PHYSICAL FUNCTION AND QUALITY OF LIFE
IN PATIENTS WITH CONGESTIVE HEART FAILURE

PHYSICAL FUNCTION AND QUALITY OF LIFE IN PATIENTS WITH CONGESTIVE HEART FAILURE

By

MARY CATHERINE HENDRICAN, B.H.K.

A Thesis

Submitted to the School of Graduate Studies

in Partial Fulfilment of the Requirements for

the Degree Master of Science

McMaster University

MASTER OF SCIENCE (1995) (Kinesiology) — McMASTER UNIVERSITY, Hamilton, Ontario

MASTER OF SCIENCE (1995) (Kinesiology)	McMASTER UNIVERSITY Hamilton, Ontario
TITLE:	Physical Function and Quality of Life in Patients with Congestive Heart Failure
AUTHOR:	Mary Catherine Hendrican, B.H.K (University of Windsor)
SUPERVISOR:	Dr. Robert S. McKelvie, M.D./ Dr. Neil McCartney, Ph.D.
SUPERVISORY COMMITTEE:	Dr. Gordon Guyatt, M.D. Dr. Laurie Swanson, Ph.D.
NUMBER OF PAGES:	x, 139

This thesis is dedicated to my parents, Mary Ellen and Peter; and my siblings Pat, Simone, Colleen, Rob, and Lucy.

Thanks for all your support.

PREFACE

This thesis is presented in three chapters. Chapter I is a review of literature which focuses on the mechanisms of congestive heart failure (CHF), tests of physical function used in the assessment of CHF and on the assessment of quality of life in clinical trials. Chapter II presents the thesis research related to measurements of function in patients with CHF and their relation to each other. Chapter III presents the thesis research related to the quality of life assessment in patients with CHF. Chapter II and III have been prepared in manuscript style suitable for publication.

ACKNOWLEDGEMENTS

I would like to extent my appreciation to my advisors, Dr. Robert McKelvie and Dr. Neil McCartney for their contributions to my education and their continuous motivation. I am also grateful to Dr. Gord Guyatt for introducing me to the area of health-related quality of life - something I'm sure I only skimmed the surface of. I'd also like to thank Dr. Laurie Swanson for coming abord on such short notice.

Attending McMaster University has been an invaluable experience never to be forgotten. The many difficult times has been overcome with friendships and endearing memories. There are many people here unnamed, who have contributed to my growth and in some way have made this thesis possible. I am grateful to all of them: those I have worked with at the Hamilton General Hospital, and those I have known personally. I thank each and all of them, especially Mo, and Rob for the gourmet pasta dinners and card games; Nikki for her English wit; the gang at 25 Gary; and the "Boyz". Last, but not least, I'd like to thank John for his patience, understanding and encouragement during the completion of this thesis.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER II

CHAPTER I:

REVIEW OF LITERATURE

1.1 INTRODUCTION

Congestive heart failure (CHF) is a syndrome where myocardial damage results in mechanical inadequacy of the heart to maintain the circulation of blood required for the tissues of the body. CHF is now the most important public health problem in cardiovascular medicine. The annual incidence of heart failure is 3 per 1000 under the age of 65 and 10 per 1000 over 65 (Kannel et al., 1988). Framingham data indicates that the prevalence of heart failure increases progressively with age from about 1 % in those aged 50 to 59 years to about 10 % in persons 80 to 89 years (Kannel and Belanger, 1991). Approximately 250,000 Canadians suffer from CHF and this condition accounts for 100,000 hospitalizations each year (Brophy, 1992); there is a 25% and 38% 5 year survival rate in male and female patients respectively (Ho et al., 1993). In Canada, the absolute number of deaths with a primary diagnosis of CHF increased by over 60 % from 1970 to 1989 (Brophy, 1992). In the United States in 1990, the mortality attributed to CHF as the primary cause of death was greater than 35,000 and there were 722,000 hospital discharges with a first listed diagnosis of heart failure (Gillum, 1993). These statistics illustrate the importance of finding new treatment strategies to delay the development of CHF.

In addition to poor prognosis, patients with CHF have a decreased exercise capacity, impaired ability to perform regular activities of daily living and have a poor quality of life. The mechanisms responsible for these debilitating sequelae are not completely understood. As a result, a variety of quantitative measurements of functional capacity have been developed in recent years, including several quality of life instruments and different exercise tolerance tests.

This review of literature will focus on the pathophysiology of CHF and on the measurements of function often utilized in the assessment of patients with CHF. It will be broken down into the following format: a) the pathophysiology of heart failure; b) the use of peak exercise capacity as an indicator of peripheral or central limitations; c) the use of the 6 minute walk test; d) the use of health-related quality of life assessment in patients with CHF; and e) a summary of the exercise training studies performed using patients with CHF.

1.2 PATHOPHYSIOLOGY OF CONGESTIVE HEART FAILURE

CHF is defined as the pathophysiological state in which an abnormality of cardiac function is responsible for the failure of the heart to pump blood at a rate commensurate with the requirements of the metabolizing tissues, or to do so only from an elevated left ventricular filling pressure (Braunwald, 1992). This syndrome of left ventricular dysfunction secondary to myocardial damage resulting from cell loss can be due to a number of different etiologies. The principal cause of CHF is hypertension accounting for approximately 70 % of the cases in men and 78% of the cases in women (Ho et al., 1993). Although only 59% and 48% of the cases in men and women, respectively, are attributable to coronary heart disease, there is an increasing prevalence among new cases of CHF (Ho et al., 1993). The remaining small percentage of the cases were attributable to idiopathic dilated cardiomyopathy, and valvular insufficiencies.

The symptoms of CHF are the clinical manifestations of the compensatory mechanisms that are activated to maintain cardiac output in response to a decline in cardiac function. Compensatory hypertrophy and remodelling of the ventricle occurs in the initial stages of CHF, with concomitant changes in systolic and diastolic function (Braunwald, 1992). Systolic dysfunction is caused by the loss of contracting myocardial cells, while diastolic dysfunction is secondary to the reduced compliance caused by replacement of normal, distensible myocardium with nondistensible fibrous scar tissue. The underlying abnormality resides in the depression of the length-active tension curve and of the myocardial force-velocity relation, reflecting reductions in the myocardial contractile state. Cardiac output at rest is within normal limits because the end-diastolic fibre length and ventricular end-diastolic volume are elevated through the Frank-Starling mechanism. The elevations of left ventricular end-diastolic volume and pressure are associated with an increased pulmonary capillary pressure, which contributes to the dyspnea experienced by patients with CHF (Braunwald, 1992).

Left ventricular dysfunction stimulates a host of neurohumoral compensations that appear fundamentally important in the expression of the heart failure syndrome. Acutely, there is a heightened adrenergic drive, activation of the renin angiotensin aldosterone axis, and an augmented release of vasopressin (Francis et al., 1984). These together act to maintain perfusion of vital organs and to expand the inadequate arterial blood volume. However, as heart failure becomes chronic, these three compensatory mechanisms can cause undesirable effects such as excessive vasoconstriction, increased afterload, excessive retention of salt and water, electrolyte abnormalities and arrhythmias (Francis et al., 1984). These changes and possibly others yet to be described, may lead to abnormalities in the periphery that may further impair exercise tolerance (Coats, 1993). By contrast, the release of atrial natriuretic factor in response to atrial distention acts as a counter-regulatory hormone, which causes vasodilation and increased excretion of salt and water (Brandt et al., 1993).

1.3 EXERCISE LIMITATIONS IN PATIENTS WITH CONGESTIVE HEART FAILURE

Exercise capacity has been shown to be a reliable prognostic indicator of mortality and morbidity in patients with CHF (Szlachcic et al., 1985). The mechanisms responsible for the limitation of exercise capacity in patients with CHF remain to be elucidated. It has been postulated that either central, peripheral or a combination of both factors may be responsible for the impairment of functional capacity.

1.3.1 CENTRAL FACTORS

It is well established that maximal oxygen consumption bears no relationship with resting cardiac indices such as left ventricular ejection fraction (EF) (Higginbotham et al., 1983; Szlachcic et al., 1985). Furthermore, there is no relationship between the change in EF from rest to peak exercise and maximal exercise performance (Higginbotham, 1983; Slachcic et al., 1985). Although right ventricular EF has been shown in one study to significantly correlate with maximal oxygen consumption (Baker, 1984), others have not found this relationship (Szlachcic et al., 1985).

The effects of pharmacological interventions on exercise performance have been examined. Improvements in exercise cardiac output have been found with infusion of dobutamine but this was not associated with an increased exercise performance (Maskin et al., 1983). A more recent study looked at the effect of short term and long term administration of angiotensin converting enzyme inhibition (ACE-I) on central hemodynamics (Drexler et al., 1989). Short term administration of ACE-I improved rest and exercise cardiac output but did not alter peak exercise performance. On the other hand, following long term administration of ACE inhibition, there were further improvements in exercise cardiac output and peak VO_2. Because this vasodilator therapy acts directly on the periphery, there are possibly mechanisms other than central hemodynamics involved in producing the limited exercise capacity in patients with CHF.

1.3.2 PERIPHERAL FACTORS

The lack of a significant correlation between central hemodynamics and exercise performance has led to investigations focused on peripheral or skeletal muscle abnormalities as a cause for the impaired exercise performance of patients with CHF. These factors include decreased muscle strength and muscle atrophy; impaired skeletal muscle blood flow; abnormal skeletal muscle metabolism, and biochemistry and histology.

Muscle Function and Atrophy. Leg fatigue is one of the limiting symptoms of patients with CHF performing exercise. As a result, muscle strength and its relationship with peak exercise has been assessed. Lipkin et al. (1988) measured isometric quadriceps strength in patients with severe CHF, and found that they had only 55% of predicted strength. These results showed a significant relationship with peak VO_2 ($r=.86$). Others have also found the same relationship between strength and peak VO_2 (Volteranni et al., 1994). Although Minotti and colleagues (1991) did not find significant difference between quadriceps isometric strength in patients with CHF and age matched controls there was a significant decrease in both static and dynamic endurance in these patients with CHF. As well, a close relationship between dynamic endurance and peak VO_2 was found in the patients with CHF (Minotti, 1991). In a more recent study, patients with CHF were found to have a decreased strength compared to age-matched healthy subjects (O'Brien et al., 1994). Again these results suggest that abnormalities of skeletal muscle function may be an important determinant of exercise performance.

To examine the effect of muscle atrophy on peak exercise performance, Voleranni et al., (1994) examined the relationship between these two variables. Twenty patients with CHF with an average EF of 24% were assessed on computed tomography for skeletal muscle bulk at mid-femur. Peak VO_2, determined using the Bruce protocol, was found to significantly correlate (r=0.63) with muscle cross sectional area (Volterrani et al., 1994). Therefore, decreased muscle strength and muscle atrophy in patients with CHF appears to contribute to exercise limitations.

Muscle atrophy is also a common finding in patients with CHF (Lipkin et al., 1988; Mancini et al., 1988; Mancini et al., 1992) and could potentially contribute to a decrease in strength. Mancini and colleagues (1988) compared 20 patients with CHF to 9 age-matched control subjects and found a significant difference in the calf circumference along with decreased pH during the highest workload of plantar flexion and a prolonged recovery time. More recently, Mancini and colleagues (1992) examined the relationship between muscle mass and exercise performance in 62 patients in New York Heart

Association Classification (NYHA) I to IV and an average EF of 23%. Positive correlation coefficients were found between peak exercise oxygen uptake and midarm circumference, muscle circumference, muscle area, skeletal muscle mass and creatinine height index. Although this suggests that muscle atrophy contributes to effort intolerance, when the work load was matched for the difference in work capacity or for muscle cross-sectional area, the abnormal muscle metabolism persists, suggesting that there are qualitative changes in skeletal muscle of patients with CHF (Mancini et al., 1992; Massie et al. 1987).

Skeletal Muscle Blood Flow. Several studies (Zelis et al., 1974; Wilson et al., 1984) have suggested that there is impaired skeletal muscle blood flow in patients with CHF and this may be a cause for impaired exercise performance (Wilson et al., 1984). Zelis and colleagues (1974) found reduced blood flow in the forearm during handgrip exercise. Furthermore, maximal leg blood flow and maximal leg oxygen uptake during exercise were reduced the most in the patients with the poorest exercise tolerance (Wilson et al., 1984).

The arteriovenous oxygen content difference (a-vo_2 diff) has been shown to be increased in patients with CHF and is believed to be a compensatory mechanism for the reduced blood flow (Zelis et al., 1974; Roubin et al., 1990). Roubin and colleagues (1990) observed that although the a-vo_2 diff across the leg during exercise was greater in patients with CHF than in control subjects, peak VO_2 was 40% lower. These studies suggest that exercise limitation in patients with CHF is primarily due to impaired oxygen availability to the exercising muscles, because of a limitation of skeletal muscle blood flow.

Reduced skeletal muscle blood flow is believed to be a result of reduced vasodilator capacity. However, increased cardiac output during exercise exerted by vasodilators cannot be translated immediately into increased exercise capacity and peak oxygen consumption (Wilson et al., 1983). Experimental and clinical studies suggest that impaired vasodilation could be due to increased vascular stiffness due to changes in arterial wall sodium content (Zelis et al., 1970), a reduction in endothelium-derived relaxing factor and increases in various vasoconstrictive neurohormones (Cody et al. 1992), such as endothelin, norepinephrine, renin, angiotensin II and vasopressin.

A reduction in skeletal muscle blood flow may not be the only factor producing a decline in exercise performance. When blood flow is occluded to the exercising limb, there is more of a decline in maximal voluntary force during sustained contraction and diminished endurance during repetitive exercise in patients with CHF compared to age-matched control subjects (Minotti et al., 1991). These observations suggest that blood flow is not the only important role in the genesis of muscle dysfunction and have prompted the hypothesis that there may be intrinsic abnormalities in skeletal muscle of patients with CHF.

Muscle Metabolism. The 31P magnetic resonance spectroscopy (PNMR) has been used to study skeletal muscle metabolism in patients with CHF. Wilson et al., (1985) examined forearm flexor muscles and found an increase in inorganic phosphate (Pi) to phosphoscreatine (PCr) ratio and a decreased pH in 9 patients with CHF when compared to 8 age-matched control subjects. In a similar study examining forearm flexor muscles of 11 patients with CHF and 7 age-matched control subjects, the same increase in Pi/PCr and decrease in pH were found in the patients with CHF (Massie et al., 1987). Studies have demonstrated that these changes in muscle metabolism are not related to muscle atrophy or reduced skeletal muscle blood flow.

Massie et al., (1987) found both PCr and pH were significantly reduced during exercise in patients with CHF compared to control even when the workload was normalized to each individual's strength (accounting for muscle atrophy). Furthermore, Massie and colleagues (1988) reported on 9 patients with CHF and 9 control subjects who performed repetitive finger flexion at submaximal workloads while the blood supply to the muscle group was completely occluded. The patients with CHF continued to exhibit greater declines in PCr and pH during exercise which again indicates a primary abnormality of muscle metabolism.

Skeletal muscle metabolism in patients with CHF has also been examined in a weight bearing muscle such as the gastrocnemius (Mancini et al., 1988; Arnolda et al., 1990; Adampoulos et al., 1993). Findings in these studies revealed similar metabolic responses found in previous studies, supporting the conclusion that in patients with CHF there is an intrinsic abnormality in skeletal muscle metabolic function.

Biochemical and Histological Changes of Skeletal Muscle. To further define the mechanism of the metabolic and functional abnormalities observed in skeletal muscle of patients with CHF, investigators have performed skeletal muscle biopsies for biochemical, histological and ultrastructural evaluations. A predominance of type II (fast twitch) muscle fibres have been found in patients with CHF (Lipkin et al., 1988). Mancini et al. (1989) compared 22 patients with CHF to 8 control subjects and found that patients with CHF had a smaller area of type IIa fibres, a significant increase in the percentage of type IIb fibres, and decreased 3 hydroxyacyl-CoA dehydrogenase activity. Citrate synthetase and phosphofructokinase activities were found to be no different in patients with CHF compared to control subjects.

Sullivan et al. (1991) found that the concentration of mitochondrial enzymes were significantly decreased in 11 patients with CHF compared to 9 control subjects. Again there was a significant decrease in 3 hydroxyacyl-CoA dehydrogenase activity, glycogen content, a decreased percent of type I fibres and an increase in the percent of type IIb fibres. Also, patients with CHF had a decrease in the number of capillaries per fibre but the ratio of capillaries to cross sectional fibre area was not different between the two groups.

Drexler et al. (1992) have shown in skeletal muscle tissue from 57 patients with CHF compared to 18 control subjects, that mitochondrial volume density, cristae surface density and cytochrome oxidase activity were substantially reduced. As well there was a shift in fibre type distribution to type II. This indicates a decreased oxidative capacity of working muscle. Furthermore, the mitochondrial volume density and mitochondrial cristae surface density were significantly related to peak exercise oxygen uptake and to oxygen uptake at anaerobic threshold. The mitochondrial volume density was inversely related to the duration of CHF. In a subgroup of patients, repeat biopsies at 4 months revealed a positive relationship between the change in mitochondrial volume density and the change in exercise results.

1.4 EXERCISE TRAINING IN PATIENTS WITH CONGESTIVE HEART FAILURE

The lack of a relationship between EF and exercise capacity in conjunction with the skeletal muscle abnormalities found in patients with CHF would suggest that exercise training may be of benefit in this group. However, patients with CHF have traditionally been advised to limit their physical activities, consequently deconditioning occurs, leading to a cycle of progressively worsening exercise tolerance (Minotti et al., 1990). In recent years, this thinking has changed and studies have examined the effects of exercise training in patients with CHF.

1.4.1 HEMODYNAMICS FOLLOWING TRAINING

As predicted by the lack of correlation between peak exercise capacity and resting left ventricular EF, exercise training in patients with CHF has not resulted in changes left ventricular EF (Lee et al., 1979; Conn, 1982; Jette, 1991). Resting cardiac output in patients with CHF has been found to either show no change (Sullivan et al., 1988) or to slightly increase (Coats et al., 1992) following exercise training. Sullivan et al., (1988) have demonstrated that following an exercise training program there is an increase in peak exercise cardiac output and leg blood flow.

1.4.2 PERIPHERAL ADAPTATIONS TO EXERCISE TRAINING

Peripheral adaptations following exercise training have been examined in a number of studies. Minotti et al. (1990) examined the effects of a localized exercise training regimen on skeletal muscle abnormalities in patients with CHF. Following 28 days of single arm training, there were no changes in muscle size yet there was a 2 to 3 fold increase in endurance which was associated with a slower rise in Pi and less of a decline in PCr with a decrease in Pi/PCr versus workload slope. These results indicate improvements in skeletal muscle oxidative metabolism.

Adampoulos and colleagues (1993) examined metabolic changes in the gastrocnemius muscle following 8 weeks of a home based cycling exercise program. Improvements were found in plantar flexion exercise tolerance which was associated with a reduction in PCr depletion, less ADP during exercise and an increase in PCr re-synthesis during the recovery period.

1.4.3 CLINICAL TRIALS OF EXERCISE TRAINING

There have been a total of 9 studies that have examined exercise training in patients with CHF. Six of the studies did not include randomization or a control group. As well many differences existed between the type of exercises performed during the training and the duration of the program, yet all showed improvements in outcome measures.

As early as 1979, Lee et al. examined the effects of exercise training in 18 patients with a previous myocardial infarction and an average EF of 18 % (NYHA I to III). The exercise protocol consisted of 6 weeks of supervised walking, jogging and cycling followed by a home program, for approximately 4 days per week at an intensity of 70 to 85% of their maximum heart rate for 20 to 45 minutes. This training resulted in an increased exercise time of 1.1 minutes using the Bruce protocol.

Conn and colleagues (1982) reported on 10 patients who suffered a myocardial infarction greater than 3 months prior to starting in the training program. The average EF of the patients was 20 %. Training consisted of walking or jogging for a total of 35 to 45 minutes, 3 to 5 days per week for 27 months. Results indicated an increase in the calculated METS by 1.5.

Arvan et al. (1988) examined the effects of exercise training in 25 patients at 12 weeks post myocardial infarction with ejection fractions of 17 to 39 % and NYHA classifications ranging from I to III. The training protocol consisted of performing aerobic exercise (cycling, walking on the treadmill and arm ergometry) at 75 to 85% of peak VO_2 for 12 weeks. Following training the average improvement in exercise time and peak VO_2

was by 4 minutes and 7 ml/min/kg respectively. Patients experiencing myocardial ischemia (11 out of 25 patients) had a more limited improvement of peak VO_2 of 3 ml/min/kg whereas the 14 patients not limited by ischemia had an 11 ml/min/kg improvement in peak VO_2. This suggests that patients experiencing myocardial ischemia may not obtain the same benefit from exercise training as those without myocardial ischemia.

Sullivan et al. (1988) examined the effects of training in 12 patients with CHF with ejection fractions ranging from 9 to 33% and NYHA I to III. These patients trained for 60 minutes, 3 to 5 times per week at 75 % of their peak VO_2. Following 16-24 weeks of training, there was an increase of 3.8 ml/min/kg in peak VO_2, an increase of 1.6 ml/dl in leg a-vo2 difference and a 0.5 l/min increase in peak exercise leg blood flow.

Jugdutt et al. (1988) recruited 22 patients at 6 to 32 weeks following anterior wall myocardial infarction, and had them perform calisthenics and stationary running everyday for 12 weeks. Although there were increases of 350 watts in total power after 12 weeks there was also a decrease in ejection fraction from 43 % to 30 %. The results of this study must be interpreted cautiously because of limitations of the study including a nonrandomized control group, a small sample size, a poorly standardized exercise program and finally the determination of asynergy was made from the echocardiographic short-axis view only (McKelvie et al., 1995). There have been other better designed studies which have not found deterioration in EF (Jette et al., 1991; Giannuzzi et al., 1992).

Baigrie and colleagues (1992) reported on 17 patients with CHF with an average EF of 21 %. Following a 16 week walking program an increase of 1.4 ml/min/kg was found in peak VO_2 and an increase of 85 meters in 6 minute walk test distance. There were also improvements found in quality of life measures.

Jette et al. (1991), randomized 18 patients into a training study, who were 10 weeks post anterior MI with no previous history of left ventricular dysfunction and in NYHA I to III. The average ejection fraction was 24 %. Eight patients were assigned to the control group which consisted of usual medical care. Ten patients participated in a 4 week exercise program consisting of jogging, calisthenics and cycling for 55 minutes in the morning, and 30 to 60 minutes of walking in the afternoon. The exercise training intensity was 70 to 80% of their peak heart rate for 5 days per week. This training led to increases in peak VO_2 of 0.2 l/min. No deterioration of EF was found in these patients.

Coats and colleagues (1990 and 1992) randomized 17 patients with CHF with an average EF of 20% into a random order cross-over design trial. In the home based program patients exercised for 20 minutes on a cycle ergometer at 70 to 80 % of peak heart rate, 5 days per week for 8 weeks. Results indicated that training increased exercise time by 2.6 minutes and peak VO_2 by 2.4 ml/min/kg.

Kostis and colleagues (1994) recently randomized 20 patients with CHF to one of 3 groups. The first group was nonpharmacologic consisting of exercise training, dietary intervention, stress management and cognitive therapy. The second and third groups were randomized to either digoxin or placebo therapy. The two latter groups were double blind. For inclusion into the study the patients had to have an EF below 40%, be in NYHA classification II to III and be greater than 12 months post MI. The exercise training consisted of 12 weeks of walking, cycling, rowing and stairclimbing for 1 hour 3 to 5 times per week at an intensity of 40 to 60% of functional capacity. Compared to the digoxin and usual care groups, the exercise group had a significantly greater increase in exercise time.

The results of these exercise training studies in patients with CHF indicate that this patient population can improve their exercise capacity with training. How these training effects translate into daily living is unknown. Studies are required to assess the effects of exercise training on the capacity to perform daily activities and quality of life in patients with CHF.

1.5 THE SIX MINUTE WALK TEST

The 6 minute walk test is a simple, inexpensive and safe assessment of submaximal functional capacity. As a correlate and shorter time version of the 12 minute walk test it was originally used to measure function in patients with chronic respiratory disease (McGavin et al., 1976; Butland et al., 1982). The 6MW has been repeatedly shown to be a useful measure of submaximal functional capacity in patients with CHF (Guyatt et al.,1984; Guyatt et al., 1985a; Guyatt et al., 1985b; Lipkin et al., 1986; Guyatt et al., 1986; Riley et al., 1992).

1.5.1 DESCRIPTION OF THE SIX MINUTE WALK TEST

The 6MW is performed in a quiet, seldom travelled corridor, approximating 33 metres in length. Patients are instructed to walk back and forth between two markers covering as much distance as they can in 6 minutes. If need be, they can stop, rest, and then resume the walk when they feel they are able to do so. Approximately every 30 seconds, the administrator of the walk provides verbal encouragement in a standardized fashion while facing the patient and iterating one of two phrases ("you're doing well" or "keep up the good work"). This encouragement has been shown to improve walking performance (Guyatt et al., 1984). Whether or not encouragement is used during a test is not so much the issue as is remaining consistent with the amount of encouragement in each subsequent test. The time remaining in the test is called out to the patient in 2 minute intervals. After the 6 minutes has elapsed, the patient is instructed to stop and the distance is recorded, rounding up to the nearest half of a meter.

The number of times the patient performs a 6MW test also influences the distance covered. Distance walked has been shown to improve over the first 3 walk tests and remain stable thereafter (Guyatt et al., 1984). Therefore, it is recommended that a minimum of 3 walk tests are performed to obtain a stable baseline when trying to assess the functional capacity of a CHF patient (Guyatt et al., 1984).

1.5.2 USE OF THE SIX MINUTE WALK IN PATIENTS WITH CONGESTIVE HEART FAILURE

The need for easily administered, reliable and clinically responsive measures of functional capacity in patients with CHF in clinical trials prompted the use of the 6MW. Guyatt, et al. (1985b) demonstrated that the 6MW correlated significantly with both peak time on an incremental cycle ergometer test and functional status questionnaires in patients with CHF. These relationships indicate that the 6MW is an indicator of functional capacity. Correlation between 6MW and functional status questionnaires and the absence of a relationship between cycle ergometer results and functional status, indicates that the walk test better reflects the patients' perception of their ability to perform daily activities (Guyatt et al., 1985b). This relationship between 6MW and functional status has also been found in patients with CHF using a larger sample size (Gorkin et al., 1993).

