Predicting physical fitness outcomes of exercise rehabilitation: An retrospective examination of program admission data from patient records in a hospital-based early outpatient cardiac rehabilitation program

by

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(ABSTRACT)

Economic justification for rehabilitative services has resulted in the need for outcome based research which could quantify success or failure in individual patients and formulate baseline variables which could predict outcomes. The purpose of this study is to investigate the utilization of baseline clinical, exercise test, and psychosocial variables to predict clinically relevant changes in exercise tolerance of cardiac patients who participated in early outpatient cardiac rehabilitation. Clinical records were analyzed retrospectively to obtain clinical, psychosocial and exercise test data for 94 patients referred to an early outpatient cardiac rehabilitation program at a large urban hospital in the Southeast US. All patients participated in supervised exercise training 3d/wk for 2-3 months. A standardized training outcome score (STO) was devised to evaluate training effect by tabulating changes in patients predicted VO_2, body weight and exercising heart rates after 8-12 weeks of exercise based cardiac rehabilitation. *STO = Predicted* VO_2 *change + BW change- HR change.* The Multi-Factorial Analysis was applied to derive coefficients in the STO formula so that the STO scores reflected the independent effects of BW, HR and Predicted $V0_2$ changes on training outcome. Patients were classified into one of three possible outcome categories based on STO scores, i.e. improvement, no change, or decline. Thresholds for classifying patients were the following; STO scores $\geq$ 3 SEM above the mean = improved, (N= 40: 41%), STO scores $\leq$ 3 SEM below the mean = decline, (N=34: 35%), STO scores within 3 SEM= no change, (N=23: 24%). Multiple logistic regression was used to identify patient attributes predictive of improvement, decline, or no change from measures routinely collected at the point of admission to rehabilitation. The model for prediction of improvement correctly classified 70% of patients as those who improved vs. those who did not (sensitivity 70%, specificity 71%). This model generated the following variables as having predictive capabilities; recent CABG, emotional status, social status, calcium channel blocker, recent angioplasty, maximum diastolic BP, maximum systolic BP and resting systolic BP. The model for predicting those who declined vs. those who did not decline demonstrated higher correct classification rate of 74% and specificity (84%). This model generated the following variables as having predictive capabilities; social status, calcium channel blocker, orthopedic limitation, role function, QOL score and Digitalis. However, these models may include certain bias because the same observations to fit the model were also used to estimate the classification errors. Therefore, cross validation was performed utilizing the single point deletion method; this method yielded somewhat lower fraction correct classification rates (66%,69%) and sensitivity rates (56%,44%) for improvement vs. no improvement and decline vs. no decline groups respectively. **Conclusion** A combined set of baseline clinical, psychosocial and exercise measures can demonstrate moderate success in predicting training outcome based on STO scores in hospital outpatient cardiac rehabilitation. In contrast psychosocial data seem to account for more of the variance in prediction of decline than other types of baseline variables examined in this study. Baseline blood pressure responses both at rest and during exercise were the greatest predictors of improvement. However, cross validation of these models indicates that these results could be biased eliciting overly optimistic predictive capabilities, due to the analysis of fitted data. These models need to be validated in independent sample with patients in similar settings.

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Chapter I

INTRODUCTION

Mortality rates from cardiovascular disease have declined dramatically in the last 30 years (Levy, 1981). This decrease can be attributed to many factors including improved detection of excess risk for disease, development of better treatment methods, and lifestyle changes. This decline in cardiovascular disease mortality has resulted in the rise of the absolute number of patients living with disease facilitating the advent and growth of cardiovascular rehabilitation programs. Cardiac rehabilitation can be defined as "the process by which persons with cardiovascular disease (including but not limited to patients with coronary artery disease) are restored to and maintained at optimal physiological, psychological, social, vocational and emotional status" (AACPR, 1995). This is accomplished through exercise training, patient education, psychological counseling, risk factor assessment and behavior modification counseling, vocational counseling, and work evaluation. One of the goals of cardiac rehabilitation is to increase functional capacity in coronary patients. This improvement can be demonstrated by an improved tolerance to large muscle dynamic exercise which can translate into enhancement in daily living activities, reduction in the expression of symptoms, and hopefully reduction in the risk of recurrent cardiac events (AACPR, 1995).

Cardiac Rehabilitation usually progresses in four phases ranging from inpatient to outpatient care. Inpatient cardiac therapy takes place in the hospital, over the 1-6 days following a cardiac event, such as a myocardial infarction or coronary artery bypass graft surgery. Early outpatient cardiac rehabilitation is an outpatient treatment service that takes place weeks after a coronary incident occurs and usually lasts 8-12 weeks. This is the most closely monitored phase of rehabilitation. Transition to a self-monitored phase is only permitted when patients demonstrate adequate safety and behavior outcomes. This phase is intermediate in nature in which patients are not as intensely monitored. Maintenance is the final phase of cardiac rehabilitation consisting of a long-term maintenance program of modified lifestyle changes and exercise. This phase can last indefinitely (AACPR, 1995).

Statement of the Problem

Third-party insurance coverage of cardiac rehabilitation services varies considerably among payers and, even when coverage is available, patient eligibility typically is limited to no more than 36 sessions in a defined calendar period. Often, telemetry monitoring of the ECG is a requisite for coverage. In some cases, providers specify criteria to exclude from coverage all but the high risk and most physically limited patients. These patients must receive coverage and begin participation within a few weeks following their cardiovascular episode of myocardial infarction or surgical revascularization. Traditionally self-monitored and maintenance phases are provided at personal cost to the patients. Conversely, inpatient and early outpatient cardiac rehabilitation is mainly funded via third party payers who reimburse healthcare providers for patient care. Increased numbers of people living with heart disease combined with more sophisticated treatment methods have added greatly to the cost of cardiac rehabilitation. The increased cost of global health care has resulted in the need for economic justification for all components of health care including cardiac rehabilitation. This economic justification was recently demanded by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) and Medicare, along with the Commission on Accreditation of Rehabilitation Facilities. This came in the form of a mandate requiring rehabilitation programs to evaluate patient outcomes resulting from the services they provide. This prompted the (AACVPR), a national organization for cardiac rehabilitation, to publish a new edition of guidelines for cardiac rehabilitation programs. In order to facilitate universal outcome studies the guidelines evaluate three domains which are to be measured during rehabilitation: These domains include a health domain, clinical domain and a behavioral domain (AACVPR, 1995).

To date many studies have been performed on the potential benefits of exercised-based cardiac rehabilitation on various outcomes in the health, clinical, and behavioral domains. However, traditionally much of the research has concentrated on the clinical domain, and specifically in the area of functional capacity. Most of these studies have demonstrated an increase in functional capacity after rehabilitation post-infarction or post-revascularization patients (AACVPR, 1995).

Fioretti and colleagues demonstrated an increase in work capacity that averaged 33% in a group of 141 post-infarction patients over three months of exercise rehabilitation (Fioretti, Simons, Zwiers, Boardman, Brower, Kazermirm and Huguenholtz, 1987).

Studies performed on coronary bypass surgery patients demonstrated increases in functional capacity ranging from 14% to 66% after three to six months of exercise training (AACVPR,1995). In most of these studies, VO_2 max was used to assess physiological changes after training. More recent studies have utilized sub-maximal outcome markers to measure these functional capacity changes. These researchers feel sub-maximal outcomes are a more relevant and accurate measurement tool for this population (McKinnis & Balady 1994, Redwood, Rosing & Epstein, 1972).

Exercise in general has been shown to have many other potential benefits for CHD patients including improved cardiovascular efficiency, improved biomechanical efficiency, lower perception of effort for sub-maximal work, improved myocardial perfusion, reduced athersclerotic risk factors for progression of CHD, reduced recurrent CHD events and improved counteraction to the deleterious effects of physical inactivity (Pierson, Herbert, Davis & Southard, 1997). In clinical settings, these improvements in "total body" efficiency allow patients to exercise at higher intensities, thus delaying the onset of limiting symptoms such as chest pain and leg cramping. Most of these exercise induced improvements are interrelated and can be explained through more efficient oxygen transport. The beneficial changes may be illustrated through consideration of the Fick equation: VO_2 = Cardiac Output x arterial - venous oxygen difference. It has been demonstrated that with chronic increases in physical activity, a "training effect" can be achieved through a multitude of cardiovascular, skeletal muscle, and neurohumoral adaptations (Hamm & Leon, 1992). "In healthy subjects exercise conditioning occurs in response to repeated bouts of aerobic exercise through both cardiac and peripheral adaptations that result in an increased maximal cardiac output and an increased capacity to use oxygen peripherally" (Ades, Grunuald, Weiss & Hanson, 1989). In coronary patients, these adaptations are believed to occur primarily at the peripheral level, although studies have demonstrated, central adaptations also may occur in this population with proper intensity and duration (Ades et al. 1989).

These positive alterations in functional capacity are not evidenced in all cardiac patients following rehabilitation (Gamble & Froeclicher 1982). Inertly cardiac rehabilitation can be expensive and carry risks (Van Camp & Peterson, 1986). Accurate outcome measurements should be devised to quantify the success or failure of cardiac rehabilitation. This information could help formulate variables which are related to the success or failure of individual patients in cardiac rehabilitation based on initial data. These predictor variables could also be made into guidelines used by physicians or therapists prior to admission in cardiac rehabilitation in order to minimize patient risk and justify third party reimbursement. These variables would not preclude patients from cardiac rehabilitation, but would allow therapy to concentrate on behavior intervention treatments such as information, education, counseling, and risk factor modification.

Purpose

The purpose of this study was to investigate the utilization of baseline clinical, exercise test and psychosocial variables to predict improvement or decline in exercise tolerance in cardiac patients who participate in early outpatient cardiac rehabilitation

Significance of the Study

To date many of the studies performed attempted to identify patient characteristics which could be utilized to predict the magnitude of change in patient functional capacity following rehabilitation (Fioretti et al., 1987, Ades et al., 1989, Hammond, Tamsin, Froelicher & Pewen, 1985, Carter & Amundensen, 1977). These studies utilized data collected from (1) treadmill tests and (2) radionuclide studies, as well as various combinations of (3) clinical variables. Hamond, Tamsin, Froelicher and Pewen utilized all three of these methods in a study which attempted to predict the magnitude improvement in the exercise capacity of 59 post MI patients after one year of rehabilitation. They found no initial features which could predict of the magnitude of training success (Hammond et al., 1985). Des PA, Granular MH, Weiss RM and Hanson TS performed a similar study on 106 patients post MI or coronary bypass grafting, and concluded that after three months of rehabilitation the magnitude of exercise conditioning response was greater in non ischemic patients (69%) than ischemic patients (50%) (Ades et al., 1989). Another study also assessing the magnitude of improvement proved unsuccessful in determining the extent of improvement in work capacity of 141 post MI patients following three months of rehabilitation (Fioretti et al., 1987). Carter et al. had similar negative results when attempting to investigate the effects of infarct size on the magnitude of training effect in 22 patients following four months of rehabilitation (Carter & Amundensen, 1977). The lack of conclusive predictor variables elicited by these studies could be attributed to several factors; (1) the use of estimated peak oxygen to quantify functional capacity improvement, (2) the measurement of the magnitude of change in functional capacity and (3) the lack of pychosocial data.

A study performed by Van Dixhoorn J, Duiveneoorden HJ, and Pool J utilized initial clinical data, psychosocial data, and exercise test data to predict success or failure in 156 post MI patients following five weeks of rehabilitation. Using a composite-based criterion, patients were categorized in one of three training outcomes: (1) no change (2) improved and (3) deteriorated. This study showed work status before infarction to be the greatest predictor of success and psychological variables (such as Type A behavior, well-being, and depression) to be the greatest predictor of failure (Van Dixhoorn, Duivenvoorden, Verhage, Kazemier & Hugenholtz, 1986). Pierson et al. utilized a similar model in a study which assessed baseline clinical and exercise test variables for improvement or decline in 60 self-monitored an maintenance phase cardiac patients. Using a sub-maximal outcome measure, this study demonstrated the ability to predict improvement in these patients. However, this study was unable to predict failure in the same population. The author attributed this to the lack of psychosocial data (Pierson et al., 1997). Psychosocial variables have been shown to predict both psychosocial outcomes and physical training effects (Erdman et al., 1986, Diederiks, Van Der Sluijs, Weeda & Schobre, 1983, Mayou, 1984, Wiklund, Vedin, Wilhelmsson, 1984, Rejeski, Morley & Miller 1984, Williams Haney & McKinnis, 1986). These studies serve as important templates for the accurate outcome measurement research. This research should be targeted towards populations such as early outpatient cardiac rehabilitation patients, where predictor variables could provide minimized patient risk and economic justification for financial allocation.

The present study examined this issue using a similar design as described by Pierson (Pierson et al.,1997), but in the context of an early outpatient treatment group of cardiac rehabilitation patients. Rather than using treadmill test data, as in the study by Pierson, this investigation used sub-maximal exercise data from early vs. late exercise rehabilitation sessions by which to evaluate the cardiorespiratory fitness outcome. This study also assessed the patient files of early outpatient cardiac rehabilitation participants, with the aim of discovering predictor variables for a population where economic justification in the form of outcome based research is most warranted.

Research Hypotheses

The following hypotheses were identified for this study:

Ho1: No set of patient attributes could be identified using variables from clinical, psychosocial, and exercise domains to provide a means for predicting those who would manifest a improvement in exercise tolerance after exercise training, (in patients with diagnosed coronary artery disease).

Ho2: No set of patient attributes could be identified using variables from clinical, psychosocial and exercise domains, to provide a means for predicting those who would manifest a decline in exercise tolerance after exercise training, (in patients with diagnosed coronary artery disease).

Description of Patient Sample, Inclusion and Exclusion Criteria

The data from this study was extracted retrospectively from the clinical records of patients who had participated in early outpatient cardiac rehabilitation at Carolinas Medical Center in Charlotte, North Carolina from October, 1995 to March, 1997. Patients' records must have been completed with initial GXT tests, exercise prescription, QOL data, and individual session reports. Records were included only if the patient had been admitted to the rehabilitation program on the bases of: MI, coronary revascularization, physician-diagnosed angina, or angiographically confirmed CAD. Cases were excluded for any of the following reasons: failure to complete 8-12 weeks of cardiac rehabilitation; failure of the patient to attend at least 70% of exercise sessions; a documentation of a change in prescription of medications during the training program, which could potentially alter hemodynamic responses or symptoms; records which demonstrate inconsistency in order of treadmill exercise from beginning to end of rehabilitation.

Delimitations

The following delimitations were posed upon the investigation;

1. The study was confined to records in the files of patients who participated in the rehabilitation program at Carolinas Medical Center between October, 1995 and March, 1997.
2. The study was confined to patients with a recent myocardial infarction, coronary revascularization procedure, physician diagnosed angina, or angoigraphically confirmed coronary artery disease.
3. The study was confined to patients who had recorded data from a graded exercise test.
4. The study was presumably confined to patients whose records demonstrated consistency in the order of treadmill exercise modality, in circuit routine, from beginning to end of rehabilitation.
5. The study was confined to patients who participated in 8-12 weeks of rehabilitation.
6. The study was confined to patients who did not have changes in prescription of medications that would alter their hemodynamic responses or symptoms during the 8-12 weeks of rehabilitation.

7. The data for each subject was confined to information available in the patient files only.
8. The study was confined to patients who had QOL information on file.
9. The study was confined to patients who had a minimum of 70% attendance to the exercise sessions during 8-12 weeks of rehabilitation.

Limitations

The following were viewed as important constraints that would limit the interpretation of the data:

1. The possibility that some inconsistency occurred with respect to different technicians recording
and monitoring blood pressure, RPE, heart rate, and work levels of patients during graded exercise test and exercise sessions.
2. The possibility that some inconsistency occurred in the systematic increase of work level, according to RPE, heart rate and symptoms (Mahler, Froelicher & Miller, 1995).
3. During initial maximal graded exercise test, test termination criteria may not have been uniformly applied, as different physicians supervised the test, hence affecting initial exercise prescription.
4. The inability to control work intensity in modalities not including treadmill.
5. The possibility that order of exercise was not held constant throughout the 8-12 weeks of rehabilitation.

Basic Assumptions

The following assumptions have been made by the investigator:

1. All graded exercise tests administered elicited a true patient max or peak as standardized by ACSM.
2. All exercise sessions were properly monitored by trained technicians..

3. Within the rehabilitation exercise program, each patient's progression of loading was done in accordance with the ACSM standards.
4. Hemodynamic responses, RPE, symptoms and medications were monitored at every exercise session, and all changes were recorded.
5. Proper metabolic equivalence was programmed for each exercise modality.
6. All equipment was properly calibrated.
7. Self monitoring of pulse and RPE were correctly taken and recorded by patients, in all modalities excluding treadmill.
8. Treadmill EKG monitoring was taken and recorded in a systematic manor by trained technicians.

Definitions and Symbols

The following are definitions and symbols for key words used in this study:

Angina- chest pain caused by a lack of adequate blood supply to the heart.

Cardiac Output- the product of stroke volume and heart rate; this is the volume of blood pumped each minute from the left ventricle.

Diastolic Blood Pressure (DBP)- the arterial pressure during the diastolic phase of the heart cycle(ventricle relaxation)

EKG- electrocardiogram

Graded Exercise Test (GXT)- a multistage test which is used to determine a patient's physiological responses to increased intensities of exercise with the hope of obtaining peak aerobic capacity.

Metabolic Equivalent (MET) - the unit used to estimate the metabolic cost of physical activity. Resting metabolic rate = 3.5 ml of oxygen per kilogram of body weight per minute.

Modalities- this refers to the type of exercise performed. For this study, they will include 3 of the following; Treadmill, Schwinn Air Dyne, Stair Master, arm ergometer or recumbent bike.

Oxygen Consumption (VO_2)- the rate which oxygen is utilized by the bodies' aerobic system; expressed in L/min or ml/kg/min.

Systolic Blood Pressure- the arterial pressure during the systolic phase of heart cycle (ventricle contraction).

Dartmouth Coop Charts- utilized the following nine pictorial charts to assess patient physical, mental and social function: physical, emotional, role and social function, overall health, change in health ,pain, overall quality of life and social support.

Summary

There has been a recent demand for accurate outcome measurements which would evaluate exercise tolerance changes that result from rehabilitative exercise. This study presented an innovative approach of quantifying success or failure in achieving cardiorespiratory fitness outcomes during cardiac rehabilitation based on sub-maximal treadmill exercise data. This data was continual in nature assessing the changes which occurred in patients predicted VO_2, exercise heart rate and body weight during 8-12 weeks of early outpatient cardiac rehabilitation. These results were utilized along with baseline clinical, exercise, and psychosocial data to predict improvement vs. no improvement and decline vs. no decline outcomes. These outcomes can prove to be helpful in selecting patients and treatment options which would yield higher success rates while conserving health care resources. The ability to predict training outcome can provide both cardiac rehabilitation programs and third party payers with justification for resource investment as demonstrated by a patient's success or failure.

CHAPTER II
REVIEW OF LITERATURE

Introduction

This review begins with a brief definition and description of cardiac rehabilitation and the patients who are candidates for these services. The review will progress to a discussion of the cost, risk, and future direction of cardiac rehabilitation in the presence of financial scrutiny. This discussion will include the recent third party demand from healthcare and Medicare organizations for outcome based research.

