule (1967). After 3 weeks of treadmill exercise training in 8 patients with COPD, they found an increase in maximal treadmill speed (mean increase of 1.4 to 2.4 mph) and improved mechanical efficiency associated with a longer stride length during walking. VO_2 max was not measured in this study.

In 1972, Vyas, Banister, Morton, and Grzybowski exercised 14 patients with COPD daily on a cycle ergometer for an average of 10 weeks (range, 6 to 26 weeks). The 11 patients who completed the exercise program experienced a significant increase in maximal work rate and in VO_2 max. In contrast to the previous treadmill training studies, there was no change in mechanical efficiency on the cycle ergometer (i.e., no reduction in VO_2 at constant work rates).

Carter et al. (1988) reported results of short-term, high intensity exercise training in 59 patients with COPD during an 11-day inpatient rehabilitation program. Patients exercised twice a day on treadmills and cycle ergometers with instructions to exercise near their ventilatory limits for 30 to 40 minutes per session, with rests allowed if necessary. Results indicated increases in work levels on a cycle ergometer, oxygen uptake, and ventilation after the program, despite minimal changes in pulmonary function. Patients maintained improvement at 3 months follow-up. These findings suggest that increases in maximum work tolerance related to improvements in maximum sustained ventilation and ventilatory efficiency, since the increase in peak exercise ventilation was due primarily to an increase in tidal volume (a normal breath).

Holle et al. (1988) reported results of a 6-week exercise program with an initial target set at 80% of peak work load. In the 44 patients who completed all of the training and follow-up testing, they found a 73% increase in metabolic equivalent (an expression of the rate of energy expenditure at rest) estimated for treadmill work levels (3.28 to 5.46), whereas measured VO_2 max increased only 15% from 1.02 to 1.11 L/min. FEV_1 , maximum heart rate, and maximum ventilation volume (Ve-max) did not change. These findings suggest significant changes in mechanical efficiency of walking as a primary mechanism of

the improvement in exercise performance. Also, 24 patients who returned for follow-up testing at 12 plus or minus 3 months, maintained 89% of peak exercise performance.

Mall and Medeiros (1988) reported the results of an outpatient pulmonary rehabilitation program in a community hospital with 197 patients. After 6 weeks of exercise training, they found an increase in maximal work load on the treadmill testing accompanied by lower heart rate and respiratory rate. However, VO_2 max did not change, indicating that the change in work load probably related to patient improvement in mechanical efficiency of walking.

Zack and Palange (1985) exercised 63 patients with COPD in an outpatient pulmonary rehabilitation program at a community hospital with levels titrated to patient symptom tolerance. Exercise training included walking and inspiratory muscle exercise. Among the 53 patients who completed the 12-week program there were no significant increases in maximum exercise workload or VO_2 max on a cycle ergometer but a 51% increase in the 12-minute walk distance and a 57% increase in endurance time. However, with supplemental oxygen patients experienced a 14% increase in maximum cycle ergometer workload, 72% increase in 12-minute walk distance, and a 98% increase in endurance time. Improvements were seen in patients with and without exercise-induced hypoxemia (abnormal deficiency of O_2 in

the arterial blood), which may have been related to reduction in the ventilatory requirements on oxygen.

Mohsenifar, Horak, Brown, and Koerner (1983) evaluated 15 patients with COPD before and after participation in a 6-week pulmonary rehabilitation program. They found little change in standard measurements of lung function or gas exchange. All patients reported a subjective improvement in exercise tolerance (perceived exertion levels) and demonstrated at least a double increase in exercise endurance time. However, maximum work rate on a cycle ergometer did not change. The only measurable changes were a decrease in heart rate and blood lactate at comparable levels of exercise.

Tydeman, Chandler, Graveling, Culot, and Harrison (1984) enrolled 24 patients with COPD in a supervised exercise program. The 16 patients who completed the training and study evaluations reported a 42% increase in 12-minute walk distance. They experienced a 22% increase in the first 4 weeks and further increase with continued training (mean time to maximum improvement of 36 weeks).