Lipkin et al. (1986) has examined the use of the 6MW as a discriminative measure in 26 patients with stable CHF and 10 normal subjects of similar age, and compared the results to maximal oxygen consumption on the treadmill. Distance walked in 6 minutes was shown to discriminate between different severities of CHF, as classified using the NYHA classification system. As well, a significant relationship existed between maximal oxygen consumption and walking distance. These results have been replicated recently (Riley et al., 1992). Furthermore, Riley and colleagues measured VO_2 during the 6MW using a portable Oxylog in 16 patients with CHF. 6MW and the highest VO_2

recorded during the 6MW were significantly related to peak VO_2 on the treadmill (r=0.88 and r=0.9, respectively). As well, the distance walked was related to the highest VO_2 recorded during the 6MW (r=0.9).

Since this earlier study (Lipkin et al., 1986) others have found the 6MW to have the same discriminative properties (Bittner et al., 1993; Pollock et al., 1990). However, Bittner et al., (1993) only found a moderate correlation between 6MW and NYHA classification in a large (898 patients) sample size, suggesting that these two assessments of performance are measuring different aspects of functional status (Bittner et al., 1993).

In addition to discriminative power, any useful test in clinical trials of CHF must be responsive and be able to detect clinically important change, even if this change is small (Guyatt et al., 1993). A high degree of precision has been found with repeat 6MW testing and this low between test variability allows for the detection of small changes in performance (Guyatt et al., 1985a). Guyatt et al. (1985a) demonstrated that subjects' walk test scores were within 6% of their mean score 65% of the time and within 12% of their mean score 95% of the time. In comparison to the functional status questionnaires the walk test showed less variability over a 10 week period (Guyatt et al., 1985b). As well, Riley et al., (1992) had 16 patients perform 6MW tests on three separate occasions at weekly intervals and found significant difference between the first and second walk test, but not between the second and third test. Therefore, the 6MW would be a useful outcome measure of performance in clinical trials of heart failure therapy because small treatment effects can be detected which may not be revealed by other indices, such as the NYHA classification (Guyatt et al., 1985a).

The 6MW has been used as an outcome measure to assess the effects of various therapies for patients with CHF. Guyatt et al. (1988) have used the 6MW to assess the effects of digoxin therapy on functional capacity in a group of patients with CHF. Walking distance for the treatment group showed a trend ($p=0.055$) towards improvement compared to the placebo group. In another study, Pollock et al. (1990) used the 6MW to assess the effect of the beta blocker, Bucindolol. The treatment group had a significant improvement in 6MW, exercise time on the treadmill and quality of life. The 6MW has also been used as an outcome measure in a study of physical training of patients with CHF (Baigrie et al., 1992). As stated previously, there were significant improvements in walking distance following a 16 week walking program.

In a substudy of the Studies of Left Ventricular Dysfunction (SOLVD) (Bittner et al., 1993), the usefulness of the 6MW as a prognostic indicator was examined in 898 patients with CHF. Patients were grouped by distance walked in 6 minutes and there was a mean follow-up period of 242 days. The distance walked was found to predict mortality and morbidity, with subjects walking the shortest distance having a significantly greater chance of dying (10.25 % vs 2.99 %) and of being hospitalized (40.91 % vs 19.9 %) compared to those walking the greatest distance. This also raises the possibility that strategies directed at improving 6MW distance could potentially decrease hospitalizations and improve survival.

1.6 THE CONCEPT OF HEALTH-RELATED QUALITY OF LIFE

The concept of quality of life (QOL) is that people want to live, not just survive. This term implicates both emotional and physical function and relates the adequacy of material circumstances and peoples' feelings about these circumstances (Friedman et al., 1985). Although factors such as income, job satisfaction and social opportunities are known to affect QOL (Guyatt and Jaescke, 1990) they are generally not considered "health-related" and are often distant from health or medical concern. In clinical trials, health-related quality of life (HRQL) as opposed to general QOL is the appropriate concept for use, since almost all aspects of life in diseased and ill patients can become health related (Guyatt, 1993).

Measurement of HRQL has been suggested when treatment has a known effect on life, when an intervention may cause adversities, in prevention trials and in new drug studies (Friedman et al., 1985). In many randomized clinical trials, HRQL is often either a primary or secondary outcome (Guyatt et al., 1989a) and therefore, an array of HRQL indexes have been developed to measure emotional and social function, well-being, disability and over all health status (Guyatt and Jaescke, 1990). The patient's own perception of change in health status is an important indicator of success of treatment (Guyatt et al., 1993; Mayou and Bryant, 1993). Therefore, these HRQL measures offer the clinical investigator new methods for assessing the impact of therapies (Guyatt et al.,

1991) and also raise a host of new questions concerning how to select, utilize and interpret QOL (Jaeschke et al., 1991).

1.6.1 PURPOSES OF QUALITY OF LIFE MEASUREMENT

There are three purposes of HRQL measures depending on the study design and requirements. The potential applications of health status measures can be divided into three broad categories: discrimination, prediction and evaluation (Kirshner and Guyatt, 1985).

First, in order to differentiate between people who have a good QOL and those who have a poor QOL, a discriminative measure is needed. Discriminative indices are used in surveys when a quantification of the burden of illness is needed across different communities (Kirshner and Guyatt, 1985). Intelligence tests are used as a discriminative index to distinguish among children's learning abilities (Guyatt and Jaeschke, 1990; Kirshner and Guyatt, 1985).

Health status measures can also be used as predictive measures. This index is used to classify individuals into a set of predefined measurement categories and a "gold standard" is then used to see if people have been classified correctly. An example of this is when a short version of a questionnaire is used to classify a patient and this classification needs to be validated against the long version (gold standard) (Guyatt and Jaescke, 1990).

Lastly, to determine how much change has occurred in HRQL after an intervention, evaluative measures must be utilized. These instruments must detect clinically important changes over time, even if the changes are small (MacKenzie et al., 1986; Guyatt et al., 1986). In clinical trials it is this type of instrument that is used most often to determine treatment benefits (Guyatt et al., 1987).

1.6.2 RELIABILITY, RESPONSIVENESS AND VALIDITY

Prior to examining the different approaches to measuring HRQL in clinical trials, it is necessary to review the attributes inherent in any useful instrument. There are three essential attributes required for a useful HRQL instrument: reproducibility, responsiveness, and validity (Guyatt et al., 1987).

The first requirement for a questionnaire to measure outcomes in clinical trials is a high degree of reliability (Guyatt et al., 1987). A reliable questionnaire will yield similar results over repeated administrations in a stable subject (Guyatt and Jaescke, 1990). The issue of reliability, however, is different for each of the three purposes. For discriminative indices, the difference obtained between scores remains constant on repeated administrations in reliable instruments. This does not take into account systematic changes as these changes are generally not important in descriptive indices and are usually interpreted in terms of referent values (Kirshner and Guyatt, 1985). Predictive indexes are different from discriminative in the sense that the scores are already meaningful in that they relate to one or more target conditions (Kirshner and Guyatt, 1985). Here reliability pertains to agreement between replicate observations. Evaluative instruments on the other hand, are reliable if replicate observations on each individual remain stable over time.

In evaluative instruments, investigators examining the effect of treatment on symptoms, feelings or other states need responsive outcome measures (Guyatt et al., 1989a and b). This responsiveness will enable the detection of change following an intervention. Thus, when clinical improvements occur, maximum change in this measure should occur if the instrument is responsive. The responsiveness of a test is directly related to the magnitude of the change in subject score which constitutes a clinically important difference (Guyatt et al., 1987).

In addition, the validity of a questionnaire must be established before it can be applied as a meaningful outcome measure in clinical studies (Guyatt and Jaescke, 1990; Guyatt et al., 1987). If an instrument is valid it is measuring what it is supposed to measure. When a short version of a questionnaire is measuring HRQL to the same extent as the long version, this questionnaire is said to have criterion validity (Kirshner and Guyatt, 1985; Guyatt et al., 1987). On the other hand, construct validity is concerned with the extent to which a particular measure relates to other measures in a manner which is consistent with theoretically derived hypotheses (Kirshner and Guyatt, 1985; Guyatt et al., 1987). Predictions are first made regarding how the instrument being tested should relate to other measures. Following this the instruments are administered and the validity is strengthened or weakened according to the extent the hypotheses are confirmed or refuted. For example, physical dimensions in QOL measures should bare close relation to functional tests.

Finally, convergent validity refers to the extent similar dimensions of various questionnaires relate to one another (Kirshner and Guyatt, 1985). If a questionnaire is valid, similar dimensions between questionnaires should bear close relation.

1.6.3 APPROACHES TO MEASURING HEALTH-RELATED QUALITY OF LIFE

Two of the basic approaches to measuring HRQL are generic measures and specific measures.

Generic Measures of Health-Related Quality of Life. Generic measures apply to a wide variety of patients and include health profiles and utility measures. The Medical Outcome Survey Short Form 36 (SF-36) and the Sickness Impact Profile (SIP) are examples of health profiles which evaluate various health dimensions covering a complete spectrum of function, disability and distress relevant to HRQL. Scores from these types of questionnaires can be aggregated into several dimensions and some may provide an overall score of HRQL. These health profiles allow the determination of the effects of the intervention on different aspects of HRQL without the use of multiple instruments. Because the SF-36 is less time consuming and has been shown to be just as responsive as the SIP (Katz et al., 1992; Weinberger et al., 1991) it is being used much more frequently.

The utility index is the other generic measure of HRQL and is based on economic and decisions theories (Bennett et al., 1991). This index provides a quantitative measure of preference which the patient attaches to their overall health status. This value ranges from 0.0 (death) to 1.0 (excellent health). The standard gamble is one method of utility measurement which asks patients to make a single rating that takes into account all aspects of their HRQL. Patients choose between their own health and a gamble in which they may die immediately or achieve full health for the remainder of their lives. Small yet significant proportions of the variance in utility scores has been found to be attributable to health status (Revicki, 1992). Although the standard gamble utility score has been shown to relate to a health profile (O'Brien et al., 1990) other studies need to be performed before the validity of the utility approach to measuring HRQL can be established. Furthermore, depending on how utility measures are obtained, the scores have been shown to vary (Revicki, 1992), which raises questions concerning their validity and needs to be further examined.

Multiattribute utility theory on the other hand consists of when the patient is asked a series of questions and classified on several categories in terms of their ability to function on each of a set of attributes or dimensions of health status. Each attribute is then rated from good to bad or normal (Feeny et al., 1992). This classification system may be linked to health status index scores that quantify HRQL in terms of preferences.

Advantages of the utility approach to QOL measurement include its generalizability, comprehensiveness, ability to integrate mortality and morbidity effects, ability to elicit preferences both for hypothetical and actual situations, ability to represent multiple viewpoints by using different types of evaluators for health states, its incorporation of time and risk preferences of subjects in their health-state evaluations, its solid theoretical foundation, and its consistency with economic evaluation (Feeny and Torrance, 1989).

Specific Measures of Health-Related Quality of Life. An important part of measuring HRQL in diseased patients is to focus on aspects of health status that are specific to that area of interest. In cardiovascular disease, attributes such as sense of well-being, extent to which they are able to maintain reasonable physical, emotional and intellectual function and the degree to which they are able to participate in valued activities should be examined (Wenger and Furberg, 1990).

Disease specific measures of HRQL have been developed for patients with CHF and have been used in a number of trials (Rector et al., 1987, 1992; Guyatt et al., 1988; Guyatt et al., 1989c; Kubo et al., 1992; Gorkin et al., 1993). The Minnesota Living with Heart Failure Questionnaire (MLHF) was developed for comprehensive assessment of patients with CHF (Rector et al., 1987) and has been shown to differentiate between different levels of impairment using either total score, physical or emotional dimensions (Rector et al., 1987; Rector et al., 1993). In the SOLVD trial, this assessment form was used to measure HRQL (Gorkin et al., 1993).

As well, the Chronic Heart Failure Index was developed to assess the impact of an intervention in patients with CHF. The dimensions measured in this questionnaire consist of dyspnea, emotion, fatigue and mastery. The striking feature of this health measure is that the dyspnea dimension is based on the amount of shortness of breath certain activities cause and these activities are listed by the patient. This method of assessing a dimension of HRQL may be more sensitive to detect changes with an intervention. The CHQ has been used as an outcome measure in a controlled trial of digoxin (Guyatt et al., 1988).

1.7 SUMMARY

CHF is a syndrome that results from left ventricular dysfunction secondary to myocardial damage. Symptoms of leg fatigue and shortness of breath often limit patients during peak exercise performance. Although central limitations exist, these are not related to exercise capacity (Higginbotham et al., 1983; Slachcic et al., 1985). Peripheral factors such as decreased blood flow, muscle atrophy and decreased muscle strength have been shown to be causes of limited peak exercise capacity, yet not exclusively. As well, metabolic abnormalities such as increased Pi, decreased PCr and pH have been found during exercise in both the forearm (Wilson et al., 1985; Massie et al., 1987) and gastrocnemius muscles (Mancini et al., 1988; Arnolda et al., 1990; Adampoulos et al., 1993). Furthermore, a predominance of type II fibres have been found as was a significant decrease in 3 hydroxyacyl-CoA dehydrogenase and mitochondrial enzymes which are indicative of a decreased oxidative capacity (Mancini et al., 1989; Sullivan et al., 1991). Because these changes are similar to those found in deconditionning, exercise training was thought to be useful in reversing some of these metabolic, biochemical and histological abnormalities. Several studies have shown improved exercise time or peak VO_2 (Lee et al., 1979; Arvan et al., 1988; Sullivan et al., 1988; Jette et al., 1991; Coats et al., 1992; Kostis et al., 1994). Some of the metabolic abnormalities were also found to be reversed following training (Minotti et al., 1990). The 6MW has also been used in the assessment of functional exercise capacity of patients with CHF. This test has been shown to be a reliable and valid measure of function. Although the 6MW relates to peak VO_2, this relationship is weak. In addition, the walk test has stronger correlations with measures of functional status indicating it is more a measure of function than peak exercise capacity. One training study examined the effects on the 6MW and found improvements in distance covered following a 16 week walking program (Baigrie et al., 1992). Furthermore, the 6MW has been shown to be a strong independent predictor of mortality and morbidity in patients with CHF (Bittner et al., 1993). This indicates that strategies directed at improving 6MW distance may potentially improve morbidity and mortality in these patients.

HRQL is an area of interest in clinical trials and various questionnaires have been designed specifically for CHF. These measures have been shown to be responsive to treatment and discriminate between different levels of function based on the NYHA classification. Research studies need to encorporate both general and specific HRQL measures.

The focus of the following research is to assess the relationships between measures of function and HRQL. Chapter Two will relate measures of peak VO_2, 6MW and dynamic muscle strength. Strength will be assessed using the arm curl, leg press and knee extensor exercises. In addition, a calculation of work performed during the walk will be presented and related to peak VO_2 and strength. The hypothesis is that the 6MW is a measure of functional status and WW is a measure of fitness. Therefore, correlations between WW and peak VO_2 and strength will be higher than between 6MW, peak VO_2 and strength. Chapter Three will report the relationships between HRQL dimensions obtained using four questionnaires. Similar dimensions scores should bear closer relation to one another than dissimilar dimensions. Furthermore, the relationships between 6MW, WW, peak VO_2 and strength and HRQL will be assessed. The measures of function should relate more to the physical dimensions of the questionnaires.

CHAPTER II:

FUNCTIONAL CAPACITY IN PATIENTS WITH CONGESTIVE HEART FAILURE

2.1 ABSTRACT

The 6 minute walk test performance (6MW) is related to activities of daily living. This test has also been shown to be an independent predictor of mortality and morbidity in congestive heart failure (CHF) patients. However, 6MW is not strongly related to peak aerobic capacity and this may be because total walk work is not included in the equation. In order to design an optimal exercise rehabilitation program that would improve activities of daily living, we assessed the relationship between 6MW and peak aerobic capacity (PVO_2), knee extensor strength (KE), leg press strength (LP) and arm curl strength (AC) in 45 patients with CHF (age=65±10yrs; 39M,6F; 2% NYHA I; 64% NYHA II, 33% NYHA III, ejection fraction (EF)=.28±.07). We also calculated the work performed during the walk test in order to account for the varying body weights of the patients with CHF.

EF did not correlate with 6MW distance, PVO_2, or muscle strength. 6MW significantly correlated with KE ($r=.38$, $p<0.009$), and PVO_2 ($r=.52$, $p<.0002$). There was a trend between 6MW and LP ($r=.27$, $p<.068$) and AC ($r=.27$, $p<0.07$). Walk work significantly correlated with KE ($r=.73$, $p<.0001$), LP ($r=.61$, $p<.0001$), AC

($r=.67$, $p<0.0001$) and PVO_2 ($r=.83$, $p<.0001$). Multivariate analysis indicated that a statistical model combining the measures of both KE and LP, and PVO_2 explained a considerable amount of the variance in walk work ($R^2=.74$).

Compared to 6MW, walk work correlates significantly better with PVO_2, KE, LP and AC suggesting that walk work may be a better reflection of a patient's performance. Furthermore, these results suggest the need for a comprehensive exercise rehabilitation program combining both aerobic and strength training in patients with CHF in order to improve exercise capacity.

2.2 INTRODUCTION

Congestive heart failure (CHF) is associated with significant morbidity and mortality (Brophy, 1992). This syndrome is characterized by symptoms of shortness of breath and fatigue, which contributes to limited exercise capacity. It has been clearly shown that left ventricular ejection fraction (EF) does not correlate with exercise capacity in patients with CHF (Higginbothom et al., 1983; Szlachcic et al., 1985) and therefore, skeletal muscle abnormalities have been postulated as the potential mechanisms for the exercise limitations observed in patients with CHF. Skeletal muscle atrophy (Lipkin et al., 1988; Mancini et al., 1988; Mancini et al., 1992) and decreased muscle strength (Lipkin et al., 1988; Volteranni et al., 1994) have been found in patients with CHF and are known to contribute to the decreased peak exercise capacity (Lipkin et al., 1988; Volteranni et al., 1994).

Exercise tolerance is usually quantified using incremental exercise testing or more recently, the six minute walk test (6MW). This 6MW is a submaximal test, easy to administer and well tolerated by patients with CHF. The 6MW has been shown to correlate with both functional status questionnaires and exercise capacity in patients with CHF and is thought to be a better measure of functional exercise capacity reflecting the activities patients are capable of performing on a daily basis (Guyatt et al., 1985b). Furthermore, its relationship to mortality and morbidity (Bittner et al., 1993) have also sparked further interest into factors affecting the distance accomplished.

The relationship between the 6MW and exercise capacity is only moderate (Guyatt et al., 1985b). However, when the oxygen consumption during the walk test is measured the oxygen consumed during the 6MW significantly relates to peak VO_2 during incremental exercise testing (Riley et al., 1992). The 6MW performance has only been expressed as a measure of distance. Perhaps if walking work performed during the test is utilized in the analysis, the relationship between 6MW performance and exercise capacity will improve, indicating that walk work may be a better measure of functional capacity.

It was the purpose of this study to determine the relationship between 6MW and other functional measures such as peak VO_2 and muscle strength and to determine whether these relationships were strengthened when using the walk work variable. Furthermore, multivariate analysis was performed to determine which factors were the determinants of 6MW performance.

2.3 METHODS

2.3.1 SUBJECTS

Forty five patients diagnosed with CHF, (mean$\pm$S.D.: 65$\pm$10yrs, 39M, 6F) agreed to participate in the study (Table 1). Patients were informed of the procedures and risks involved in the study and written consent was freely obtained; the study was approved by the institutional ethics committee.

Patients were included in the study if they were in NYHA Class I to III, had a measured left ventricular ejection fraction < 40 % based on radionuclide ventriculography and walked less than 500 metres on a screening 6 minute walk test. Patients were excluded if they could not be stabilized on a diuretic, digoxin, or angiotensin converting enzyme inhibitor, were limited by symptoms of angina or leg claudication during exercise testing, had an abnormal blood pressure response to clinical exercise testing (decrease in systolic pressure below resting during exercise; or a decrease in systolic pressure of > 20 mmHg after the normal exercise increase; or rise in diastolic pressure of > 15 mmHg; maximal systolic pressure in excess of 250 mmHg), cerebrovascular disease with residual impairment that prevented formal exercise testing or training, respiratory limitation (FEV1 and/or VC < 60% of predicted).

2.3.2 EXPERIMENTAL DESIGN

Each patient performed two 6MW tests (in addition to the screening walk test). The second 6MW distance was used in the analysis. Patients performed two dynamic muscle strength tests. The sum of the highest right and left limb strengths was used for the analysis. An incremental exercise test on a cycle ergometer to determine peak VO_2 was also performed by each patient.

2.3.3 MEASUREMENTS

Six Minute Walk Test. Patients were instructed to walk a 33 meter course in a hospital corridor, covering as much distance as they could in six minutes. If need be, they could stop, rest and then continue on when they felt ready to do so. The time was not stopped during these rest periods. Standardized encouragement, consisting of "you are doing well" or "keep up the good work", was given to the patients at approximately 30 second intervals. Markers were located along the walking course at 1.5 metre intervals and the total distance walked was measured to the nearest 0.5 metre. Patients were allotted a 5 minute rest period prior to commencing and following the walk test.

The work performed during the walk was calculated by the following equation: WW=body weight · g · distance, where WW is walking work, body weight is the patient's actual weight in kilograms, g is the force of gravity (9.8 $m \cdot sec^{-1} \cdot sec^{-1}$) and distance is the total distance in meters covered by the patient in 6 minutes.

Dynamic Muscle Strength. Universal-type Global Gym single-station training apparatus was used to assess the patient's 1 repetition maximum (1 RM) defined as the heaviest weight in kilograms that the patient could lift only once through a full range of movement. Each patient's 1 RM was determined for the single arm curl (AC), single leg press (LP) and single knee extension (KE) exercises. Warm up prior to testing included walking for approximately 5 minutes and 5 repetitions of each the AC, LP and KE exercises using very low weight.

The initial weight used to determine the 1 RM was based on the patient's demonstrated performance during the warm-up. For the AC the initial weight applied was between 1 and 4 kg, for the LP it was between 35 and 50 kg, and for the KE it ranged from 7 to 10 kg. The 1 RM was determined by having the patient perform single repetitions with progressively heavier weights, resting two to three minutes between attempts. Increments were made in accordance to the perceived exertion of the patient during the lift.

A second strength testing session was performed within approximately one week of the initial test. Following the same warm-up procedure, weights were placed at 80 % then 100 % of the 1 RM they performed on the first testing day. Following these 2 lifts, small increments in weight were made to attain a true 1 RM.

Peak Oxygen Uptake. Peak oxygen uptake was assessed during a symptom limited exercise test on a cycle ergometer. The initial workload was 100 kpm/min and was increased by 100 kpm/min every 2 minutes. The patient was instructed to maintain a pedalling rate of 60 r.p.m. The patient breathed through a mask with expired gas sampled and analyzed using a Sensor Medics 2900 metabolic cart. The peak VO_2 was defined as the maximum VO_2 achieved during exercise. Both the absolute and relative peak VO_2 were measured as well as the peak power.

2.3.4 STATISTICAL ANALYSIS

The data were analyzed using a Pearson's correlation coefficient analysis. Multivariate stepwise regression analysis was performed using walk work as the dependent variable and the other measures of function as the independent variables. The probability level of less than 0.05 was deemed statistically significant.

2.4 RESULTS

All 45 patients were able to complete the testing protocols.

Means and standard deviations of both 6MW distances, peak VO_2, AC, LP and KE are found in Table 2. The second 6MW distance was significantly increased from the first 6MW performed by the patients (from 416 ± 79.3 to 427.7 ± 84, $p < 0.04$). EF did not correlate with 6MW performance, peak VO_2 or dynamic muscle strength measures.

2.4.1 6 MINUTE WALK DISTANCE AND WALK WORK

Relationships between 6MW and other functional measures were improved by using WW in the analysis (Table 3). There was a significant relationship between 6MW and peak VO_2 ($r=0.52$, $p<0.001$) and a stronger relationship between WW and absolute peak VO_2 ($r=0.83$, $p<0.001$) (Figure 1). When modifying the peak VO_2 for body mass, the relationship improved with 6MW ($r=0.62$, $p<0.001$), but not with WW ($r=0.34$, $p<0.02$) (Figure 2).

AC significantly correlated with WW ($r=0.67$, $p<0.001$) but not with 6MW ($r=.27$, $p<0.08$) (Figure 3). Similarly, LP was significantly related to WW ($r=0.61$, $p<0.001$) but not walk distance ($r=0.27$, $p<0.07$) (Figure 4). Although there was a significant relationship between KE strength and 6MW ($r=0.38$, $p<0.009$), this relationship was improved when using WW ($r=0.74$, $p<0.001$) (Figure 5).

When strength values were normalized for body weight by dividing by body weight, the correlations remained similar between 6MW and muscle strength measures:

for AC strength, $r=0.24$, $p<0.113$; for LP, $r=0.21$, $p<0.176$; for KE, $r=0.36$, $p<0.016$.

2.4.2 MULTIVARIATE ANALYSIS

Forward stepwise regression analysis using peak VO_2 ($L \cdot min^{-1}$) and strength variables as predictors (Table 4) revealed that peak VO_2 in absolute terms was the most valuable individual predictor of walking work ($r^2=0.68$), suggesting that the peak VO_2 explained 68 % of the variation in WW. KE added an additional 6 % of explanation of variance. Although, LP did not increase the percent of variance explained in walking work, the mean squared error remained low and therefore LP does contribute to the model.