The next section includes physiological adaptations to exercise in CAD patients. The review of studies performed on post MI, post CABG, Angina, and patients with severely depressed left ventricular function will provide the reader with an understanding of how a "training effect" can be quantified in this population. This section is followed by a discussion and literature review on psychosocial influences in predicting both psychosocial and "training effect" outcomes, both of which are crucial components of the present study. The final section provides the reader with a review of previous research performed in the area of predicting both the magnitude and presence of "training effect", based on initial data, in CAD patients.

Coronary Artery Disease and Rehabilitation Programs

Coronary artery disease is the leading cause of death in the United States. In 1986, it was estimated that 1 million people died from CAD and one out four of people (young and old) had cardiovascular disease, costing an excess of 72 billion dollars. However between the years 1979-1989, a 30% decrease in the mortality rate for coronary artery disease was evidenced (Oldridge, Foster & Schmidt 1988). The Framingham study contributes these findings to improved treatment methods and improved prevention methods. In 1988 Frey et al. performed a similar study which illustrated a 20% decline in mortality from heart disease, but demonstrated a 6% increase in the prevalence of CAD. These findings suggest that fewer people are dying from heart disease, but more people are living with it as a chronic condition. More recent research has estimated that the prevalence of CHD will increase up to 30% by the year 2015, while the number of incidents of fatalities due to heart disease will decrease by up to 25% (Frey, Higgins, & Smith 1988). The increasing number of people living with this disease has lead to the advent and growth of rehabilitation programs which address the following issues; "efficacious risk factor reduction, behavioral intervention, exercise rehabilitation and medical and surgical management"(AACVPR, 1995).

Cardiac rehabilitation was introduced three decades ago, in 1960's, when researchers discovered patients who remained active had better recoveries compared to their sedentary counterparts (AACVPR, 1995). Today cardiac rehabilitation has expanded its focus to more than just exercise. This is evidenced through a recent definition found in AACVPR guidelines " Cardiac rehabilitation is the process by which persons with cardiovascular disease (including but not limited to patients with coronary heart disease) are restored to and maintained at optimal physiological, psychological, social, vocational, and emotional status",(AACVPR, 1995). These goals are achieved during four phases of recovery. Inpatient hospital based is the most acute phase, lasting from 1-14 days post acute event or invasive procedure. Immediately following the initial phase, the patient enters the outpatient hospital based setting for 8 to 12 weeks. This is the most closely monitored phase of rehabilitation. Transition to the hospital or community based outpatient maintenance is only permitted when patients demonstrate adequate safety and behavior outcomes. This phase is intermediate in nature where patients are not as intensely monitored. The final phase, consisting of a long-term maintenance program can last indefinitely (AACVPR,1995).

Cost and Risk of Cardiac Rehabilitation

In combination, Medicare programs, the aging population, and the advent of technological advances have dramatically raised the cost of health care over the past four decades. Health care costs exceed 500 billion dollars annually in the U.S. alone. Wittels, Hay & Golton, 1990, estimated the five-year cost to exceed $50,000 for some CAD patients and estimated the five-year cost of coronary bypass and angioplasty surgery to be 32,000 and 20,000 respectively. Cardiac rehabilitation in the United States costs the health care system more than 240 billion dollars annually (Wittels, Hay, & Golton 1990). However many researchers argue that the benefits of these programs more than offset the costs. Levin, Perk & Hedback 1991, concluded that five months of cardiac rehabilitation resulted in earlier return to work and decreased readmission into hospitals which translated into lower costs and positive health effects. Similar studies also demonstrated cardiac rehabilitation patients to have decreased outpatient medical costs, lower rehospitalization rates and fewer days of rehospitalization (Ades, Huang & Weaver 1992; Picard, Dennis, Schactz, Ahn, Kraemer, Berger, Blumberg, Helter, Lew & Debusk 1989; Oldridge, Furlong, Feeny, Torrance, Guyatt, Crove & Jones 1993; Bondstam, Breikss & Hartford 1995).

Inherent with any rehabilitation program is patient risk and safety. There have only been a few studies performed, which have assessed patient risks in cardiac rehabilitation programs. Van camp and Peterson, 1986, assessed 167 outpatient programs in the United States., and calculated only one cardiovascular event to occur for every 81,101 patient hours of exercise. An earlier study performed by Haskel ,1978, demonstrated similar findings.

Future Directions of Health Care and Cardiac Rehabilitation

Despite studies demonstrating cardiac rehabilitation to be both cost effective and safe, recent economic justification was suggested by the Joint Commission on Accreditation of Healthcare Organizations (JCAHO), Medicare and the Commission on Accreditation of Rehabilitation Facilities. This came in the form of a mandate that rehabilitation programs evaluate patient outcomes. This prompted the (AACVPR), a national organization for cardiac rehabilitation, to publish a new edition of guidelines for cardiac rehabilitation programs (AACVPR, 1995), which suggested three domains of patients and measures to be measured during rehabilitation to facilitate universal outcome studies. These domains include a health domain, clinical domain and a behavioral domain.

The future of cardiac rehabilitation calls for accurate outcome measures, which could be used to quantify success or failure of cardiac rehabilitation programs. This information could also help formulate variables, which relate to the prediction of success or failure of individual patients in cardiac rehabilitation, based on their initial data. These predictor variables could be made into guidelines used by physicians and therapists prior to patient admittance into cardiac rehabilitation, and might lead to more consistent attainment of outcomes for individual patients, while stabilizing the costs of such care.

Evidence of Training Effect in CAD Population

Through exercise, CAD patients traditionally demonstrate a lower HR and RPE at any matched submaximal workload after training (Pierson, Herbert, Davis and Southard 1997). The following section reviews training studies done on various subsets of CAD patients including post-MI, post CABG, angina pectoris, and patients with severely depressed left ventricular function.

Post MI Patients

The positive effects of exercise training on post MI patients have been well established. Studies have demonstrated that exercise training results in an improvement in systemic oxygen transport, a reduction in myocardial oxygen requirement for a given amount of work, and a decrease in the extent of ischemia during physical activity (Squires, Gau, Miller, Allison and Lavie 1990).

Tsoukas, Andonakoudis & Christakos, 1995, studied the effects of short-term exercise training on the submaximal heart rate, blood pressure, rate pressure product (SBP x HR) and ST changes in post MI patients. This study utilized 100 patients 60 were exercised at modest intensity for three months while the remaining 40 served as controls. As submaximal treadmill test was performed a week after discharge and again three months later. When comparing post vs. pre-submaximal test data, the test duration was longer ($p < .01$), while heart rate ($p < .001$), systolic blood pressure ($p < .01$) and rate pressure product ($p < .01$), and the onset of ST depression were attenuated ($p <.01$). Taken together, this evidence demonstrated that post-infarction short-term exercise training could increase exercise tolerance, decrease heart rate, blood pressure and double product response to exercise while also improving the ischemic threshold.

Hung, Gordon, Houston, Haskell, Goris & Debusk, 1984 studied the effect of exercise training on exercise tolerance in 53 acute post-MI male (AMI) patients. Twenty three men (23) were randomized to exercise training and 30 randomized to no training. Exercise thallium myocardial perfusion scintigraphy and equilibrium gated radionuclide ventriculography were used to assess changes in exercise myocardial perfusion and left ventricular function between 3, 11 and 26 weeks after AMI. These patients' protocol consisted of cycle ergometer exercise at 70-85% of baseline HR, five times a week with 30 min/sessions for 11 weeks. At 26 weeks post-infarction, a follow-up exercise group demonstrated a significant increase in exercise capacity when compared with the control group.

Stern, Gorman & Kaslow, 1983, studied the effects of exercise therapy or group counseling in 106 post-MI patients. The exercise group consisted of 38 patients who participated in three 1-hour dynamic exercise sessions per week for a total of 12 weeks. Exercise intensity was set at 85% of predicted maximal baseline heart rate. The counseling group consisted of 31 patients and 22 patients were assigned to a control group In this study, exercise substantially increased the mean work capacity and decreased fatigue after three and six months of exercise training for exercise group compared to other 2 groups. However, after 12 months these significant changes were not reported when comparisons were made between counseling and control groups.

Post CABG Patients

Exercise therapy has also been demonstrated to have a positive physiological effect on patients following revascularization. A few of these studies are presented below.

Wosornu, Allardyce, Ballantyne & Tansey, 1994, studied the effects of aerobic and power exercise training on the homeostatic factor after CABG in 55 males within six months of surgery. Exercise groups trained three times a week for six months with varied intensities based on sub-grouping (aerobic or power), while the control group did no formal exercise. This study demonstrated that exercise capacity, in control, did not change while the aerobic exercise group showed an improvement in treadmill exercise tolerance, and power training demonstrated less of an improvement in exercise tolerance when compared with aerobic exercise group.

Foster, Pollock, Anholm, Squires, Ward, Dymond, Rod, Saichek & Schmidt, 1984, studied the effects of exercise therapy in 28 CABG patients. These patients were assigned to either an exercise or control group. The exercise group was required to perform one hour of aerobic activity three times per week for a total of 24 weeks. The exercise intensity was set at 50-70% of the heart rate reserve. The exercise group in this study demonstrated a significant increase in exercise tolerance when compared to the control group.

Angina Pectoris Patients

Many studies have demonstrated exercise training to have a positive effect on the onset of exertional symptoms like angina pectoris in patients. These patients have shown the ability to work at higher workloads before becoming symptomatic, as the result of exercise therapy.

Todd & Ballantyne, 1992, conducted a study to examine the effect of prolonged high intensity training on 40 ischemic men with chronic stable angina pectoris. Through this study, they concluded that exercise training reduced total ischemic burdens in patients with angina pectoris by reducing the frequency and duration of all ischemic episodes. This was demonstrated by a 30% reduction in the frequency of ST depression.

Todd et. al., 1991, performed another study on the effects of high-intensity exercise on myocardial perfusion in 40 males with stable angina pectoris. These patients' ischemic defects were assessed using circumferential profile analysis. Patients were then randomly assigned to exercise or control groups. Exercise group performed formal high intensity training for a period of one year, utilizing the Canadian Airforce plan for physical fitness. After one year patients were restudied demonstrated a 34% reduction in overall ischemia ($p < 0.02$). Regional analysis showed marked improvement in perfusion throughout the heart. These results support the belief that exercise training improves myocardial function by enhancing collateral circulation.

Patients with Severely Depressed Left Ventricular Function

Exercise training has been demonstrated to be beneficial in patients with conditions including coronary artery disease, post-MI, and post CABG, when left ventricular function and ejection fraction are relatively well preserved. Patients who have severely limited ventricular function due to a large MI are at greater risk not to succeed in exercise therapy as well as to suffer from an exercise induced injury. However, these risks should not preclude them from exercise training, as demonstrated by the following studies.

Carter, Damri & Snir, 1992, studied the effects of exercise training on 12 patients with an ejection fraction less than 30%. These patients performed isotonic exercise for a total of 11 months. Results demonstrated a mean left ventricle ejection fraction increase of 28% to 33% ($p<.0002$) at rest and 29.4% to 33.2% ($p<.0002$) during exercise. Significant increases were also seen in exercise tolerance and double product (symptom limited), and a decrease was seen in double product for a defined sub-maximal workload post training. Patients returned to work within a mean of 3.7 months. This study demonstrates the potential benefits of exercise based cardiac rehabilitation for patients with severe left ventricular impairment.

Scalvini, Marangoni, Volterrani, Schena, Quadri& Levi, 1992, studied the effects of five weeks of bicycle training on 12 post-MI patients with left ventricular dysfunction. These patients were separated into two groups according to their initial VO_2 data. Cardiopulmonary and hemodynamic parameters were evaluated during maximal testing along with a catherization pre and post training. The group with the higher initial VO_2 demonstrated significant improvements in minute ventilation and VO_2, while the group with the lower initial VO_2 demonstrated no significant changes in these parameters. This study demonstrates exercise training to improve exercise tolerance in mildly depressed cardiac patients while the more severely depressed cardiac function group did not elicit these positive alterations.

Sulivan, Higginbotham & Cobb, 1988, investigated the effects of exercise training in 12 patients with an ejection fraction ranging from 10-33%. This exercise protocol consisted of a one hour session of exercise at an intensity of 75% of VO_2 peak, 3-5 times a week for four to six months. The results demonstrated a decrease in resting and exercise heart rate as well as an increase in VO_2 peak. Although cardiac output did not improve, the fact that blood lactate levels were decreased could be attributed to peripheral adaptations.

These studies demonstrate that although patients with left ventricular depression are less likely to succeed in exercise based rehabilitation, positive cardiovascular adaptations can occur in this population.

The Effects of Psychosocial Variables in Exercise Training

It has been well reported that exercise based cardiac rehabilitation results in both physiological and psychological benefits. The psychological benefits include the reduction of emotional symptoms as well as the modification of long-standing habits deemed to be detrimental to patients cardiac health. Many studies have investigated the various psychosocial variables associated with post-MI patients.

Many studies have proved successful in predicting psychosocial outcomes, but only a few studies have investigated the prediction of the training effect.

Predicting Psychosocial Outcomes

Erdman, Duivenvoorden, Verhage, Kazemier & Hugenholtz ,1986, examined the effects of cardiac rehabilitation on 80 post-MI patients' psychological functioning, resumption of work, habitual exercise, and smoking habits over a five year period. These patients were randomly allocated to six months of systematic rehabilitation or home rehabilitation. Patients were tested at baseline, after six months of rehabilitation and then five years later. Patients who participated in rehabilitation demonstrated healthier habits, were quicker return to work and exercise more regularly when compared with home exercisers.

Wiklund, Sanne, Vedin & Wilhelmsson ,1984, performed a study examining psychosocial variables including mental state, health preoccupation, leisure activity, avoidance behavior, sexual activity and attitude towards life in 177 males, one-year post MI. A reference group of

175 non-MI subjects was used as a control group. Brief interviews and questionnaires were utilized to assess psychological and social data while the somatic variables were collected via medical examination. Results of this study indicated that after two months patients reported frequent emotional distress, avoidance behavior, self-reported symptoms, overprotection, pessimism and diminished sexual activity. They demonstrated poor adaptation when compared to controls. This study suggests that intervention should take place early during rehabilitation concentrating on not only the cardiac condition, but on psychological factors as well.

Mayou et al. performed a study which utilized multiple logistic regression to analyze the extent to which early findings can predict later psychological and social outcomes in two series of patients. Data was gathered from two studies comprising of 129 and 100 post MI patients. These patients were assessed at three stages: immediately post MI, early convalescence, and late convalescence. Ratings were derived via interview and included information obtained from spouses. This study concluded that prediction of emotional and social outcome is difficult during the hospital stay, however prediction improves considerably when assessments are made during convalescence phases. The following variables were defined in this study as possible predictors: cardiological, psychological factors, pre-morbid social adjustments, family support, demographic factors, and early progress. These findings suggest that it is possible to identify patients at risk for psychosocial morbidity during early convalescence.

It is evident through these studies that cardiac incidents can lead to a multitude of psychological repercussions. Only a few studies have examined the ability of psychosocial data to predict physical training effect.

Prediction of Training Effect Utilizing Psychosocial Variables

Rejeski, Morley, & Miller, 1984, examined the multivariate relationship between scores from the Jenkins Activity Survey (JAS) and various exercise parameters including intensity, attendance, and MET gain in 57 patients attending cardiac rehabilitation. The JAS identifies patients with type A psychological profile yielding sub-scores including composite A, sub-scale, impatience, hard driving competitive behavior and job involvement. All subjects filled out Jenkins Activity Survey (JAS), GXT pre and post three months of exercise training which included 35 minutes of jogging/walking at 60-85% of max HR. Changes in MET level were correlated with sub-scales from JAS. The results of this study demonstrated that MET improvement co-varied with JAS- defined type A behavior.(Rejeski, Morley & Miller 1984).

Williams, Haney, McKinnis, Harrell, Lee, Pryor, Calif, Kong, Rosati, & Blumenthal, 1985, performed a study with the aim of identifying psychosocial and physical characteristics that independently predict angina relief in 570 patients. However a subset of 382 patients who were diagnosed with NYHA class III or IV angina. Psychosocial variables assessed included a broad range of psychological (MMPI) and social (social support, work status, functional level, Type A behavior) characteristics. Follow-up data collection took place six months and one year following angiography. Results demonstrated three social, psychological and physical characteristics to be significant predictors of angina pain at six month follow-up: MMPI hypochondrias score, work status and percent stenosis of the right coronary artery. The findings from this study indicate the possibility of finding descriptors which allow discrimination between angina suffers who will have relief after six months of medical management versus those who will not under similar conditions. Williams, Haney, McKinnis, Harrell, Lee, Pryor, Calif, Kong, Rosati, & Blumenthal)

Van Dixhoorn & Duivenvoorden, 1990, attempted to predict success or failure of exercise training in 156 patients post-MI patients based on their initial clinical information, psychosocial data and initial exercise test data. Patients underwent five weeks of cycle ergometer training once a day for 30 minutes. Well being in-patients was assessed via Heart Patients Psychological questionnaire, anxiety was measured via the state trait anxiety inventory (STAI), and sleeping habits and functional symptoms type A behavior (JAS) and vital exhaustion were also measured. Logistic regression analysis demonstrated the ability to identify psychosocial variables including work status to be the single greatest predictor of success and psychological variables including type A behavior, well being and depression were important for predicting failure, but not success.

Milani, Littman & Lavie, 1993, investigated the impact of depressive symptoms on functional improvement and risk modification in 77 early outpatient cardiac rehabilitation patients. At baseline, patients were exercise tested, functional capacity was assessed via NYHA classification and blood work was taken. Depressive symptoms were assessed via questionnaire at program entry. Groups were made according to presence of depressive symptoms, 16 acknowledged depressive symptoms and 61 denied symptoms. Exercise protocol consisted of 30-40 min of continuous exercise at 70-85% max HR two to three times per week. Results demonstrated similar baseline characteristics between the two groups, however after training METS improved by 26% in group II (non-depressive) compared with only 11% in depressive group I (depressive). These results demonstrate the ability to predict improvement in functional capacity based on the presence of depressive symptoms.

Predicting of Physical Training Outcomes Effect in CAD Patients Population

It has been well documented that exercise based cardiac rehabilitation has a positive effect on work capacity in most patients with coronary artery disease. Accordingly, many studies have attempted to identify initial baseline variables, which could be used to predict both magnitude and presence of work capacity improvements in this population. This would allow clinicians and therapist to refer patients with low initial success potential to alternate options including behavior modification and relaxation therapy.

Predicting Magnitude of Change

Hammond, Kelly, Froelicher & Pewen, 1985, conducted a retrospective investigation on data from 59 patients following one year of cardiac rehabilitation. The purpose of this study was to determine whether clinical data could be used to predict training effect, investigating the role treadmill and radionuclide tests play in this prediction and determine if intensity of training could predict beneficial changes. Exercise protocol consisted of 45 minutes of aerobic training at 60-85% VO_2 max three times a week. After one year exercise records were reviewed and examined on a month by month basis. GXT test, ST segment analysis, thallium scintiography and radionuclide ventriculography were assessed before and after one year of exercise. Clinical descriptors and exercise test results were entered into a computerized database and used to retrospectively predict patients training response. Results demonstrated poor correlation between any of the initial features and training effect. This study was unable to predict the magnitude of change in training ability based using initial measurements after one year of exercise based cardiac rehabilitation.