Most studies report results of short-term exercise training in patients with COPD. However, reports of longer-term results exist. Nicholas, Gilbert, Gabe, and Auchincloss (1970) reported the effect of exercise training after a 3-month control period in 8 patients with COPD who completed the full study protocol. They found an increase

in exercise tolerance without change in ventilatory function or gas exchange measurements. They noted improvement in mechanical efficiency of walking as patients demonstrated improved mechanical work tolerance without changes in measured oxygen uptake (VO_2 max). They also found that the patients seemed to show improved exercise performance during the 3-month "control" period, suggesting that such patients may show improvements related to participation in a study with repeated exercise testing not necessarily related to the exercise training.

Brundin (1974) enrolled 31 patients with severe COPD (17 with and 14 without periods of respiratory failure) in a long-term study of cycle ergometry exercise training (accompanied by breathing exercise and chest physiotherapy). Twenty-four patients were able to perform the training over the 6 to 18 months of follow-up. These patients noted subjective improvement (perceived exertion) in activity level with less dyspnea (shortness of breath) and demonstrated increased exercise tolerance.

Mertens, Shepard, and Kavanagh, (1978) followed 13 patients during one year of exercise training and 6 patients for a second year. They found an increase in predicted VO_2 max at one year and noted a greater magnitude of improvement in those patients who were more compliant with their training regimen.

All studies reviewed gave either a mean age or an age range of participants being studied. The age of the individuals in the reported studies parallels the mean age and the age range of participants in this study. COPD has an insidious onset developing over a 20- to 30-year period with a long asymptomatic period; therefore, it has a latent effect on older adults (Conners & Hilling, 1993).

CHAPTER 3

METHODS

Design

A correlation descriptive design allows the investigator to assess the extent to which levels of one phenomenon correspond to levels of another. In a correlational survey the researcher studies a sample representing a cross-section of a single population of interest (Woods, 1988a). This correlation study evaluated the physiologic effects of a 12-week exercise program from an assessable population of older adults with COPD. Considering the complexity of human health, this study is multivariate. The empirical aspects of the variables being studied are cardiovascular function, oxygen saturation, level of work capacity and perceived symptoms of exertion. The researcher remained unobtrusive and did not influence the variables being studied, as many of the participants had completed the 12-week program before the researcher contacted them.

Population and Sample

Individuals selected for this exercise program were classified as out-patients and considered to be in a stable phase of COPD. This population shared a common set of criteria. For example, they were 55 years of age or older, had a diagnosis of moderate to severe COPD, and had completed all aspects of the 12-week exercise program. All individuals chosen for the sample possessed the characteristics to be studied and represented the population of interest.

In order to ensure an adequate representation of the targeted group a purposive sample was used. The purposive sample method allowed the investigator to hand-pick the cases based on a judgment of the extent to which the potential participants met the selection criteria (Woods, 1988a). Selection of the purposive sample occurred through examination of data collected by the staff in the pulmonary rehabilitation program at St. Peter's Community Hospital. (For a full description of the program see Appendix A). Thirty-seven older adults who completed the 12-week exercise program participated in the study. Demographic data collected included age, gender, race, occupation, supplemental oxygen therapy, smoking history, and accompanying chronic diseases.

Procedure for Data Collection

Data were collected by reviewing the participants' medical record in the Medical Record Department at St. Peter's Hospital. Participants in this study were identified by the pulmonary rehabilitation nurse as meeting the study criteria. The researcher mailed a written explanation of the study to each potential participant. If the person agreed to participate, he or she signed and returned the consent form. The signed consent form allowed for release of medical record information collected during the individual's 12-week exercise program.

Instrumentation

Non-invasive physiological measures for exercise testing were used for the study. Physiologic data recorded each day before exercise was initiated included, blood pressure, heart rate, and arterial oxygen saturation. Duration of exercise, MET level, and perceived symptoms of exertion measurements represent data recorded at the completion of the day's exercise program.

Blood Pressure

Blood pressure was measured indirectly, using an calibrated aneroid manometer. It consists of an inflatable cuff that, when inflated to a pressure beyond that in the vessels over which it is placed, will impede blood flow.