2.4.3 PEAK EXERCISE PERFORMANCE

Peak VO_2 ($l \cdot min^{-1}$) correlated significantly with AC ($r=.75$, $p<0.001$), LP ($r=.61$, $p<0.001$), and KE ($r=.74$, $p<0.001$) (Figure 6) (Table 5). Peak VO_2 did have a positive relationship with body weight of patients (Figure 7). However, peak VO_2 relative to body weight only showed a significant relationship with AC ($r=.33$, $p<0.03$) but not with LP ($r=.21$) or KE ($r=.22$) (Figure 8).

2.5 DISCUSSION

The 6MW is a simple and inexpensive assessment of functional capacity that has been shown to significantly correlate with mortality and morbidity in patients with CHF (Bittner et al., 1993). As well, this walk test has the added advantage of reproducing more closely and naturally the daily activity of patients. This leads to the conclusion that it is important to determine what may improve the 6MW performance. One of the purposes of this study was to assess the relationship between 6MW, peak VO_2 and muscle strength in patients with CHF. In keeping with previous studies (Guyatt et al., 1985b; Lipkin et al., 1986), a significant relationship existed between 6MW and peak VO_2 performed on the cycle ergometer ($r=0.52$, $p<0.001$). Furthermore, one measure of leg strength, KE, correlated with 6MW distance ($r=0.38$, $p<0.009$). However, the other two measures of dynamic strength (AC and LP) did not relate to distance walked. Although aerobic training has been shown to improve 6MW performance (Baigrie et al., 1992), these results indicate that a rehabilitation program directed at improving both aerobic capacity and leg strength may increase 6MW distance.

The 6MW has been found to relate only poorly to peak VO_2. However, 6MW performance has only been assessed as a distance and does not take into account work. Since the patients had different body masses this would mean that 2 patients of different body mass covering the same distance would be performing different amounts of work. Therefore, the work performed during the 6MW was calculated and related to peak VO_2. The results revealed strong relationships between walk work and peak VO_2 as well as other measures of fitness, such as strength (Table 3). Therefore, walk performance is strongly related to peak VO_2 when some measure of work during the test is taken into consideration. These results are consistent with the findings of Riley et al. (1992), where they measured oxygen uptake during the 6MW and found that it was significantly related to peak VO_2.

There is no agreement in the literature regarding the type of exercise training that should be recommended for patients with CHF. Previous studies have utilized a variety of types of training ranging from walking to calesthenics (Lee et al., 1979; Arvan et al., 1988; Sullivan et al., 1988; Baigrie et al., 1992; Jette et al., 1991; Coats et al., 1992). These studies examining the effects of exercise training in patients with CHF have found improvements in peak VO_2 and exercise time. Various training intensities and durations were used, and for the most part, walking and cycling were the modes of exercise. Since patients with CHF have impairments of both aerobic capacity and muscle strength, it would be appropriate to use training programs that combine both of these components. The results of this study would further support the combination of aerobic and strength training for patients with CHF. Multivariate analysis results from this study indicate that using both aerobic and strength training versus just aerobic training may produce the greatest improvement of functional capacity and walk work. Further studies need to examine the combined effect of aerobic and strength training in patients with CHF.

Endpoints that are relevant to patients with CHF in their day-to-day lives are both necessary and feasible when we try to determine the usefulness of therapies in patients with CHF (Guyatt et al., 1985b). An outcome variable such as the 6MW is therefore a desirable assessment, as it is an indicator of what a patient is capable of performing on a daily basis in terms of activities (Guyatt et al., 1985b) and has been shown to be of prognostic value (Bittner et al., 1993). Furthermore, results of this study revealed that when WW is considered, the 6MW can be used as an assessment of fitness.

Peak VO_2 has been found to be the strongest independent predictor of mortality when compared to NYHA classification system and left ventricular EF (van den Broek et al., 1992). The mechanisms underlying exercise limitations in patients with CHF remains unclear. In the present study, there were no relationships between EF and peak VO_2 or EF and 6MW, which is consistent with previous research (Higginbotham et al., 1983; Szlachcic et al., 1985). These results suggest that the limiting feature to exercise in patients with CHF may be some aspect of the exercising skeletal muscle.

Skeletal muscle abnormalities have been found in patients with CHF. Specifically, muscle atrophy has been found in patients with CHF compared to control subjects (Mancini et al., 1988). This loss of mass in the periphery is known to contribute to the reduced strength in this patient population (Lipkin et al., 1988; Mancini et al., 1988, Mancini et al., 1992; Volteranni et al., 1994) and is known to be related to a reduced exercise capacity (Volteranni et al., 1994). In this study, similar correlation coefficients were found between peak VO_2 and strength measures (Table 5).

The interpretation of the relationship between AC and peak VO_2 is difficult. It may be that patients who consume more oxygen during exercise generally have more muscle mass, or it may be that arm strength is a reflection of how active the patient is on a daily basis. If the latter were true, one would expect a significant relationship between AC and 6MW, yet this was not the case in this study (Table 3). However, WW and AC strength were significantly related to each other indicating that the amount of work performed by the patient is an indicator of strength.

In summary, 6MW was moderately related to peak VO_2 and weakly related to muscle strength. When WW was calculated in patients with CHF, strong positive relationships were found with measures of peak VO_2 and muscle strength. These correlation coefficients surpassed those found between 6MW and peak VO_2 and strength. When assessing the impact of exercise training on patients with CHF, a test which is sensitive to aerobic and strength changes would be ideal. The 6MW is recommended for this assessment because of its use as an indicator of functional status, morbidity and mortality and because of its use as an indicator of fitness when WW is calculated.

TABLE 1. PATIENT CHARACTERISTICS

n	45
Male	87 %
Female	13 %
Age	65±9.8yrs*
Weight	81.7±17.8kg*
EF	0.28±0.07*
NYHA I	2 %
NYHA II	64 %
NYHA III	33 %
ACE-I	84 %
Digoxin	76 %
Diuretic	84 %

EF = ejection fraction
NYHA = New York Heart Association Classification
ACE-I = angiotensin converting enzyme inhibitor
* = mean ± standard deviation

TABLE 2. PARAMETERS OF FUNCTIONAL MEASURES (MEANS ± SD).

6 minute walk distance (#1)	416.6±79.3
6 minute walk distance (#2)	427.7±84
Peak VO_2 ($ml \cdot min^{-1} \cdot kg^{-1}$)	14.53±3.24
Peak VO_2 ($l \cdot min^{-1}$)	1.18±0.36
Arm curl strength (kg)	19.9±9.47
Leg press strength (kg)	146.4±36.9
Knee extensor strength (kg)	43.7±18.3

Strength = sum of the right and left limb 1 repetition maximum

TABLE 3. CORRELATION COEFFICIENTS BETWEEN 6 MINUTE WALK PERFORMANCE VARIABLES AND OTHER FUNCTIONAL MEASURES

Variable	6 Minute Walk Distance		6 Minute Walk Work	
	R	*P*	R	*P*
Peak VO_2 ($ml \cdot min^{-1} \cdot kg^{-1}$)	.62	<0.001	.34	<0.03
Peak VO_2 ($l \cdot min^{-1}$)	.52	<0.001	.83	<0.001
Arm curl strength	.27	NS	.67	<0.001
Leg press strength	.27	NS	.61	<0.001
Knee extensor strength	.38	<0.009	.74	<0.001

R = linear correlation coefficient;
P = probability;
NS = not significant.

TABLE 4. STEPWISE REGRESSION ANALYSIS OF POTENTIAL WALK WORK PREDICTORS.

Variable	R^2	P
Peak VO_2 ($l \cdot min^{-1}$)	0.68	<0.05
Peak VO_2 ($l \cdot min^{-1}$) & Knee extension	0.74	<0.05
Peak VO_2 ($l \cdot min^{-1}$) & Knee extension & Leg Press	0.74	NS

R^2 = adjusted R-squared;
P = probability.

TABLE 5. CORRELATION COEFFICIENTS BETWEEN BOTH PVO_2 PERFORMANCE VARIABLES AND OTHER FUNCTIONAL MEASURES.

	Absolute Peak VO_2 ($L \cdot min^{-1}$)		Relative Peak VO_2 ($ml \cdot min^{-1} \cdot kg^{-1}$)	
Variable	R	*P*	R	*P*
6 minute walk distance	.52	<0.001	.62	<0.001
Walk work	.83	<0.001	.34	<0.021
Arm curl strength	.75	<0.001	.33	<0.03
Leg press strength	.61	<0.001	.21	NS
Knee extensor strength	.67	<0.001	.22	NS

R = linear correlation coefficient;
P = probability;
NS = not significant.

FIGURE LEGENDS

FIGURE 1. *Top:* Relationship between peak VO_2 ($l \cdot min^{-1}$) and 6 minute walk distance ($r=0.52$, $p<0.001$). *Bottom:* Relationship between peak VO_2 ($l \cdot min^{-1}$) and walking work (kJ) ($r=0.83$, $p<0.001$).

FIGURE 2. *Top:* Relationship between peak VO_2 relative to body weight ($ml \cdot min^{-1} \cdot kg^{-1}$) and 6 minute walk distance ($r=.62$, $p<0.001$). *Bottom:* Relationship between peak VO_2 and walking work (kJ) ($r=0.34$, $p<0.021$).

FIGURE 3. *Top:* Relationship between arm curl strength as measured by a 1 repetition maximum (1 RM) and 6 minute walk distance ($r=0.27, p<0.08$). *Bottom:* Relationship between arm curl strength and walking work (kJ) ($r=0.67$, $p<0.001$).

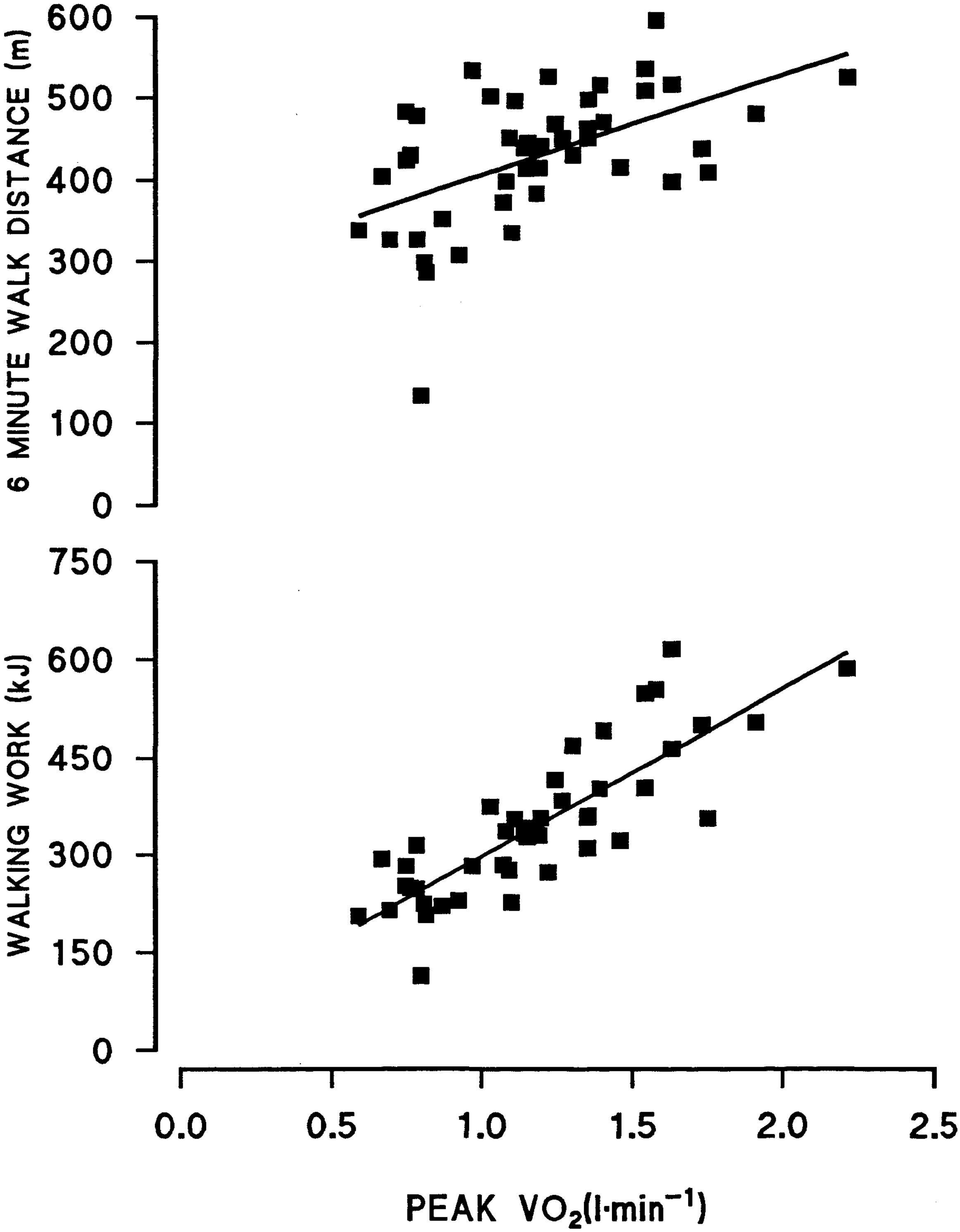
FIGURE 4. *Top:* Relationship between leg press strength as measured by a 1 repetition maximum (1 RM) and 6 minute walk ($r=0.27$, $p<0.07$). *Bottom:* Relationship between leg press strength and walking work (kJ) ($r=0.61$, $p<0.001$).

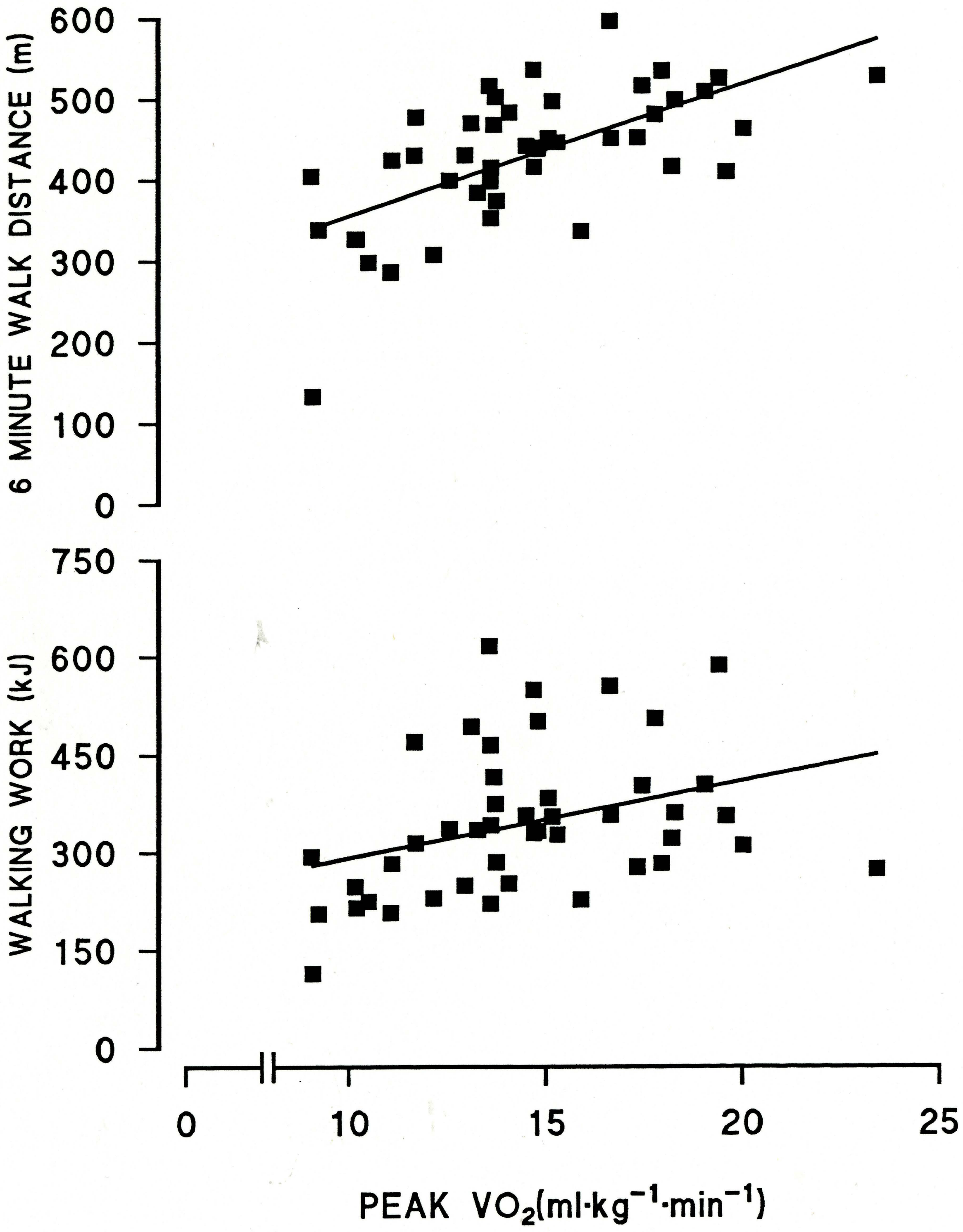
FIGURE 5. *Top:* Relationship between knee extensor strength as measured by the sum of a unilateral 1 repetition maximum (1 RM) and 6 minute walk distance ($r=0.38$, $p < 0.009$). *Bottom:* Relationship between knee extensor strength and walking work (kJ) ($r=0.74$, $p<0.001$).

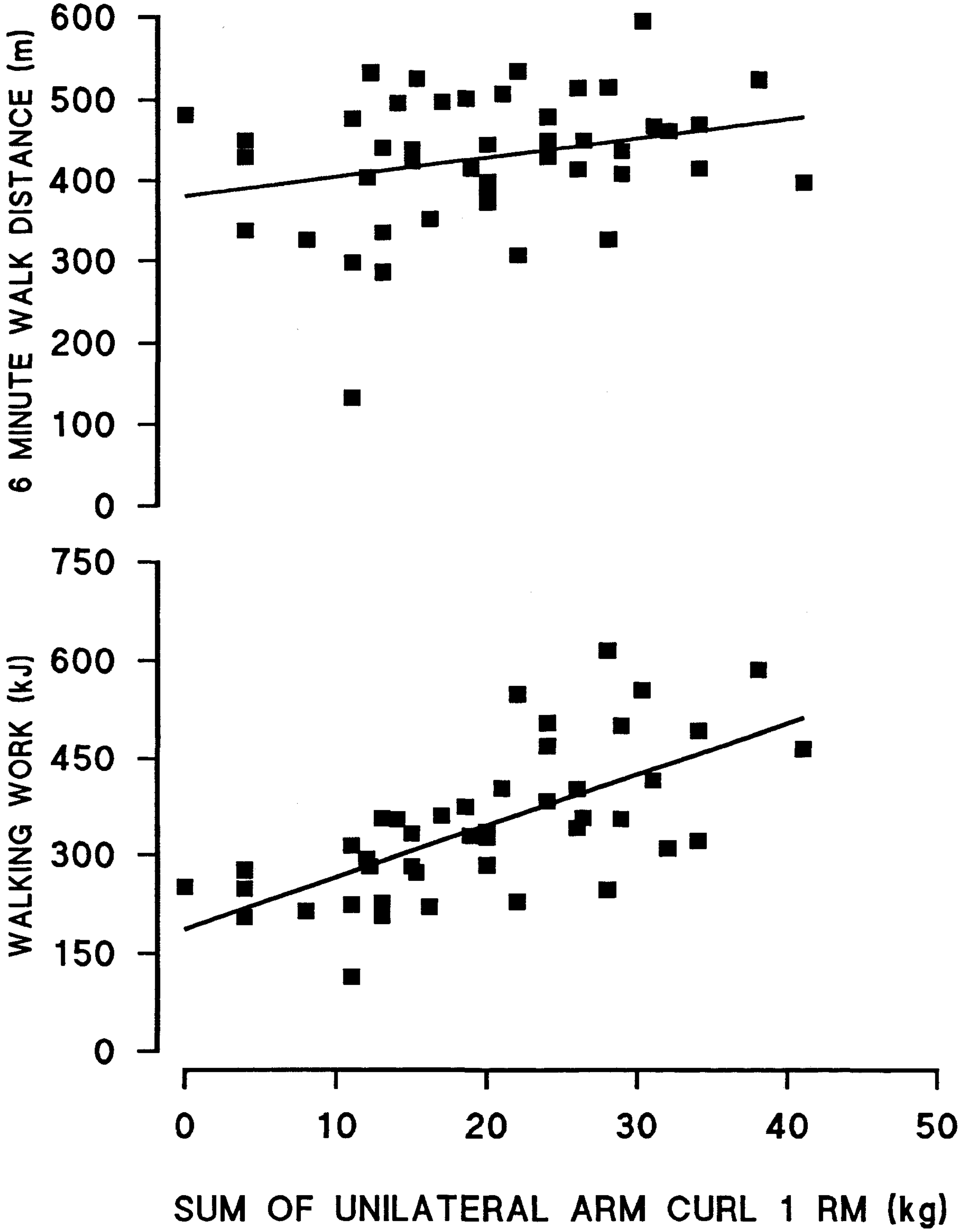
FIGURE 6. Relationship between peak VO_2 ($l \cdot min^{-1}$) and dynamic muscle strength measures as measured by the sum of a 1 repetition maximum (1 RM). *Top:* Relationship between peak VO_2 and arm curl ($r=0.75$, $p<0.001$). *Middle:* Relationship between peak VO_2 ($l \cdot min^{-1}$) and leg press strength ($r=0.61$, $p<0.001$). *Bottom:* Relationship between peak VO_2 ($l \cdot min^{-1}$) and knee extensor strength ($r=0.67$, $p<0.001$).

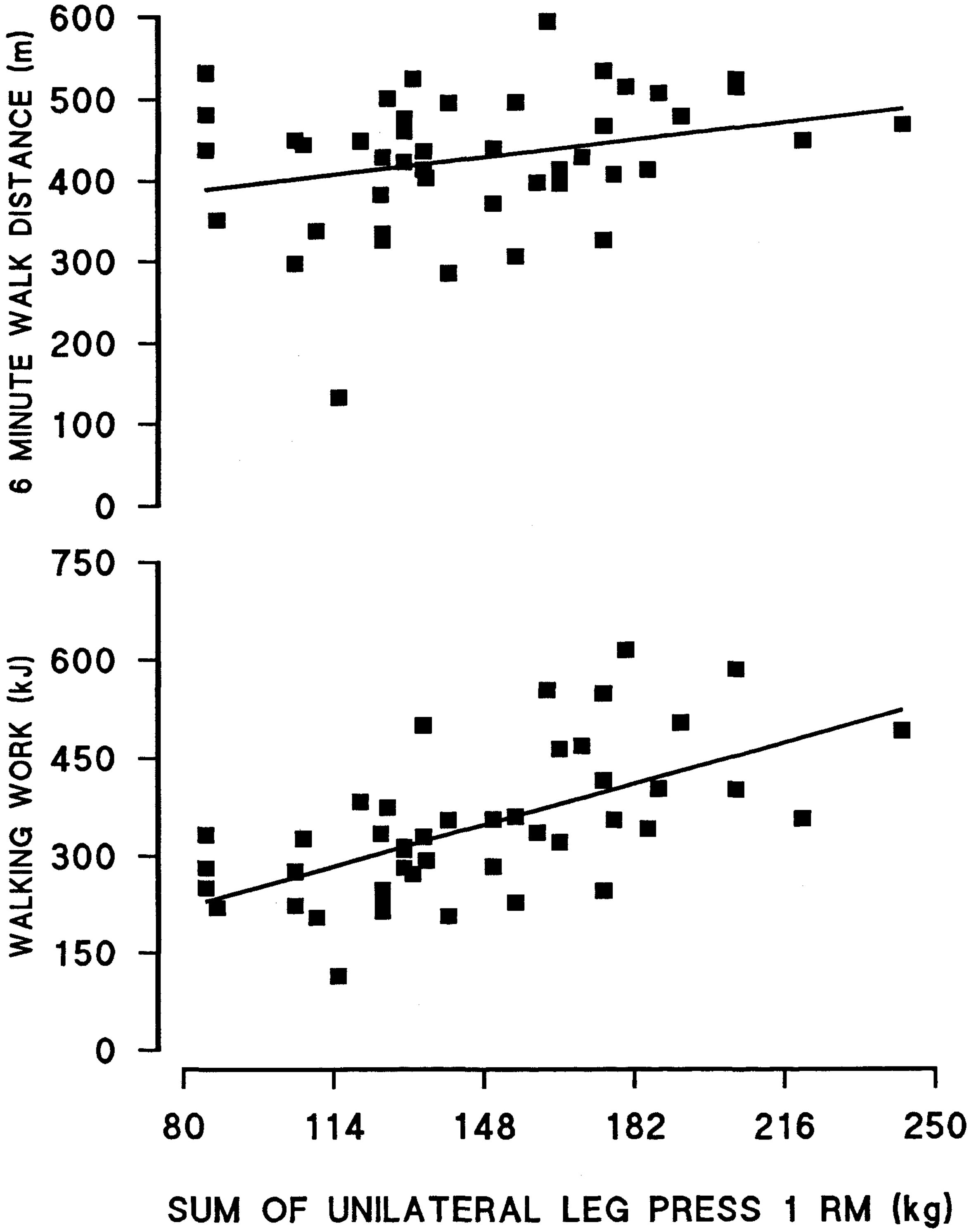
FIGURE 7. Relationship between peak VO_2 ($l \cdot min^{-1}$) and body weight (kg).

FIGURE 8. Relationship between peak VO_2 ($ml \cdot min^{-1} \cdot kg^{-1}$) and dynamic muscle strength measures as measured by the sum of a 1 repetition maximum (1 RM). *Top:* Relationship between peak VO_2 and arm curl ($r=0.75$, $p<0.001$). *Middle:* Relationship between peak VO_2 ($l \cdot min^{-1}$) and leg press strength ($r=0.61$, $p<0.001$). *Bottom:* Relationship between peak VO_2 and knee extensor strength ($r=0.67$, $p<0.001$).