Ades, Grunvald, Weiss & Hanson, 1989, attempted to predict the magnitude of work capacity increase based on myocardial ischemia in 106 coronary patients following 12 weeks of cardiac rehabilitation. A graded exercise test was performed at entry to obtain VO_2 and angina results. Two groups were formulated based on ishemic response.Exercise protocol consisted of 36 sessions of aerobic exercise 45 minutes per session at 70-85% VO_2 max. The magnitude of exercise conditioning response was greater in the non-ischemic group when compared to ischemic sufferers illustrated by increases in VO_2 max of 28% and 10% respectively. This study demonstrated the presence of exercise-enduced ischemia to have a predictive capability in exercise training effect.

Carter & Amundsen, 1977, performed a study which investigated the relationship between infarct size and exercise capacity in 22 post-MI patients following three to four months of exercise training. Infarct size was estimated based on serum creatine phosphokinase level changes as a function of time. Subjects were given an initial GXT test and participated in outpatient cardiac rehabilitation consisting of 20 minutes of aerobic exercise at 85% VO_2 max three times per week. Post training testing demonstrated a significant increase in aerobic power vs. controls (SE mean 1.42). However, the results did not demonstrate a significant relationship between increase in aerobic power and infarct size. According to this study, size is not a predictor of training effect when defined as improvement in aerobic power.

All of these studies demonstrate only moderate success in the prediction of magnitude of training effect change in patients with coronary artery disease. However more recent studies, using initial data to predict the presence of change, have elicited more promising results.

Predicting Presence of Change

Van Dixhoorn & Durvenvoorden, 1990, attempted to predict success or failure of exercise training in 156 post MI patients based on clinical information, psychosocial data and initial exercise testing data. This study utilized a composite criterion to obtain a single outcome measure including three categories; positive (79), negative (42) and no change (35). This criterion served as the indicator of training success or failure after five weeks of 30 minutes of daily interval training at 70-80% max heart rate. This study utilized stepwise logistic regression to predict outcome based on sets of the following variables; (1) medical histories and hospital records (2) interviews, (3) exercise testing and (4) psychological questionnaires. Results demonstrated mean max work load to increase from 134 to 142 watts ($p < 0.0001$) and HR to decrease at equal highest work load from 134 to 139 bpm ($p<0.0001$).Training success was observed in 50% of patients, but a substantial percent of the patients (27%) demonstrated failure and the remaining (33%) were categorized as no change. The chief predictor of training success seemed to be work status before infarct, while the main predictor of failure seemed to be psychological variables. This study demonstrated the ability to predict both success and failure in post-MI following exercise based rehabilitation.

Pierson, Herbert, Davis & Southard, 1996, performed a similar study evaluating the effects of baseline clinical and exercise test variables in the attempt to predict success or failure in 60 maintenance phase cardiac rehabilitation patients. Clinical records were extracted retrospectively from patients who participated in exercise training three days a week for 5-8 months. Pierson et al. utilized a similar composite criterion as the before mentioned method developed by Van Dixhoorn et al., making sub-maximal RPP an outcome measure. Treadmill data was gathered pre and post training and subsequent analysis and comparisons yielded 37 (62%) patients in improvement group, 13 (22%) in no change group and 10 (17%) in decline group. This study demonstrated low initial level of fitness as the single greatest predictor of training success, however it was unable to predict training failure. The author attributes this inability to the lack of psychosocial data.

Summary

The studies in this review demonstrate that initial fitness levels and depression are predictors of training outcome in CAD patients following exercise. Mixed results indicate the following variables as possible predictors of training effect: (1) beta blocker medication, (2) the presence of angina pectoris or myocardial ischemia and (3) exercise training duration.

Chapter III

JOURNAL MANUSCRIPT

PREDICTING PHYSICAL FITNESS OUTCOMES IN CARDIAC REHABILITATION PATIENTS

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PREDICTING PHYSICAL FITNESS OUTCOMES IN CARDIAC REHABILITATION PATIENTS
by
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(ABSTRACT)

Economic justification for rehabilitative services has resulted in the need for outcome based research which could quantify success or failure in individual patients and formulate baseline variables which could predict outcomes. The purpose of this study is to investigate the utilization of baseline clinical, exercise test, and psychosocial variables to predict clinically relevant changes in exercise tolerance of cardiac patients who participated in early outpatient cardiac rehabilitation. Clinical records were analyzed retrospectively to obtain clinical, psychosocial and exercise test data for 94 patients referred to an early outpatient cardiac rehabilitation program at a large urban hospital in the Southeast US. All patients participated in supervised exercise training 3d/wk for 2-3 months. A standardized training outcome score (STO) was devised to evaluate training effect by tabulating changes in patients predicted VO_2, body weight and exercising heart rates after 8-12 weeks of exercise based cardiac rehabilitation. *STO = Predicted* VO_2 *change + BW change- HR change.* The Multi-Factorial Analysis was applied to derive coefficients in the STO formula so that the STO scores reflected the independent effects of BW, HR and Predicted $V0_2$ changes on training outcome. Patients were classified into one of three possible outcome categories based on STO scores, i.e. improvement, no change, or decline. Thresholds for classifying patients were the following; STO scores $\geq$ 3 SEM above the mean = improved, (N= 40: 41%), STO scores $\leq$ 3 SEM below the mean = decline, (N=34: 35%), STO scores within 3 SEM= no change, (N=23: 24%). Multiple logistic regression was used to identify patient attributes predictive of improvement, decline, or no change from measures routinely collected at the point of admission to rehabilitation. The model for prediction of improvement correctly classified 70% of patients as those who improved vs. those who did not (sensitivity 70%, specificity 71%). This model generated the following variables as having predictive capabilities; recent CABG, emotional status, social status, calcium channel blocker, recent angioplasty, maximum diastolic BP, maximum systolic BP and resting systolic BP. The model for predicting those who declined vs. those who did not decline demonstrated higher correct classification rate of 74% and specificity (84%). This model generated the following variables as having predictive capabilities; social status, calcium channel blocker, orthopedic limitation, role function, QOL score and Digitalis. However, these models may include certain bias because the same observations to fit the model were also used to estimate the classification errors. Therefore, cross validation was performed utilizing the single point deletion method; this method yielded somewhat lower fraction correct classification rates (66%,69%) and sensitivity rates (56%,44%) for improvement vs. no improvement and decline vs. no decline groups respectively. **Conclusion** A combined set of baseline clinical, psychosocial and exercise measures can demonstrate moderate success in predicting training outcome based on STO scores in hospital outpatient cardiac rehabilitation. In contrast psychosocial data

seem to account for more of the variance in prediction of decline than other types of baseline variables examined in this study. Baseline blood pressure responses both at rest and during exercise were the greatest predictors of improvement. However, cross validation of these models indicates that these results could be biased eliciting overly optimistic predictive capabilities, due to the analysis of fitted data. These models need to be validated in independent sample with patients in similar settings.

INTRODUCTION

Exercise in general has been shown to have many potential benefits for CHD patients including; improved cardiovascular efficiency, lower perception of effort for sub-maximal work, improved myocardial perfusion, reduced athersclerotic risk factors for progression of CHD, reduced recurrent CHD events and improved counteraction to the deleterious effects of physical inactivity. [1,7,9,11,21]In clinical settings, these physiological improvements allow patients to exercise at higher intensities, before reaching the onset of limiting symptoms such as chest pain and leg cramping.

This improved cardiorespiratory fitness after exercise rehabilitation is not evident in all cardiac patients. [11] Cardiac rehabilitation can be expensive and can present a certain amount of risk to the patient, including cardiac complications, injury and even death in rare cases.[26] Accurate outcome measurements should be devised to quantify success or failure in each domain of importance to cardiac rehabilitation. Accountability, economic justification, quality assurance, are all important if cardiac rehabilitation is to be justified as a service for third-party reimbursement. Therefore, it would be valuable to identify factors that explain success or failure of individual patients in cardiac rehabilitation, based on initial data. These predictor variables also might help formulate guidelines for physicians or therapist to select patients for cardiac rehabilitation who likely will benefit from treatment. These variables should not be used to exclude patients from cardiac rehabilitation, but rather allow therapist to concentrate on behavioral interventions treatments such as information, education, counseling and risk factor modification.[7,8] To date several studies have been performed in the attempt to identify patient characteristics which could be utilized to predict the magnitude of change in patient functional capacity, following rehabilitation..[1,7,9,12] These studies utilized data collected from treadmill tests and radionuclide studies, as well as various combinations of clinical variables. Hammond, Tamsin, Froelicher and Pewen [12], utilized all three of these data collection methods in a study which attempted to predict the magnitude improvement in the exercise capacity for 59 post-MI patients as a result of one year of rehabilitation. They did find any initial features which could predict of the magnitude of training success. Ades, Grunvald, Weiss and Hanson TS [1] performed a similar study with 106 post-MI or coronary bypass graft patients. They concluded that after 3 months of rehabilitation, the magnitude of exercise conditioning response was greater in non-ischemic patients (69%) than ischemic patients (50%). Another study, which focused on prediction of improvement in work capacity of 141 post-MI patients following 3 months of rehabilitation, demonstrated that clinically important markers of cardiovascular disease severity had little to do with training outcome.[9] Carter et al. also demonstrated an inability to predict training outcome when attempting to investigate the effects of infarct size on magnitude of training effect in 22 patients following 4 months of rehabilitation.[7] The lack of conclusive predictor variables reported by these investigations could be attributed to several factors: (A) the use of estimated peak oxygen to quantify functional capacity improvement, (B) the measurement of magnitude of change in functional capacity and/or the lack of psychosocial data.

A study performed by Van Dixhoorn, Duiveneoorden, and Pool.[27] utilized initial clinical data, psychosocial data, and exercise test data to predict success or failure, as measured by improved functional capacity, in 156 post-MI patients following five weeks of rehabilitation. A composite criteria for assessing training outcome was developed by integrating measurements obtained from exercise testing. This tool was then used to group patients in one of three training outcomes: (1) no change (2) improved and (3) deteriorated. This study demonstrated work status before infarction as the most important predictor of success. Psychological variables such as Type A behavior, perception of well-being, and depression as predicting failure. Pierson et al.[20] utilized a similar model in a study which retrospectively assessed baseline clinical and exercise test variables for improvement or decline in 60 cardiac patients, 6 months post event and/or surgery. Using a submaximal exercise test outcome measure, this study demonstrated the ability to predict improvement in these patients. However, this study was unable to predict failure in this population. The author attributed this to the lack of psychosocial data, which has been shown to predict both psychosocial and physical training outcomes.[8,17,24,28,29]

Insurance coverage for rehabilitation usually last no longer than 36 sessions, therefore the most relevant outcome based research should target patients in early outpatient cardiac rehabilitation. Thus, the purpose of this study was to determine if the cardiorespiratory fitness outcome of participation in early outpatient cardiac rehabilitation can be predicted for individual patients from data commonly collected in the clinical setting at the time exercise training is initiated. In contrast to previous investigations with similar objectives, the outcome measure was established for each patient as the change in sustainable treadmill exercise performance that occurred over the course of 8-12 weeks of exercise rehabilitation. This study examined whether a set of routinely collected baseline clinical, exercise test and psychosocial variables could be utilized to predict improvement or decline of exercise tolerance in patients enrolled in hospital based cardiac rehabilitation.

METHODS

Subjects

This was a retrospective study of clinical records of random patients who had participated in hospital-based outpatient cardiac rehabilitation at Carolinas Medical Center in Charlotte, North Carolina from October 1995 to March 1997. To be eligible for inclusion patients' records must have been complete with initial GXT tests, exercise prescription, quality of life (QOL) data and individual session reports. Only records were included if the patient had been admitted to the rehabilitation program on the bases of: MI, coronary revascularization, physician-diagnosed angina, or angiographically confirmed CAD. Cases were excluded for any of the following reasons: failure to complete 8-12 weeks of cardiac rehabilitation; failure of the patient to attend at least 70% of exercise sessions; a documented change in prescription of medications during training program; and records which demonstrated inconsistency in order of treadmill activity within the circuit program used in each session. A total of 135 records from consecutive patients were reviewed for potential inclusion in the study. Of these, 41 records were excluded for the following reasons: less than 70% attendance to exercise sessions (N= 28); files incomplete for GXT data, exercise records, psychosocial data or medication records (N= 10). The remaining 94 patient files were used for analysis in this study. Of these, 45 patients experienced a recent MI and 46 patients had undergone a recent coronary revascularization procedure. There were 46 patients who experienced recent angina, 29 who had recently undergone an angioplasty procedure and 23 patients received calcium channel blocker medication, 44 received beta blocker, 26 received diuretics and 14 patients received digitalis medication.

Initial Exercise Testing

Prior to admission into the outpatient cardiac rehabilitation program at Carolinas Medical Center, a maximal graded exercise treadmill test is required. This is a test which measures physiological responses of the heart to incremental work load increase. Depending on the protocol, the increase will occur at 2 or 3 minute stages. No standard protocol was used because tests were performed at various locations, hence the use of Bruce vs. Balke protocols may have influenced estimates of peak METS from these tests.

Exercise Prescription

Exercise prescription and assignment to training activities was based on a master list where patient protocols were determined on patient capability and equipment availability. Patient capability was determined by $MET_{pk,}$ which is the maximum amount of symptom limited metabolic work achieved during initial treadmill test. Initial exercise intensity was prescribed at 50% of MET_{pk} achieved during baseline graded exercise test Exercise was prescribed on three of the following exercise modes: Quinton Medtrack^{TM} (Seattle, Washington); Schwinn Air-Dyne ^{TM}(Chicago, Illinois); Concept II rowing ergometer^{TM} (Morrissville, Vermont); Techtrex Climax^{TM} (Irvine California), and PTS Turbo 1000 recumbent cycle ergometer^{TM}. Each 30 minute exercise session included a 10 min warm-up, a 10 min exercise stimulus period at three of the above specified exercise modalities, and a 10 minute cool down. The MET level was subject to increase over sessions, according to staff judgment, based on the following hemodynamic responses; blood pressure and heart rate. The MET level for each apparatus was calculated via metabolic equations published by the ACSM [2] or metabolic formula contained in the manufacturer's literature. Treadmill MET level was set according to the following ACSM equation:

Predicted VO_2 *=3.5ml/kg/min + .1 x walking speed + 1.8 x speed (m/min) x grade (as a decimal)*

Patient heart rate in the treadmill mode was taken by ECG and recorded by a trained technician at the end of the treadmill station utilizing PhysioControl Life Pack^{TM} defribulator. Self-monitored pulse checks, using a 10 second count also were performed and recorded by participants at the end of each exercise modality. Rate of perceived exertion measurements also were self-recorded for each exercise modality. The treadmill station represented the most accurate and convenient measure of daily activity. Exercise heart rates, taken by trained technicians, also provided a precise method of systematic hemodynamic monitoring. The present study utilized treadmill exercise data in conjunction with patient body weight to quantify cardiovascular fitness levels before and after cardiac rehabilitation.

Definition of Training Outcome Criterion

For the purpose of quantifying changes in cardiorespiratory fitness from the exercise sessions, exercise tolerance was determined from baseline and post-training treadmill data. Training effect was quantified statistically by measuring differences in the predicted VO_2 of the patients adjusted for heart rate and body weight changes using the following formula:

Treadmill Fitness Outcome = change in *predicted* VO_2 *+ body weight - heart rate.*

These differences were measured by establishing graphically confirmed heart rate steady state conditions for the treadmill exercise station during the first 2 weeks of exercise and then comparing the predicted VO_2 at this level with that for the 34 and 35 sessions of rehabilitation. Criteria for establishing which exercise sessions elicited stability at baseline for subject response was determined by graphing the first two weeks of treadmill workload and using the predicted VO_2 level representative of steady state activity, corresponding heart rate, and body weight measurements. The final workload level, final exercise heart rate and final body weight were all recorded using data collected from the two sessions prior to the last day of exercise. The change in these measurements was determined by subtracting initial response (average of first two steady state responses) from final responses (average of two sessions prior to final day of exercise).

Research Design and Statistical Analyses

A physical training outcome score was tabulated using changes in predicted VO_2, body weight and exercising heart rate. Exercise training has been shown to increase functional capacity, as measured by VO_2, decrease sub-maximal exercise heart rate and reduce body weight.[6,13,20,22,23] However, research has demonstrated an inverse relationship between body weight reduction and peak VO_2.[5,14,16,30] Therefore, the following formula treats weight reduction as a negative in calculating training outcome. *These scores were standardized to facilitate the following equation:*

Training Outcome = Predicted VO_2 change[1] + *Body Weight change*[2] - *Heart Rate change*[3]

[1] **Predicted VO_2 change** = difference between an average predicted VO_2 of first two sessions representative of steady state treadmill activity and an average of the two sessions prior to final day of exercise. *post predicted VO_2 - pre predicted VO_2 = predicted VO_2 change*

[2] **Body Weight Change** = difference between an average body weight of first two sessions representative of steady state activity and an average of the two sessions prior to final day of exercise. *post body weight* **-** *pre body weight = body weight change*

[3] **Heart Rate Change** = difference between treadmill exercise heart rate of first two sessions representative of steady state activity and an average of two sessions prior to the final day of exercise. *post exercise heart rate- pre exercise heart rate = heart rate change*

The outcome measure was tabulated utilizing the following seven steps:

1. Changes in predicted VO_2, exercise heart rate and body weight were all standardized and made unitless in order to facilitate comparison.
2. The relationship between these variables were analyzed with Multi-Factorial Analysis which yielded coefficients that were equal in magnitude, making direct tabulation possible.
3. These standardized variables were inserted into the following equation
   Treadmill Fitness Outcome = change in *predicted VO_2+ body weight* **-** *heart rate.*
4. Training outcome scores were then standardized and analyzed utilizing descriptive statistics for mean, standard deviation and standard error of the mean.
5. A value of three standard errors of the mean was statistically designated as the most appropriate cut-off point to classify patients into the following groups: *improved, declined* or *no change*
6. This "data driven" cut-off was empirically constructed based on prediction models fraction correctly classified percentages (sensitivity and specificity) which quantifies models standard of fit.
7. Ten separate prediction models were constructed utilizing the following cut-off parameters for

comparison: 1 SEM ,1.5 SEM ,2 SEM, 2.5 SEM and 3 SEM percentages. Three SEM elicited the highest fraction correctly classified, sensitivity and specificity in both improvement vs. no improvement models and decline vs. no decline models (Table 1).

improvement group = 3 SEM > mean

no change group = within 3 SEM of the mean

decline group = 3 SEM< mean

For the purpose of creating two separate models of prediction, training outcome scores were sorted for individual patients according to the following dichotomous groupings: *improvement vs.*

no change and decline and decline vs. no change and improve The association between initial patient attributes and training outcome was analyzed first utilizing univariate methods and then multivariate analysis was used to identify patient characteristics predictive of improvement vs. no improvement outcome, and then, decline vs. no decline outcome. In the univariate approach to data analysis patient characteristics were tested as predictors of outcome with (1) chi-square analysis for variables containing nominal data and (2) Student t-test for variables of interval data.