As the pressure releases, the cuff only partially occludes the vessels and blood escapes through the opening in the vessel, producing a Korotkoff sound. Turbulence of flow and arterial wall movement produces the sound heard through a stethoscope placed over the artery. When carefully done this auscultatory method is fairly reliable and has an accuracy of about plus or minus 5 mm Hg (Feinberg & Fleming, 1978).

In order to control extraneous variables and minimize error, health care providers in the pulmonary rehabilitation department use the following guidelines when taking blood pressure: (1) accurate calibration of all blood pressure aneroid manometers, (2) consistent use of the left arm to obtain initial and subsequent blood pressures, and (3) to assure the use of a proper size blood pressure cuff, the rubber bladder of the blood pressure cuff encircles at least two-thirds of the patient's arm.

Heart Rate and Arterial Oxygen Saturation

The cutaneous pulse oximeter measured heart rate and oxygen saturation. The principle of oximetry is based on Beer's law which states the concentration of an unknown solute dissolved in a solute can be determined by light absorption. When the light from a probe passes through a finger, the majority of light is absorbed by connective tissue, skin, bone, and venous blood. The amount of light

absorbed does not vary during a cardiac cycle. With each heart beat a small increase in arterial blood results in an increase in light absorbed. By comparing peak to trough absorbance, the contributions from non-arterial sources become irrelevant. Therefore, the thickness of the skin, fat, and skin pigment do not influence the accuracy of the cutaneous oximeter (Schnapp & Cohen, 1990).

The cutaneous pulse oximeter used to measure the arterial oxygen saturation and heart rate has a mean error of less than 2% at normal saturation and perfusion (Schnapp & Cohen, 1990). The pulse oximeter cannot be calibrated by the user; the oximetry equipment is a battery powered device and has internal quality control monitors for accuracy.

Metabolic Equivalent Table and Duration of Exercise

St. Peter's Hospital uses the Bruce or Naughton-Balke treadmill protocol for initially calculating MET level achieved by the exercising patient. The Bruce protocol divides into five stages and measures miles per hour (mph) plus grade (MET level) and duration, for men, women, and cardiac patients. This protocol, generally reserved for the more conditioned patients, involves a change in speed and grade every 3 minutes. Another disadvantage of the Bruce protocol is the relative brevity as most deconditioned patients cannot complete stage 3 of the five-stage

protocol. In recent studies (American College of Sports Medicine, 1991), researchers have shown 10% to 20% error in estimating VO_2 from the Bruce protocol. The researchers attribute this error to rapid increases in treadmill speed and grade that exceed the VO_2 uptake kinetics of deconditioned patients.

The Naughton-Balke treadmill protocol utilizes constant walking speeds of 2.0 to 3.3 mph with increasing grade increments (2% to 3%) (MET level) every 2 or 3 minutes. This protocol is more acceptable for limited exercise capacities because of the more gradual incremental increases in exercise intensity at each stage and the decreased chance of error in estimating oxygen consumption. The Naughton-Balke protocol format accommodates a variety of individual walking speeds and grades, while allowing selection of appropriate, comfortable and safe exercise protocol. This format measures exercise intensity (speed plus grade) by MET level calculated by the treadmill equipment (American College of Sports Medicine, 1991).

The manufacturer calibrates the treadmills and cycle ergometer used in this study with error codes and alarms. The Biomedical Department at St. Peter's performs treadmill calibrations every 6 months to verify the accuracy and safety of these instruments.

Rating of Perceived Exertion

The 0-to-10 category-ratio RPE scale provides a subjective method to quantify exercise intensity. When using the category-ratio scale, respondents understand a rating of 10 is not truly maximal. If the subjective intensity raises above a rating of 10, the person may choose any larger number to verify the perception of exertion (American College of Sports Medicine, 1991).

The rating of perceived exertion (RPE) response to exercise has a high correlation with cardiorespiratory and metabolic variables such as oxygen consumption, heart rate, and ventilation. RPE reliably indicates the level of physical exertion during steady-state exercise intensity for endurance training (American College of Sports Medicine, 1991).

Rights of Human Subjects and Consent Process

Individuals selected for the study shared a common set of criteria. For example, they were 55 years of age or older, had a diagnosis of moderate to severe COPD, and were able to complete all aspects of the 12-week exercise program. The pulmonary rehabilitation nurse who coordinates the pulmonary rehabilitation program supplied the investigator with a list of prospective participants. All individuals chosen for the sample possess

characteristics required for the study and represented the population of interest.