600
500
400
300
200
100
0
6 MINUTE WALK DISTANCE (m)
750
600
450
300
150
0
WALKING WORK (kJ)
0.0
0.5
1.0
1.5
2.0
2.5
PEAK VO2(l·min-1)


600
500
400
300
200
100
0
6 MINUTE WALK DISTANCE (m)
750
600
450
300
150
0
WALKING WORK (kJ)
0
10
15
20
25
PEAK VO2(ml·kg−1·min−1)


600
500
400
300
200
100
0
6 MINUTE WALK DISTANCE (m)
750
600
450
300
150
0
WALKING WORK (kJ)
0
10
20
30
40
50
SUM OF UNILATERAL ARM CURL 1 RM (kg)


6 MINUTE WALK DISTANCE (m)
600
500
400
300
200
100
0
WALKING WORK (kJ)
750
600
450
300
150
0
80
114
148
182
216
250
SUM OF UNILATERAL LEG PRESS 1 RM (kg)

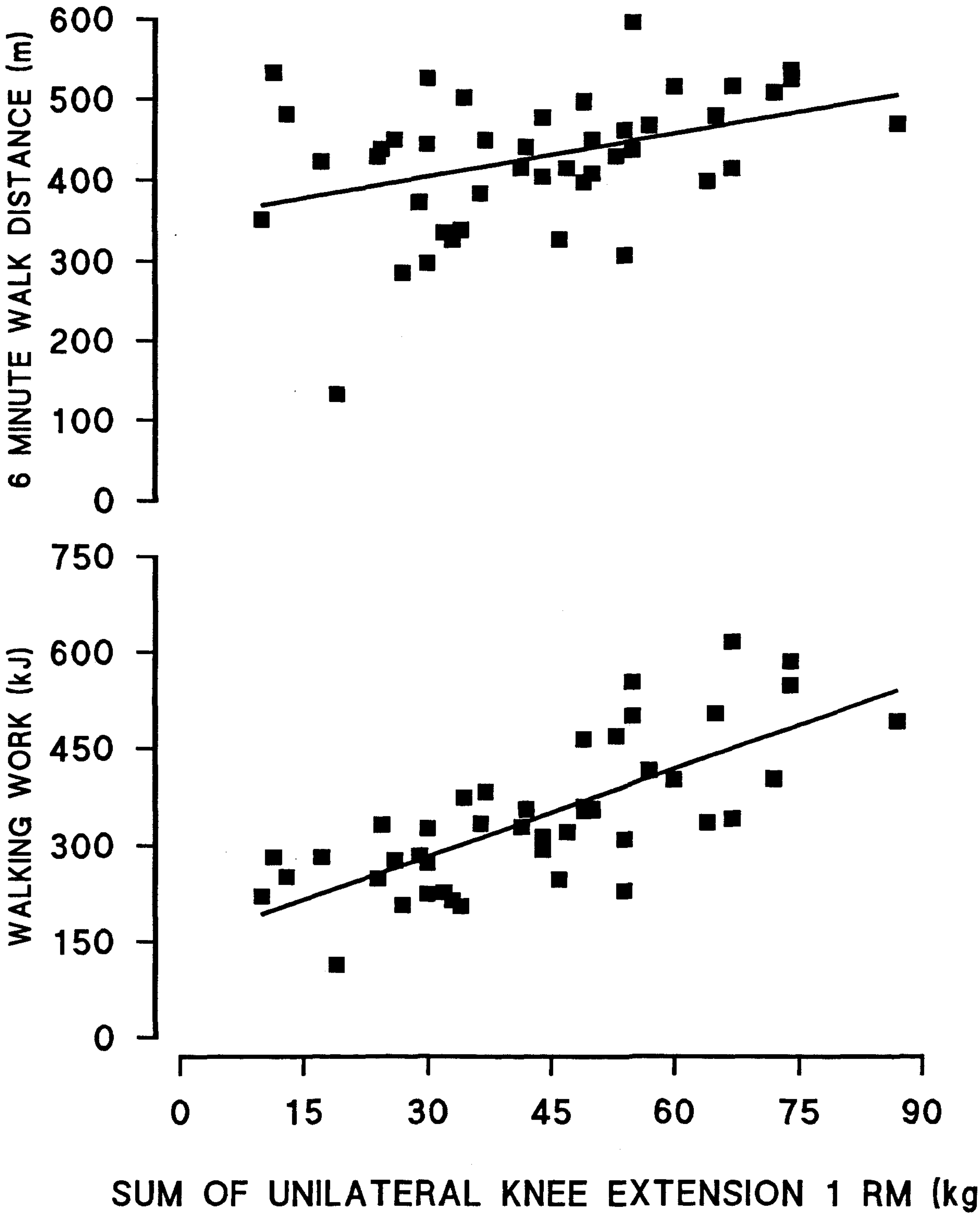
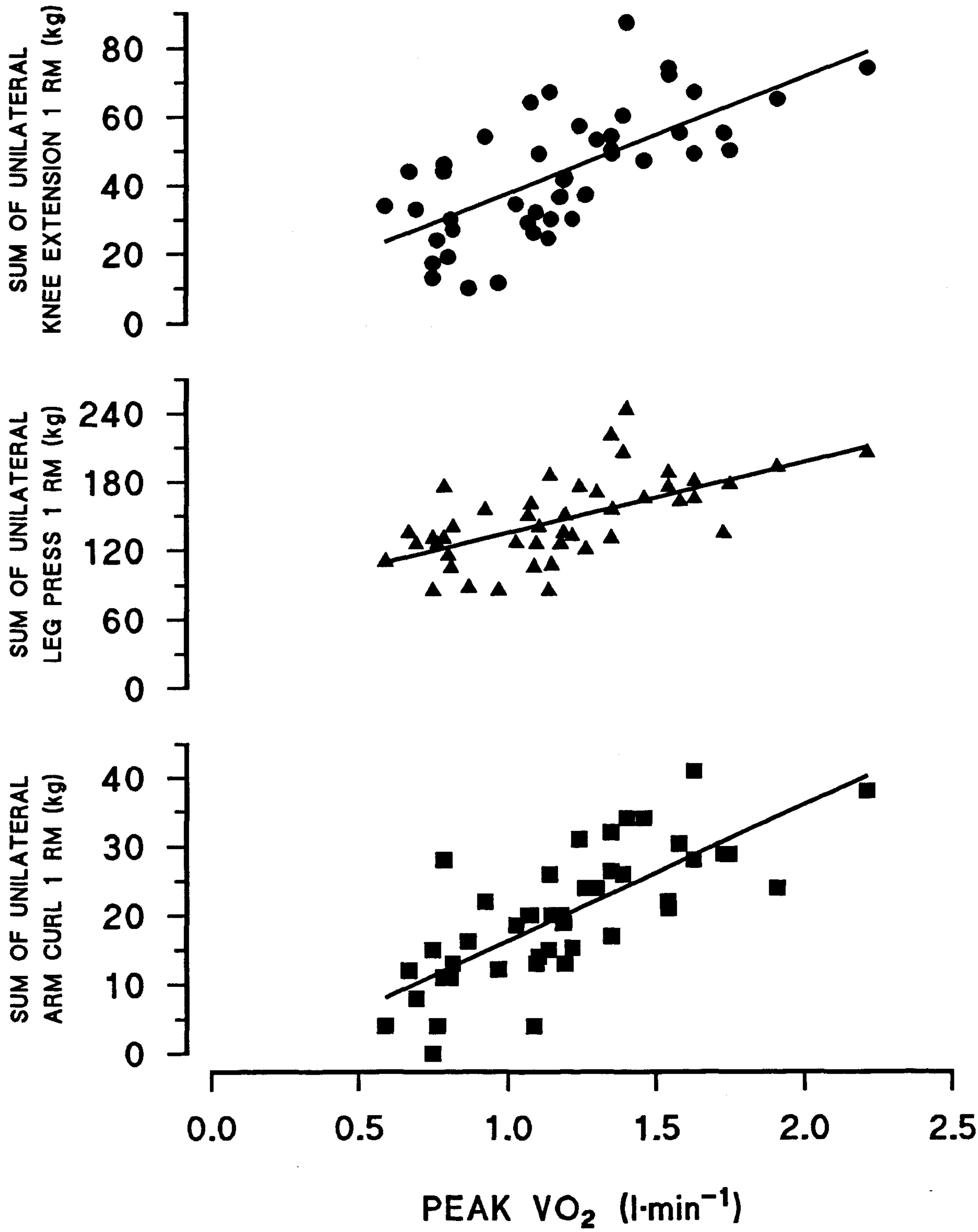

600
500
400
300
200
100
0
6 MINUTE WALK DISTANCE (m)
750
600
450
300
150
0
WALKING WORK (kJ)
0
15
30
45
60
75
90
SUM OF UNILATERAL KNEE EXTENSION 1 RM (kg)

Figure 6. 57


SUM OF UNILATERAL KNEE EXTENSION 1 RM (kg)
0
20
40
60
80
SUM OF UNILATERAL LEG PRESS 1 RM (kg)
0
60
120
180
240
SUM OF UNILATERAL ARM CURL 1 RM (kg)
0
10
20
30
40
0.0
0.5
1.0
1.5
2.0
2.5
PEAK VO_2 ($l \cdot min^{-1}$)

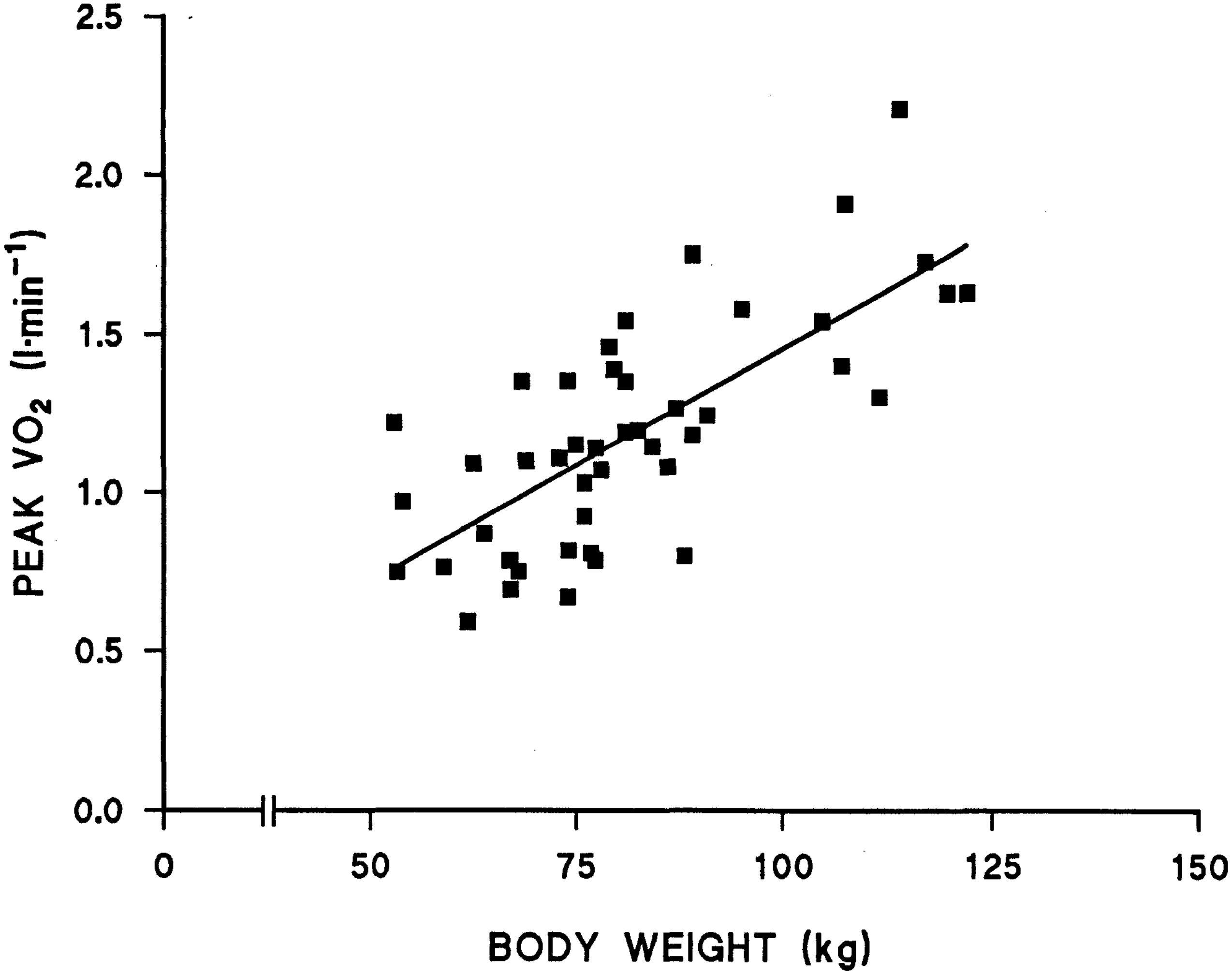
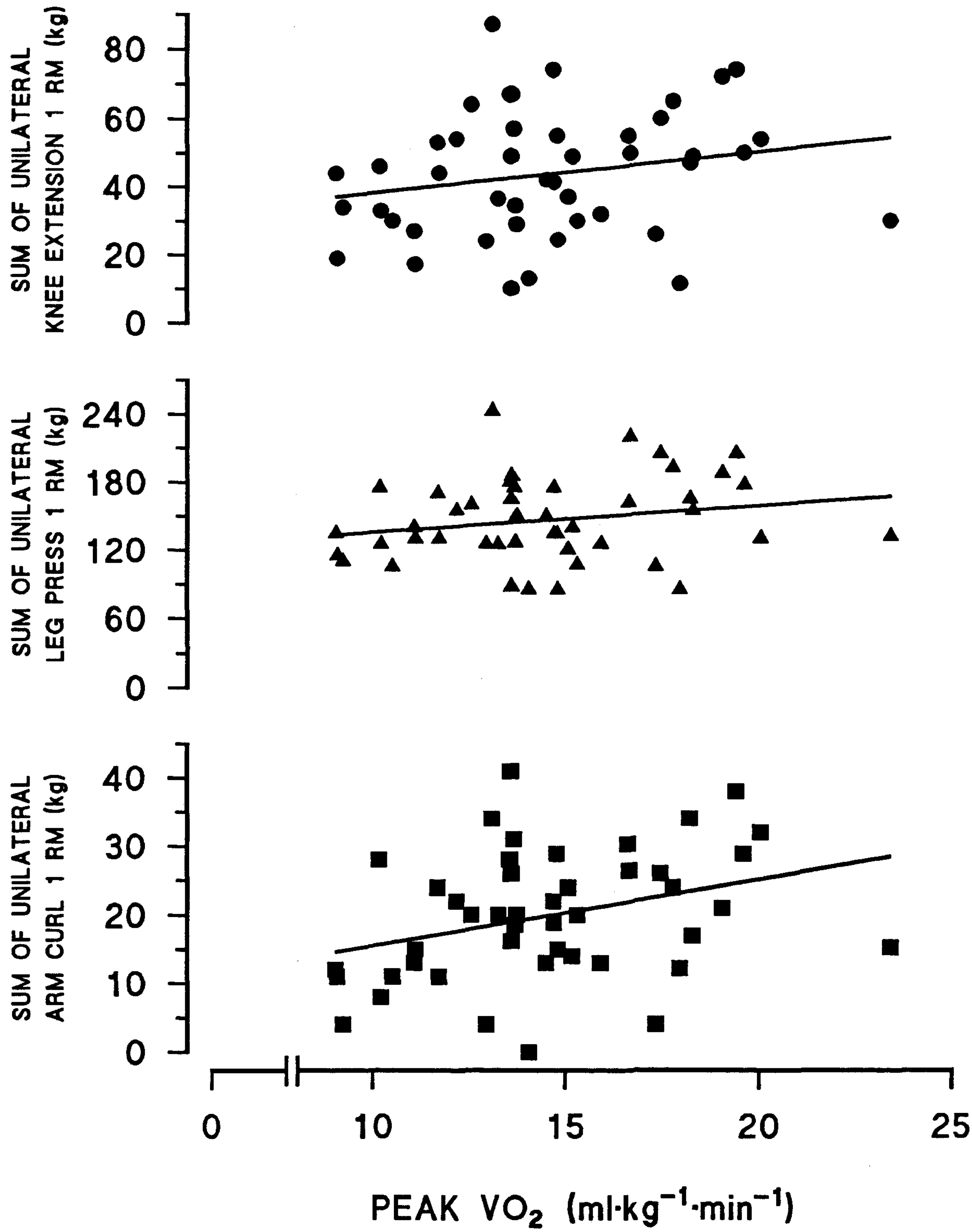

2.5
2.0
1.5
1.0
0.5
0.0
PEAK VO2 (l·min-1)
0
50
75
100
125
150
BODY WEIGHT (kg)

Figure 7. 58

Figure 7. 58


SUM OF UNILATERAL
KNEE EXTENSION 1 RM (kg)
0
20
40
60
80
SUM OF UNILATERAL
LEG PRESS 1 RM (kg)
0
60
120
180
240
SUM OF UNILATERAL
ARM CURL 1 RM (kg)
0
10
20
30
40
0
10
15
20
25
PEAK VO2 (ml·kg-1·min-1)

CHAPTER III

ASSESSMENT OF QUALITY OF LIFE IN CONGESTIVE HEART FAILURE PATIENTS

3.1 ABSTRACT

The syndrome of congestive heart failure (CHF) is known to contribute to poor health-related quality of life (HRQL). As a result, HRQL has become an important outcome measure in clinical trials. Many health status measures have therefore been designed to evaluate either general health or specific diseased health states. The purpose of this study was to examine the relationship between results of generic measures and specific measures of HRQL in patients with CHF. The questionnaires that were utilized include the Minnesota Living With Heart Failure (MLHF), Chronic Heart Failure questionnaire (CHQ), the Medical Outcome Survey Short Form 36 (SF-36) and the Standard Gamble Utility Index (SG). As well, physical tests of function such as the 6 minute walk (6MW), peak VO_2, arm curl strength (AC), leg press strength (LP), and knee extensor strength (KE) were assessed to determine the relationship between HRQL and functional capacity.

Forty two patients with CHF completed the series of questionnaires (age=65±10yrs; 36M,6F; 2% NYHA I; 62% NYHA II, 36% NYHA III, EF=.27±.07). Significant relationships were found between physical dimensions of the CHQ, MLHF and

SF-36 ($r=0.33$ to 0.80, $p<0.05$). As well, significant relationships were found between the emotional dimensions of these HRQL measures ($r=0.32$ to 0.72, $p<0.05$). Furthermore, the SF-36 physical functioning, and SF-36 energy and fatigue significantly correlated with the 6MW distance ($r=0.41$ and $r=0.33$, respectively, $p<0.05$). The SF-36 physical functioning also correlated with the calculated work performed during the walk test ($r=0.36$, $p<0.05$). Peak VO_2 and dynamic muscle strength measures did not significantly correlate with any HRQL physical dimensions. The SG utility measure was significantly related to the CHQ emotion dimension ($r=0.34$), the MLHF physical ($r=-0.49$), emotional ($r=-0.52$) and total score ($r=-0.48$), the SF-36 social function ($r=0.48$), mental health ($r=0.35$), pain ($r=0.32$), and general health perception ($r=0.33$). As well, the utility score had a significant relationship with 6MW distance ($r=0.33$, $p<0.05$). Although there was a trend for a these functional tests to differentiate between New York Heart Association Class II and Class III, only LP (156.5 ± 39.0 vs 126.1 ± 27.8, $p<0.011$), the MLHF physical dimension (9.1 ± 9.5 vs 15.5 ± 8.0, $p<0.033$) and the SF-36 physical function dimension (21.7 ± 3.9 vs 19.0 ± 3.7, $p<0.036$) were statistically significant.

The CHQ, MLHF and SF-36 questionnaires were shown to be valid measures of HRQL. Some physical dimensions of these questionnaires significantly related to the 6MW test. These results indicate that these health status measures are indicative of the patient's functional capacity. Furthermore, these results indicate that the standard gamble does reflect health status in patients with CHF.

3.2 INTRODUCTION

The syndrome of congestive heart failure (CHF) has a marked impact on patients' physical and mental health (Wenger and Furberg, 1990; Guyatt et al., 1985b). Therefore an important goal of therapy for patients with CHF is to improve how they feel and function during activities of daily living. As such, the measurement of health related quality of life (HRQL) has become more common in clinical trials of CHF.

Two of the basic approaches available to measure HRQL include generic instruments and specific instruments. Generic instruments are essential in providing a summary of HRQL and consist of health profiles and utility measures. Health profiles are used to measure different aspects of HRQL and can be aggregated into a small number of scores. The Medical Outcome Survey Short Form-36 (SF-36) is an example of a health profile which gives the patient a score for 9 different dimensions, ranging from physical function to emotional function to perception of general health. Utility measures such as the Standard Gamble, are measured as a single score along a continuum where death is 0 and full health is 1.0. The utility index is based on economic and decision theories (Bennett et al., 1991). A limited number of studies have been done relating the utility index to other measures of health status (O'Brien et al., 1990; Revicki, 1992), and depending which method is used, the scores have been found to vary (Revicki, 1992). This raises questions concerning its use as a measure of HRQL.

Disease specific questionnaires focus on problems associated with individual diseased states. A number of disease-specific measures for CHF have been developed. Two such measures include the Chronic Heart Failure Questionnaire (CHQ) and the Minnesota Living With Heart Failure Questionnaire (MLHF). The MLHF covers physical, socioeconomic and psychological impairments that patients often relate to their CHF and has been found to be a valid, reliable and responsive measure (Rector et al., 1987 and 1992). Furthermore, this HRQL measure has been used in the Studies of Left Ventricular Dysfunction (SOLVD) (Gorkin et al., 1993). Although the CHQ has not been used to the same extent, it has been shown to be a responsive evaluative measure (Guyatt et al., 1988).

There is little experience to date with the use of generic measures in CHF trials (Guyatt, 1993). Therefore, the purpose of this study was to utilize generic measures in the assessment of HRQL in patients with CHF and to examine the relationship between results of generic measures and specific measures of HRQL. Similar dimensions between questionnaires should bear close relation. Furthermore, the utility score obtained using the Standard Gamble was correlated with all other health dimensions. Another purpose of this study was to evaluate the relationships between physical dimensions of HRQL and tests of physical function such as peak VO_2, 6 minute walk distance and work, and muscle strength.

3.3 METHODS

3.3.1 PATIENTS

Forty two patients (mean $\pm$ SD.: 66$\pm$9.7yrs) diagnosed with CHF agreed to participate in the study (Table 1). Patients were informed of the procedures and risks involved in the study and written consent was freely obtained; the study was approved by the institutional ethics committee.

Inclusion into the study required an NYHA Class I to III heart failure, left ventricular ejection fraction < 40 % based on radionuclide ventriculography and a screening 6 minute walk test distance of less than 500 meters. Exclusion criteria included unable to be stabilized on diuretic, digoxin, or angiotensin converting enzyme inhibitor, limited exercise test by symptoms of angina or leg claudication, abnormal blood pressure response to clinical exercise testing (decrease in systolic pressure below resting during exercise; or a decrease in systolic pressure of > 20 mmHg after the normal exercise increase; or rise in diastolic pressure of > 15 mmHg; maximal systolic pressure in excess of 250 mmHg), cerebrovascular disease with significant residual impairment that prevents formal exercise testing or training, respiratory limitation (FEV1 and/or VC < 50% of predicted).

3.3.2 EXPERIMENTAL DESIGN

Each patient was assessed on the 6 minute walk twice, dynamic muscle strength twice, peak VO_2 and HRQL. The second walk test and the sum of the highest right and left limb strengths were used in the analysis.

3.3.3 MEASUREMENTS OF HEALTH RELATED QUALITY OF LIFE

HRQL was measured using several questionnaires which include the CHQ, MLHF, SG, and SF-36. The order of administration was randomly altered between two orders. This will allow for easy detection of order effects since an instrument is at the top of the list in one and at the bottom in the other. Furthermore, the most "important" instruments should be furthest away from one another so that order effects on these can be estimated if they exist. The QOL battery lasted approximately 1 hour.

The Chronic Heart Failure Questionnaire. The CHQ is an interviewer administered questionnaire which first asks patients to list activities that they have done in the last two weeks that have caused shortness of breath. These activities are then ranked by the patient on the basis of importance and then rated in terms of the amount of shortness of breath they caused. A minimum of three activities is required for an accurate evaluation of the dyspnea dimension for evaluative purposes. For the purpose of this study, any missing items in this dimension was given a rating of 7 in order to depict good function in terms of dyspnea. The 15 remaining questions encompass emotional (questions 5, 8, 11, 13, 15, 17), fatigue (questions 7, 10, 14, 16) and mastery dimensions (questions 6, 9, 12, 18) (Table 2). All dimensions are calculated by adding numerical responses. Low scores indicate poor function.

Minnesota Living With Heart Failure Questionnaire. The MLHF questionnaire consists of twenty one questions and was designed as a self administered questionnaire. This specific measure focuses on how much physical, socioeconomical and emotional impairments prevent patients with CHF from living as they wanted to during the last month. The total score is obtained by adding all 21 ratings; the emotional dimension by adding scores 17 to 21; and the physical dimensions were calculated by adding question scores 2 to 7, 12 and 13 (Table 2). Low scores indicate good function.

Medical Outcome Survey Short Form-36. The SF-36 is a self administered questionnaire which focuses on general health perceptions and subjective evaluations (de Haan et al., 1993). This questionnaire is the short version of the Sickness Impact Profile questionnaire and reveals 8 dimensions of HRQL. SF-36 items and scales are prepared for analysis in two steps. The first step involves the recoding of certain questionnaire items. The second step combines the coded items, thereby giving a summary score for each of the eight health concepts. Table 2 illustrates the 9 dimensions in the SF-36 where scores range from using responses from one question to 10 questions. Low scores indicate poor function.

Standard Gamble Questionnaire. The Standard Gamble (SG) questionnaire is a classical method of utility measurement and is based directly on the fundamental axioms of utility theory (Bennett et al., 1991). This provides us with cardinal values between 0 and 1 indicating the patients' preference for current health state relative to perfect health (1) and death (0) (Bennett et al., 1991). The interviewer uses a visual aid called the chance board which allows for changing of probabilities and asks the patient to make a choice between remaining in their current health state or the possibility of returning to excellent health or immediate death.