Multiple Logistic Regression

The outcome variable in the logistic regression model is dichotomous, coded one for presence of a certain outcome and zero for its absence. Variables utilized for prediction models were chosen based on previous research and current data selection. The criteria for inclusion of variables in the prediction model was $p<0.10$. Forward logistic regression procedure was used in an attempt to identify the best prediction models for the two outcomes (improve and decline) based on the patient attributes obtained at program entry. The equation which resulted from the logistic regression function consisted of variables found to be the best predictors of outcome, along with their respective coefficients and intercept. This equations yielded an estimation of the probability of a particular outcome for all 94 patients. The prediction success of these models was evaluated by comparing the estimated outcome to the actual outcome for each patient. Correct classification rates were calculated, along with sensitivity, specificity and total error rates for each model.

Model Cross-Validation (Single Point Deletion)

This method examined the models ability to predict STO scores with patient data which was not used to construct the regression equation. This helped determine if the models, which were constructed with fitted data, demonstrated overly optimistic predictive capabilities. Single point deletion yielded predicted values for both predicting improvement vs. no improvement and decline vs. no decline. This process was achieved through the following steps; (1) systematically removing one patent from 94 patient data set, (2) re-estimating the parameters of regression model with remaining 93 patients, (3) classifying the observation based on the new parameter estimates, which did not include patient data comprised in model construct. This process was done with all 94 patients, treating each patient as a new subject.

RESULTS

Standardized Training Outcome (STO). Of the 94 patients studied, 40 patients (41%) were classified into improvement group, 22 patients (24%) were classified into the no change group, and 32 patients (35%) were classified into the decline group using the STO as a marker of change.

Improvement group. Table 2 shows the results of the univariate analysis used to test patient attributes for potential predictive ability of improvement vs. no improvement. Only one initial patient variable was found to have acceptable predictive validity ($p<0.05$). Patients who improved demonstrated higher SBP max values during maximal treadmill exercise graded exercise test, when compared with patients who did not elicit improvements. Significant differences were found between post-exercise measurements including body weight change and heart rate change, however no significant differences were demonstrated in predicted VO_2 change. Patients who improved demonstrated greater weight gain and reduced exercise heart rates, when compared to “no improvement” patients.

Decline group. Table 3 presents the results of the univariate analysis used to test patient attributes for potential predictive ability of decline vs. no decline. The patients which demonstrated a decline in exercise tolerance, as defined by STO scores, were prescribed less calcium antagonist medication, then “no decline” group. Post-training analysis demonstrated decline patients to have greater weight reduction and higher exercise heart rates when compared to "no decline" patients.

Training improvement. Table 4 presents the classification rates for the prediction of improvement in exercise tolerance as defined by STO scores. The logistic regression model utilizing clinical data, exercise variables, and psychosocial data demonstrated the ability to correctly classify training success, as defined by STO > 3 SEM, in 70% of the cases; 69% of the patients with a good training result (sensitivity) and 71% of patients without an improvement (specificity) were properly classified. These results suggest that training success was predictable based on high fraction correctly classified with only a modest error rate. The variables selected in the logistic regression analysis are shown in Table 5. Variables of high predictive value ($p<0.05$) included the following: clinical recent CABG, recent angioplasty, max systolic and diastolic blood pressures observed in baseline GXT test data, resting systolic BP, whether the patient was receiving calcium channel blockers and psychosocial sub-scale scores from the Dartmouth COOP charts including emotional and social status.

Cross-Validation

The cross validation of this model using single point deletion yielded a fraction correctly classified of 66%, slightly lower than 70% elicited by the fitted model. The cross-validation model also demonstrated lower sensitivity 56% when compared to fitted model 69%. Table 4 shows classification rate comparisons between improvement vs. no improvement model and single point deletion cross-validation model.

Training decline. Table 4 presents the classification rates for the prediction of decline in exercise tolerance as defined by STO scores 3 SEM < mean. The percent of training failures correctly classified was 74.2%, a higher true positive rate than found with the improvement model. Furthermore, true negatives were predicted at a rate of 84% (specificity). However, the sensitivity of this model (50%) was much lower than demonstrated by improvement model (69%).

The prediction of failure to improve cardiorespiratory fitness in this data set was more predictable than training success demonstrated by higher percent correctly classified and lower percent incorrectly classified. The variables selected by the logistic regression are shown in Table 5. Variables of high predictive value ($p<0.05$) included clinical, orthopedic limitations, whether patient was receiving calcium channel blockers and/or digitalis medication, and the scores on the Dartmouth COOP charts psychosocial sub-scale for social status, role function and overall QOL.

Model Cross-Validation

The cross validation of this decline model, using single point deletion, yielded a lower fraction of correctly classified cases (69%) than fitted model (74%). Low sensitivity and high specificity rates were demonstrated in both validation vs. the fitted models, (sensitivities: 44% vs. 50%) and
(specificities: 82% vs. 84%) respectively. Table 4 compares decline vs. no decline with single point deletion cross-validation model.

DISCUSSION

This study was conducted to investigate the utilization of variables conveniently measured at the time of a patient's entry into hospital-based outpatient cardiac rehabilitation to predict the patients ability to achieve an improved exercise tolerance outcome or to predict those who were likely to decline in exercise tolerance over the course of their treatment. Previous studies have successfully predicted patient outcome for physical training utilizing similar patient populations.[21] Much like the present investigation, these studies utilized exercise data to establish outcome measurements consisting of three categories (positive, negative and no change). These studies also utilized multivariate techniques to identify baseline patient attributes which could be predictive of patient outcome. However only one of the studies, Van Dixhoorn et al.[27], utilized psychological and psychosocial variables in prediction variables. Unfortunately the differences in the specific outcome measurement, baseline variables and statistical analysis make direct numerical comparison between results difficult The introduction of single point deletion, (cross validation), provides the opportunity to compare these models ability to predict training effect in both patients whose data set make up regression model with those who are independent. This can provide information on a models ability to predict training outcome, based on variables collected from new patients.

Evaluation of Training

In this study, the outcome was assessed by the standardization of three variables which included the differences between pre-training and post-training predicted VO_2 + body weight - exercise heart rate. Factor Analysis demonstrated these variables to each present an equal but unique magnitude of importance to STO score. Pearson product correlation supported this by demonstrating no significant correlation between these variables. However, did demonstrate a significant correlation r =.41 ($p<.05$) between STO scores and predicted VO_2 changes. This formula treats increased body weight as a positive in STO outcome however, weight gain is not a desirable result of exercise based rehabilitation. When attempting to quantify training effect one has to account for the deleterious effects body weight gain has on exercising VO_2 capabilities. A study performed by Borghols et. al [5] demonstrated that each extra kilogram of bodyweight increased oxygen uptake by 3.35 ml/kg/min, and heart rate 1.1 beats per minute . Many other studies have illustrated this inverse relationship between body weight and predicted peak VO_2, some demonstrating VO_2 improvements as a function of weight loss independent of exercise training.[10,14,15,16,30]

Factor analysis confirmed the relationship between these three variables adjusting each value from confounding influences of weight change, failure in the training protocol of staff to standardize either the initial and/or final exercise sessions for intensity, metabolic demand or cardiovascular stress. This criterion differs from any single measure used in others studies, however, the final step of this outcome measurement which classified patients into training success or training failure has been utilized often in previous research.[1,7] The present study utilization of a statistically derived training outcome allows for a non subjective measurement of training effect based on physiological changes and hemodynamic exercise responses. The greatest advantage of this outcome measurement was that data included in STO equation constituted a measure with continuous scaling properties, not the result of one test outcome, as utilized in similar research. [1,7]

Success of training outcome in this study was statistically quantified based on established cutoffs which accounted for the effects of body weight and heart rate changes on patients predicted VO_2. However, failure does not necessarily imply a decline in physical state it simply means a failure to significantly improve, as determined by established 3 SEM cut-off. This “data driven" cut-off represented the point which generated the highest fraction correctly classified scores in prediction models. Histogram and dot-plot graphing confirmed 3 SEM as an appropriate parameter, yielding three distinct groups; improvement, no change and decline. The importance of measuring both exercise heart rate and body weight changes in conjunction with VO_2 changes offers a more accurate measurement than quantifying training outcome based on VO_2 changes alone. This is evidenced by statistical analysis which found no significant differences in entire group patient VO_2 changes, however, significant changes in both exercise heart rate and body weight changes allowed for discrimination between subject outcomes (Table 2,3). Measuring VO_2 changes without taking into account body weight and exercise heart rate changes can result in either an over estimation or under estimation of training success.

Predicting improvement in exercise tolerance. For 39 (41%) of the 94 patients who participated in 8-12 weeks of cardiac rehabilitation, training was beneficial. Based on initial patient attributes, 70% of these 39 patients could be correctly classified. This model only demonstrates a modest ability to predict success when compared to similar studies performed by Van Dixhoorn et al.[27] and Pierson et al.[21] which yielded correct classification rates of 81% and 87%, respectively. Van Dixhoorn et al. also demonstrated an ability to predict 84% of the patients as improving when training was actually beneficial (specificity). As previously mentioned it is difficult to compare these models due to the differences in outcome measures and statistical techniques. Some of the most significant variables utilized to predict patient success in the present study were also found in previous literature. The Peirson et al. [21] model to predict success identified the variable of resting systolic blood pressure as a predictor of training improvement; this variable was also evidenced in the present model. Furthermore, Van Dixhoorn et al's [27] model to predict success demonstrated maximal systolic blood pressure as an important predictor variable. The present study demonstrated a significant difference ($p<.005$) in maximal systolic blood pressure when comparing improvement vs. non improvement initial patient data (Table 2). A random sampling of 67 patients, in the present study, was used to develop an emulation of a cross-prediction model; (Table 6) this model identified the variables of calcium channel blocker, maximum systolic blood pressure and resting blood pressure as predictors of training improvement. This model demonstrated a lessened ability to correctly classify those patients who improved 63% vs.70%, when compared to results of 94 patient model, however illustrated a greater ability to correctly categorize the patients who did not improve 82% vs. 71% (Table 6). The repeatability of the same variables across different studies could demonstrate an ability to predict patient success regardless of the training outcome or statistical analysis. Blood pressure response seems to play an important role in the prediction of training success, as evidenced in all three models. The current model demonstrates lower resting SBP values to have the greater propensity to predict training improvement. Conversely, the model constructed by Pierson et al. Demonstrated higher resting SBP to predict a positive outcome. Both the current model and the Van Dixhoorn et al.[26] model demonstrated higher maximum SBP to elicit the greatest probability of improvement. According to this study, if one would deem BP values as indicative of initial fitness levels, the patients with the lowest resting SBP and highest maximum SBP would achieve the greatest results. This is in direct conflict with the results yielded by Pierson et al.[21] which found low baseline fitness levels as the greatest predictor of success. However, the results elicited by Van Dixhoorn et al.[27] demonstrated lower resting exercise heart rates, ability to generate higher blood pressures during exercise, absence of angina, arrhythmia and signs of heart failure indicate that good physical state is conducive to training success. The relationship between initial fitness level and the prediction of improvement was further investigated when a separate model was constructed utilizing patients which were deemed as having a low levels of initial fitness (<8METS). This 60 patient one variable model demonstrated lower fraction correctly classification (67%) and specificity (36%) when compared to 94 patient model which elicited 70% and 72% respectively (Table 7). According to this study low levels of initial fitness does not seem to have the ability to predict training improvement as evidenced by 94 patient model construct and the low predictive capabilities demonstrated by 60 (<8METS) patient model.

According to the 94 patient model one of the primary variables for predicting improvement was recent coronary artery bypass graphing. One could postulate that this could be due to the weight lost during hospitalization and subsequent regaining of lost weight during rehabilitation, which translates into a higher STO score. Psychosocial variables, which were included in this model, have been demonstrated by many studies to be predictive of both psychosocial and physical training outcomes. [8,17,24,28,29] The negative relationship between calcium channel blockers and training improvement in this model could be due to the fact that the patients who do not have to take this medication could represent a healthier population, which in this study seems to translate into training improvement.

Cross validation of this model demonstrated an lessened ability to predict improvement vs. no improvement in patients not utilized in regression model. The lower fraction of correctly classified patients (66%) compared with fitted classification (70%) can be attributed to the fact that when a set of binary data is classified, if the same observations used to fit the model are also used to estimate the classification error, the resulting error count is biased. This bias is removed in the cross validation model which predicts the outcome of patient variables not utilized to generate model parameter estimates, a more difficult task to accomplish. The fitted prediction model will always demonstrate an overly optimistic ability to predict outcome.

Predicting training failure. Training failure occurred in 33 (35%) of 94 patients. The overall 74.2% fraction correctly classified was higher than those correctly classified as improved, in the prediction model for improved training outcome. The low sensitivity score (50%) was counteracted by a high sensitivity score (84%) ,a trend witnessed in previous studies by Van Dixhoorn et. al.[26] and Pierson et al.[21] which reported low sensitivity scores of 30%, 69% and high specificity scores of 94% and 90% respectively. Although in the present study, not all patients with training failure could be identified, 68% of the patients who were predicted to have training failure had a negative outcome, similar to results demonstrated by Van Dixhoorn et al.[26]. The success of this model could be attributed to the use of psychosocial variables which have been demonstrated to predict failure in previous literature.[8,17,27] The Dartmouth COOP charts applied in this study utilized the following nine pictorial charts to assess patient physical, mental and social function: physical, emotional, role and social function, overall health, change in health ,pain, overall quality of life and social support. These variables combined for a composite score which assesses the functional status of patients living with heart disease. Each of these charts were complete with five responses and a corresponding numeric score. In accordance with clinical convention high scores represented unfavorable levels of health on all charts. These charts have undergone extensive validation and are strongly associated with related measures correlating with clinical measures in the expended manor.[19] However this type of measurement was not taken in the study performed by Pierson et al. whom attributed their extremely low sensitivity scores to the lack of availability of psychosocial predictors in their data set. The present study identified such psychosocial variables as social status, role function and quality of life scores as important in explaining predisposition for training failure in cardiac patients.. Although no studies to date could be found which utilize the predictor set generated by our models to predict training outcome, a random sub-group sample of 67 patients yielded a prediction model identifying QOL and role function scores as the primary predictors of training failure (Table 6). This model demonstrated a greater ability to predict those patients who declined, 60% vs. 50%, compared to 94 patient model as well as those patients who did not decline 86% vs. 84%. Many studies have linked the patient's personal feeling on how heart disease affects him/her physically, socially and emotionally as a indicator of an ability to succeed in cardiac rehabilitation.[21,24,25]

The positive relationship evidenced for patients with orthopedic limitations, in the 94 patient model, could be due the fact that patients with orthopedic problems, because of pain or limited range of motion, may have a more difficult time achieving and maintaining prescribed training heart rates. The inclusion of psychosocial data in the decline model was expected however, the negative relationship demonstrated by these variables is difficult to rationalize. According to Dartmouth COOP charts higher scores represent lower levels of health, which according to this model would translate into a lower probability of training decline. This relationship is opposite from what has been illustrated in related research which associate low psychosocial health to training failure.[8,17,19,27]

A model was also constructed utilizing 60 patients who demonstrated low initial fitness levels(<8METS). This model yielded a 6 variables which included similar variables as generated by both 94 and 67 patient models including; orthopedic limitation, calcium channel blockers and digitalis medication. However, when compared to 94 patient model this model demonstrated higher correct classifications,76.7% vs.74.2%, sensitivity 83.8% vs. 50% (Table 7). This could demonstrate that patients with low levels of initial fitness have a greater ability to predict decline in exercise training

Cross validation of the 94 patient model demonstrated an expected decrease in correct classification with the utilization of patients variables which did not comprise the original regression model. Correct classification rate of 74% was elicited by original model while cross validation model only elicited correct classification rate of 69%. This decrease in classification ability can be attributed to the reduced bias in the validation model, which will usually yield conservative prediction abilities when compared to the overly optimistic predictions of the fitted regression model. This validation model also demonstrated the same low sensitivity and high specificity demonstrated in previously mentioned fitted models. This lends support to the belief that it is more difficult to correctly classify patients who decline than to classify the patients who will not decline as the result of exercise-based cardiac rehabilitation.[21]

This study demonstrated a modest ability to predict training outcome based on initial patient attributes. Cross validation methods demonstrated these results to be possibly overly optimistic estimates of models prediction capabilities, when applied to external, but similar, patient data sets. The utilization of patients with low levels of initial fitness seemed to generate a model which was a good predictor of decline in exercise. The 67 patients models provided solid predictive capabilities utilizing fewer variables than generated by 94 patient models. Fewer variables facilitates a more clinically applicable model which can easily be utilized by practitioners in assessing patient training success or failure probability. Future research should include validation studies performed on similar populations, utilizing the identical outcome measures, statistical techniques and similar methodology. These studies should be prospective in nature, where measures are defined at rehab entry and then patients are followed, until rehab exit.. This would enable researchers to directly compare models and depict the model which yielded the greatest correct classification percentages with the highest reproducibility in independent data sets. Specific validation should also be performed on the outcome measure utilized in this study. Some of the conflicting variable relationships generated by both improvement vs. no improvement and decline vs. no decline models could be attributed to the construct of the outcome measurement.

The results from this study illustrates the importance of resting and exercise blood pressure, medication status, entry diagnosed and psychosocial measurements in the prediction of training outcome. These measurements can be easily taken at program entry and could provide insight on a patients ability to significantly improve in exercise based cardiac rehabilitation. The utilization of COOP charts provide practitioners with a simple, time efficient method of evaluating psychosocial status, which has been linked to predicting training decline. However, the results of model cross validation should caution the clinician on the slight bias of fitted data.

CONCLUSION

This study demonstrated moderate success in predicting both success and failure in cardiac patients, based on initial clinical, exercise, and psychosocial variables. The utilization of a mathematically derived outcome measure makes the results difficult to compare with previous research. The utilization of psychosocial variables yielded a greater ability to predict decline in patients than improvement. Resting systolic blood pressure seems to be the best predictor of success through the various studies. However, before any prediction rules can be established patients from a multitude of rehab settings must be assessed utilizing similar outcome measures and statistical techniques, making results directly comparable. This validation will make it possible for clinicians to design a set of baseline variables which could provide insight on a patients ability to succeed or fail in cardiac rehabilitation.

REFERENCES

1. Ades PA, Grunvald MH, Weiss RM, Hanson JS. Usefulness of myocardial ishemia as prediction of training effect in cardiac rehabilitation after acute myocardial infraction or coronary artery bypass grafting. **Am J Cardiol**. 1989; 63:1038-1036.

2. American College of Sports Medicine, **Guidelines for Exercise Testing and Prescription**, 4th ed. Philadelphia: Lea and Febiger Co, 1991: 285-300.

3. Baker R, Fraser RC. Development of review criteria: linking guidelines and assessment of quality. **British Medical Journal** 1995; 311:370-373.

4. Batalden PB, Mohr JJ, Nelson EC, Plume SK. Improving health care, part: concepts for improving any clinical process. **Journal of Quality Improvement** 1996; 22:651-659.

5. Borghols EA, Dresen MH, Hollander AP. Influence of heavy weight carrying on the cardiorespiratory system during exercise. **Eur J Appl Physiol**. 1978; 38(3):161-169.

6. Clauso, J.P; Trap-Jensen,J Effects of training on the distribution of cardiac output in patients with coronary artery disease **Circulation**.1970; 42:611-624.