The researcher sent a letter of explanation to all prospective participants (Appendix B). This letter described the nature and intent of the research, and requested formal consent to gain access to the patient's medical record. In addition, the letter informed the individual of the right to refuse participation in the study by not returning the informed consent.

The hospital supplied a formal consent titled "Authorization for Disclosure of Medical Record Information" (Appendix C), a necessary chart form authorizing the researcher access to the patient's medical record. Fifty letters of explanation with consent forms attached were mailed, each with a self-addressed stamped envelope for return of information. A 74% return rate created a sample of 37 participants.

Human subjects participating in this study allowed the investigator access to their medical record. The researcher restricted information gathered to the specific dates of the 12-week exercise program that included the program entry assessment data. The participant's name did not accompany the physiologic data recorded; however, the data are identifiable through the participant's medical record number. All data for the research project were gathered under supervision in the Medical Records

Department. The researcher did not remove any medical record from the department for the purpose of the study; therefore, all records remained in a safe protected area. Registered nurses and St. Peter's employees maintain a high standard of confidentiality and professional conduct. The utmost care and respect for patient information was strictly adhered to throughout the study.

Planned Statistical Analysis

The purpose of this study was to describe relationships between variables. According to Brink and Wood (1983), this represents a level II research design. The first step in analysis is to place data in tables that describe trends; the second step is to test the significance of the relationship between exercise and physiological functions of patients with COPD.

Two factors make the appropriate test for this statistical analysis a parametric test. The distribution of the variable in the population is known, and the variable is measurable on an interval scale (Brink & Wood, 1983). The mean, an arithmetical average of the scores, measures central tendency, while the measure of variation corresponds to standard deviation (Woods, 1988b). The data collected provided three sets of scores from the same group of people. The single factor ANOVA, the statistical test used in this study, performs an analysis of variance which

tests the hypothesis that the means from several samples are equal (Woods, 1988c).

CHAPTER 4

RESULTS

Medical records from 37 patients were reviewed to determine the effects of an exercise program on patients with moderate to severe COPD. Descriptive data gathered included the participants, gender, age, race, supplemental oxygen therapy, and cigarette smoking history. Additional demographic information included occupation and accompanying chronic diseases.

Sample Description

The study sample is described by age, gender, and incidence of oxygen therapy in Tables 1 and 2. The sample included 19 (51%) females, 9 (24%) who exercised on room air and 10 (27%) who exercised with an O₂ supplement, and 18 (49%) males, 9 (24.5%) who exercised on room air and 9 (24.5%) who exercised with an O₂ supplement. Participants who exercised on room air represented patients with moderate COPD, while those who exercised with an oxygen supplement were considered to have severe COPD. All participants were Caucasian; their ages ranged from 55 to 82 with an age mean of 70.3 years. Participants who exercised on room air had an age mean of 70.7 years; those

who exercised with an oxygen supplement had an age mean of 69.9 years.

Table 1. Age Distribution of Participants (N=37).

Age Range	Females	Males	Total
55 to 65	3 (8.1%)	6 (16.2%)	9 (24.3%)
66 to 75	9 (24.3%)	10 (27.0%)	29 (51.4%)
76 to 85	3 (8.1%)	6 (16.2%)	9 (24.3%)

Table 2. Gender Distribution With and Without O₂ Therapy (N=37).

Gender	Without O ₂	With O ₂	Total
Females	9 (24%)	10 (27%)	19 (51%)
Males	9 (24.5%)	9 (24.5%)	18 (49%)

Table 3 depicts the smoking history of study participants who exercised without an oxygen supplement. Their mean number of cigarettes smoked a day was 23.0, and pack years averaged 49.4.

Table 4 depicts the smoking history of participants who exercised with an oxygen supplement. Oxygen dependent participants smoked an average of 27.3 cigarettes a day with a pack year mean of 54.3. Participants considered to have moderate COPD smoked 4.3 fewer cigarettes a day or 4.9 pack years less than participants with severe COPD.