3.3.4 SIX MINUTE WALK TEST

Patients were instructed to walk a 33 meter course in a hospital corridor, covering as much distance as they could in six minutes. If need be, they could stop, rest and then continue on when they felt ready to do so. The time was not stopped during these rest periods. Standardized encouragement, consisting of "you are doing well" or "keep up the good work", was given to the patients at approximately 30 second intervals. Markers were located along the walking course at 1.5 metre intervals and the total distance walked was measured to the nearest 0.5 metres. Patients were allotted a 5 minute rest period prior to commencing and following the walk test.

The work performed during the walk was calculated by the following equation: WW=body weight · g · distance, where WW is walking work, body weight is the patient's actual weight in kilograms, g is the force of gravity (9.8 $m \cdot sec^{-1} \cdot sec^{-1}$) and distance is the total distance in meters covered by the patient in 6 minutes.

3.3.5 DYNAMIC MUSCLE STRENGTH

A Universal-type Global Gym single-station training apparatus was used to assess the patient's 1 repetition maximum (1 RM) defined as the heaviest weight in kilograms that the patient could lift only once through a full range of movement. Each patient's 1 RM was determined for the single arm curl (AC), single leg press (LP) and single knee extension (KE) exercises. Warm up prior to testing included walking for approximately 5 minutes and 5 repetitions of each the AC, LP and KE exercises using very low weight.

The initial weight used to determine the 1 RM was based on the patient's demonstrated performance during the warm-up. For the AC the initial weight applied was between 1 and 4 kg, for the LP it was between 35 and 50 kg, and for the KE it ranged from 7 to 10 kg. The 1 RM was determined by having the patient perform single repetitions with progressively heavier weights, resting two to three minutes between attempts. Increments were made in accordance to the perceived exertion of the patient during the lift.

A second strength testing session was performed within approximately one week of the initial test. Following the same warm-up procedure, weights were placed at 80 % then 100 % of the 1 RM they performed on the first testing day. Following these 2 lifts, small increments in weight were made to attain a true 1 RM.

3.3.6 PEAK OXYGEN UPTAKE

Peak oxygen uptake was assessed during a symptom limited exercise test on a cycle ergometer. The initial workload was 100 kpm/min and was increased by 100 kpm/min every 2 minutes. The patient was instructed to maintain a pedalling rate of 60 r.p.m. The patient breathed through a mask with expired gas sampled and analyzed using a Sensor Medics 2900 metabolic cart. The peak VO_2 was defined as the maximum VO_2

achieved during exercise. Both the absolute and relative peak VO_2 were measured.

3.3.7 STATISTICAL ANALYSIS

The data were analyzed using a Pearson's correlation coefficient. A probability level of less than 0.05 was deemed statistically significant. The following predictions on the correlation coefficients were made between the CHQ and MLHF and SF-36:

1) The dimensions will bear a close relation ($r \geq 0.5$) to corresponding dimension in the MLHF and SF-36 and;

2) Some relation ($r \geq 0.3$) should exist between similar dimensions in the CHQ and those in the MLHF and the SF-36.

As well, a student's T-test was performed between the NYHA class II and class III to see if the two groups were statistically different from each other in terms of HRQL and physical function. A probably level of less than 0.05 was deemed statistically significant.

3.4 RESULTS

3.4.1 SUBJECTS

In all, 45 patients were recruited for the study. Three subjects did not complete the HRQL battery due to the inability to read or comprehend english and therefore were not included in the analysis.

3.4.2 RELATIONSHIPS BETWEEN PHYSICAL DIMENSIONS OF HRQL MEASURES

As predicted, the intercorrelations between similarly defined dimensions were higher than between non-similar dimensions. The dyspnea dimension of the CHQ significantly correlated with all other physical dimension ratings (Table 3), with the highest correlation coefficient existing with the CHQ fatigue (r=.66) and the MLHF physical (r=-.62) dimensions. The direction of this latter relationship is appropriate since high scores in the MLHF questionnaire depict poor function which is opposite to the CHQ and the SF-36. The CHQ fatigue dimension correlated highly with the SF-36 energy and fatigue dimensions (r=.80). Some relationship does exist between the mastery dimension of the CHQ and other physical dimensions, however these remain below 0.50 (0.46-0.33). As expected, the SF-36 pain dimension was the only other dimension which did not show high correlation coefficients with other physical dimensions (0.19-0.37).

3.4.3 RELATIONSHIPS BETWEEN PHYSICAL DIMENSIONS AND OBJECTIVE TESTS OF PHYSICAL FUNCTION

Correlation coefficients depicting the relationship between physical dimensions of HRQL measures and physical function tests are found in Table 3. The 6MW distance and walk work variables were only weakly related to SF-36 physical function (r=0.41 and r=0.36, respectively). The 6MW distance also correlated with SF-36 energy and fatigue (r=.33). Peak VO_2, AC, LP and KE strength did not relate to the physical dimensions of the HRQL battery (Table 3).

3.4.4 RELATIONSHIPS BETWEEN EMOTIONAL DIMENSIONS OF HRQL MEASURES

The CHQ emotion dimension correlated highly with the SF-36 mental health (r=0.72), with the MLHF emotion dimension (r=-0.66) and the SF-36 role limitations due to emotional problems (r=0.62) (Table 4). Again, lower correlation coefficients were found between the CHQ mastery dimension and other emotionally based dimensions (0.19-0.44), although one coefficient did fall above 0.5 (SF-36 general health perception).

The MLHF emotion dimension did reveal strong relationships with all but two HRQL emotional scores (Table 4). By contrast, the SF-36 social function only showed a strong relationship with the MLHF emotion dimension (r=-0.50). All other relationships with the SF-36 social function dimension were weak (r=0.32-0.47) or non-significant (r=0.28). Finally, the SF-36 perceived change in health only showed a weak relationship with social function (r=0.44).

3.4.5 RELATIONSHIP BETWEEN STANDARD GAMBLE AND OTHER HRQL MEASURES

The mean utility score obtained by the SG questionnaire was 0.81±0.17. A moderate relationship existed between the MLHF emotion dimension and utility index (r=-0.52) (Table 5). Only one physical dimension (of the MLHF) had a weak relationship with the utility score (r=-.49). Other weaker relationships existed with the emotional dimension of the CHQ (r=0.34), the SF-36 social function (r=0.48), the SF-36 mental health (r=0.35), SF-36 pain dimension (r=0.32) and the SF-36 general health perception (r=0.33). The utility score also significantly correlated with the 6MW (r=0.33), but not with other measures of physical function.

3.4.6 COMPARISON OF HRQL AND PHYSICAL FUNCTION BETWEEN NYHA CLASS II AND III

There was a trend for better performance in 6MW distance, walk work and peak VO_2 for the patients in NYHA class II compared to class III but this was not statistically significant (Table 6). Muscle strength also tended to be greater in the NYHA class II patients but the difference was only statistically significant for LP (Table 6). The HRQL dimensions all tended to have better scores in the NYHA class II compared to class III patients but this was only statistically significant for the MLHF physical dimension ($p<0.033$).

3.5 DISCUSSION

This study incorporated a relatively comprehensive set of HRQL measures. These measures included two CHF specific questionnaires, a generic health profile measure and a generic utility measure. One of the purposes of this study was to evaluate the construct validity of these questionnaires by comparing similar dimensions from different questionnaires to one another. Although significant relationships were found between dissimilar dimensions (ie. between emotional and physical dimensions), these relationship were weaker and the correlation coefficients were lower than those found between similar dimensions. The following discussion will be divided into sections covering each questionnaire separately and a summary. Each section will address the purposes of this study.

3.5.1 CHRONIC HEART FAILURE QUESTIONNAIRE

The relationship between the CHQ and other health status measures has not been examined prior to this study. In this study, the dyspnea and fatigue dimensions related to the physical dimensions of the MLHF and the SF-36. As well, the CHQ emotional dimension correlated with the emotional dimensions of the MLHF and SF-36 questionnaires. These relationships were predicted since the questions making up these dimension scores are similar. Since both the physical and emotional dimensions of the MLHF and SF-36 related to the mastery dimension of the CHQ, it appears that both physical and emotional components have an impact on how much control the patient feels they have over the disease. Overall, these results indicate that the CHQ is a valid measure of HRQL since its dimension scores significantly correlated with the dimensions of already validated questionnaires.

Another purpose of the study was to examine the relationship between the CHQ functional tests. The 6MW did not significantly correlate with the fatigue and dyspnea dimension. The CHQ dyspnea dimension is based on the rating of shortness of breath experienced doing the five most important activities in the patient's life. As such, this dimension is individualized for each patient and has been useful in studies examining the effect of an intervention on symptoms (Guyatt et al., 1988). Guyatt and colleagues (1988) found that the dyspnea dimension score improved in the treatment group taking digoxin ($p < 0.044$) as compared to the placebo group. There were no significant differences between the groups for the fatigue or emotional dimensions of the CHQ. The change in the CHQ dyspnea score showed moderate correlations with changes in patient global ratings, in 6 minute walk test scores, and in clinical assessments of CHF. The CHQ proved to be both reliable and responsive (distinguished those who reported improvement or deterioration form those who did not).

3.5.2 MINNESOTA LIVING WITH HEART FAILURE QUESTIONNAIRE

The MLHF physical dimension incorporates information regarding resting during the day, walking and climbing stairs, working around the house, going away from home, sleeping, doing things with others, dyspnea and general fatigue. As predicted, the physical dimension of the MLHF significantly correlated with both the CHQ dyspnea and fatigue dimensions. As well, physical dimensions of the SF-36 were related to both the physical dimension and total score of the MLHF questionnaire.

The MLHF emotion score is based on questions incorporating feelings of burdensome, feeling a loss of self-control, worry, difficulty concentrating and remembering and feeling depressed. A strong relationship was found between this dimension and the CHQ emotional dimension, the SF-36 social function, role limitations due to emotional problems, and mental health. Since these dimensions measure similar aspects of emotion health, the results indicate that the MLHF is a valid measure of HRQL.

Similar to previous studies (Rector et al., 1987 and 1993), in this study, the MLHF discriminated between NYHA classifications. This questionnaire has also been shown to be a reliable and responsive measure of HRQL (Pollock et al., 1990; Rector et al., 1993).

3.5.3 MEDICAL OUTCOME SHORT FORM-36 QUESTIONNAIRE

Another significant feature of the study, was the use of a generic measure in the assessment of patients with CHF. As outlined in table 1, the SF-36 has 3 major health attributes which include functional status, well-being, and overall evaluation of health. The results of this study illustrate that dimensions of this questionnaire are suitable in the CHF population since they correlate with dimensions of specific HRQL measures. In particular, the energy and fatigue dimension correlates highly with the CHQ fatigue dimension ($r=0.80$) and with the physical component of the MLHF ($r=0.66$).

Another significant finding of this study is the relationship between the SF-36 physical function and energy and fatigue dimensions with the 6MW. This walk test has previously been shown to be related to functional status questionnaires (Guyatt et al., 1985b) and to be an independent predictor of mortality and morbidity in patients with CHF (Bittner et al., 1993). Therefore, patients with CHF can accurately rate their level of function.

The SF-36 survey was constructed to achieve the representation of multidimensional health concepts and the measurement of the full range of health states (McHorney et al., 1993). In this study, the range of health states ranged between NYHA Class II to III, with one patient classified as I. The physical function dimension was shown to discriminate between these two levels of function in patients with CHF. In a larger study (n=1582 patients) involving two family practices, the SF-36 questionnaire was reliable and valid in terms of distinguishing between groups with expected health differences (Brazier et al., 1992). Although the Sickness Impact Profile has been used more frequently in the past, the SF-36 proved to be a valid representation of the patients' health when compared to the SIP (Weinberger et al., 1991).

3.5.4 STANDARD GAMBLE UTILITY INDEX

The standard gamble utility score indicates the relative value patients attach to their current health status when compared with the therapeutic pay off of the gamble. To determine which aspects of HRQL are responsible for changes in utility scores, dimensions of the MLHF, CHQ and SF-36 were correlated with the standard gamble results. MLHF physical, emotional and total scores all related to the utility index. Furthermore, the SF-36 social function, mental health and general health perception all significantly correlated with the utility score obtained using the standard gamble method. These results indicate that both physical and emotional aspects of HRQL specific to CHF affect the relative value patients attribute to their current health state. In general, reductions in social function, mental health and general health perception is related to a reduction in utility score.

In previous studies of rheumatoid arthritis patients, the associations between the willingness to accept risk decreased with the duration of disease and increased with reductions in self assessed health status (O'Brien et al., 1990). Revicki (1992) also demonstrated that a small yet significant proportion of the variance in utility scores is attributable to the health status in chronic renal diseased patients. Although there is a relationship between health status measures and utility scores, these relationships are weak. Therefore, patient preferences may also be influenced in part by risk-taking attitudes.

Another intriguing finding was the significant relationship between utility index and 6MW in patients with CHF. This indicates that the percent of risk a patient is willing to take on their life is related to functional capacity or activities of daily living. As well, since 6MW is a predictor of mortality and morbidity, it can be assumed, the patients who take more risk (have a lower utility score), have a higher chance of mortality and morbidity.

3.5.5 SUMMARY

Construct validity is one of the necessary attributes of a health status measures when it is being considered for an outcome measure in clinical trials. In this study, both specific measures (CHQ and MLHF) have been shown to have construct validity when compared to one another. Benefits of using the MLHF is that it has been used in large trials (Gorkin et al., 1993), and is brief and easy to administer. However, the CHQ may be the measure of choice when an intervention may have an effect on symptoms, as it is based on individualized activities and has been shown to be responsive to changes (Guyatt et al., 1989c).

Generic measures, such as the SF-36 and the utility score, may be useful in clinical trials when comparing a patient population to the norm or other patient populations. In this study, the SF-36 was shown to be a valid measure of HRQL in patients with CHF. However, the standard gamble only weakly related to HRQL measures indicating that studies examining quality of life and using utility scores should incorporate other health status questionnaires for the outcome measures.

TABLE 1. PATIENT CHARACTERISTICS (n=42)

Male	86 %
Female	14 %
Age	65±10yrs*
EF	0.27±0.07*
NYHA I	2 %
NYHA II	62 %
NYHA III	36 %
ACE-I	83 %
Digoxin	81 %
Diuretic	81 %

* = means ± standard deviations
EF = ejection fraction
NYHA = New York Heart Association classification
ACE-I = angiotensin converting enzyme inhibitor

TABLE 2. COMPONENTS OF THE HEALTH RELATED QUALITY OF LIFE MEASURES

	PHYSICAL DIMENSIONS	EMOTIONAL DIMENSIONS	OTHER DIMENSIONS
Chronic Heart Failure Questionnaire	Dyspnea (7-35) Fatigue (4-28)	Emotion (6-42)	Mastery (4-28)
Minnesota Living with Heart Failure Questionnaire	Physical (0-25)	Emotional (0-40)	Total (0-105)
Medical Outcome Survey Short Form 36	<u>Functional Status</u> Physical functioning (10-30) Social functioning (2-11) Role limitations due to physical problems (0-4) Role limitations due to emotional problems (0-3)	<u>Well-Being</u> Mental health (5-30) Energy/fatigue (4-24) Pain (2-11)	<u>Overall Health</u> General health perception (5-25) Change in health (1-5)
Standard Gamble			Utility score

Number in brackets indicate the possible range of scores in that dimension.

TABLE 3. CORRELATION MATRIX OF PHYSICAL DIMENSIONS AND FUNCTIONAL MEASURES.

HRQL Physical Dimensions	1	2	3	4	5	6	7	8
1 - CHQ dyspnea								
2 - CHQ fatigue	.66†							
3 - CHQ mastery	.52†	.49†						
4 - MLHF physical	-.62†	-.61†	-.45†					
5 - SF-36 physical functioning	.54†	.44†	.37†	-.47†				
6 - SF-36 role limitations due to physical function	.56†	.62†	.41†	-.50†	.55†			
7 - SF-36 energy and fatigue	.61†	.80†	.46†	-.66†	.57†	.66†		
8 - SF-36 pain	.35†	.37†	.33†	-.30	.19	.34†	.30	
Functional Capacity and Strength Measures								
6 minute walk distance	.13	.21	.19	-.29	.41†	.10	.33†	-.06
Walk work (kJ)	.05	.23	.18	-.26	.36†	.20	.28	.01
Peak VO_2 ($ml \cdot min^{-1} \cdot kg^{-1}$)	-.19	-.06	-.06	-.05	.24	-.07	.10	-.25
Peak VO_2 ($l \cdot min^{-1}$)	-.17	.08	.02	-.12	.26	.11	.15	-.16
Arm Curl Strength	-.23	.01	-.18	.07	.05	-.09	.08	-.22
Leg Press Strength	-.03	.05	.11	-.07	.15	.01	.14	-.19
Knee Extensor Strength	-.07	.09	.11	.05	.21	.03	.07	-.15

CHQ = Chronic Heart Failure Questionnaire
MLHF = Minnesota Living with Heart Failure Questionnaire
SF-36 = Medical Outcome Survey Short Form-36
† = $p < 0.05$

TABLE 4. CORRELATION MATRIX OF EMOTIONAL FUNCTION.

	1	2	3	4	5	6	7
1 - CHQ emotion							
2 - CHQ mastery	.60†						
3 - MLHF emotion	-.66†	-.44†					
4 - SF-36 social function	.32†	.28	-.50†				
5 - SF-36 role limitations due to emotional problems	.62†	.38†	-.51†	.32			
6 - SF-36 mental health	.72†	.33†	-.59†	.40†	.53†		
7 - SF-36 general health perception	.54†	.53†	-.63†	.47†	.30	.21	
8 - SF-36 perceived change in health	.19	.19	-.08	.44†	.14	-.03	.42

CHQ = Chronic Heart Failure Questionnaire
MLHF = Minnesota Living with Heart Failure Questionnaire
SF-36 = Medical Outcome Survey Short Form-36
† = $p < 0.05$

TABLE 5. CORRELATION COEFFICIENTS BETWEEN THE STANDARD GAMBLE UTILITY MEASURES AND BOTH HEALTH RELATED QUALITY OF LIFE AND FUNCTIONAL MEASURES.

CHQ Dyspnea	0.28
CHQ Fatigue	0.13
CHQ Emotion	0.34†
CHQ Mastery	0.21
MLHF Physical	-0.49†
MLHF Emotional	-0.52†
MLHF Total Score	-0.48†
SF-36 Physical Function	0.21
SF-36 Social Function	0.48†
SF-36 Role Limits due to Physical Problems	0.30
SF-36 Role Limits due to Emotional Problems	0.09
SF-36 Mental Health	0.35†
SF-36 Energy and Fatigue	0.24
SF-36 Pain	0.32†
SF-36 General Health Perception	0.33†
SF-36 Perceived Health change in the last year.	0.03
6 Minute Walk Distance	0.33†
6 Minute Walk Work	0.24
Peak VO_2 (ml·min-1·kg-1)	0.14
Peak VO_2 (L·min-1)	0.12
Dynamic Muscle Strength Measures	0.0-0.08

TABLE 6. DIFFERENCES IN PHYSICAL FUNCTION AND HEALTH RELATED QUALITY OF LIFE BETWEEN NEW YORK HEART ASSOCIATION CLASS II AND III.

Scale	NYHA Class II	NYHA Class III	p-level
6 Minute Walk Test Distance (m)	441.4±75.6	403.2±99.8	NS
Walk Work (Kj)	369.2±121.2	304.3±94.7	NS
Peak VO_2 ($L \cdot min^{-1}$)	1.24±0.37	1.06±0.35	NS
Arm Curl (kg)	21.6±9.4	16.2±9.1	NS
Leg Press (kg)	156.5±39.0	126.1±27.8	0.011
Knee Extension (kg)	47.7±20.1	36.9±14.4	NS
CHQ Dyspnea	28.0±6.1	24.7±7.0	NS
CHQ Fatigue	18.6±4.8	16.4±4.9	NS
MLHF Physical	9.1±9.5	15.5±8.0	0.033
MLHF Total Score	23.0±21.6	34.3±17.6	NS
SF-36 Physical Function	21.7±3.9	19.0±3.7	0.036
SF-36 Role Limitations due to physical problems	1.7±1.7	0.9±0.9	NS
SF-36 Energy and Fatigue	15.78±4.4	13.3±4.1	NS

NYHA = New York Heart Association Classification
CHQ = Chronic Heart Failure Questionnaire
MLHF = Minnesota Living with Heart Failure Questionnaire
SF-36 = Medical Outcome Survey Short Form-36

REFERENCES

Adamopoulos, S., A.J.S. Coats, F. Brunotte, L. Arnolda, T. Meyer, C.H. Thompson, J.F., Dunn, J. Stratton, G.J. Kemp, G.K. Radda, and B. Rajagopalan. Physical training improves skeletal muscle metabolism in patients with chronic heart failure. *J. Am. Coll. Cardiol.* 21: 1101-1106, 1993.

Arnolda, L., M. Conway, M. Dolecki, H. Sharif, B. Rajagopalan, J.G.G. Ledingham, P. Sleight, and G.K. Radda. Skeletal muscle metabolism in heart failure: A 31P nuclear magnetic resonance spectroscopy study of leg muscle. *Clinical Science* 79: 583-589, 1990.

Arvan, S. Exercise performance of the high risk acute myocardial infarction patient after cardiac rehabilitation. *Am. J. Cardiol.* 62: 197-201, 1988.

Baigrie, R.S., M.G. Myers, T. Kavanagh, and G. Guyatt. Benefits of physical training in patients with heart failure. *Can. J. Cardiol.* 8 SupplB:107B, 1992.

Baker, B.J., M.M. Wilen, C.M. Boyd, H.A. Dinh, and J.A. Franciosa. Relation of right ventricular ejection fraction to exercise capacity in chronic left ventricular failure. *Amlodipine. J. Cardiol.* 54: 596-599, 1984.

Bennett, K., G. Torrance, and P. Tugwell. Methodological challenges in the development of utility measures of health related quality of life in rheumatoid arthritis. *Controlled Clin. Trials* 12: 118S-128S, 1991.

Bittner, V., D.H. Weiner, S. Yusuf, W.J. Rogers, K.M. McIntyre, S. Bangdiwala, M.W. Kronenberg, J.B. Kostis, R.M. Kohn, M. Guillotte, B. Greenberg, P.A. Woods, and M.G. Bourassa for the SOLVD Investigators. Prediction of mortality and morbidity with a 6 minute walk test in patients with left ventricular dysfunction. *JAMA* 270: 1702-1707, 1993.

Brandt, R.R., R.S. Wright, M.M. Redfield, and J.C. Burnett. Atrial natriuretic peptide in heart failure. *J. Am. Coll. Cardiol.* 22, Suppl A: 86A-92A, 1993.

Braunwald, E. Pathophysiology of Heart Failure. In: *Heart Disease, A Textbook of Cardiovascular Medicine* (4th Ed.) edited by E. Braunwald. Toronto: Saunders, 1992, p.393-418.

Brophy, J.M. Epidemiology of congestive heart failure: Canadian data from 1970 to 1989. *Can. J. Cardiol.* 8: 495-498, 1992.

Butland, R.J.A., J. Pan, E.R. Gross, A.A. Woodcock, and D.M. Geddes. Two-, six-, and twelve-minute walking test in respiratroy disease. *Br. Med. J.* 284:1007-1008, 1982.

Coats, A.J.S., S. Adamopoulos, A. Radaelli, A. McCance, T.E. Meyer, L. Bernardi, P.L. Solda, P.Davey, O. Ormerod, C. Forfar, J. Conway, and P. Sleight. Controlled trial of physical training in chronic heart failure. Exercise performance, hemodynamics, ventilation and autonomic function. *Circulation* 85: 2119-2131, 1992.

Coats, A.J.S. Exercise rehabilitation in chronic heart failure. *J. Am. Coll. Cardiol.* 22(Suppl A): 172A-177A, 1993.

Coats, A.J.S., S. Adamopoulos, T.E. Meyer, J. Conway, and P. Sleight. Effects of physical training in chronic heart failure. *Lancet* 335: 63-66, 1990.

Cody, R.J., G.J. Haas, P.F. Binkley, Q. Capers, and R. Kelley. Plasma endothelin correlates with the extent of pulmonary hypertension in patients with chronic congestive heart failure. *Circulation* 85: 504-509, 1992.

Conn, E.H., R.S. Williams, and A.G. Wallace. Exercise responses before and after physical conditioning in patients with severely depressed left ventricular function. *Amlodipine. J. Cardiol.* 49: 296-300, 1982.

de Haan, R., N. Aaronson, M. Limburg, R.L. Hewer, and H. van Crevel. Measuring quality of life in stroke. *Stroke* 24: 320-327, 1993.

Drexler, H., U. Riede, T. Munzel, H. Konig, E. Funke, and H. Just. Alterations of skeletal muscle in chronic heart failure. *Circulation* 85: 1751-1759, 1992.

Drexler, H., U. Banhardt, T. Meinertz, H. Wollschlager, M. Lehmann, and H. Just. Contrasting peripheral short-term and long-term effects of converting enzyme inhibition in patients with congestive heart failure: a double-blind, placebo-controlled trial. *Circulation* 79: 491-502, 1989.

Feeny, D.H., and G.W. Torrance. Incorporating utility-based quality of life assessment measures in clinical trials. *Med. Care* 27: S190-S204, 1989.

Feeny, D., W. Furlong, R.D. Barr, G.W. Torrance, P. Rosenbaum, and S. Weitzman. A comprehensive multiattribute system for classifying the health status of survivors of childhood cancer. *J. Clin. Oncol.* 10: 923-928, 1992.

Francis, G.S., S.R. Goldsmith, T.B. Levine, M.T. Olivari, and J.N. Cohn. The neurohormonal axis in congestive heart failure. *Ann. Intern. Med.* 101:370-377, 1984.

Friedman, L.M., C.D. Furberg, and D.L. Demets. *Assessment of Quality of Life. In: Fundamentals of Clinical Trials.* Mosby-Year Book, Inc: St. Louis, 1985.