7. Carter CL, Amundson LR. Infarct size and exercise capacity after myocardial infarction**. J Appl Physiol**. 1977; 42(5): 782-785.

8. Erdman R, Duivenvoorden J, Verhage F, Kazemies, m, Hugenholtz P. Predictability of beneficial effects in cardiac rehabilitation: a randomized clinical trail of psychosocial variables. **J Cardiopulmonary Rehab**. 1986; 6: 206-213.

9. Fioretti P, Simoons ML, Zwiers G, Baardman T, Brower RW, Kazemir M, and Hugenholtz PG. Value of predischarge data for the prediction of exercise capacity after cardiac rehabilitation in patients with recent myocardial infarction**. Eur Heart J** 1987;(suppl G):33-38.

10. Freyschuss U, Melcher A. Exercise energy expenditure in extreme obesity: influence of ergometry type and weight loss. **Scand J Clin Invest** .1978; 38: 753-759.

11. Gamble P, Froelicher VF. Can an exercise program worsen heart disease? **Physician Sport Med** 1982;10(5):69-77.

12. Hammond HK, Kelly TL, Froelicher VF, Pewen W. Use of clinical data in predicting improvement in exercise capacity after cardiac rehabilitation**. J Am Coll Cardiol**. 1985; 6:19-26.

13. Hartung, G.H; Rangel, R. Exercise training in post-myocardial infarction patients: Comparison of results with high risk coronary and post-bypass patients. **Arch. Phys. Med.Rehal**.1981; 62:147-150.

14. Holewijn M, Physiological strain due to load carrying. **Eur J Appl Physiol**. 1990; 61:237-245.

15. Kappagoda CT, Linden RJ, Newell JP. A comparison of the oxygen consumption/body weight relationship obtained during submaximal exercise on a bicycle ergometer and on a treadmill.Q J Exp **Physiol Cogn Med Sci**. 1979; 64:205-215.

16. Katch V. Correlational V ratio adjustments of body weight in exercise-oxygen studies. **Ergonomics**. 1972;15:671-680.

17. Mayou R. Prediction of emotional and psychosocial outcome one year after a first myocardial infarction. **J of Psychosomatic Research**. 1984; 28(1): 17-25.

18. Milani RU, Littlman AB, Lavic CJ. Depressive symptoms predict functional improvement following cardiac rehabilitation and exercise program**. J Cardiopulmonary Rehabil**. 1993; 13: 406-411.

19. Neilson NC, Landgraf JM, Hays RD. The functional status of patients how can it be measured in physicians' offices? **Medical Care**. 1990; 28 (12): 1111-1118.

20. Ornish D, Brwn SE, Scherwitz LW, BillingsLW, AmstrogW,PorsTa,Mclanahan SM,Kirkeeide RL,Braud RJ, Gld KL Can lifestyle changes reverse coronary heart disease?**The Lifestyle Trail Lancet** 190;336:129-133).

21. Pierson LM, Herbert WG, Davis SE, Southard DR. Defining a set of patient attributes that predict exercise performance outcome following an exercise training program in a population of coronary artery disease patients. M.S. Thesis, Virginia Tech, 1998.

22. Rechnitzer PA, Cunningham DA, Andrew GM, Buck CW, Jones NL, Kavanagh T, Oldridge NB, Parke JO, Shephard RJ, Sutton JR et al. Ontario Exercise-Heart Collaborative Study: relation of exercise to the reoccurrence rate of myocardial infarction in men. **Am J Cardiol** 1983; 51:65-9.

23. Redwod, D.R.; Rosing, D.R: Epstien, S.E. Circulatory and symptomatic effects of physical training in patients with coronary- artery disease and angina pectoris. **N. Engl J. Med**. 286;959-96;1972.

24. Rejeski WJ, Morley D, Miller HS. The Jenkins activity survey: exploring its relationship with compliance to exercise prescription and MET gain within a cardiac rehabilitation setting**. J Cardiac Rehabil**. 1984; 90(4): 90-94.

25. Squires RW and Williams LW. Coronary atherosclerosis and acute myocardial infarction. In Durstin JL, King AC, Painter PL, Roitman JL, Zwiren LD, Kenney WL (eds): **American College of Sports Medicine's Resource Manual for Guidelines for Exercise Testing and Prescription. 2nd edition** (p168). lea and Febiger, Philadelphia, PA, 1993.

26. VanCamp SP and Peterson RA. Cardiovascular complications of outpatient cardiac rehabilitation programs**. JAMA**. 1986; 256: 1160-1163.

27. VanDixhorn J and Durvenvoorden HJ. Success and failure of exercise training after myocardial infarction: is the outcome predictable? **J Am Coll Cardiol**. 1990; 15: 974-982.

28. Wilklund I, Sanne H, Vedia A, Willhelmsson C. Psychosocial outcome one year after a first myocardial infarction. **J of Psychosomatic Research**. 1984; 28(4): 309-321.

29. Williams RB, Haney TL, McKinnis RA, Harrell FE, Lee KL, Pryor D, Califf R, Kony YH, Rosati RA, Blumenthal JA. Psychosocial and physical predictors of anginal pain relief with medical management. **Psychosomatic Medicine**. 1985; 48: 200-209.

30. Zuti WB, Golding LA, Equations for estimating percent body fat and body density of active adult males. **Med Sci Sports**.1973;5(4): 262-266.

Table 1

Outcome Measure Model Cut-off Comparisons

Improvement Vs No Improvement

	3 SEM	2.5 SEM	2.0 SEM	1.5 SEM	1 SEM
Fraction Correctly Classified	70%	62%	63%	60%	62%
Sensitivity	69%	61%	58%	60%	60%
Specificity	71%	63%	66%	62%	65%

Decline Vs No Decline

	3 SEM	2.5 SEM	2.0 SEM	1.5 SEM	1 SEM
Fraction Correctly Classified	74%	72%	72%	69%	71%
Sensitivity	50%	46%	45%	48%	44%
Specificity	84%	78%	80%	78%	82%

Fraction Correctly Classified = # correctly classified as improvement + # correctly classified as no change or decline x 100
total # of patients

Table 2

Univariate Analysis of Variables for Training Improvement Vs No Improvement as Defined by STO: Clinical, Exercise and Psychosocial Data on 94 patients.

Variable	Improve[a]	No Improvement[b]	**P**
Clinical Data			
Age	58±9	57±10	NS
History of Hypertension	16 (15)%	7 (12%)	NS
History of Smoking	21 (53%)	32 (56%)	NS
Family History	23 (58%)	34 (60%)	NS
Body Weight(kg)	82±19	86±14	NS
Total Cholesterol (mg/dL)	202±-44	194.5±39	NS
Resting Heart Rate (bpm)	80±14.6	75.5±14	NS
Resting SBP	139±26	139.5±20	NS
COOP Score	20±-5	21±4.8	NS
Medications			
Beta Blockers	19 (48%)	25 (44%)	NS
Calcium Channel Blockers	6 (15%)	17 (30%)	NS
Diuretics	7(18%)	16 (28%)	NS
Digitalis	7(18%)	7 (12%)	NS
Nitrates	4(10%)	13 (23%)	NS
Ace Inhibitors	7(18%)	12 (21%)	NS
Exercise Data			
Maximum METS	7.2±2.1	7.4±2	NS
Maximum SBP (mmHg)	182±23	171±28	<.005
Maximum Heart Rate (bpm)	140±21	13.7±22	NS
Post Exercise Training Data			
Heart Rate Change(bpm)	-7.3±12	7.8±1.6	NS
Prd. VO2 Change (ml/kg/min)	6.1±4.3	4.9±3.6	NS
Body Weight Change (lbs)	0.5±1.8	-0.6±2	NS

Data are reported as number of cases or mean values ± SD. Percentages are shown in parentheses
[a] n=39, [b] n = 55 patients

Coop Score- Nine pictorial charts utilized to assess patient physical, mental and social function. These charts are numerically scored and added together to generate one outcome.

Table 3

Univariate Analysis of Variables for Training Decline Vs No Decline as Defined by STO: Clinical, Exercise and Psychosocial Data on 94 patients.

Variable	Decline[a]	No Decline[b]	P
Clinical Data			
Age	56±11	57±9	NS
History of Hypertension	5 (15)%	8(13%)	NS
History of Smoking	15 (44%)	38(60%)	NS
Family History	19 (56%)	38(60%)	NS
Body Weight(kg)	190±29	183±40	NS
Total Cholesterol (mg/dL)	197±44	198±40	NS
Resting Heart Rate (bpm)	76±14	78±14	NS
Resting SBP	139±20	137±23	NS
COOP Score	21±-5	20±5	NS
Medications			
Beta Blockers	16 (47%)	28 (44%)	NS
Calcium Channel Blockers	14 (41%)	9 (14%)	NS
Diuretics	8(24%)	15 (24%)	NS
Digitalis	1(3%)	13 (21%)	NS
Nitrates	7(21%)	10 (16%)	NS
Ace Inhibitors	6(18%)	13 (21%)	NS
Exercise Data			
Maximum METS	7±2.1	7.2±2.2	NS
Maximum SBP (mmHg)	177±22	176±33	<.005
Maximum Heart Rate (bpm)	139±21	138±22	NS
Post Exercise Training Data			
Heart Rate Change(bpm)	11±17	7.8±1.6	NS
Prd. VO2 Change (ml/kg/min)	5.1±4	5.5±3.9	NS
Body Weight Change (lbs)	0.9±2.5	0.2±1.5	NS

Data are reported as number of cases or mean values ± SD. Percentages are shown in parentheses
[a] n=33, [b] n = 61 patients

Coop Score- Nine pictorial charts utilized to assess patient physical, mental and social function. These charts are numerically scored and added together to generate one outcome.

Table 4

Improvement / No Improvement Model Vs Single Point Deletion Cross Validation Model

Model	Improvement Vs No Improvement Model	Cross Validation
Fraction Correctly Classified	70%	66%
Sensitivity	69%	56%
Specificity	71%	73%

Fraction Correctly Classified = $\frac{\text{\# correctly classified as improvement + \# correctly classified as no change or decline}}{\text{total \# of patients}} \times 100$

Decline / No Decline Model Vs Single Point Deletion Cross Validation Model

	Decline vs. No Decline Model	Cross Validation Model
Fraction Correctly Classified	74%	69%
Sensitivity	50%	44%
Specificity	84%	82%

Fraction Correctly Classified = $\frac{\text{\# correctly classified as improvement + \# correctly classified as no change or decline}}{\text{total \# of patients}} \times 100$

Table 5

Improvement Vs No Improvement Predictive Variables

Parameter	Estimate	Pr>Chi
Intercept	-7.7573	.0052
Recent CABG	1.8455	.0033
Emotional Status	-.6889	.0192
Social Status	0.7184	.0223
Calcium Channel Blocker	-2.0803	.0095
Recent Angioplasty	1.4368	.0340
Max Diastolic BP	.0592	.0035
Max Systolic BP	.0331	.0050
Resting Systolic BP	-.0308	.0263

***** bolded are the variables demonstrated to have predictive capabilities in both improvement vs. no improvement and decline vs. no decline models.

Decline Vs No Decline Predictive Variables

Parameter	Estimate	Pr>Chi
Intercept	-1.977	.0772
Social Status	-0.598	.0242
Calcium Channel Blocker	1.375	.0205
Orthopedic Limitation	1.396	.0136
Role Function	-0.911	.0180
QOL Score	-.189	.0016
Digitalis	- 2.391	.0345

***** bolded are the variables demonstrated to have predictive capabilities in both improvement vs. no improvement and decline vs. no decline models.

Table 6

Improvement Vs No Improvement Predictive Variables
(67 patient cross validation model)

Parameter	Estimate	Pr>Chi
Intercept	-2.492	.2979
Calcium Channel Blocker	-1.2941	.0797
Max Systolic BP	.0420	.0030
Resting Systolic BP	-.0308	.0223
Digitalis	1.7726	.0529

***** bolded are the variables demonstrated to have predictive capabilities in both original and cross validation improvement vs. no improvement models.

Fraction Correctly Classified = 74%
Sensitivity = 63%
Specificity = 82%

Decline Vs No Decline Predictive Variables
(67 patient cross validation model)

Parameter	Estimate	Pr>Chi
Intercept	-3.426	.0116
Calcium Channel Blocker	1.522	.0205
Role Function	-1.0809	.0109
QOL Score	.2309	.0048

***** bolded are the variables demonstrated to have predictive capabilities in both original and cross validation decline vs. no decline models.

Fraction Correctly Classified = 76%
Sensitivity = 60%
Specificity = 86%

Table 7

Models of Patient Data with Low Initial Level of Fitness (<8METS)

Improvement vs. No Improvement Predictive (60 patients)

Parameter	Estimate	Pr>Chi
Intercept	0.6614	.0317
Digitalis	-1.4723	.0292

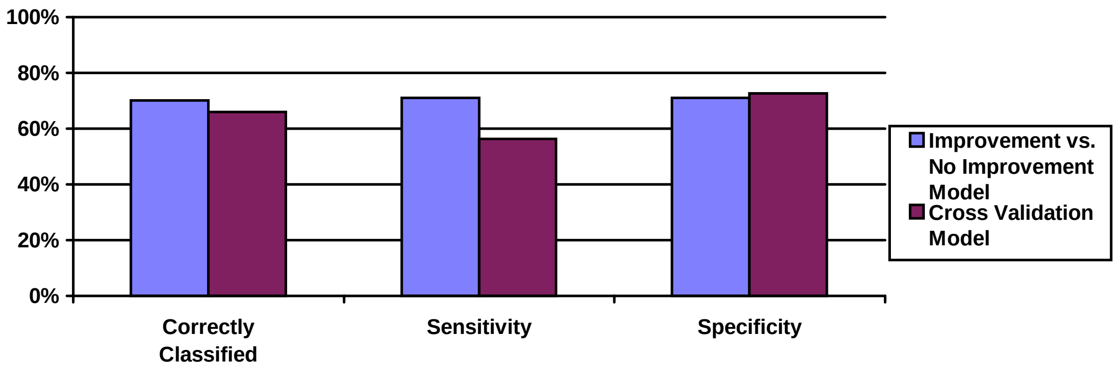
Decline Vs No Decline Predictive Variables (60 patients)

Parameter	Estimate	Pr>Chi
Intercept	5.4605	.0377
Orthopedic Limitation	1.6790	.0400
HR Max	-0.0552	.0133
Recent CABG	2.1226	.0050
Family History	1.8034	.0238
Calcium Channel Blocker	-1.2836	.1063
Digitalis	1.7202	.0616

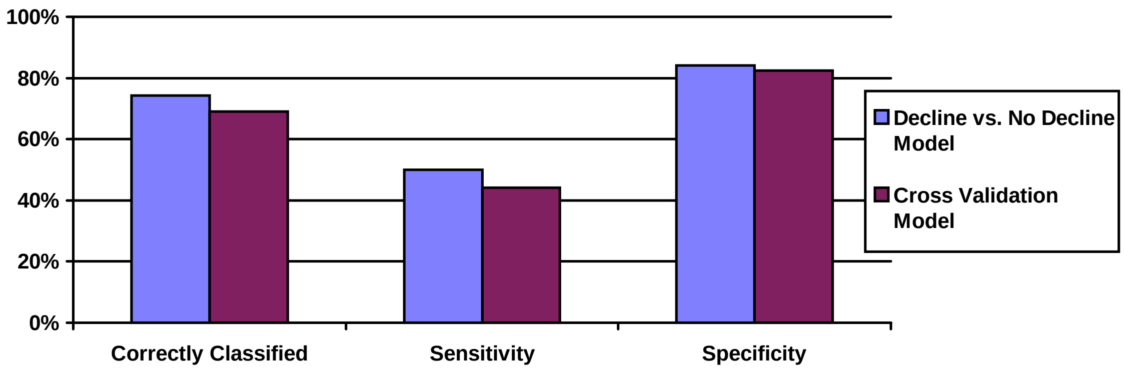
***** bolded are the variables demonstrated to have predictive capabilities in both original and cross validation decline vs. no decline models.

Figure 1

Improvement/ No Improvement Model Vs Cross Validation Model (Single Point Deletion)



Decline/ No Decline Model Vs Cross Validation Model (Single Point Deletion)



CHAPTER IV

SUMMARY, CONCLUSIONS,
AND RECOMMENDATIONS

Summary and Conclusions

Clinical, exercise and psychosocial data were collected from the records of 94 consecutive participants of the Cardiac Rehabilitation program at Carolinas Medical Center, from October 1995 to April 1997. Patient records eligible for inclusion in the study were those that included a GXT test results, exercise prescription, and QOL data at the point of admission to cardiac rehabilitation, and individual sessions reports. Only records were included if the patient had been admitted to rehabilitation program on the bases of: MI; coronary revascularization; angioplasty procedure; physician-diagnosed angina; or angiographically confirmed coronary artery disease. Documented change in medications during the study interval, records indicating attendance less than 70% of 8-12 week exercise training sessions, and inconsistent daily order of exercise training modalities were all criteria which excluded patients from pool of potential study candidates.

This study was conducted to: (1) quantify changes in exercise tolerance (2) identify patient characteristics that are predictive of changes in exercise tolerance, occurring in cardiac patients who participate in hospital-based cardiac rehabilitation.

The outcome training marker utilized to assess improvement or decline in exercise tolerance in this study was a standardized training effect score. This score was derived by standardization of the following exercise training variables: pre and post training differences in body weight, heart rate and predicted VO_2. Multi-factorial analysis confirmed the relationship of the variables in the following equation; (standardized variables were implemented and subsequently standardized).

$$\textit{Training Outcome} = \textit{predicted } VO_2 \textit{ change} + \textit{body weight change} - \textit{heart rate change}$$

All data analysis was performed using the SAS statistical software system. The data were analyzed using multi-factorial analysis, descriptive statistics, univariate (chi-square and Student t-tests) and logistic regression (backward stepwise). Multi-factorial analysis was used to examine the relationship of variables utilized to construct the outcome measurement equation, while descriptive statistics were applied to tabulate mean, standard deviation and standard error of the mean of these standardized scores. Univariate analysis was used to test individual patient attributes for predictive capabilities. Forward logistic regression was utilized to identify potential predictors of each outcome (improvement, decline).

Improvement in exercise tolerance. Variables selected by the forward logistic regression from clinical, exercise test and psychosocial data sets to predict improvement outcome as defined by STO scores were formulated into the following equation with beta coefficients:

y= -7.75+ Recent CABG(1.85)+ Emotional Status(-0.69)+Social Status(0.72)+Calcium Channel Blocker(-2.08) + Recent Angioplasty(1.43)+ Max DBP(0.06)+Max SBP(0.03)+Rest SBP(-0.03)

Individual patient data must be substituted for the variables in the above formula and multiplied by beta coefficients, with the resultant sum then entered into the following probability of training improvement for an individual patient:

$$p=1/1+exp(-y).$$

where p = probability of training improvement,

The precision of prediction for a dichotomous outcome, i.e. improvement vs. no improvement in 94 patients, resulted in only modest precision with a correct classification rate of 70% (sensitivity 69%, specificity 71%). Cross validation of this model utilizing the single point deletion method demonstrated a slightly lower correct classification rates of 66% (56% sensitivity, 73% specificity) with patient data foreign to the regression equation. The evidence from this analysis suggests that generalizing a formula to another, similar, patient population should result in somewhat greater error, particularly with prediction of true positives (those who would improve).

Decline in exercise tolerance. Variables selected by the backward stepwise logistic regression from clinical, exercise and psychosocial data sets to predict decline outcome as defined by STO scores were formulated into the following equation with beta coefficients:

y=-1.98+Social Status(-0.60)+Calcium Channel Blocker(1.38)+Orthopedic Limitation(1.40)+Role Function(-0.91)+ Quality of Life(0.19)+Digitalis(-2.40)

Individual patient data must be substituted for the variables in the above formula and multiplied by beta coefficients, with the resultant sum then entered into the following probability of training improvement for an individual patient:

$$p=1/1+exp(-y).$$

P= the probability of training decline

Model for decline vs. no decline demonstrated good classification results (74%), facilitated in part to a high specificity (84%). Cross validation utilizing single point deletion demonstrated a lower correct classification rate (69%), relatively high specificity (82%), and extremely low sensitivity (44%). These results suggest that the correction classification of decline is much more difficult than the classification of those did not improve. Although overall fraction correctly classified in both decline models are higher than demonstrated by either improvement models, cross validation shows these values to be an overly optimistic estimation of model power.

Recommendations for Future Research

This study demonstrated a modest ability to predict training outcome based on initial patient attributes. Cross validation methods demonstrated these results to be possibly overly optimistic estimates of models prediction capabilities, when applied to external, but similar , patient data sets. Future research should include validation studies performed on current models utilizing the single point deletion method to find which model demonstrates the greatest ability to predict outcomes for patients not comprised in regression model construct. Future research should also include prospective studies where measures are defined at rehabilitation entry and then patients are followed, until rehabilitation exit. This outcome based research could be used to identify baseline patient attributes which could be predictive of training effect. Research should also include studies which utilize similar populations, outcome measures, statistical techniques and methodology This would enable researchers to directly compare models and depict the model which yielded the greatest correct classification percentages with the highest reproducibility in independent data sets. Specific validation should also be performed on the outcome measure utilized in this study. Some of the conflicting variable relationships generated by both improvement vs. no improvement and decline vs. no decline models could be attributed to the construct of the outcome measurement.

The outcome measure utilized in this study was a statistically derived score taking in account changes in body weight, heart rate and predicted VO_2 throughout exercise training. Although both statistically and physiologically sound, this outcome measure should be researched in cross-validation studies which compare this measurement with more traditional outcome measurements. This information is important in interpreting the results of the present study as well as in any study which would utilize the same outcome measurement or prediction models.

As represented by the lower classification percentages yielded by the smaller 67 patient subgroup models (compared to 94 patient models), patient sample seems to play a role in creating prediction models. Future research which utilizes 200 or more patients could provide stronger prediction models as well as offer greater cross validation information.

The above suggestions for external validation of prediction models, outcome measures and suggestions for larger sample sizes should improve the probability of these prediction models.

Implications for Clinical Practice

The results from this study illustrate the importance of resting blood pressure and psychosocial measurements in the prediction of training outcome. The 67 patients models provided solid predictive capabilities utilizing fewer variables than generated by 94 patient models. Fewer variables facilitates a more clinically applicable model which can easily be utilized by practitioners in assessing patient training success or failure probability. These measurements can be easily taken at program entry and could provide insight on a patients ability to significantly improve in exercise based cardiac rehabilitation. The utilization of Dartmouth COOP charts provide practitioners with a simple, time efficient method of evaluating psychosocial status, which has been linked to predicting training decline. However, the results of model cross validation should caution the clinician on the slight bias of fitted data.

Conclusion

This study demonstrated moderate success in predicting both success and failure in the exercise tolerance of cardiac patients, based on initial clinical, exercise, and psychosocial variables. The utilization of a mathematically derived outcome measure makes the results difficult to compare with previous research. The utilization of psychosocial variables helped predict decline, but was not as useful in predicting improvement in patients. Resting and maximal blood pressure values seem to be the greatest predictor of success as evidenced through cross validation, utilizing a random sampling of 67 patients. The utilization of patients with low levels of initial fitness (<8 METS) seemed to generate a model which was a good predictor of decline in exercise. However, before any prediction rules can be established, patients from a multitude of rehabilitation settings must be assessed carefully and objectively at program entry and exit to assess fitness levels. These studies must also utilize similar outcome measures and statistical techniques, so that results can be directly compared. This type of research will make it possible for clinicians to design a set of baseline variables which could provide insight on a patients ability to succeed or fail in cardiac rehabilitation.

BIBLIOGRAPHY

1. Ades PA, Grunuald MH, Weiss RM, Harison JS. Usefulness of myocardial ishemia as prediction of training effect in cardiac rehabilitation after acute myocardial infraction or coronary artery bypass grafting. **Am J Cardiol.** 1989; 63:1038-1036.

2. Ades PA, Haung D, Weaver SD. Cardiac rehabilitation predicts lower re-hospitalization costs. **Am Heart J**. 1992; 123: 916-921.

3. American Association of Cardiovascular and Pulmonary Rehabilitation: Guidelines for Cardiac Rehabilitation Programs (Second edition). Champaign, IL: Human Kinetics, 1995.

4. American College of Sports Medicine, Guidelines for Exercise Testing and Prescription, 4th ed. Philadelphia: Lea and Febiger Co, 1991: 285-300.

5. Baker R, Fraser RC. Development of review criteria: linking guidelines and assessment of quality. **British Medical Journal** 1995; 311:370-373.

6. Batalden PB, Mohr JJ, Nelson EC, Plume SK. Improving health care, part: concepts for improving any clinical process. **Journal of Quality Improvement** 1996; 22:651-659.

7. Borghols EA, Dresen MH, Hollander AP. Influence of heavy weight carrying on the cardiorespiratory system during exercise. **Eur J Appl Physiol**. 1978, 38(3):161-1694.

8. Bondstam E, Breikss A, Harford M. Effects of early rehabilitation on consumption of medical care during the first year after acute mydocardial infarction in patients greater than 65 years of age. **Am J Cardiol**. 1995; 75: 767-771.

9. Brooks G. Current concepts in lactate exchange. **Med Sci Sports Exerc**. 1991; 23(8): 895-906.

10. Brooks G and Fahey, T. **Exercise Physiology: Human Bioenergetics and Its Application**, 1984; 239-255.

11. Cantor, A, Damri E, Snir Y. Physical training in coronary patients with poor left ventricular function. **Harefugh**. 1992; 122(8); 493-497, 552,557.

12. Carter CL, Amundson LR. Infant size and exercise capacity after myocardial infarction. **J Appl Phsiol.** 1977; 42(5): 782-785.

13. Clauso, J.P; Trap-Jensen,J Effects of training on the distribution of cardiac output in patients with coronary artery disease **Circulation**. 42:611-624 1970.

14. Dowers KS. Fundamentals of exercise metabolism. In Durstin JL, King AC, Painter PL, Roitman JL, Zwiren LD, Kenney WL (eds): **American College of Sports Medicine's Resource Manual for Guidelines for Exercise Testing and Prescription**. **2nd edition** (p59-65). Lea and Febiger, Philadelphia, PA, 1993.

15. Durstine JL, Pate R, Branch, DJ. Cardiorespiratory responses to acute exercise. In Durstin JL, King AC, Painter PL, Roitman JL, Zwiren LD, Kenney WL (eds): **American College of Sports Medicine's Resource Manual for Guidelines for Exercise Testing and Prescription. 2nd edition** (p66-74). Lea and Febiger, Philadelphia, PA, 1993.

16. Ekblom B and Hermangen L. Cardiac output in athletes. **J Appl Physiol**. 1968; 25: 619.

17. Erdman R, Duivenvoorden J, Verhage F, Kazemies, m, Hugenholtz P. Predictability of beneficial effects in cardiac rehabilitation: a randomized clinical trail of psychosocial variables. **J.Cardiopulmonary Rehab.** 1986; 6: 206-213.

18. Fioretti P, Simoons ML, Zwiers G, Baardman T, Brower RW, Kazemir M, and Hugenholtz PG. Value of predischarge data for the prediction of exercise capacity after cardiac rehabilitation in patients with recent myocardial infarction**. Eur Heart J** 1987;(suppl G):33-38.

19. Foster C, Pollock ML, Anholm JD, Sqires RW, Ward A, Dymond DS, Rod JL, Saichek RP, Schmidt DH. Work capacity and left ventricular function during rehabilitation after myocardial revascualrization surgery. **Circulation**. 1984; 69:748-755.

20. Freedson PF. Intra-arterial blood pressure during free weight and hydraulic resistive exercise. **Med Sci Sports Exer**. 1984; 16:131.

21. Freyschuss U, Melcher A. Exercise energy expenditure in extreme obesity: influence of ergometry type and weight loss. **Scand J Clin Invest** .1978; 38: 753-759.

22. Froelicher VF, Herbert WG, Myers J, Ribisil P. How cardiac rehabilitation is being influenced by changes in health care. **J Cardiopulmonary Rehabil**. 1996; 16:151-159.

23. Frye RL, Higgins MW, Beller GA. Major demographic and epidemiological trends affecting adult cardiology. **J Am Coll Cariol**. 1988; 12: 840-846.

24. Gaesser GA and Brooks GA. Metabolic basis of excess post-exercise oxygen consumption: a review. **Med Sci Sports and Exerc**. 1984; 16: 29-43.

25. Gamble P, Froelicher VF. Can an exercise program worsen heart disease? **Physician Sport Med** 1982;10(5):69-77.

26. Guyton AC and Hall JE. **Textbook of Medical Physiology (9th edition).** WB Saunders Company: Philadelphia, PA. 1996.

27. Hammond HK, Kelly TL, Froelicher VF, Pewen W. Use of clinical data in predicting improvement in exercise capacity after cardiac rehabilitation. **J Am Coll Cardiol**. 1985; 6:19-26.

28. Hartung, G.H; Rangel, R. Exercise training in post-myocardial infarction patients: Comparison of results with high risk coronary and post-bypass patients. **Arch. Phys. Med.Rehal**.1981 62:147-150.

29. Haskell WL. Cardiovascular complications during exercise training of cardiac patients. **Circulation.** 1978; 57: 980-984.

30. Holewijn M, Physiological strain due to load carrying. **Eur J Appl Physiol**. 1990; 61:237-245.

31. Holloszy JO. Muscle metabolism during exercise. **Arch Phys Med Rehabl**. 1982; 63: 231-234.

32. Hossack KF, Bruce RA, Green B, Fusako, K, DeRoulon T, Trimble S. Maximal cardiac output during upright exercise : approximate normal standards and variations with coronary artery disease. **Am J Cardiol**. 1980; 46: 204.

33. Hung J, Gordan EP, Houston N, Haskell WL, Goris ML, DeBusk RF. Changes in rest and exercise myocardial perfusion and left ventricular function 3 to 26 weeks after clinically uncomplicated acute myocardial infarction: effects of exercise training. **Am J Cardiol.** 1984; 54: 943-950.

34. Kappagoda CT, Linden RJ, Newell JP. A comparison of the oxygen consumption/body weight relationship obtained during submaximal exercise on a bicycle ergometer and on a treadmill.**Q J Exp Physiol Cogn Med Sci**. 1979; 64:205-215.

35. Katch V. Correlational v ratio adjustments of body weight in exercise-oxygen studies. **Ergonomics**. 1972;15:671-680.

36. Levin LA, Perk J, Hedback B. Cardiac rehabilitation: a cost analysis. **J Internal Medicine**. 1991; 230: 427-434.

37. Mayou R. Prediction of emotional and psychosocial outcome one year after a first myocardial infarction. **J of Psychosomatic Research**. 1984; 28(1): 17-25.

38. McArdle WP, Katch FI, Katch VL. **Exercise Physiology: Energy, Nutrition and Human Performance (3rd edition).** Philadelphia, PA: Lea and Febigen, 1991.

39. Milani RU, Littlman AB, Lavic CJ. Depressive symptoms predict functional improvement following cardiac rehabilitation and exercise program. **J Cardiopulmonary Rehabil**. 1993; 13: 406-411.

40. Neilson NC, Landgraf JM, Hays RD. The functional status of patients how can it be measured in physicians' offices? **Medical Care**. 1990; 28 (12): 1111-1118.

41. Oldridge NB, Foster C, Schmidt DH. **Pathophysiology and Epidemiology of Cardiovascular Disease in Cardiac Rehabilitation and Clinical Exercise Programs: Theory and Practice**. Movement Publications Inc: Ithica, NY. 1988.

42. Oldridge N, Furlong W, Feeny D, Crowe J, Jones n. Economic evaluation of cardiac rehabilitation soon after myocardial infarction. **Am J Cardiol**. 1993; 72: 154-161.

43. Ornish D, Brwn SE, Scherwitz LW, Billings LW, Amstrog W, Pors TA, Mclanahan SM, Kirkeeide RL, Braud RJ, Can lifestyle changes reverse coronary heart disease? **The Lifestyle Trail Lancet** 1990;336:129-133).

44. Picard MH, Dennis C, Schwartz RG, Ahn DK, Kraemer HC, Berger WE, Blumberg R, Heller R, Lew H, DeBusk RF. Cost-benefit analysis of early return to work after uncomplicated myocardial infarction. **Am J Cardiol**. 1989; 63: 1308-1314.

45. Pierson LM, Herbert WG, Davis SE, Southard DR. Defining a set of patient attributes that predict exercise performance outcome following an exercise training program in a population of coronary artery disease patients. M.S Virginia Tech 1998.

46. Rechnitzer PA, Cunningham DA, Andrew GM, Buck CW, Jones NL, Kavanagh T, Oldridge NB, Parke JO, Shephard RJ, Sutton JR etal. Ontario Exercise-Heart Colaborative Study:relation of exercise to the reccurence rate of myocardial infarction in men. **Am J Cardiol** 1983; 51:65-9.

47. Redwod, D.R.; Rosing, D.R: Epstien, S.E. Circulatory and symptomatic effects of physical training in patients with coronary- artery disease and angina pectoris. **N. Engl J. Med**. 1972;286;959-96.

48. Rejeski WJ, Morley D, Miller HS. The Jenkins activity survey: exploring its relationship with compliance to exercise prescription and MET gain within a cardiac rehabilitation setting. **J Cardiac Rehabil.** 1984; 90(4): 90-94.

49. Rhoades RA and George AT. **Medical Physiology**. 1st edition (p168). Little, Brown and Company: Boston, MA. 1995.

50. Scaluini S, Marangoni S, Volterrani M, Schena M, Quadri A, Levi GF. Physical rehabilitation in coronary patients who have suffered from episodes of cardiac failure. **Cardiology.** 1992; 80(5-6): 417-423.

51. Sherwood L. **Human Physiology: From Cells to Systems (3rd edition)**. Wadsworth Publishing Company: Belmont,CA. 1997.

52. Squires RW, Gau GT, Miller TD, Allison TG, Lavie CJ. Cardiovascular rehabilitation status. **Mayo Clin Proc**. 1990; 65(5): 731-755.

53. Squires RW and Williams LW. Coronary atherosclerosis and acute myocardial infarction. In Durstin JL, King AC, Painter PL, Roitman JL, Zwiren LD, Kenney WL (eds): **American College of Sports Medicine's Resource Manual for Guidelines for Exercise Testing and Prescription. 2nd edition** (p168). Lea and Febiger, Philadelphia, PA, 1993.

54. Stein MJ, Gorman PA, Kaslow P. Group concealing versus exercise therapy: a controlled intervention with subjects following myocardial infarction. **Arch Intern Med**. 1983; 143: 1719-1783.

55. Sullivan MJ, Higginbothem MB, Cobb FR. Exercise training in patients with severe left ventricular dysfunction: homodynamic and metabolic effects. **Circulation**. 1988; 78: 506-515.

56. Todd IC and Ballantyne D. Effect of exercise training on the total ischemic burden: an assessment by 24 hour ambulatory electrocardiographic monitoring. **Br Heart J**. 1992; 68(6): 560-566.

57. Todd IC, Bradham MS, Cooke MB, Ballantyne D. Effects of daily high-intensity exercise on myocardial perfusion in angina pectoris. **Am J Cardiol**. 1991;68(17): 1593-1599.

58. Tsoukas A, Andonakoudis H, Chistakos S. Short-term exercise training effect after myocardial infarction on myocardial oxygen consumption indices and ischemic threshold. **Arch Phys Med Rehabil.** 1995; 76:262-265.

59. VanCamp SP and Peterson RA. Cardiovascular complications of outpatient cardiac rehabilitation programs. **JAMA.** 1986; 256: 1160-1163.

60. Vander AJ, Sherman JH, Luciano DS. **Human Physiology: The Mechanisms of the Body (5th EDITION**). McGraw-Hill Publishing Company: New York,NY. 1990.

61. VanDixhorn J and Durvenvoorden HJ. Success and failure of exercise training after myocardial infarction: is the outcome predictable? **J Am Coll Cardiol**. 1990; 15: 974-982.

62. Wasserman K, Whipp BJ, Koyal SN, Beaer WL. Anaerobic threshold and respiratory gas exchange during exercise. **J Appl Physiol.** 1973; 35: 236-243.

63. Whip BJ and Wasserman K. Effect of anaerobosis on the kinetics of oxygen uptake during exercise. **Federation Proc**. 1986; 45:2942-2947.

64. Wilklord I, Sanne H, Vedia A, Willhelmson C. Psychosocial outcome one year after a first myocardial infarction. **J of Psychosomatic Research**. 1984; 28(4): 309-321.

65. Williams RB, Haney TL, McKinnis RA, Harrell FE, Lee KL, Pryor D, Califf R, Kony YH, Rosati RA, Blumenthal JA. Psychosocial and physical predictors of anginal pain relief with medical management. **Psychosomatic Medicine**. 1985; 48: 200-209.

66. Wittels EH, Hay JW, Gotto AM. Medical costs of coronary artery disease in the United States. **Am J of Cardiol**. 1990; 65: 432-440.

67. Wosornu D, Allardyre W, Ballantyne D, Tansey P. Influence of power and aerobic exercise training on homeostatic factors after coronary artery surgery. **Br Heart Journ**. 1992; 68(2): 181-186.

68. Zuti WB, Golding LA, Equations for estimating percent body fat and body density of active adult males. **Med Sci Sports**.1973;5 (4): 262-266.

APPENDIX A
DETAILED METHODOLOGY

Subjects

This was a retrospective study of clinical records of random patients who had participated in hospital-based outpatient cardiac rehabilitation at Carolinas Medical Center in Charlotte, North Carolina from October 1995 to March 1997. To be eligible for inclusion patients' records must have been complete with initial GXT tests, exercise prescription, quality of life (QOL) data and individual session reports. Only records were included if the patient had been admitted to the rehabilitation program on the bases of: MI, coronary revascularization, physician-diagnosed angina, or angiographically confirmed CAD. Cases were excluded for any of the following reasons: failure to complete 8-12 weeks of cardiac rehabilitation; failure of the patient to attend at least 70% of exercise sessions; a documented change in prescription of medications during training program; and records which demonstrate inconsistency in order of treadmill activity within the circuit program used in each session. A total of 135 records from consecutive patients were reviewed for potential inclusion in the study. Of these, 41 records were excluded for the following reasons: less than 70% attendance to exercise sessions (N= 28); files incomplete for GXT data, exercise records, psychosocial data or medication records (N= 13). The remaining 94 patient files were used for analysis in this study. Of these, 45 patients experienced a recent MI and 46 patients had undergone a recent coronary revascularization procedure. There were 46 patients who experienced recent angina, 29 who had recently undergone an angioplasty procedure and 23 patients received calcium channel blocker medication, 44 received beta blocker, 26 received diuretics and 14 patients received digitalis medication.