Giannuzzi, P., L. Temporelli, L. Tavazzi, U. Corra, M. Gattone, A. Imparato, A. Giordano, C. Schweiger, L. Sala, C. Malinverni and the EAMI Study Group. EAMI - exercise training in anterior myocardial infarction: An on-going multicenter randomized study. Preliminary results on left ventricular function and remodelling. *Chest* 101: 315S-322S, 1992.

Gillum, RF. Epidemiology of heart failure in the United States. *Am. Heart J.*, 126: 1042-1047, 1993.

Gorkin, L., N.K. Norvell, R.C. Rosen, E. Charles, S.A. Shumaker, K.M. McIntyre, R.J. Capone, J. Kostis, R. Niaura, P. Woods, J. Hosking, C.Garces, E. Handberg, D.K. Ahern, and M.J. Follick. Assessment of quality of life as observed from the baseline data of the studies of left ventricular dysfunction (SOLVD) trial quality of life substudy. *Am. J. Cardiol.* 71:1069-1073, 1993.

Guyatt, G.H., P.J. Thompson, L.B. Berman, M.J. Sullivan, M. Townsend, N.L. Jones, and S.O. Pugsley. How should we measure function in patients with chronic heart and lung disease? *J. Chron. Dis.* 38:517-524, 1985b.

Guyatt, G.H., S. Pugsley, M.J. Sullivan, P.J. Thompson, L.B. Berman, N.L. Jones, E.L. Fallen, and D.W. Taylor. Effect of encouragement on walking test performance. *Thorax* 39: 818-822, 1984.

Guyatt, G.H., and R. Jaescke. How to develop and validate a new quality of life instrument. In: *QOL Assessments in Clinical Trials.* Raven Press Ltd, New York: 42-46, 1990.

Guyatt, G.H., M.J. Sullivan, E.L. Fallen, H. Tihal, E.Rideout, S. Halcrow, S. Nogradi, M. Townsend, and W. Taylor. A controlled trial of digoxin in congestive heart failure. *Am. J. Cardiol.* 61:371-375, 1988.

Guyatt, G.H., M.J. Sullivan, P.J. Thompson, E.L. Fallen, S.O. Pugsley, D.W. Taylor, and L.B. Berman. The 6-minute walk: a new measure of exercise capacity in patients with chronic heart failure. *Can. Med. Assoc. J.* 132:919-923, 1985a.

Guyatt, G.H., D.H. Feeny, and D.L. Patrick. Measuring health-related quality of life. *Ann. Int. Med.* 118: 622-629, 1993.

Guyatt, G.H., D.H. Feeny, and D.L. Patrick. Issues in quality of life measurement in clinical trials. *Controlled Clin. Trials* 12:81S-90S, 1991.

Guyatt, G.H., S.J. Van Zanten, D.H. Feeny, and D.L. Patrick. Measuring quality of life in clinical trials: a taxonomy and review. *Can. Med. Assoc. J.* 140: 1441-1448, 1989a.

Guyatt, G.H., M. Townsend, J.L. Keller, and J. Singer. Should study subjects see their previous responses: data from a randomized controlled trial. *J. Clin. Epidemiol.* 42: 913-920, 1989b.

Guyatt, G.H., S. Nogradi, S. Halcrow, J. Singer, M.J. Sullivan, and E.L. Fallen. Development and testing of a new measure of health status for clinical trials in heart failure. *J. Gen. Intern. Med.* 4:101-107, 1989c.

Guyatt, G.H., C. Bombardier, and P.X. Tugwell. Measuring disease-specific quality of life in clinical trials. *Can. Med. Assoc. J.* 134: 889-895, 1986.

Guyatt, G.H., S. Walter, and G. Norman. Measuring change over time: Assessing the usefulness of evaluative instruments. *J. Chron. Dis.* 40: 171-178, 1987.

Higginbotham, M.B., K.G. Morris, E.H. Conn, R.E. Coleman, and F.R. Cobb. Determinants of variable exercise performance among patients with severe left ventricular dysfunction. *Am. J. Cardiol.* 51: 52-60, 1983.

Ho, K.K.L, J.L. Pinsky, W.B. Kannel, and D. Levy. The epidemiology of heart failure: The Framingham study. *J. Am. Coll. Cardiol.* 22, Suppl. A: 6A-13A, 1993.

Jaeschke, R., G.H. Guyatt, J. Keller, and J. Singer. Interpreting changes in quality of life score in N of 1 randomized trials. *Controlled Clin. Trials* 12: 226S-233S, 1991.

Jaeschke, R., J. Singer, and G. Guyatt. Measurement of health status. Ascertaining the minimal clinically important difference. *Controlled Clin. Trials* 10: 407-415, 1989.

Jette, M., R. Heller, F. Landry, and G. Blunmchen. Randomized 4 week exercise program in patients with impaired left ventricular function. *Circulation* 84: 1561-1567, 1991.

Jugdutt, B.I., B.L. Michorowski, and C.T. Kappagoda. Exercise training after anterior Q wave myocardial infarction: Importance of regional left ventricular function and topography. *J. Am. Coll. Cardiol.* 12:362-72, 1988.

Kannel, W.B., and A.J. Belanger. Epidemiology of heart failure. *Am. Heart J.* 121: 951-957, 1991.

Kannel, W.B., J.F. Plehn, and L.A. Cupples. Cardiac failure and sudden death in the Framingham Study. *Am. Heart J.* 115: 869-875, 1988.

Katz, J.N., M.G. Larson, C.B. Phillips, A.H. Fossel, and M.H. Liang. Comparative measurement sensitivity of short and longer health status instruments. *Med. Care* 30: 917-925, 1992.

Kirshner, B. and G.H. Guyatt. A methodological framework for assessing health indices. *J. Chron. Dis.* 38: 27-36, 1985.

Kostis, J.B., R.C. Rosen, N.M. Cosgrove, D.M. Shindler, and A.C. Wilson. Nonpharmacologic therapy improves functional and emotional status in congestive heart failure. *Chest* 106: 996-1001, 1994.

Kubo S.H., S. Gollub, R. Bourge, P. Rahko, F. Cobb, M. Jessup, S. Brozena, M. Brodsky, P. Kirlin, J. Shanes, M. Konstam, a. Gradman, J. Morledge, M. Conquegrani, S. Singh, T. Lejemtel, J. Nicklas, J. Troha, and J.N. Cohn. Beneficial effects of pimobendan on exercise tolerance and quality of life in patients with heart failure: results of a multicenter trial. *Circulation* 85: 942-949, 1992.

Lee, A.P., R. Ice, R. Blessy, and M.E. Sanmarco. Long-term effects of physical training on coronary patients with impraired ventricular function. *Circulation* 60: 1519-26, 1979.

Lipkin, D.P., A.J. Scriven, T. Crake, and P.A. Poole-Wilson. Six minute walking test for assessing exercise capacity in chronic heart failure. *Br. Med. J.* 292:653-655, 1986.

Lipkin, D.P., D.A. Jones, J.M. Round, and P.A. Poole-Wilson. Abnormalities of skeletal muscle in patients with chronic congestive heart failure. *Int. J. Cardiol.* 18: 187-195, 1988.

MacKenzie, C.R., M.E. Charlson, D. Digioria, and K. Kelley. Can SIP measure change? An example of scale assessment. *J. Chron. Dis.* 39: 429-438, 1986.

Mancini, D.M., E. Coyle, A. Coggan, J. Beltz, N. Ferraro, S. Montain, and J.R. Wilson. Contribution of intrinsic skeletal muscle changes to 31P NMR skeletal muscle metabolic abnormalities in patients with chronic heart failure. *Circulation* 80: 1338-1346, 1989.

Mancini, D.M., N. Ferraro, M. Tuchler, B. Chance, and J.R. Wilson. Detection of abnormal calf muscle metabolism in patients with heart failure using phosphorus-31 nuclear magnetic resonance. *Am. J. Cardiol.* 62: 1234-1240, 1988.

Mancini, D.M., G. Walter, N. Reichek, R. Lenkinski, K.K. McCully, J.L. Mullen, and J.R. Wilson. Contribution of skeletal muscle atrophy to exercise intolerance and altered muscle metabolism in heart failure. *Circulation* 85: 1364-1373, 1992.

Maskin, C.S., R. Forman, E.J. Sonneblick, W.H. Frishman and T.H. LeJemtel. Failure of dobutamine to increase exercise capacity despite hemodynamic improvement in severe congestive heart failure. *Am. J. Cardiol.* 51: 177-182, 1983.

Massie, B., M. Conway, R. Yonge, S. Frostick, J. Ledingham, P. Sleight, G. Radda and B. Rajagopalan. Skeletal muscle metabolism in patients with congestive heart failure: relation to clinical severity and blood flow. *Circulation* 76: 1009-1019, 1987.

Massie, B.M., M. Conway, B. Rajagopalan, R. Yonge, S. Frostick, J. Ledingham, P. Sleight, and G. Radda. Skeletal muslce metabolism during exercise under ischemic conditions in congestive heart failure. Evidence for abnormalities unrelated to blood flow. *Circulation* 78: 320-326, 1988.

Massie, B.M. Exercise tolerance in congestive herat failure: Role of cardiac function, peripheral blood flow, and muscle metabolism and effect of treatment. *Am. J. Med.* 84 Suppl3A: 75-82, 1988.

Mayou, R., and B. Bryant. Quality of life in cardiovascular disease. *Br. Heart J.* 69: 460-466, 1993.

McGavin, C.R., S.P. Gupta, and G.J.R. McHardy. Twelve-minute walk test for assessing disability in chronic bronchitis. Br. Med. J. 1: 822-3, 1976.

McKelvie, R.S., K.K. Teo, N. McCartney, D. Humen, T. Montague, and S. Yusuf. Effects of exercise training in patients with congestive heart failure: A critical review. *J. Am. Coll. Cardiol.* 25:789-796, 1995.

Minotti, J.R, E.C. Johnson, T.L. Hudson, G. Zuroske, G. Murata, E.Fukushima, T.G. Cagle, T.W. Chick, B.M. Massie, and M.V. Icenogle. Skeletal muscle response to exercise training in congestive heart failure. *J. Clin. Invest.* 86:751-758, 1990.

Minotti, J.R., I. Christoph, R. Oka, M.W. Weiner, L. Wells, and B.M. Massie. Impaired skeletal muscle function in patients with congestive heart failure: Relationship to systemic exercise performance. *J. Clin. Invest.* 88:2077-2082, 1991.

O'Brien, B.J., J. Elswood, and A. Calin. Willingness to accept risk in the treatment of rheumatic disease. *J. Epidemiol. Comm. Health* 44: 249-252, 1990.

O'Brien, J.L., A.L. Hicks, and R.S. McKelvie. Neuromuscular assessment of heart failure subjects. *Can. J. Cardiol.* 10 Suppl A: 93A, 1994.

Pollock, S.G., J. Lystash, C. Tedesco, G. Craddock, and M.L. Smucker. Usefulness of bucindolol in congestive heart failure. *Am. J. Cardiol.* 66: 603-607, 1990.

Rector, T.S., S.H. Kubo, and J.N. Cohn. Validity of the Minnesota Living with Heart Failure questionnaire as a measure of therapeutic response to Enalapril or placebo. *Am. J. Cardiol.* 71: 1106-1107, 1993.

Rector, T.S., S.H. Kubo, and J.N. Cohn. Patients' self-assessment of their congestive heart failure; content, reliability and validity of a new measure-the Minnesota Living with Heart Failure questionnaire. *Heart Failure* 3: 198-209, 1987.

Rector, T.S., and J.N. Cohn. Assessment of patient outcome with the Minnesota Living with Heart Failure questionnaire: reliability and validity during a randomized, double-blind, placebo controlled trial of pimobendan. *Am. Heart J.* 124: 1017-1025, 1992.

Revicki, D.A. Relationship between health utiltiy and psychometric health status measures. *Med. Care* 30: MS274-MS282, 1992.

Riley, M., J. McParland, C.F. Stanford and D.P. Nicholls. Oxygen consumption during corridor walk testing in chronic cardiac failure. *Eur. Heart J.* 13: 789-793, 1992.

Roubin, G.S., S.D. Anderson, W.F. Shen, C.Y. Choong, M. Alwyn, S. Hillery P.J. Harris, and D.T. Kelly. Hemodynamic and metabolic basis of impaired exercise tolerance in patients with severe left ventricular dysfunction. *J. Am. Coll. Cardiol.* 15: 986-994, 1990.

Sullivan, M.J., H.J. Green and F.R. Cobb. Altered skeletal muscle metabolic response to exercise in chronic heart failure. Relation to skeletal muscle aerobic enzyme activity. *Circulation* 84: 1597-1607, 1991.

Sullivan, M.J., M.B. Higginbotham, and F.R. Cobb. Exercise training in patients with severe left ventricular dysfunction. Hemodynamic and metabolic effects. *Circulation* 78: 506-515, 1988.

Szlachcic, J., B.M. Massie, B.L. Kramer, N. Topic, and J. Tabau. Correlates and prognostic implications of exercise capacity in chronic congestive heart failue. *Amlodipine. J. Cardiol.* 55:1037-1042, 1985.

Volterrani, M., A.L. Clark, R.F. Ludman, J.W. Swan, S. Adamopoulos, M. Piepoli, and A.J.S. Coats. Predictors of exercise capacity in chronic heart failure. *Eur. Heart J.* 15: 801-809, 1994.

Weinberger, M., G.P. Samsa, J.T. Hanlon, K. Schmader, M.E. Doyle, P.A. Cowper, K.M. Uttech, H.J. Chen and J.R. Feussner. An evaluation of a brief health status measure in elderly veterans. *J. Am. Geriatr. Soc.* 39: 691-694, 1991.

Wenger, N.K. and C.D. Furberg. Cardiovascular disorder. In: *Quality of Life Assessments in Clinical Trials.* New York: Raven Press, Ltd. 1990: 335-345.

Wilson, J.R., J.L. Martin, and N. Ferraro. Effect of hydralazine on perfusion and metabolism in the leg during upright bicycle exercise in patients with heart failure. *Circulation.* 68: 425-432, 1983.

Wilson, J.R., J.L. Martin, D. Schwartz, and N. Ferraro, Exercise intolerance in patients with chronic heart failure: role of impaired nutritive flow to skeletal muscle. *Circulation* 69: 1079-1087, 1984.

Wilson, J.R., L. Fink, J. Maris, N. Ferraro, J. Power-Vanwart, S. Eleff, B. Chance. Evaluation of energy metabolism in skeletal muscle of patients with heart failure with gated phosphorus-31 nuclear magnetic resonance. *Circulation.* 71: 57-62, 1985.

Zelis, R., and D.T. Mason. Diminished forearm arteriolar dilator capacity produced by mineralocorticoid induced salt retention in man. *Circulation* 41: 589-592, 1970.

Zelis, R., J. Longhurst, R.J. Capone, and D.T. Mason. A comparison of regional blood flow and oxygen utilization during dynamic forearm exercise in normal subjects and patients with congestive heart failure. *Circulation* 50: 137-143, 1974.

APPENDIX A:

CONSENT FORM

CONSENT FORM

You have been found to have heart failure which means that the heart does not pump blood adequately. The symptoms of heart failure include fatigue, shortness of breath and a decrease in exercise capacity. Some preliminary studies suggest that regular exercise may improve these symptoms, but this has not been conclusively proven. McMaster University and the University of Alberta are conducting a research study in Canada to clarify this. The aim of the study is to find out whether or not regular exericse reduces the symptoms assiciated with heart failure, improves your ability to carry out your usual activities and your sense of well being.

For this first phase of the study you will be seen by one of the physicians involved in the study. During this time you will perform the 6 minute walk test (involves walking in a corridor for 6 minutes) twice on two separate days, have your muscle strength assessed and complete a quality of life questionnaire. There is an extremely small risk of having a heart attack or collapsing while perfoming the 6 minute walk test or muscle strength assessment. However, this test will be performed under supervision in hospital, and emergency equipment will be available at all times. If you experience any untoward symptoms (eg. Chest pain, shortness of breath, fatigue or dizziness) the tests may be stopped.

You will be assessed with a radionuclide ventriculogram, to determine the ability of the heart to pump blood, before the study starts. There is no risk associated with this test. You will perform an exercise test on a cycle ergometer. There is a 1 in 10,000 risk of having a heart attack or dying during this test. However, this risk is no higher than it would be for anyone else who has heart disease. The tests will be supervised by a physician trained in exercise testing. Your heart rate, blood pressure, electrocardiogram and symptoms will be continuously monitored throughout the exercise test.

Your participation in the study is entirely voluntary and will not affect any medical care to which you are entitled. You are free to refuse to participate or withdraw form the study at any time without penalty. All information obtained as part of the study will be confidential and only used for research purposed.

I aggree to participate in the study of patients with heart failure and I have been given a copy of this form.

____________________ ____________

Patient's Signature Date

____________________ ____________

Witness' Signature Date

APPENDIX B:

RAW DATA CHAPTER II

PATIENT CHARACTERISTICS

Patient Number	Age	Weight	EF	NYHA	Gender	ACE-I	Diuretic	Digoxin
						(1=Yes, 0=No)		
1	66	76.8	21	3	M	1	1	1
2	67	77.3	15	2	M	1	1	1
3	63	74.1	37	2	F	1	1	1
4	47	119.6	26	2	M	1	1	1
5	48	68.5	21	2	M	1	1	1
6	54	122.0	18	2	M	0	1	1
7	68	79.6	19	2	M	1	1	0
8	75	86.0	20	3	M	1	1	1
9	64	107.4	23	2	M	1	1	1
10	57	79.0	34	2	M	1	1	0
11	70	87.0	20	2	M	1	0	0
12	78	67.1	19	3	M	1	1	1
13	47	114.0	37	2	M	1	0	0
14	73	59.1	35	2	F	1	1	1
15	74	62.0	23	3	M	1	1	1
16	69	74.0	33	2	M	1	0	0
17	68	88.0	30	3	M	1	1	1
18	80	73.0	31	2	M	0	1	1
19	72	78.0	38	2	M	1	1	0
20	66	67.0	21	3	M	1	1	0
21	79	76.0	36	2	M	0	1	0
22	69	104.7	35	2	M	1	1	1
23	72	69.0	34	2	M	1	1	1
24	60	90.8	38	3	M	1	1	1
25	69	62.7	20	2	F	0	1	1
26	51	107.0	27	2	M	1	0	1
27	77	74.0	26	2	M	1	1	1
28	71	82.5	34	2	M	1	1	1
29	71	111.5	28	1	M	1	0	1
30	45	81.0	32	2	M	1	1	1
31	64	53.3	15	3	F	0	1	1
32	57	84.2	28	2	M	1	0	1
33	62	53.0	36	3	M	1	0	0
34	70	77.4	19	3	M	1	1	1
35	51	117.0	26	3	M	0	1	1
36	48	81.0	18	2	F	1	1	0
37	57	89.0	28	3	M	1	1	1
38	66	81.0	32	2	M	0	1	1
39	61	95.0	39	2	M	1	1	1
40	60	54.0	25	2	F	1	1	1
41	71	89.0	22	3	M	1	1	1
42	72	75.0	37	3	M	1	1	1
43	74	64.0	36	2	M	1	1	1
44	61	76.0	20	3	M	1	1	1
45	83	68.0	33	2	M	1	1	0
Mean	65.0	81.7	27.7	2.3	6F	84%	84%	76%
SD	9.6	17.6	7.2	0.5	39M			

PEAK OXYGEN CONSUMPTIONS RESULTS

PATIENT NUMBER	PEAK VO2 (ml/kg/min)	PEAK VO2 (l/min)
1	10.51	0.810
2	10.17	0.786
3	11.07	0.817
4	13.58	1.630
5	20.03	1.350
6	13.56	1.630
7	17.46	1.390
8	12.56	1.080
9	17.78	1.910
10	18.22	1.460
11	15.06	1.265
12	10.21	0.694
13	19.41	2.210
14	12.95	0.764
15	9.23	0.591
16	18.29	1.353
17	9.09	0.800
18	15.17	1.108
19	13.73	1.071
20	11.71	0.785
21	12.17	0.925
22	14.68	1.542
23	15.91	1.098
24	13.66	1.243
25	17.34	1.090
26	13.10	1.402
27	9.05	0.670
28	14.49	1.195
29	11.67	1.301
30	19.05	1.543
31	14.05	0.749
32	13.60	1.145
33	23.40	1.220
34	14.80	1.140
35	14.78	1.730
36	14.69	1.190
37	19.60	1.750
38	16.67	1.350
39	16.63	1.580
40	17.96	0.970
41	13.26	1.180
42	15.30	1.150
43	13.60	0.870
44	13.70	1.030
45	11.10	0.750
Mean	14.53	1.185
SD	3.20	0.357

6 MINUTE WALK AND WORK RESULTS

PATIENT NUMBER	6 MINUTE WALKS #1	#2	WALK WORK
1	222.0	297.0	223.53
2	330.0	325.5	246.58
3	310.5	285.0	206.96
4	409.5	396.0	464.14
5	520.5	460.5	309.13
6	493.0	514.5	615.14
7	504.0	514.0	400.96
8	390.0	397.5	335.01
9	462.0	478.5	503.63
10	408.0	414.0	320.52
11	428.0	448.5	382.39
12	316.5	325.5	214.04
13	501.0	523.5	584.85
14	407.5	429.0	248.43
15	346.5	337.5	205.07
16	465.5	496.5	360.06
17	120.0	132.0	113.84
18	491.5	495.0	354.12
19	366.0	372.0	284.36
20	466.0	476.5	312.87
21	355.5	306.5	228.28
22	495.0	534.0	547.92
23	370.0	334.5	226.19
24	462.0	466.5	415.11
25	453.0	449.5	276.20
26	444.0	468.5	491.27
27	415.5	403.5	292.62
28	418.5	439.5	355.34
29	430.5	429.0	468.77
30	508.0	507.0	402.46
31	458.0	481.5	251.51
32	336.0	413.0	340.79
33	396.0	525.0	272.69
34	481.0	438.0	332.23
35	429.0	436.0	499.92
36	444.0	414.0	328.63
37	381.0	407.0	354.99
38	447.0	449.0	356.42
39	495.0	594.0	553.01
40	510.0	532.5	281.80
41	372.0	382.5	333.62
42	439.0	444.0	326.34
43	340.5	351.0	220.15
44	495.0	501.0	373.14
45	412.0	423.0	281.89
Mean	416.6	427.7	344.4
SD	78.5	83.1	110.8

DYNAMIC MUSCLE STENGTH RESULTS

ARM CURL 1 REPETITION MAXIMUM

PATIENT NUMBER	TEST #1 LEFT	RIGHT	TEST #2 LEFT	RIGHT	SUM OF HIGH L&R
1	5	6			11
2	12	16			28
3	6	7			13
4	21	20			41
5	16	16			32
6	12	16			28
7	11	15			26
8	10	10			20
9	12	12			24
10	17	17	17	17	34
11	12	12	12	12	24
12	2	6	2	5	8
13	17	20	17	21	38
14	2	2	2	2	4
15	2	2	2	2	4
16	7	7	10	7	17
17	2	2	5	6	11
18	7	7	7	7	14
19	7	7	10	10	20
20	5	6	5	6	11
21	10	12	7	12	22
22	7	10	10	12	22
23	6	7	6	6	13
24	12	12	16	15	31
25	2	1	2	2	4
26	17	17	17	17	34
27	2	6	5	7	12
28	6	7	2	7	13
29	12	12	12	12	24
30	10	7	11	10	21
31	0	0	0	0	0
32	10	12	11	15	26
33	8.9	6.4			15.3
34	7.5	7.5	7.5	7.5	15
35	15	13.9	15	13.9	28.9
36	8.9	10	8.9	10	18.9
37	11.4	12.5	13.9	15	28.9
38	13.9	12.5	13.9	12.5	26.4
39	12.5	16.4	13.9	16.4	30.3
40	6.4	5	7.2	5	12.2
41	8.9	10	10	10	20
42	8.9	10	10	7.5	20
43	6.4	7.5	7.3	8.9	16.2
44	8.9	8.9	8.9	9.7	18.6
45	5	10	5	8.9	15
Mean	8.1	8.8	9.4	10.3	19.9
SD	4.7	4.6	5.0	5.0	9.4

DYNAMIC MUSCLE STRENGTH RESULTS (continued)

LEG PRESS 1 REPETITION MAXIMUM

PATIENT NUMBER	TEST #1 LEFT	RIGHT	TEST #2 LEFT	RIGHT	SUM OF HIGH L&R
1	50	55			105
2	95	80			175
3	75	65			140
4	80	85			165
5	65	65			130
6	90	90			180
7	102.5	102.5			205
8	80	80			160
9	90	102.5			192.5
10	75	85	80	80	165
11	55	60	60	60	120
12	60	50	65	60	125
13	102.5	102.5	102.5	102.5	205
14	50	55	60	65	125
15	45	45	55	55	110
16	75	70	80	75	155
17	40	45	60	55	115
18	70	70	65	65	140
19	70	75	70	80	150
20	65	65	60	65	130
21	90	65	80	55	155
22	85	85	85	90	175
23	60	55	60	65	125
24	95	80	95	80	175
25	55	50	50	45	105
26	125	110	125	117.5	242.5
27	65	70	65	70	135
28	65	70	70	80	150
29	80	90	80	85	170
30	70	90	85	102.5	187.5
31	35	40	40	45	85
32	90	90	90	95	185
33	65	67			132
34	42.5	42.5	37.2	42.5	85
35	65	65	67.2	67.2	134.4
36	67.2	67.2	59.7	67.2	134.4
37	95	82.2	87.5	80	177.2
38	95	97.2	110	110	220
39	74.9	74.9	80	82.2	162.2
40	42.5	42.5	42.5	42.5	85
41	50	57.5	59.7	65	124.7
42	44.7	52.2	50	57.5	107
43	35.5	40	40	47.5	87.5
44	57.5	61.1	61.1	65	126.1
45	51.4	58.9	65	65	130
Mean	67.9	68.2	72.9	73.6	146.4
SD	20.6	18.2	19.3	18.6	36.4

DYNAMIC MUSCLE STRENGTH RESULTS (continued)