Initial Exercise Testing

Prior to admission into the outpatient cardiac rehabilitation program at Carolinas Medical Center, a maximal graded exercise treadmill test is required. This is a test which measures physiological responses of the heart to incremental work load increase. Depending on the protocol, the increase will occur at 2 or 3 minute stages. No standard protocol was used because tests were performed at various locations, hence the use of Bruce vs. Balke protocols may have influenced estimates of peak METS from these tests.

Exercise Prescription

Exercise prescription and assignment to training activities was based on a master list where patient protocols were determined on patient capability and equipment availability. Patient capability was determined by $MET_{pk,}$ which is the maximum amount of symptom limited metabolic work achieved during initial treadmill test. Initial exercise intensity was prescribed at 50% of MET_{pk} achieved during baseline graded exercise test Exercise was prescribed on three of the following exercise modes: Quinton Medtrack™ (Seattle, Washington); Schwinn Air-Dyne ™(Chicago, Illinois); Concept II rowing ergometer™ (Morrissville, Vermont); Techtrex Climax™ (Irvine California), and PTS Turbo 1000 recumbent cycle ergometer™. Each exercise session included a 10 min warm-up, a 10 min exercise stimulus period at three of the above specified exercise modalities, and a 10 minute cool down. The MET level was subject to increase over sessions, according to staff judgment, based on the following hemodynamic responses; blood pressure and heart rate. The MET level for each apparatus was calculated via metabolic equations published by the ACSM or metabolic formula contained in the manufacturer's literature. Treadmill MET level was set according to the following ACSM equation:

Predicted VO_2 *=3.5ml/kg/min + .1 x walking speed + 1.8 x speed (m/min) x grade (as a decimal)*

Patient heart rate in the treadmill mode was taken by ECG and recorded by a trained technician at the end of the treadmill station. Self-monitored pulse checks, using a 10 second count also were taken and recorded by participants at the end of each exercise modality. Rate of perceived exertion measurements also were self-recorded for each exercise modality. The treadmill station represented the most accurate and convenient measure of daily activity. Exercise heart rates, taken by trained technicians, also provided a precise method of systematic hemodynamic monitoring. The present study utilized treadmill exercise data in conjunction with patient body weight to quantify cardiovascular fitness levels before and after cardiac rehabilitation.

Definition of Training Outcome Criterion

For the purpose of quantifying changes in cardiorespiratory fitness from the exercise sessions, exercise tolerance was determined from baseline and post-training treadmill data. Training effect was quantified statistically by measuring differences in the predicted VO_2 of the patients adjusted for heart rate and body weight changes using the following formula:

Treadmill Fitness Outcome = change in *predicted* VO_2 *+ body weight - heart rate.*

These differences were measured by establishing graphically confirmed heart rate steady state conditions for the treadmill exercise station during the first 2 weeks of exercise and then comparing the predicted VO_2 at this level with that for the 34 and 35 sessions of rehabilitation. Criteria for establishing which exercise sessions elicited stability at baseline for subject response was determined by graphing the first two weeks of treadmill workload and using the predicted VO_2 level representative of steady state activity, corresponding heart rate, and body weight measurements. The final workload level, final exercise heart rate and final body weight were all recorded using data collected from the two sessions prior to the last day of exercise. The change in these measurements was determined by subtracting initial response (average of first two steady state responses) from final responses (average of two sessions prior to final day of exercise).

Research Design and Statistical Analyses

A physical training outcome score was tabulated using changes in predicted VO_2, body weight and exercising heart rate. Exercise training has been shown to increase functional capacity, as measured by VO_2, decrease sub-maximal exercise heart rate and reduce body weight.[6,13,20,22,23] However, research has demonstrated an inverse relationship between body weight reduction and peak VO_2.[5,14,16,30] Therefore, the following formula treats weight reduction as a negative in calculating training outcome. *These scores were standardized to facilitate the following equation:*

Training Outcome = Predicted VO_2 *change*[1] *+ Body Weight change*[2] *- Heart Rate change*[3]

[1] **Predicted VO_2 change** = difference between an average predicted VO_2 of first two sessions

representative of steady state treadmill activity and an average of the two sessions prior to final day of exercise. *post predicted* VO_2 *- pre predicted* VO_2

[2] **Body weight change** = difference between an average body weight of first two sessions representative of steady state activity and an average of the two sessions prior to final day of exercise. *post body weight - pre body weight*

[3] **Heart rate change** = difference between treadmill exercise heart rate of first two sessions representative of steady state activity and an average of two sessions prior to the final day of exercise. *post exercise heart rate- pre exercise heart rate*

The outcome measure was tabulated utilizing the following seven steps:

1. Changes in predicted VO_2, exercise heart rate and body weight were all standardized and made unitless in order to facilitate comparison.
2. The relationship between these variables were analyzed with Multi-Factorial Analysis which yielded coefficients that were equal in magnitude, making direct tabulation possible.
3. These standardized variables were inserted into the following equation
   Treadmill Fitness Outcome = change in *predicted* VO_2*+ body weight - heart rate.*
4. Training outcome scores were then standardized and analyzed utilizing descriptive statistics for mean, standard deviation and standard error of the mean.
5. A value of three standard errors of the mean was statistically designated as the most appropriate cut-off point to classify patients into the following groups: *improved, declined* or *no change*
6. This "data driven" cut-off was empirically constructed based on prediction models fraction correctly classified percentages (sensitivity and specificity) which quantifies models standard of fit.
7. Ten separate prediction models were constructed utilizing the following cut-off parameters for

comparison: 1 SEM ,1.5 SEM ,2 SEM, 2.5 SEM and 3 SEM percentages. Three SEM elicited the highest fraction correctly classified, sensitivity and specificity in both improvement vs. no improvement models and decline vs. no decline models (Table 1).

improvement group = 3 SEM > mean

no change group = within 3 SEM of the mean

decline group = 3 SEM< mean

For the purpose of creating two separate models of prediction, training outcome scores were sorted for individual patients according to the following dichotomous groupings: *improvement vs.*

no change and decline and decline vs. no change and improve The association between initial patient attributes and training outcome was analyzed first utilizing univariate methods and then multivariate analysis was used to identify patient characteristics predictive of improvement vs. no improvement outcome, and then, decline vs. no decline outcome. In the univariate approach to data analysis patient characteristics were tested as predictors of outcome with (1) chi-square analysis for variables containing nominal data and (2) Student t-test for variables of interval data.

Multiple Logistic Regression

The outcome variable in the logistic regression model is dichotomous, coded one for presence of a certain outcome and zero for its absence. Variables utilized for prediction models were chosen based on previous research and current data selection. The criteria for inclusion of variables in the prediction model was $p<0.10$. Forward logistic regression procedure was used in an attempt to identify the best prediction models for the two outcomes (improve and decline) based on the patient attributes obtained at program entry. The equation which resulted from the logistic regression function consisted of variables found to be the best predictors of outcome, along with their respective coefficients and intercept. This equations yielded an estimation of the probability of a particular outcome for all 94 patients. The prediction success of these models was evaluated by comparing the estimated outcome to the actual outcome for each patient. Correct classification rates were calculated, along with sensitivity, specificity and total error rates for each model.

Model Cross-Validation (Single Point Deletion)

This method examined the models ability to predict STO scores with patient data which was not used to construct the regression equation. This helped determine if the models, which were constructed with fitted data, demonstrated overly optimistic predictive capabilities. Single point deletion yielded predicted values for both predicting improvement vs. no improvement and decline vs. no decline. This process was achieved through the following steps; (1) systematically removing one patent from 94 patient data set, (2) re-estimating the parameters of regression model with remaining 93 patients, (3) classifying the observation based on the new parameter estimates, which did not include patient data comprised in model construct. This process was done with all 94 patients, treating each patient as a new subject.

APPENDIX B
FACTOR ANALYSIS AND PEARSON PRODUCT CORRELATION

Factor Analysis

Factor Analysis Coefficients

Variable	Factor1	Factor2	Factor3
STD VO_2	0.604	0.77	-0.761
STD BW	0.555	-0.779	0.357
STD HR	-0.566	0.622	-0.542

Correlations (Pearson)

	HR diff	BW diff
BW diff	-0.083 0.425	
VO_2 diff	-0.184 0.75	0.155 0.136

Correlations (Pearson)

	STD VO_2	STD HR	STD BW
STD HR	-0.184 0.075		
STD BW	0.155 0.136	-0.083 0.425	
STO	**0.418** **0.000**	**-0.589** **0.000**	**0.570** **0.000**

Correlations (Pearson)

	STO	STD VO_2	STD BW	STD HR
#sessions	-0.02334	0.103508	0.109475	-0.03063

	STO	STD VO_2
MAX METS	-0.02103	-0.03931

APPENDIX C
RAW DATA

Key For Raw Codes

Predictor Variables Extracted from Patient Files

Pt ID- patient identification number.

Gender- male/female

Orth limit- presence of orthopedic problems

Body weight- body weight in kilograms.

Age- patient age in years.

Max Mets- peak METS on baseline GXT as estimated from peak treadmill speed and grade.

HR max- maximum heart rate demonstrated during baseline GXT test.

R MI- recent myocardial infarction (program entry diagnoses).

Tchol- total cholesterol

SBP Max- maximum systolic blood pressure achieved during GXT.

DBP Max- maximum diastolic blood pressure achieved during GXT.

HR rest- resting heart rate recorded during GXT.

SBPrest- resting systolic blood pressure recorded during GXT.

ComplxVe- presence of complex ventricular ectopy during GXT, defined as 2 or more PVCs in sequence.

R Angio- recent angioplasty procedure(entry diagnoses).

R CABG- recent coronary bypass graphing (entry diagnoses).

R Angina- recent angina pectoris (entry diagnoses)

Fam Hx- presence of a positive family history for coronary artery disease.

Hx Diabet- history of diabetes

Hx Htn- history of hypertension.

Ca2+B- calcium channel blocker medication.

Beta B- beta blocker medication

Diuretic- diuretic medication

Digitalis- digitalis medication.

OverallH- entry level overall health as measured by COOP charts.

Social sup- entry level social support as measured by COOP charts.

QOL score- entry level quality of life score as measured by COOP charts.

Emot Stat- entry level emotional status as measured by COOP charts.

Role Fun- role function as measured by COOP charts

Variables Used in Assessing Training Outcome

Training Outcome = predicted VO_2 *difference + body weight difference – heart rate difference*

BW Differ- difference between initial and final steady state body weight (kg).

HR Differ- difference between initial and final steady state exercise heart rate response (bpm).

$V0_2$diff- difference between initial and final predicted exercise VO_2 (ml/kg/min).

STO- categorized actual training outcome score.

Pd STO- categorized predicted training outcome score.

$$STD\ VO_2 = VO_2\ diff - mean\ (VO_2\ diff)\ /\ stdev\ (VO_2\ diff)$$

STD BW= BW diff-mean (BW diff) / stdev (BW diff)

STD HR= HR diff-mean (HR diff) /stdev (HR diff)

TO SCR= STD VO_2 + STD BW – STD HR

STO= TO SCR-mean (TO SCR) / stdev (TO SCR)

Pt ID#	BW diff	HR diff	VO_2 diff	STD VO_2	STD BW	STD HR	TO SCR	STO
1	-1.8	15.0	4.8	-0.17	-0.70	0.69	-1.56	-0.99
2	0.0	-1.0	7.3	0.45	0.18	-0.35	0.97	0.67
3	-1.4	27.0	8.2	0.67	-0.48	1.46	-1.27	-0.81
4	-1.8	-4.5	7.1	0.40	-0.70	-0.58	0.27	0.17
5	-1.4	-15.0	-3.1	-2.14	-0.48	-1.25	-1.37	-0.87
6	-0.5	-6.5	10.5	1.24	-0.04	-0.71	1.91	1.21
7	-2.0	16.0	5.3	-0.05	-0.81	0.75	-1.61	-1.02
8	-1.6	0.0	10.0	1.12	-0.59	-0.28	0.81	0.52
9	-0.9	25.5	-5.4	-2.71	-0.26	1.36	-4.34	-2.75
10	-1.8	16.5	2.4	-0.77	-0.70	0.78	-2.26	-1.43
12	3.0	-13.0	1.6	-0.97	1.60	-1.13	1.76	1.11
13	-5.5	14.0	5.3	-0.05	-2.46	0.62	-3.13	-1.98
14	-1.8	20.0	13.8	2.07	-0.70	1.01	0.36	0.23
15	0.2	4.0	8.3	0.70	0.29	-0.03	1.01	0.64
16	3.1	6.5	3.5	-0.50	1.71	0.14	1.08	0.68
17	1.8	20.0	0.5	-1.24	1.05	1.01	-1.20	-0.76
18	-4.3	12.0	6.7	0.30	-1.91	0.49	-2.10	-1.33
19	0.2	-13.5	7.6	0.52	0.29	-1.16	1.97	1.25
20	-0.7	10.0	8.2	0.67	-0.15	0.36	0.16	0.10
21	0.7	4.0	1.0	-1.12	0.50	-0.03	-0.59	-0.37
22	-3.6	14.5	8.4	0.72	-1.58	0.65	-1.51	-0.96
23	-1.1	-3.0	7.6	0.52	-0.37	-0.48	0.63	0.40
24	-3.6	20.5	10.1	1.14	-1.58	1.04	-1.48	-0.93
25	0.5	-28.0	2.0	-0.87	0.39	-2.10	1.62	1.03
27	1.4	15.0	5.4	-0.02	0.83	0.69	0.12	0.08
28	-0.9	-7.0	5.1	-0.10	-0.26	-0.74	0.37	0.24
29	3.4	23.0	5.5	0.00	1.82	1.20	0.62	0.39
30	1.7	75.0	0.0	-1.37	0.50	4.57	-5.43	-3.44
31	0.0	0.0	8.4	0.72	0.18	-0.28	1.18	0.75
32	-1.4	9.5	3.1	-0.60	-0.48	0.33	-1.41	-0.89
33	0.2	25.0	8.1	0.65	0.29	1.33	-0.40	-0.25
34	-0.7	-20.5	2.7	-0.70	-0.15	-1.61	0.76	0.48
35	-0.7	5.0	12.6	1.77	-0.15	0.04	1.57	1.00
36	5.2	18.5	13.3	1.94	2.70	0.91	3.73	2.36
37	3.0	-3.0	2.6	-0.72	1.60	-0.48	1.36	0.86
38	0.0	27.0	6.4	0.22	0.18	1.46	-1.06	-0.67
39	0.0	-8.0	5.4	-0.02	0.18	-0.80	0.95	0.60

Pt ID#	BW diff	HR diff	VO_2 diff	STD VO_2	STD BW	STD HR	TO SCR	STO
40	-4.1	4.5	12.3	1.69	-1.80	0.01	-0.11	-0.07
41	-1.4	0.0	3.4	-0.52	-0.48	-0.28	-0.72	-0.46
42	-2.0	5.0	9.9	1.10	-0.81	0.04	0.25	0.15
43	-2.5	-18.0	10.2	1.17	-1.03	-1.45	1.59	1.01
44	3.2	-9.0	1.4	-1.02	1.71	-0.87	1.56	0.99
45	1.6	13.0	8.4	0.72	0.94	0.56	1.11	0.70
46	-0.5	19.0	8.1	0.65	-0.04	0.94	-0.34	-0.22
47	-0.9	-12.0	4.5	-0.25	-0.26	-1.06	0.55	0.35
48	0.5	-11.5	7.0	0.37	0.39	-1.03	1.80	1.14
49	-3.4	6.5	3.5	-0.50	-1.47	0.14	-2.10	-1.33
50	-5.2	29.5	13.2	1.92	-2.35	1.62	-2.05	-1.30
51	-3.6	0.0	5.0	-0.12	-1.58	-0.28	-1.42	-0.90
52	1.8	-4.0	2.6	-0.72	1.05	-0.54	0.87	0.55
53	-1.6	7.0	2.3	-0.80	-0.59	0.17	-1.56	-0.99
54	1.6	21.0	11.2	1.42	0.94	1.07	1.29	0.82
55	0.0	-15.0	7.2	0.42	0.18	-1.25	1.85	1.17
56	-0.5	0.0	-1.4	-1.72	-0.04	-0.28	-1.48	-0.94
57	0.7	6.5	4.9	-0.15	0.50	0.14	0.22	0.14
58	-1.6	-8.0	9.3	0.95	-0.59	-0.80	1.16	0.73
59	0.5	28.5	5.3	-0.05	0.39	1.56	-1.21	-0.77
60	-0.5	2.5	0.0	-1.37	-0.04	-0.12	-1.29	-0.82
61	1.8	-24.5	0.0	-1.37	1.05	-1.87	1.55	0.98
62	0.9	4.0	1.2	-1.07	0.61	-0.03	-0.43	-0.27
63	-1.6	-12.0	10.0	1.12	-0.59	-1.06	1.59	1.01
64	-0.9	2.0	2.7	-0.70	-0.26	-0.16	-0.80	-0.51
65	-0.7	4.0	1.4	-1.02	-0.15	-0.03	-1.15	-0.73
66	1.4	14.5	4.5	-0.25	0.83	0.65	-0.07	-0.04
67	2.3	-16.0	6.2	0.17	1.27	-1.32	2.77	1.75
68	1.1	23.5	9.4	0.97	0.72	1.24	0.46	0.29
69	-2.3	22.5	3.3	-0.55	-0.92	1.17	-2.64	-1.67
70	0.2	2.0	3.5	-0.50	0.29	-0.16	-0.06	-0.04
71	-0.5	20.0	1.9	-0.90	-0.04	1.01	-1.95	-1.24
72	-0.5	11.5	0.0	-1.37	-0.04	0.46	-1.87	-1.19
73	-2.3	-3.0	4.9	-0.15	-0.92	-0.48	-0.59	-0.37
74	-1.3	31.5	11.3	1.44	-0.37	1.75	-0.68	-0.43
75	-1.6	4.0	5.4	-0.02	-0.59	-0.03	-0.59	-0.37
76	-0.9	-2.5	6.3	0.20	-0.26	-0.45	0.38	0.24
77	0.0	-3.0	4.9	-0.15	0.18	-0.48	0.50	0.32
78	1.6	-6.0	3.0	-0.62	0.94	-0.67	0.99	0.63
79	-2.8	-17.0	4.9	-0.15	-1.03	-1.38	0.20	0.13
80	-4.8	-1.0	3.9	-0.40	-2.13	-0.35	-2.18	-1.38
81	1.4	11.0	17.2	2.91	0.83	0.43	3.32	2.10
82	-2.0	9.0	3.0	-0.62	-0.81	0.30	-1.73	-1.10
83	-1.8	-2.0	9.7	1.05	-0.70	-0.41	0.76	0.48
84	0.0	8.5	9.7	1.05	0.18	0.27	0.96	0.61
85	0.0	-19.5	0.0	-1.37	0.18	-1.55	0.35	0.22
86	0.7	6.5	10.0	1.12	0.50	0.14	1.49	0.94
87	-0.9	1.0	2.9	-0.65	-0.26	-0.22	-0.69	-0.44
88	2.7	-6.0	7.3	0.45	1.49	-0.67	2.61	1.66
89	5.7	6.0	0.7	-1.19	2.92	0.10	1.62	1.03

Pt ID#	BW diff	HR diff	VO_2 diff	STD VO_2	STD BW	STD HR	TO SCR	STO
90	0.0	3.0	4.1	-0.35	0.18	-0.09	-0.08	-0.05
92	0.0	-1.5	7.3	0.45	0.18	-0.38	1.01	0.64
93	1.8	5.0	2.7	-0.70	0.94	0.04	0.21	0.13
94	1.4	6.5	3.7	-0.45	0.83	0.14	0.25	0.16
95	1.4	-24.0	0.8	-1.17	0.83	-1.83	1.50	0.95
96	-2.5	10.0	6.9	0.35	-1.03	0.36	-1.04	-0.66
97	0.9	-17.5	2.5	-0.75	0.61	-1.42	1.28	0.81

* patients 11,26 and 91 were deleted from study due to lack of data.