KNEE EXTENSION 1 REPETITION MAXIMUM

PATIENT NUMBER	TEST #1 LEFT	RIGHT	TEST #2 LEFT	RIGHT	SUM OF HIGH L&R
1	15	15			30
2	25	21			46
3	15	12			27
4	22	27			49
5	27	27			54
6	35	32			67
7	30	30			60
8	32	32			64
9	30	35			65
10	22	22	22	25	47
11	15	20	17	17	37
12	15	12	17	16	33
13	37	35	37	37	74
14	10	10	12	12	24
15	12	12	17	17	34
16	22	27	22	27	49
17	10	7	12	7	19
18	21	27	22	25	49
19	12	17	12	16	29
20	15	15	22	22	44
21	27	27	22	11	54
22	32	32	37	37	74
23	12	7	17	15	32
24	25	22	30	27	57
25	15	11	15	10	26
26	45	35	47	40	87
27	21	21	22	22	44
28	15	22	17	25	42
29	20	22	26	27	53
30	25	30	35	37	72
31	2	7	6	6	13
32	27	27	32	35	67
33	15	15			30
34	12.2	12.2	10	12.2	24.4
35	22.5	22.5	30	25	55
36	17.2	20.2	20	21.4	41.4
37	16.4	10	25	25	50
38	20	25	25	25	50
39	20	17.2	25	30	55
40	6.4	5	6.4	5	11.4
41	16.4	15	15	20	36.4
42	11.4	12.2	15	15	30
43	5	5	5	5	10
44	16.4	16.4	17.2	17.2	34.4
45	7.2	6.4	8.6	8.6	17.2
Mean	18.2	18.5	22.1	21.9	43.7
SD	8.8	8.5	9.2	9.3	18.1

APPENDIX C:

CORRELATION MATRIX FOR CHAPTER II

AND MULTIVARIATE ANALYSIS

	6MW	Walk Work	Arm Curl	Leg Press	Knee Extension	VO_2 ($l \cdot min^{-1}$)
6MW						
Walk Work	.6971 $p < .000$	-				
Arm Curl	.2663 $p < .077$	.6690 $p < .000$	-			
Leg Press	.2741 $p < .068$	.6091 $p < .000$	.6961 $p < .000$	-		
Knee Extension	.3835 $p < .009$	.7373 $p < .000$	.6855 $p < .000$	.8574 $p < .000$	-	
VO_2 ($l \cdot min^{-1}$)	.5239 $p < .000$	.8316 $p < .000$	.7537 $p < .000$	.6076 $p < .000$	.6710 $p < .000$	-
VO_2 ($ml \cdot min^{-1} \cdot kg^{-1}$)	.6239 $p < .000$	.3432 $p < .021$	.3295 $p < .027$	.2062 $p < .174$	.2145 $p < .157$	.6533 $p < .000$

Regression Models for Dependent Variable: Walk Work

Variables in Model	R-squared	Adjusted R-square	C(p)	MSE	p-level
VO_2 ($l \bullet min^{-1}$)	0.691	0.684	9.77	3963.06	.000
KE	0.543	0.533	34.13	5864.40	
AC	0.447	0.434	49.94	7098.45	
LP	0.370	0.356	62.55	8082.75	
KE, VO_2	0.750	0.738	2.15	3288.34	.003
LP,VO_2	0.708	0.694	8.96	3832.76	
AC, VO_2	0.695	0.681	11.09	4003.06	
AC, KE	0.594	0.574	27.82	5339.74	
LP, KE	0.545	0.524	35.80	5977.50	
AC, LP	0.487	0.463	45.38	6742.84	
LP, KE, VO_2	0.757	0.739	3.00	3274.36	.283
AC, KE, VO_2	0.750	0.732	4.03	3358.87	
AC, LP, VO_2	0.708	0.687	10.96	3925.87	
AC, LP, KE	0.607	0.578	27.65	5292.34	
AC, LP, KE, VO_2	0.757	0.732	5.00	3356.13	.974

APPENDIX D:

RAW DATA FOR QUALITY OF LIFE QUESTIONNAIRES

PATIENT NUMBER	QUESTION # 4a	4b	4c	4d	4e	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	Dimension Scores D	F	E	M
1	3	5	1	5	4	4	7	4	7	7	3	6	5	5	3	7	4	7	7	6	18	14	42	26
2	7	7	7	7	7	4	6	7	5	5	4	7	6	7	5	7	7	6	4	7	35	23	43	21
3	7	4	7	7	7	5	7	6	7	6	5	7	7	6	6	7	5	7	6	5	32	22	44	26
4	4	4	4	3	3	6	5	2	7	5	4	5	3	1	3	6	2	4	4	5	18	11	34	17
5	4	4	4	4	3	3	2	3	3	3	3	3	1	3	3	3	3	3	1	3	19	12	21	7
6	7	6	6	7	7	6	7	3	4	5	5	5	6	5	4	4	6	4	7	7	33	18	35	25
7	6	6	7	7	7	5	7	4	6	5	5	5	7	3	5	6	6	4	6	5	33	20	34	25
8	4	3	4	6	6	7	7	7	7	7	5	7	7	7	7	7	7	5	7	7	23	26	47	28
9	7	7	7	7	7	6	7	6	7	6	5	6	6	6	6	6	5	6	7	6	35	22	43	26
10																								
11	4	4	4	6	5	4	5	5	5	4	4	5	5	4	5	4	5	4	5	5	23	19	31	19
12	7	7	7	7	7	4	7	5	4	5	3	1	7	4	3	2	3	3	6	5	35	14	23	25
13	5	4	4	7	7	6	7	7	7	7	6	7	6	6	6	7	6	5	6	7	27	25	45	26
14	6	7	7	7	7	5	7	6	7	4	4	4	3	6	4	4	4	4	7	4	34	18	34	21
15	4	3	7	7	7	4	7	4	5	6	2	5	6	3	3	5	2	3	7	4	28	11	29	26
16																								
17	4	6	5	2	1	2	6	6	2	6	3	3	1	1	3	1	1	2	2	4	18	13	15	15
18	7	7	7	7	7	7	7	7	7	6	6	7	7	7	7	7	7	7	7	7	35	27	49	27
19																								
20	6	7	7	7	7	6	7	6	7	6	4	6	6	6	6	6	7	4	6	6	34	23	41	25
21	5	3	5	7	7	6	7	2	4	5	3	6	4	6	4	4	4	5	6	5	27	13	36	22
22	5	4	6	4	6	6	6	6	7	7	5	6	5	6	5	6	6	6	6	6	25	22	43	24
23	2	1	1	7	7	7	6	3	7	7	4	7	3	6	2	7	4	4	7	4	18	13	42	23
24	1	6	4	5	3	6	7	4	7	7	4	7	1	6	3	7	3	6	7	7	19	14	46	22
25	7	7	7	7	7	5	6	6	7	6	4	6	6	5	4	7	6	6	6	6	35	20	42	24
26	4	5	6	7	7	6	7	4	7	7	4	7	7	6	6	7	7	5	7	4	29	21	42	28
27	5	4	4	5	7	6	7	3	6	4	4	6	4	5	6	6	4	5	6	5	25	17	39	21
28	5	3	7	7	7	6	7	6	6	6	5	6	6	5	4	6	6	4	6	6	29	21	39	25
29	7	7	7	7	7	7	7	5	7	7	5	7	7	6	7	7	6	7	7	7	35	23	48	28
30	4	7	3	5	4	3	7	2	7	5	4	3	3	4	4	4	3	2	7	4	23	13	27	22
31	3	5	3	2	5	3	6	4	6	5	3	5	3	4	3	5	3	6	6	4	18	13	33	20
32	2	4	5	2	6	3	7	4	6	5	3	4	2	1	3	3	2	4	7	4	19	12	25	21
33	3	4	5	7	7	7	7	5	5	7	2	4	7	5	2	4	4	4	6	4	26	13	33	27
34	3	5	7	7	7	4	7	6	5	7	4	5	6	6	6	5	6	5	6	6	29	22	36	26
35	5	5	6	7	7	5	6	5	7	6	4	6	6	5	5	6	5	6	6	5	30	19	40	24
36	5	4	7	7	7	5	7	2	7	7	5	5	6	5	4	6	6	4	7	4	30	17	36	27
37	5	3	3	1	1	4	5	2	5	5	5	6	5	4	4	6	3	6	5	6	13	14	37	20
38	5	2	4	4	5	5	7	2	5	7	4	6	2	6	3	6	3	7	5	5	20	12	40	21
39	5	3	4	3	6	3	7	5	6	5	4	5	6	5	3	6	3	5	7	5	21	15	35	25
40	3	6	5	7	7	4	7	5	6	5	4	5	6	3	4	5	5	4	7	5	28	18	32	25
41	4	5	5	3	7	5	7	3	7	6	2	6	5	6	2	6	4	6	6	5	24	11	41	24
42	4	3	4	4	5	4	5	4	3	3	4	4	3	4	4	3	4	3	4	4	20	16	25	15
43	7	7	7	7	7	7	7	7	7	6	7	7	7	7	7	7	7	7	7	7	35	28	49	27
44	7	7	7	7	7	7	6	6	8	6	5	7	6	6	6	7	6	7	7	7	35	23	49	25
45	6	5	7	7	7	6	5	5	6	5	4	6	5	4	5	6	5	4	6	6	32	19	38	21

	D	F	E	M
Means	25.0	16.6	34.7	21.6
SD	9.1	6.4	12.0	7.0

D = dyspnea dimension
F = fatigue dimension
E = emotion dimension
M = mastery dimension

MINNESOTA LIVING WITH HEART FAILURE QUESTIONNAIRE RESULTS

	QUESTION #																					Dimension Scores		
PATIENT NUMBER	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	P –	E	T
1	0	5	5	5	0	0	0	5	5	3	5	5	5	5	0	0	0	4	0	0	0	25.0	4.0	52.0
2	0	0	0	0	0	1	1	1	1	1	2	0	0	0	0	0.6	1	1	1	0	1	2.0	4.0	11.6
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
4	1	3	4	3	2	2	3	5	5	5	3	4	4	0	3	0	0	0	0	1	0	25.0	1.0	48.0
5	0	3	2	5	5	3	4	5	5	5	4	4	4	0	4	4	4	4	4	3	3	30.0	18.0	75.0
6	0	1	1	1	0	0	0	3	1	1	0	1	1	0	0	0	2	2	0	0	0	5.0	4.0	14.0
7	0	3	0	2	0	0	0	0	0	5	0	0	2	0	0	5	0	0	1	1	1	7.0	3.0	20.0
8	0	3	3	3	0	0	3	3	1	1	4	5	4	0	0	0	0	2	0	0	0	21.0	2.0	32.0
9	0	0	0	0	0	0	0	5	2	3	0	0	2	0	0	1	0	0	0	0	1	2.0	1.0	14.0
10																								
11	0	0	1	1	0	1	0	1	0	4	1	1	1	0	0	0	0	0	0	1	0	5.0	1.0	12.0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	0.0
13																								
14																								
15	0	2	2	4	2	1	2	5	5	5	3	5	5	1	0	0	1	2	2	2	2	23.0	9.0	51.0
16																						0.0	0.0	0.0
17	0	5	4	4	4	5	1	5	0	5	0	5	5	0	0	0	5	5	5	5	5	33.0	25.0	68.0
18	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0.0	0.0	1.0
19																								
20	0	1	0	1	2	5	1	0	2	2	1	5	1	0	0	2	1	1	1	0	0	16.0	3.0	26.0
21	4	1	4	3	1	1	2	5	2	4	3	3	4	0	0	3	1	1	1	0	1	19.0	4.0	44.0
22	0	1	1	1	0	1	0	0	1	1	0	1	0	0	0	0	0	0	0	0	0	5.0	0.0	7.0
23	0	0	0	0	0	0	0	0	0	5	5	1	4	0	0	0	0	0	0	0	0	5.0	0.0	15.0
24	0	0	1	0	2	0	4	5	5	5	4	4	4	0	5	0	3	4	0	0	0	15.0	7.0	46.0
25	0	3	0	2	1	0	1	0	1	0	1	0	1	0	0	3	0	0	0	1	0	8.0	1.0	14.0
26	0	0	2	0	0	0	0	5	0	0	5	5	1	0	0	0	0	0	0	1	1	8.0	2.0	20.0
27	0	2	1	3	1	0	0	5	4	4	2	2	3	0	1	3	1	0	0	2	1	12.0	4.0	35.0
28	0	0	1	1	0	0	0	0	1	1	0	1	1	0	0	0	0	1	4	0	0	4.0	5.0	11.0
29	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0.0	0.0	3.0
30	0	3	2	3	1	2	3	5	4	0	5	3	4	0	0	0	3	4	2	3	4	21.0	16.0	51.0
31	0	1	2	2	0	0	0	0	0	0	0	3	3	0	0	0	0	0	0	0	0	11.0	0.0	11.0
32	1	4	4	4	5	3	5	5	5	0	5	4	5	5	3	5	4	3	3	2	3	34.0	15.0	78.0
33	0	2	3	3	1	0	2	2	3	1	5	1	4	5	1	4	2	2.3	1	4	2	16.0	11.3	48.3
34	0	3	0	0	1	3	2	0	1	4	1	2	2	0	3	0	4	4	3	3	3	13.0	17.0	39.0
35	0	1	1	2	2	0	0	5	1	0	0	1	2	0	1	2	0	1	1	2	1	9.0	5.0	23.0
36	1	1	0	1	2	4	1	0	1	0	5	1	1	0	2	1	0	0	2	1	0	11.0	3.0	24.0
37	0	0	2	2	0	0	0	5	2	5	3	2	2	0	2	0	1	1	1	2	1	8.0	6.0	31.0
38	3	2	3	2	1	1	2	5	4	4	3	5	3	0	2	0	3	3	1	0	0	19.0	7.0	47.0
39	0	0	0	1	0	0	1	3	3	3	5	2	3	0	4	1	0	0	1	0	1	7.0	2.0	28.0
40	0	0	1	2	1	1	0	0	3	0	3	1	3	0	0	1	1	1	3	3	2	9.0	10.0	26.0
41	0	3	1	2	0	5	1	0	1	5	3	3	3	2	2	2	0	1	0	1	1	18.0	3.0	36.0
42	0	1	2	2	2	3	1	0	2	4	2	2	2	0	2	2	2	1	1	1	2	15.0	7.0	34.0
43	0	0	2	0	0	1	0	0	0	0	3	0	0	0	4	0	0	1	1	0	0	3.0	2.0	12.0
44	0	1	1	2	1	0	2	1	1	1	1	1	1	1	1	1	0	1	0	0	0	9.0	1.0	17.0
45	0	1	1	1	1	0	0	1	1	0.5	0	0	0	0	2	1	0	0	0	0	0	4.0	0.0	9.5
																					Mean	10.6	4.5	25.2
																					SD	9.4	5.7	20.9

P = physical dimension

E = emotional dimension

T = total score

MEDICAL OUTCOME SURVEY SHORT FORM-36 RESULTS

Part I: Numerical Answers to Each Question

PATIENT NUMBER	1	2	3a	3b	3c	3d	3e	3f	3g	3h	3i	3j	4a	4b	4c	4d	5a	5b	5c	6	7	8	9a	9b	9c	9d	9e	9f	9g	9h	9i	10	11a	11b	11c	11d
1	4	4	1	2	2	1	2	2	1	1	2	2	2	1	1	1	2	2	2	3	4	3	4	6	6	2	4	6	4	6	3	3	5	5	1	5
2	5	3	1	1	2	2	3	3	1	1	1	3	2	1	1	1	1	1	2	1	3	1	3	6	4	4	2	5	6	2	6	1	3	3	4	3
3	2	1	2	3	3	2	2	2	2	2	2	3	2	2	2	2	2	2	2	1	4	1	2	4	6	5	5	6	5	1	5	5	3	2	3	2
4	4	3	1	1	1	1	2	3	1	1	2	2	2	2	1	1	2	2	2	1	3	3	5	6	6	5	6	6	5	2	4	5	3	5	3	5
5	5	3	1	2	2	1	2	2	1	2	3	3	1	1	1	1	1	1	1	2	4	2	5	4	3	4	6	4	2	4	2	4	1	4	1	5
6	3	3	1	2	3	3	3	3	3	3	3	3	2	2	1	1	2	2	2	1	1	1	3	6	6	2	2	5	6	2	5	5	3	3	3	3
7	3	2	1	3	3	3	3	3	3	3	3	3	1	1	2	1	1	1	1	2	2	2	3	4	6	3	2	5	6	3	5	4	3	2	3	2
8	4	2	1	2	1	1	2	2	1	2	2	3	2	1	1	1	2	2	2	1	1	1	5	6	6	1	2	6	5	1	4	5	5	5	2	4
9	3	2	1	3	3	2	3	2	2	2	3	3	2	2	2	2	2	2	2	1	4	1	3	4	6	3	3	5	5	3	4	5	5	2	3	2
10																																				
11	4	2	2	2	2	2	2	3	2	2	3	3	1	1	1	1	1	1	2	2	2	2	4	5	6	3	4	5	5	1	5	4	1	3	4	3
12	3	3	2	3	3	1	2	2	1	2	3	3	1	1	2	1	1	1	2	1	3	3	6	2	4	4	5	2	3	4	3	5	4	2	3	2
13	3	2	2	2	3	2	3	2	3	3	3	3	2	2	2	2	2	2	2	1	4	3	2	6	6	2	2	6	6	1	6	5	5	2	5	2
14	3	1	1	2	2	1	2	2	2	2	3	3	2	2	2	2	2	1	2	1	2	2	3	5	6	2	2	3	5	2	4	5	5	3	2	2
15	4	4	1	1	1	1	2	2	1	1	1	3	2	1	1	1	1	1	2	2	1	1	6	5	4	3	2	3	1	4	1	4	2	5	3	4
16																																				
17	5	2	1	3	2	1	2	1	1	1	1	3	1	1	1	1	1	1	1	4	2	1	6	1	1	5	5	1	2	4	1	2	4	5	1	5
18	2	1	2	3	3	3	3	2	3	3	3	3	2	2	2	2	2	2	2	1	1	1	2	6	6	1	1	6	6	2	6	5	5	2	3	2
19																																				
20	3	3	2	2	3	3	3	3	3	3	3	3	2	1	2	2	2	2	2	2	5	2	3	4	5	2	2	6	5	2	5	4	5	4	2	3
21	3	1	1	2	2	1	2	2	2	2	2	3	1	1	1	1	1	1	2	3	4	3	5	5	6	5	4	5	5	2	3	4	2	5	4	3
22	3	2	1	2	3	2	2	2	2	3	3	3	2	2	2	2	2	2	2	1	2	1	4	5	6	2	4	5	5	2	5	5	3	2	3	2
23	4	5	1	2	2	3	3	1	1	1	2	3	1	1	1	1	2	1	1	3	2	1	6	6	6	1	5	6	3	1	4	5	5	5	4	5
24	5	3	1	1	1	1	2	0.1	2	2	3	3	1	1	1	1	2	2	2	4	6	1	5	6	6	2	5	6	4	2	3	1	5	5	1	5
25	3	4	1	2	2	2	3	2	2	3	3	3	2	2	1	1	2	2	2	3	2	2	4	5	6	3	4	6	5	2	4	4	4	2	5	4
26	3	3	1	2	2	2	2	3	1	1	1	3	1	2	1	1	2	2	2	1	1	1	4	5	6	2	5	5	5	2	5	5	5	5	2	5
27	3	3	1	2	3	2	3	2	1	2	3	3	1	1	2	1	2	1	2	1	3	1	4	6	6	2	4	5	5	2	5	5	4	2	3	2
28	4	4	1	1	2	1	2	1	1	1	3	2	1	1	1	1	2	2	2	3	4	3	5	5	6	2	5	6	5	2	4	3	2	3	2	3
29	2	1	3	3	3	3	3	3	2	3	3	3	2	2	2	2	2	2	2	1	1	1	2	6	6	6	2	6	6	6	5	5	5	1	5	1
30	4	4	1	2	2	2	2	2	2	3	3	2	1	1	1	1	1	1	1	4	4	4	5	6	5	4	5	3	4	4	4	3	4	4	3	5
31	4	4	1	1	1	1	2	2	1	2	3	3	2	1	1	1	2	1	2	4	1	1	4	5	4	3	5	5	4	2	4	4	3	2	3	4
32	5	5	1	2	2	1	2	3	1	2	3	2	1	1	1	1	1	1	2	4	4	4	6	5	5	6	6	4	4	6	2	1	2	5	3	5
33	3	3	1	2	2	3	3	2	2	2	3	3	1	1	1	1	1	1	1	4	3	2	3	5	5	4	3	2	5	3	4	4	5	4	5	4
34	4	1	1	2	2	1	3	3	2	2	3	2	2	1	1	2	1	1	1	1	1	1	4	5	6	3	4	4	5	2	4	5	2	4	2	3
35	3	3	1	2	2	1	3	3	1	2	3	3	1	1	1	1	2	2	2	1	2	1	5	4	6	2	6	5	5	2	5	5	1	4	4	5
36	3	1	2	3	3	2	3	2	2	3	3	3	2	2	2	2	2	2	2	1	1	1	2	4	6	4	2	6	4	2	4	4	4	3	4	2
37	4	1	3	1.8	1	1	2	1	2	2	2	2	2	1	1	1	1	1	2	2	4	2	3	5	6	2	2	4	4	4	4	4	4	3	5	4
38	3	2	1	2	2	1	2	1	2	2	3	2	1	1	1	1	2	2	2	2	4	2	3	6	6	2	4	6	3	6	2	5	4	5	3	3
39	3	2	1	2	2	1	2	2	2	3	3	3	1	1	1	1	1	1	1	3	3	2	4	2	2	3	3	1	2	2	2	4	4	3	5	4
40	3	1	1	2	2	2	3	3	2	2	3	3	2	1	1	1	2	1	2	2	3	3	4	4	6	5	4	5	4	3	4	5	4	5	3	5
41	4	4	1	2	1	2	2	3	3	3	3	2	2	1	1	1	1	1	1	1	3	1	5	5	6	5	6	4	3	2	3	3	3	4	5	3
42	4	4	1	1	2	1	2	2	1	1	2	3	1	1	1	1	1	1	2	3	5	3	4	5	4	3	5	4	5	4	4	4	2	4	2	4
43	2	1	3	3	3	2	1	2	1	2	2	1	2	2	2	2	2	2	1	3	1	1	2	6	2	4	1	6	6	2	6	5	3	2	3	1
44	2	4	1	2	2	1	2	2	2	2	1	3	1	2	1	2	2	2	2	3	2	1	2	6	6	1	2	6	5	5	5	4	4	2	2	2
45	3	4	1	2	3	2	2	1	1	1	2	3	1	1	1	1	1	1	1	1	2	2	3	6	6	1	4	6	5	1	4	5	5	5	3	4

MEDICAL OUTCOME SURVEY SHORT FORM-36 RESULTS (continued)
Part II: Recoding of Certain Items

QUESTION #

PATIENT NUMBER	1	2	3a	3b	3c	3d	3e	3f	3g	3h	3i	3j	4a	4b	4c	4d	5a	5b	5c	6	7	8	9a	9b	9c	9d	9e	9f	9g	9h	9i	10	11a	11b	11c	11d
1	2	2											1	0	0	0	1	1	1	3	3	3	3			5	3			1				1		1
2	1	3											1	0	0	0	0	0	1	5	4	5	4			3	5			5				3		3
3	4.4	5											1	1	1	1	1	1	1	5	3	5	5			2	2			6				4		4
4	2	3											1	1	0	0	1	1	1	5	4	3	2			2	1			5				1		1
5	1	3											0	0	0	0	0	0	0	4	3	4	2			3	1			3				2		1
6	3.4	3											1	1	0	0	1	1	1	5	6	5	4			5	5			5				3		3
7	3.4	4											0	0	1	0	0	0	0	4	5	4	4			4	5			4				4		4
8	2	4											1	0	0	0	1	1	1	5	6	5	2			6	5			6				1		2
9	3.4	4											1	1	1	1	1	1	1	5	3	5	4			4	4			4				4		4
10																																				
11	2	4											0	0	0	0	0	0	1	4	5	4	3			4	3			6				3		3
12	3.4	3											0	0	1	0	0	0	1	5	4	3	1			3	2			3				4		4
13	3.4	4											1	1	1	1	1	1	1	5	3	3	5			5	5			6				4		4
14	3.4	5											1	1	1	1	1	0	1	5	5	4	4			5	5			5				3		4
15	2	2											1	0	0	0	0	0	1	4	6	5	1			4	5			3				1		2
16																																				
17	1	4											0	0	0	0	0	0	0	2	5	5	1			2	2			3				1		1
18	4.4	5											1	1	1	1	1	1	1	5	6	5	5			6	6			5				4		4
19																																				
20	3.4	3											1	0	1	1	1	1	1	4	2	4	4			5	5			5				2		3
21	3.4	5											0	0	0	0	0	0	1	3	3	3	2			2	3			5				1		3
22	3.4	4											1	1	1	1	1	1	1	5	5	5	3			5	3			5				4		4
23	2	1											0	0	0	0	1	0	0	3	5	5	1			6	2			6				1		1
24	1	3											0	0	0	0	1	1	1	2	1	5	2			5	2			5				1		1
25	3.4	2											1	1	0	0	1	1	1	3	5	4	3			4	3			5				4		2
26	3.4	3											0	1	0	0	1	1	1	5	6	5	3			5	2			5				1		1
27	3.4	3											0	0	1	0	1	0	1	5	4	5	3			5	3			5				4		4
28	2	2											0	0	0	0	1	1	1	3	3	3	2			5	2			5				3		3
29	4.4	5											1	1	1	1	1	1	1	5	6	5	5			1	5			1				5		5
30	2	2											0	0	0	0	0	0	0	2	3	2	2			3	2			3				2		1
31	2	2											1	0	0	0	1	0	1	2	6	5	3			4	2			5				4		2
32	1	1											0	0	0	0	0	0	1	2	3	2	1			1	1			1				1		1
33	3.4	3											0	0	0	0	0	0	0	2	4	4	4			3	4			4				2		2
34	2	5											1	0	0	1	0	0	0	5	6	5	3			4	3			5				2		3
35	3.4	3											0	0	0	0	1	1	1	5	5	5	2			5	1			5				2		1
36	3.4	5											1	1	1	1	1	1	1	5	6	5	5			3	5			5				3		4
37	2	5											1	0	0	0	0	0	1	4	3	4	4			5	5			3				3		2
38	3.4	4											0	0	0	0	1	1	1	4	3	4	4			5	3			1				1		3
39	3.4	4											0	0	0	0	0	0	0	3	4	4	3			4	4			5				3		2
40	3.4	5											1	0	0	0	1	0	1	4	4	3	3			2	3			4				1		1
41	2	2											1	0	0	0	0	0	0	5	4	5	2			2	1			5				2		3
42	2	2											0	0	0	0	0	0	1	3	2	3	3			4	2			3				2		2
43	4.4	5											1	1	1	1	1	1	0	3	6	5	5			3	6			5				4		5
44	4.4	2											0	1	0	1	1	1	1	3	5	5	5			6	5			2				4		4
45	3.4	2											0	0	0	0	0	0	0	5	5	4	4			6	3			6				1		2