Raw Data Used to Construct Prediction Equations

Pt ID#	Gender	Orth limit.	Age	Max Mets	HR max	R MI	Tchol	SBP Mx
1	1	0	42	6.2	129	0	195	172
2	1	0	63	6.2	132	0	196	154
3	1	0	50	9.3	163	1	200	163
4	1	0	50	8.7	145	1	198	115
5	1	0	54	11	127	0	182	198
6	1	1	60	4.8	149	1	292	190
7	0	0	68	4.5	135	1	198	179
8	1	1	72	5.5	100	1	181	167
9	1	0	62	9	159	1	199	197
10	0	0	52	3.6	140	0	207	201
12	1	0	76	7	117	0	197	160
13	1	1	58	7.1	122	0	134	175
14	1	0	53	11.4	151	0	200	215
15	0	0	68	6.2	110	1	245	144
16	1	1	66	6	103	1	155	188
17	0	1	54	4.9	174	0	200	177
18	1	1	30	7.6	163	1	184	160
19	1	0	53	8.5	166	0	207	190
20	0	0	73	5.6	113	0	258	204
21	1	1	57	10	185	1	168	158
22	0	0	66	4.3	152	0	286	218
23	1	0	59	8.5	141	1	215	174
24	0	0	53	5	135	1	222	140
25	1	0	48	9.4	142	0	142	200
27	1	0	56	6.2	160	0	191	173
28	1	1	55	9.7	130	1	246	200
29	1	0	42	8.3	146	1	204	144
30	1	0	50	7.6	149	0	210	166
31	0	1	71	4	179	1	215	179
32	1	0	41	10.4	153	1	228	210
33	0	1	56	2.2	74	1	207	186
34	1	1	52	7.6	146	0	177	180
35	1	1	73	4.9	92	1	235	229
36	1	0	52	4.2	120	0	297	158
37	1	0	58	5.6	135	0	168	180
38	1	0	46	9	169	0	192	223
39	0	0	63	5.8	146	0	186	172
40	1	0	47	11.7	184	1	169	152
41	1	0	52	7.6	147	0	195	158
42	1	0	53	7	145	0	190	192
43	1	0	51	11	149	1	117	180
44	1	0	62	8	155	0	118	204
45	0	0	44	7.7	144	0	181	194
46	1	1	65	4.9	108	0	233	188
47	0	0	42	4	135	0	185	145
48	1	0	50	9	169	0	209	173
49	1	0	47	6.2	150	0	119	144
50	1	0	48	7.7	132	0	254	247
51	0	1	63	5.6	147	0	163	180

Pt ID#	Gender	Orth limit.	Age	Max Mets	HR max	R MI	Tchol	SBP Max
52	1	1	57	5.6	134	1	176	201
53	1	1	63	9	166	0	211	164
54	1	0	53	11.4	151	0	200	215
55	0	0	68	6.2	110	1	245	144
56	1	0	69	7	117	1	114	173
57	1	0	58	10.7	152	1	166	151
58	1	0	56	9.7	160	0	142	198
59	1	0	63	7.2	146	0	258	171
60	0	0	41	9.6	146	0	167	125
61	0	0	39	7	152	0	148	129
62	1	0	46	9.7	128	0	164	173
63	1	1	58	7.2	142	1	187	161
64	0	0	71	4.8	160	1	219	200
65	1	1	46	9.9	158	1	197	175
66	1	0	57	4	123	0	211	160
67	1	0	59	7	144	1	217	175
68	0	1	67	5.1	140	1	231	172
69	1	0	57	7.7	123	1	159	162
70	1	0	50	9.7	100	0	203	149
71	0	0	72	3.6	155	0	202	186
72	1	1	54	9.5	146	0	192	155
73	1	1	62	4.6	134	1	219	164
74	1	0	49	7	122	1	191	197
75	1	0	69	4.4	98	1	137	117
76	1	0	54	4.6	102	1	235	184
77	1	0	53	9	180	0	161	215
78	1	0	56	7	147	1	250	264
79	1	1	70	7	127	0	171	202
80	1	1	49	9.7	164	1	193	185
81	1	0	38	7.9	142	0	188	174
82	0	0	68	5	135	1	198	179
83	1	0	50	5.2	130	1	210	175
84	1	1	50	13.5	160	1	145	180
85	0	1	50	7.8	99	0	352	179
86	1	0	47	8.3	135	1	233	169
87	1	1	68	8.3	130	0	145	194
88	1	1	73	6.2	119	0	142	165
89	1	1	60	7	145	0	167	224
90	1	0	66	7.6	131	0	225	240
92	1	1	53	8.3	130	1	164	146
93	0	0	64	6.2	154	1	169	154
94	1	1	49	9.3	136	1	142	193
95	1	0	62	6	132	1	188	178
96	0	1	64	5.6	140	1	270	210
97	1	0	57	4.6	163	0	247	134

* patients 11,26 and 91 were deleted from study due to lack of data

Raw Data Used to Construct Prediction Equations

Pt ID#	DPB Max	HR rest	SBP rest	DPB rest	Complx Ve	R Angio	R CABG	R Angina
1	74	77	135	78	0	0	1	0
2	76	71	149	72	0	0	1	0
3	55	69	124	75	0	1	0	0
4	58	78	107	73	1	1	0	0
5	67	52	133	99	0	1	1	0
6	90	136	150	90	0	1	0	1
7	70	75	134	66	0	1	1	0
8	75	64	149	80	0	0	0	1
9	87	93	137	57	1	1	1	0
10	86	110	152	86	0	0	0	0
12	70	56	146	60	0	0	0	1
13	50	61	145	77	0	1	0	0
14	65	50	119	85	0	0	0	1
15	66	57	131	57	0	1	1	0
16	78	60	108	68	0	0	1	0
17	98	80	164	95	1	0	0	1
18	82	88	121	72	1	1	0	0
19	100	70	130	80	0	0	0	1
20	78	71	164	78	0	0	1	0
21	93	62	131	81	0	0	0	0
22	96	108	194	114	0	0	0	1
23	98	72	116	86	1	0	1	0
24	84	68	120	72	0	0	0	1
25	80	92	150	88	1	0	1	1
27	95	95	167	106	1	0	1	1
28	92	65	144	72	0	1	0	0
29	64	55	103	58	0	1	0	0
30	85	91	123	80	1	0	1	0
31	105	72	172	75	1	0	1	0
32	80	88	110	94	1	1	0	1
33	91	55	169	81	1	0	1	0
34	70	93	110	86	0	0	1	0
35	99	74	135	77	0	1	0	0
36	95	103	141	85	0	0	1	1
37	80	94	160	70	0	0	1	1
38	65	71	156	99	1	1	0	1
39	90	70	115	77	0	1	1	1
40	89	70	120	58	0	0	0	1
41	86	105	142	80	0	0	0	1
42	97	88	133	87	0	0	1	0
43	100	66	122	88	0	1	0	0
44	73	102	154	74	0	0	1	1
45	89	98	161	92	0	0	1	0
46	75	90	149	62	0	0	1	1
47	66	92	139	93	0	0	1	1
48	80	85	113	79	0	0	1	0
49	60	75	129	73	0	0	1	0
50	110	57	164	103	0	1	0	1
51	80	77	120	84	0	0	1	1

Pt ID#	DPB Max	HR rest	SBP rest	DPB rest	Complx Ve	R Angio	R CABG	R Angina
52	74	94	166	97	0	0	1	0
53	60	89	126	72	1	0	1	0
54	65	50	119	85	0	0	0	1
55	66	57	131	57	0	1	0	1
56	61	74	141	79	0	0	0	0
57	54	56	124	69	0	0	1	0
58	98	98	160	98	0	0	0	1
59	96	84	151	99	0	0	1	1
60	43	79	111	78	0	0	1	1
61	74	66	110	63	0	0	1	1
62	73	66	113	62	0	0	0	1
63	90	86	107	74	0	1	0	0
64	84	89	191	94	0	0	0	1
65	73	75	133	81	1	0	0	1
66	80	81	160	90	1	0	1	1
67	81	89	144	78	0	0	1	1
68	84	76	152	80	0	0	0	0
69	100	73	112	78	0	1	0	1
70	82	51	128	74	0	0	1	1
71	102	86	107	80	0	0	0	0
72	88	62	131	94	0	1	0	0
73	69	92	147	57	0	0	1	0
74	71	69	153	88	0	1	0	0
75	77	63	115	68	0	1	0	0
76	74	71	120	69	0	0	1	1
77	82	99	142	90	0	0	1	1
78	103	82	209	89	0	0	1	0
79	74	74	161	80	0	0	0	1
80	72	90	138	76	0	1	0	1
81	80	76	118	73	0	0	1	0
82	70	75	134	66	0	1	0	1
83	66	104	149	74	0	0	1	0
84	68	77	127	58	0	0	1	0
85	179	99	160	59	0	0	0	0
86	99	66	138	88	0	1	1	0
87	94	66	157	99	0	0	0	1
88	76	66	149	64	0	1	1	0
89	151	66	177	100	0	0	0	0
90	79	81	110	86	0	0	0	1
92	86	63	126	84	0	0	0	0
93	62	88	120	76	0	1	1	1
94	83	66	131	87	0	0	1	1
95	95	80	138	89	0	1	0	0
96	98	77	169	98	0	0	0	0
97	74	90	116	78	1	0	0	1

* patients 11,26 and 91 were deleted from study due to lack of data

Raw Data Used to Construct Prediction Equations

Pt ID#	Fam Hx	Hx Diabetes	Hx Htn	Beta B	Ca2+ B	Diuretics	Digitalis	Body W
1	1	0	0	1	0	0	0	84
2	1	0	0	1	0	0	0	83
3	1	0	0	1	0	0	0	80
4	1	0	1	1	0	0	0	77
5	1	0	0	1	1	0	0	78
6	1	0	0	0	0	1	1	75
7	0	0	0	0	1	0	0	71
8	0	0	0	1	1	0	0	84
9	1	0	1	0	0	0	0	72
10	0	1	1	0	0	0	0	75
12	0	0	1	0	0	1	1	59
13	0	0	1	1	0	0	0	110
14	1	0	0	1	0	0	0	95
15	1	0	1	0	0	0	0	55
16	0	0	0	0	0	0	0	95
17	1	1	0	1	1	0	0	89
18	1	0	1	0	1	0	0	114
19	1	0	1	1	0	0	0	110
20	0	0	1	1	0	0	0	64
21	1	0	0	0	0	0	0	75
22	1	0	0	0	0	1	0	83
23	1	0	0	0	0	0	0	74
24	1	0	0	0	0	1	1	76
25	1	0	0	0	0	1	0	108
27	1	0	1	0	0	0	0	95
28	1	0	1	1	0	0	0	94
29	1	0	0	1	1	0	0	78
30	1	0	0	0	1	0	0	72
31	1	0	1	0	1	0	1	45
32	0	0	0	0	1	0	0	100
33	1	1	1	1	1	0	0	60
34	1	0	0	1	0	0	0	115
35	0	0	0	1	0	0	0	100
36	0	0	1	0	0	0	0	87
37	0	0	0	1	1	1	1	63
38	1	0	1	0	0	0	0	88
39	1	0	0	0	0	0	1	76
40	1	0	0	0	1	0	0	80
41	0	1	0	0	0	1	1	89
42	1	1	0	0	0	0	0	96
43	1	0	0	1	1	0	0	85
44	1	1	1	0	0	0	0	75
45	1	0	1	0	0	0	0	48
46	1	0	0	0	0	0	1	90
47	1	0	1	0	0	1	0	108
48	0	0	0	1	0	0	0	91
49	0	0	0	1	0	1	0	73
50	1	0	1	0	1	1	0	91
51	0	0	0	1	1	1	0	91

Pt ID#	Fam Hx	Hx Diabetes	Hx Htn	Beta B	Ca2+ B	Diuretics	Digitalis	Body W
52	0	1	0	0	0	0	0	66
53	0	0	0	0	0	0	0	81
54	1	0	0	1	0	0	0	95
55	1	0	0	1	0	0	0	55
56	1	1	0	0	0	0	0	99
57	0	0	0	0	1	0	0	84
58	0	0	0	0	0	0	0	70
59	0	0	1	0	0	1	0	105
60	1	0	0	1	0	0	0	61
61	0	0	0	0	0	1	1	57
62	0	0	0	1	1	0	0	93
63	1	0	0	1	0	0	0	77
64	1	0	1	1	0	1	0	78
65	0	0	0	0	0	0	0	89
66	0	1	1	1	0	0	0	92
67	1	0	0	1	0	0	0	80
68	0	0	1	1	0	1	0	69
69	0	0	1	0	0	0	0	76
70	1	0	1	1	0	0	0	73
71	0	0	1	0	1	0	0	59
72	0	1	1	0	0	0	0	97
73	0	0	0	0	0	1	1	92
74	1	0	1	1	1	0	0	98
75	0	0	1	1	0	0	0	83
76	0	0	1	1	0	1	0	114
77	0	0	1	1	0	0	0	116
78	1	0	0	0	0	1	0	64
79	1	0	0	1	1	0	0	90
80	1	0	0	1	0	0	0	94
81	1	0	1	0	1	0	0	84
82	0	0	0	0	0	1	0	71
83	1	1	1	1	0	0	1	95
84	1	0	0	1	0	1	0	82
85	0	0	1	1	0	1	0	83
86	1	0	1	0	0	0	0	94
87	1	0	1	1	0	0	0	69
88	0	1	1	0	0	0	0	85
89	0	0	1	1	0	0	1	120
90	1	0	0	1	1	0	0	97
92	1	0	1	0	0	0	0	107
93	1	0	0	0	0	0	0	56
94	1	0	0	1	0	0	1	96
95	0	0	0	0	0	0	0	77
96	0	0	1	0	0	0	0	94
97	1	0	1	0	0	1	1	126

* patients 11,26 and 91 were deleted from study due to lack of data

Raw Data Used to Construct Prediction Equations

Pt ID#	Phys F	Overall H	Social sup	QOL score	Emot Stat	Role Fun
1	3	2	1	16	1	1
2	5	4	1	28	4	3
3	1	3	2	18	3	3
4	3	4	2	23	3	4
5	3	2	1	18	2	1
6	4	4	1	31	3	5
7	3	2	4	19	3	1
8	4	2	1	18	3	1
9	4	1	2	21	3	2
10	5	4	3	31	3	3
12	4	1	3	19	2	3
13	1	1	1	23	1	1
14	3	4	1	10	1	2
15	4	3	2	19	3	3
16	3	2	3	24	3	2
17	5	4	4	23	4	4
18	4	4	2	33	4	3
19	2	2	1	27	2	3
20	4	2	2	16	1	1
21	3	4	2	16	3	3
22	4	3	1	28	1	3
23	4	2	2	22	1	2
24	1	1	1	19	2	1
25	4	3	2	11	3	3
27	2	1	1	15	1	1
28	4	3	1	10	3	2
29	4	3	1	22	2	2
30	3	3	1	20	3	2
31	3	1	1	12	1	1
32	2	3	4	20	2	1
33	4	2	2	24	3	3
34	3	3	1	23	3	3
35	2	2	1	14	1	1
36	3	2	2	19	1	2
37	4	2	2	18	1	2
38	4	4	1	22	1	3
39	3	3	1	22	2	2
40	2	2	1	15	2	1
41	4	2	1	21	1	4
42	3	3	1	23	3	3
43	3	2	1	15	1	2
44	3	3	2	16	1	1
45	3	1	1	12	1	1
46	3	1	2	14	1	1
47	1	3	3	28	4	3
48	1	1	1	13	1	1
49	3	3	5	26	4	1
50	2	2	1	23	4	1
51	4	2	3	28	3	3

Pt ID#	Phys F	Overall H	Social sup	QOL score	Emot Stat	Role Fun
52	2	2	4	29	4	3
53	2	1	1	11	1	1
54	3	4	1	19	1	2
55	4	3	2	24	3	3
56	4	3	1	24	3	4
57	2	1	3	23	4	4
58	2	1	2	13	2	1
59	2	2	2	14	2	1
60	3	1	3	19	3	2
61	4	1	3	20	1	3
62	3	1	2	15	2	1
63	2	1	3	19	2	3
64	4	2	3	25	3	2
65	2	3	2	21	3	3
66	3	2	4	22	3	2
67	4	4	3	28	3	3
68	3	3	1	17	1	2
69	3	1	1	17	3	3
70	4	1	2	23	3	3
71	4	2	1	24	2	3
72	3	1	2	19	2	2
73	5	2	3	27	4	3
74	1	4	1	20	3	2
75	3	1	1	21	3	3
76	3	2	2	21	2	2
77	3	2	2	22	2	3
78	3	4	1	30	4	4
79	1	2	1	16	2	2
80	3	2	1	24	2	3
81	3	1	4	21	2	2
82	2	3	3	25	4	2
83	4	1	3	18	2	2
84	1	1	2	19	3	3
85	1	1	2	19	3	3
86	2	3	3	18	3	1
87	3	3	4	29	3	3
88	4	1	1	15	1	1
89	2	1	3	19	2	2
90	5	1	5	27	2	3
92	2	3	2	18	1	2
93	4	2	2	17	1	3
94	4	2	2	26	3	4
95	1	1	2	15	2	2
96	3	2	1	15	1	2
97	4	3	1	22	4	2

* patients 11,26 and 91 were deleted from study due to lack of data

VITA

Francois Stephane Fabiato was born on January 30, 1971 in Paris, France. His immediate family resides in Richmond, Virginia while the rest of his family still lives in France.

Francois attended college at Bridgewater where he obtained a B.S. in Health Science. While in college Francois remained active playing football and working as a personal trainer. Through the influence of his father, a cardiologist, Francois developed an interest in Cardiac Rehabilitation.

Francois decided to explore this interest further by attending Virginia Tech's Masters program in Clinical Exercise Physiology/Cardiac Rehabilitation. As a graduate student he remained busy taking classes, fulfilling internship requirements and teaching classes as a GTA.

Francois' career objectives include working in hospital based cardiac rehabilitation with the hopes of becoming a program director. Francois is currently working as a Clinical Exercise Physiologist at Richmond Memorial Hospital, in Richmond, Virginia.