MEDICAL OUTCOME SURVEY SHORT FORM-36 RESULTS (continued)
Part III: Combination of Correctly Coded Items

Dimension Scores

PATIENT NUMBER	PH	S	RP	RE	MH	EF	P	GH	CH
1	16	6	1	6	24	13	6	10	2
2	18	6	1	4	23	21	9	14	3
3	23	10	4	6	24	17	8	18.4	5
4	15	10	2	6	25	12	7	10	3
5	19	8	0	3	17	7	7	6	3
6	27	10	2	6	27	20	11	15.4	3
7	28	8	1	3	23	20	9	17.4	4
8	17	10	1	6	30	16	11	12	4
9	24	10	4	6	23	17	8	19.4	4
10									
11	23	8	0	4	26	16	9	13	4
12	22	10	1	4	14	9	7	18.4	3
13	26	10	4	6	29	22	6	21.4	4
14	20	10	4	5	24	18	9	17.4	5
15	14	8	1	4	19	8	11	10	2
16									
17	16	4	0	3	8	6	10	8	4
18	28	10	4	6	29	23	11	20.4	5
19									
20	28	8	3	6	25	19	6	15.4	3
21	19	7	0	4	23	13	6	13.4	5
22	23	10	4	6	26	16	10	17.4	4
23	19	8	0	4	30	10	10	13	1
24	16.2	3	0	6	28	11	6	9	3
25	23	7	2	6	26	15	9	18.4	2
26	18	10	1	6	26	15	11	12.4	3
27	22	10	1	5	27	16	9	18.4	3
28	15	6	0	6	27	13	6	12	2
29	29	10	4	6	20	21	11	24.4	5
30	21	5	0	3	20	12	5	12	2
31	17	6	1	5	23	13	11	14	2
32	19	3	0	4	16	8	5	8	1
33	23	6	0	3	19	17	8	17.4	3
34	21	10	2	3	24	15	11	11	5
35	21	10	0	6	25	13	10	11.4	3
36	26	9	4	6	24	18	11	18.4	5
37	17.8	8	1	4	23	17	7	16	5
38	18	9	0	6	24	12	7	14.4	4
39	21	7	0	3	14	11	8	17.4	4
40	23	9	1	5	21	14	7	12.4	5
41	22	8	1	3	22	9	9	15	2
42	16	7	0	4	20	14	5	10	2
43	20	8	4	5	22	23	11	19.4	5
44	18	7	2	6	26	20	10	18.4	2
45	18	10	0	3	30	16	9	14.4	2
Mean	19.3	7.5	1.4	4.5	21.7	13.9	7.9	13.7	3.1
SD	6.4	2.8	1.5	1.7	7.3	5.6	2.9	5.4	1.4

PH = physical functioning
S = social functioning
RP = role limitations due to physical problems
RE = role limitations due to emotional problems
MH = mental health
EF = energy and fatigue
P = pain
GH = general health perception
CH = change in health

STANDARD GAMBLE RESULTS

PATIENT NUMBER	Utility Score
1	0.65
2	0.95
3	0.95
4	0.90
5	0.95
6	0.85
7	0.85
8	0.75
9	0.65
10	
11	0.65
12	0.95
13	0.95
14	0.95
15	0.95
16	
17	0.15
18	0.95
19	
20	0.60
21	0.65
22	0.95
23	0.95
24	0.85
25	0.90
26	0.85
27	0.65
28	0.65
29	0.95
30	0.65
31	0.95
32	0.55
33	0.85
34	0.90
35	0.95
36	0.95
37	0.75
38	0.70
39	0.90
40	0.70
41	0.95
42	0.75
43	0.75
44	0.75
45	0.95
Mean	0.79
SD	0.20

APPENDIX E:

CORRELATION MATRICES AND T-TEST

FOR CHAPTER III

		6MW	ARM CURL	LEG PRESS	KNEE EXTENSION	VO_2 (ML/KG/MIN)	VO_2 (L/MIN)	WALK WORK
CHQ	Dyspnea	.13	-.23	-.03	-.07	-.19	-.17	.05
	Fatigue	.21	.01	.05	.09	-.06	.08	.23
	Emotion	.20	.11	.19	.15	-.06	.13	.28
	Mastery	.19	-.18	.11	.11	-.06	.02	.18
MLHF	Physical	-.29	.07	-.07	.05	-.05	-.12	-.26
	Emotional	-.21	.02	-.12	-.05	.15	-.04	-.26
	Total	-.22	.18	-.00	.09	.08	-.03	-.21
STANDARD GAMBLE		.33†	.08	.00	.04	.14	.12	.24
SF-36	Physical Function	.41†	.05	.15	.21	.24	.26	.36†
	Social Function	.17	.07	.08	.10	-.05	.19	.30
	Role Limitations due to Physical Problems	.10	-.09	.01	.03	-.07	.11	.20
	Role Limitations due to Emotional Problems	.13	.07	.20	.23	-.16	.17	.33†
	Mental Health	.28	.09	.15	.17	.02	.15	.28
	Energy and Fatigue	.33†	.08	.14	.07	.10	.15	.28
	Pain	-.06	-.22	-.19	-.15	-.25	-.16	.01
	General Health	.27	-.10	.13	.02	.10	.13	.23
	Change in Health	.02	.12	.06	.00	.09	.14	.08

† indicates $p < 0.05$

		CHQ				MLHF			SG	SF-36							
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
CHQ	1 Dyspnea	-															
	2 Fatigue	.66†	-														
	3 Emotion	.38†	.65†	-													
	4 Mastery	.52†	.49†	.60†	-												
MLHF	5 Physical	-.62†	-.61†	-.52†	-.45†	-											
	6 Emotional	-.39†	-.41†	-.66†	-.44†	.70†	-										
	7 Total	-.63†	-.65†	-.54†	-.47†	.95†	.79†	-									
STANDARD GAMBLE	8	.28	.13	.34†	.21	-.49†	-.52†	-.48†	-								
SF-36	9 Physical Function	.54†	.44†	.24	.37†	-.47†	-.27	-.45†	.21	-							
	10 Social Function	.43†	.42†	.32†	.28	-.52†	-.50†	-.55†	.48†	.41†	-						
	11 Role Limitations due to Physical Problems	.56†	.62†	.50†	.41†	-.50†	-.45†	-.56†	.30	.55†	.53†	-					
	12 Role Limitations due to Emotional Problems	.27	.45†	.62†	.38†	-.29	-.51†	-.39†	.09	.15	.32†	.54†	-				
	13 Mental Health	.19	.45†	.72†	.33†	-.42†	-.59†	-.47†	.35†	.12	.40†	.25	.53†	-			
	14 Energy & Fatigue	.61†	.80†	.64†	.46†	-.66†	-.52†	-.66†	.24	.57†	.41†	.66†	.40†	.50†	-		
	15 Pain	.35†	.37†	.30	.33†	-.30	-.23	-.37†	.32†	.19	.42†	.34†	.12	.19	.30	-	
	16 General Health	.60†	.54†	.54†	.53†	-.74†	-.63†	-.73†	.33†	.69†	.47†	.69†	.30	.21	.71†	.29	-
	17 Change In Health	.25	.41†	.19	.19	-.34†	-.08	-.28	.03	.41†	.44†	.52†	.14	-.03	.46†	.23	.42†

† indicates $p < 0.05$

Variable	2-Tailed t	TEST p-level	NYHA Class II(x±SD)	NYHA Class III(x±SD)
6MW Distance	1.390	.172	441.4±75.6	403.2±99.8
Walk Work	1.669	.103	369.2±121.2	304.3±94.7
Peak VO_2	1.458	.153	1.24±0.37	1.06±0.35
Arm Curl	1.732	.091	21.6±9.4	16.2±9.1
Leg Press	2.574	.014	156.5±39.0	126.1±27.8
Knee Extension	1.760	.086	47.7±20.1	36.9±14.4
CHQ Dyspnea	1.457	.153	28.0±6.1	24.7±7.0
CHQ Fatigue	1.272	.211	18.6±4.8	16.4±4.9
MLHF Physical	-2.073	.045	9.1±9.5	15.5±8.0
MLHF Total Score	-1.607	.116	23.0±21.6	34.3±17.6
Standard Gamble	.698	.489	.82±.14	.78±.21
SF-36 Physical Dimension	1.998	.053	21.7±3.9	19.0±3.7
SF-36 Role Limitations due to physical problems	1.507	.140	1.7±1.7	0.9±0.9
SF-36 Energy and Fatigue	1.618	.114	15.78±4.4	13.3±4.1

APPENDIX F:

CHRONIC HEART FAILURE QUESTIONNAIRE

CHRONIC HEART FAILURE INDEX QUESTIONNAIRE

First Administration, 7 Point Scale

Interviewer Form

This questionnaire is designed to find out how you have been feeling during the last 2 weeks. You will be asked about how short of breath you have been, how tired you have been feeling and how your mood has been.

1. I would like you to thing of the activities that you have done during the last 2 weeks that have made you feel short of breath. These should be activities which you do frequently and which are important in your day-to-day life. Please list as many activities as you can that you have done during the last 2 weeks that have made you feel short of breath.

[CIRCLE THE NUMBER ON THE ANSWER SHEET LIST ADJACENT TO EACH ACTIVITY MENTIONED. IF AN ACTIVITY MENTIONED IS NOT ON THE LIST, WRITE IT IN, IN THE RESPONDENT'S OWN WORDS IN THE SPACE PROVIDED]

Can you think of any other activities you have done during the last 2 weeks that have made you feel short of breath?

[RECORD ADDITIONAL ITEMS]

2. I will now read a list of activities which make some people with heart problems feel short of breath. I will pause after each item long enough for you to tell me if you have felt short of breath doing that activity during the last 2 weeks. If you haven't done the activity during the last 2 weeks, just answer "NO". The activities are:

[READ ITEMS, OMITTING THOSE WHICH RESPONDENT HAS VOLUNTEERED SPONTANEOUSLY. PAUSE AFTER EACH ITEM TO GIVE RESPONDENT A CHANCE TO INDICATE WHETHER HE/SHE HAS BEEN SHORT OF BREATH WHILE PERFORMING THAT ACTIVITY DURING THE LAST WEEK. CIRCLE THE NUMBER ADJACENT TO APPROPRIATE ITEMS ON ANSWER SHEET.]

1. BEING ANGRY OR UPSET
2. HAVING A BATH OR SHOWER
3. BENDING
4. CARRYING, SUCH AS CARRYING GROCERIES
5. DRESSING
6. EATING
7. GOING FOR A WALK
8. DOING YOUR HOUSEWORK
9. HURRYING
10. LYING FLAT
11. MAKING A BED
12. MOPPING OR SCRUBBING THE FLOOR
13. PLAYING WITH CHILDREN OR GRANDCHILDREN
14. MOVING FURNITURE
15. PLAYING SPORTS
16. REACHING OVER YOUR HEAD
17. RUNNING, SUCH AS FOR A BUS

18. SHOPPING
19. TALKING
20. VACUUMING
21. WALKING AROUND YOUR OWN HOME
22. WALKING UPHILL
23. WALKING UPSTAIRS
24. WALKING WITH OTHERS ON LEVEL GROUND
25. PREPARING MEALS
26. WHILE TRYING TO SLEEP

Other activities:____
____
____
____

3. a) Of the items which you have listed, which is the most important to you in your day-to-day life? I will read through the items, and when I am finished, I would like you to tell me which is the most important.

[READ THROUGH ALL ITEMS SPONTANEOUSLY VOLUNTEERED AND THOSE FROM THE LIST WHICH PATIENT MENTIONED.]

Which of these items is most important to you in your day-to-day life?

[LIST ITEM ON RESPONSE SHEET]

3. b) Of the remaining items, which is the most important to you in your day-to-day life? I will read through the items, and when I am finished, I would like you to tell me which is the most important.

[READ THROUGH REMAINING ITEMS]

Which of these items is most important to you in your day-to-day life?

[LIST ITEM ON RESPONSE SHEET]

3. c) Of the remaining items, which is the most important to you in your day-to-day life?

[READ THROUGH REMAINING ITEMS]

Which of these items is most important to you in your day-to-day life?

[LIST ITEM ON RESPONSE SHEET]

3. d) Of the remaining items, which is the most important to you in your day-to-day life?

[READ THROUGH REMAINING ITEMS]

Which of these items is most important to you in your day-to-day life?

[LIST ITEM ON RESPONSE SHEET]

3. e) Of the remaining items, which is the most important to you in your day-to-day life?

[READ THROUGH REMAINING ITEMS]

Which of these items is most important to you in your day-to-day life?

[LIST ITEM ON RESPONSE SHEET]

[FOR ALL SUBSEQUENT QUESTIONS, ENSURE RESPONDENT HAS APPROPRIATE RESPONSE CARD IN FRONT OF THEM BEFORE STARTING QUESTION]

4. I would now like you to describe how much shortness of breath you have experienced during the last 2 weeks while doing the five most important activities you have selected.

a) Please indicate how much shortness of breath you have had during the last 2 weeks while [INTERVIEWER: INSERT ACTIVITY LIST IN 3a] by choosing one of the following options from the card in front of you: [GREEN CARD]

1. EXTREMELY SHORT OF BREATH
2. VERY SHORT OF BREATH
3. QUITE A BIT SHORT OF BREATH
4. MODERATE SHORTNESS OF BREATH
5. SOME SHORTNESS OF BREATH
6. A LITTLE SHORTNESS OF BREATH
7. NOT AT ALL SHORT OF BREATH

b) Please indicate how much shortness of breath you have had during the last 2 weeks while [INTERVIEWER: INSERT ACTIVITY LIST IN 3b] by choosing one of the following options from the card in front of you: [GREEN CARD]

1. EXTREMELY SHORT OF BREATH
2. VERY SHORT OF BREATH
3. QUITE A BIT SHORT OF BREATH
4. MODERATE SHORTNESS OF BREATH
5. SOME SHORTNESS OF BREATH
6. A LITTLE SHORTNESS OF BREATH
7. NOT AT ALL SHORT OF BREATH

c) Please indicate how much shortness of breath you have had during the last 2 weeks while [INTERVIEWER: INSERT ACTIVITY LIST IN 3c] by choosing one of the following options from the card in front of you: [GREEN CARD]

1. EXTREMELY SHORT OF BREATH
2. VERY SHORT OF BREATH
3. QUITE A BIT SHORT OF BREATH
4. MODERATE SHORTNESS OF BREATH
5. SOME SHORTNESS OF BREATH
6. A LITTLE SHORTNESS OF BREATH
7. NOT AT ALL SHORT OF BREATH

d) Please indicate how much shortness of breath you have had during the last 2 weeks while [INTERVIEWER: INSERT ACTIVITY LIST IN 3d] by choosing one of the following options from the card in front of you: [GREEN CARD]

1. EXTREMELY SHORT OF BREATH
2. VERY SHORT OF BREATH
3. QUITE A BIT SHORT OF BREATH
4. MODERATE SHORTNESS OF BREATH
5. SOME SHORTNESS OF BREATH
6. A LITTLE SHORTNESS OF BREATH
7. NOT AT ALL SHORT OF BREATH

e) Please indicate how much shortness of breath you have had during the last 2 weeks while [INTERVIEWER: INSERT ACTIVITY LIST IN 3e] by choosing one of the following options from the card in front of you: [GREEN CARD]

1. EXTREMELY SHORT OF BREATH
2. VERY SHORT OF BREATH
3. QUITE A BIT SHORT OF BREATH
4. MODERATE SHORTNESS OF BREATH
5. SOME SHORTNESS OF BREATH
6. A LITTLE SHORTNESS OF BREATH
7. NOT AT ALL SHORT OF BREATH

5. In general, how much of the time during the last 2 weeks have you felt frustrated or impatient? Please indicate how often during the last 2 weeks you have felt frustrated or impatient by choosing one of the following options from the card in front of you: [BLUE CARD]

1. ALL OF THE TIME
2. MOST OF THE TIME
3. A GOOD BIT OF THE TIME
4. SOME OF THE TIME
5. A LITTLE OF THE TIME
6. HARDLY ANY OF THE TIME
7. NONE OF THE TIME

6. How often during the past 2 weeks did you have a feeling of fear or panic when you had difficulty getting your breath? Please indicate how often you had a feeling of fear or panic when you had difficulty getting your breath by choosing one of the following options from the card in front of you: [BLUE CARD]

1. ALL OF THE TIME
2. MOST OF THE TIME
3. A GOOD BIT OF THE TIME
4. SOME OF THE TIME
5. A LITTLE OF THE TIME
6. HARDLY ANY OF THE TIME
7. NONE OF THE TIME

7. What about fatigue? How tired have you felt over the last 2 weeks? Please indicate how tired you have felt over the last 2 weeks by choosing one of the following options from the card in front of you: [ORANGE CARD]

1. EXTREMELY TIRED
2. VERY TIRED
3. QUITE A BIT TIRED
4. MODERATELY TIRED
5. SOMEWHAT TIRED
6. A LITTLE TIRED
7. NOT AT ALL TIRED

8. How often during the last 2 weeks have you felt inadequate, worthless, or as if you were a burden on other? Please indicate how much of the time you have felt inadequate, worthless, or as if you were a burden on others by choosing one of the following options from the card in front of you: [BLUE CARD]

1. ALL OF THE TIME
2. MOST OF THE TIME
3. A GOOD BIT OF THE TIME
4. SOME OF THE TIME
5. A LITTLE OF THE TIME
6. HARDLY ANY OF THE TIME
7. NONE OF THE TIME

9. In the last 2 weeks, how much of the time did you feel very confident and sure that you could deal with you illness? Please indicate how much of the time you felt very confident and sure that you could deal with your illness by choosing one of the following options from the card in front of you: [YELLOW CARD]

1. NONE OF THE TIME
2. A LITTLE OF THE TIME
3. SOME OF THE TIME
4. A GOOD BIT OF THE TIME
5. MOST OF THE TIME
6. ALMOST ALL OF THE TIME
7. ALL OF THE TIME

10. How much energy have you had in the last two weeks? Please indicate how much energy you have had by choosing one of the following options from the card in front of you: [PINK CARD]

1. NO ENERGY AT ALL
2. A LITTLE ENERGY
3. SOME ENERGY
4. MODERATELY ENERGETIC
5. QUITE A BIT OF ENERGY
6. VERY ENERGETIC
7. FULL OF ENERGY

11. In general, how much of the time did you feel upset, worried or depressed during the last 2 weeks? Please indicate how much of the time you have felt upset, worried, or depressed during the past 2 weeks by choosing one of the following options from the card in front of you: [BLUE CARD]

1. ALL OF THE TIME
2. MOST OF THE TIME
3. A GOOD BIT OF THE TIME
4. SOME OF THE TIME
5. A LITTLE OF THE TIME
6. HARDLY ANY OF THE TIME
7. NONE OF THE TIME

12. How often during the last 2 weeks did you feel you had complete control of your breathing problems with shortness of breath and tiredness? Please indicate how often you felt you had complete control of your breathing problems with shortness of breath and tiredness by choosing one of the following options from the card in front of you: [YELLOW CARD]

1. NONE OF THE TIME
2. A LITTLE OF THE TIME
3. SOME OF THE TIME
4. A GOOD BIT OF THE TIME
5. MOST OF THE TIME
6. ALMOST ALL OF THE TIME
7. ALL OF THE TIME

13. How much of the time during the last 2 weeks did you feel relaxed and free of tension? Please indicate how much of the time you felt relaxed and free of tension by choosing one of the following options from the card in front of you: [YELLOW CARD]

1. NONE OF THE TIME
2. A LITTLE OF THE TIME
3. SOME OF THE TIME
4. A GOOD BIT OF THE TIME
5. MOST OF THE TIME
6. ALMOST ALL OF THE TIME
7. ALL OF THE TIME

14. How often during the last 2 weeks have you felt low in energy? Please indicate how often during the last 2 weeks you have felt low in energy by choosing one of the following options from the card in front of you: [BLUE CARD]

1. ALL OF THE TIME
2. MOST OF THE TIME
3. A GOOD BIT OF THE TIME
4. SOME OF THE TIME
5. A LITTLE OF THE TIME
6. HARDLY ANY OF THE TIME
7. NONE OF THE TIME

15. In general, how often during the last 2 weeks have you felt discouraged or down in the dumps? Please indicate how much of the time during the last 2 weeks you felt discouraged or down in the dumps by choosing one of the following options from the card in front of you: [BLUE CARD]

1. ALL OF THE TIME
2. MOST OF THE TIME
3. A GOOD BIT OF THE TIME
4. SOME OF THE TIME
5. A LITTLE OF THE TIME
6. HARDLY ANY OF THE TIME
7. NONE OF THE TIME

16. How often during the last 2 weeks have you felt worn out or sluggish? Please indicate how much of the time you felt worn out or sluggish by choosing one of the following options from the card in front of you: [BLUE CARD]

1. ALL OF THE TIME
2. MOST OF THE TIME
3. A GOOD BIT OF THE TIME
4. SOME OF THE TIME
5. A LITTLE OF THE TIME
6. HARDLY ANY OF THE TIME
7. NONE OF THE TIME

17. How happy, satisfied, or pleased have you been with your personal life during the last 2 weeks? Please indicate how happy, satisfied or pleased you have been by choosing one of the following options from the card in front of you: [GRAY CARD]

1. VERY DISSATISFIED, UNHAPPY MOST OF THE TIME
2. GENERALLY DISSATISFIED, UNHAPPY
3. SOMEWHAT DISSATISFIED, UNHAPPY
4. GENERALLY SATISFIED, PLEASED
5. HAPPY MOST OF THE TIME
6. VERY HAPPY MOST OF THE TIME
7. EXTREMELY HAPPY, COULD NOT HAVE BEEN MORE SATISFIED OR PLEASED

18. How often during the last 2 weeks did you feel upset or scared when you had difficulty getting your breath? Please indicate how often during the past 2 weeks you felt upset or scared when you had difficulty getting your breath by choosing one of the following options from the card in front of you: [BLUE CARD]

1. ALL OF THE TIME
2. MOST OF THE TIME
3. A GOOD BIT OF THE TIME
4. SOME OF THE TIME
5. A LITTLE OF THE TIME
6. HARDLY ANY OF THE TIME
7. NONE OF THE TIME

19. In general, how often during the last 2 weeks have you felt restless, tense, or uptight? Please indicate how often you felt restless, tense or uptight by choosing one of the following options from the card in front of you: [BLUE CARD]

1. ALL OF THE TIME
2. MOST OF THE TIME
3. A GOOD BIT OF THE TIME
4. SOME OF THE TIME
5. A LITTLE OF THE TIME
6. HARDLY ANY OF THE TIME
7. NONE OF THE TIME

CHQ RESPONSE SHEET

Activity 3a____________________	4a ___
Activity 3b____________________	4b ___
Activity 3c____________________	4c ___
Activity 3d____________________	4d ___
Activity 3e____________________	4e ___

5. ___
6. ___
7. ___
8. ___
9. ___
10. ___
11. ___
12. ___
13. ___
14. ___
15. ___
16. ___
17. ___
18. ___
19. ___

APPENDIX G:

MINNESOTA LIVING WITH HEART FAILURE QUESTIONNAIRE

LIVING WITH HEART FAILURE QUESTIONNAIRE

Instructions: This questionnaire asks for your views on how your heart failure (heart condition) has prevented you from living as you wanted during the last month. The items listed on the questionnaire describe different ways some people are affected. If you are sure an item does not apply to you or is not related to your heart failure then circle 0 (No) and go to the next item. If an item does apply to you, then circle the number rating how much it prevented you from living as you wanted. Remember to think about ONLY THE LAST MONTH. Please respond to ALL questions.

Did your heart failure prevent you from living as you wanted during the last month by:

	No	Very Little				Very Much
1. causing swelling in your ankles, legs, etc.?	0	1	2	3	4	5
2. making you sit or lie down to rest during the day?	0	1	2	3	4	5
3. making your walking about or climbing stairs difficult?	0	1	2	3	4	5
4. making your working around the house or yard difficult?	0	1	2	3	4	5
5. making your going places away from home difficult?	0	1	2	3	4	5
6. making your sleeping well at night difficult?	0	1	2	3	4	5
7. making your relating to or doing things with your friends or family difficult?	0	1	2	3	4	5
8. making your working to earn a living difficult?	0	1	2	3	4	5
9. making your recreational pastimes, sports or hobbies difficult?	0	1	2	3	4	5
10. making your sexual activities difficult?	0	1	2	3	4	5
11. making you eat less of the foods you like?	0	1	2	3	4	5
12. making you short of breath?	0	1	2	3	4	5
13. making you tired, fatigued, or low on energy?	0	1	2	3	4	5
14. making you stay in hospital?	0	1	2	3	4	5
15. costing you money for medical care?	0	1	2	3	4	5
16. giving you side effects from medications?	0	1	2	3	4	5
17. making you feel you are a burden to your family or friends?	0	1	2	3	4	5
18. making you feel a loss of self-control in your life?	0	1	2	3	4	5
19. making you worry?	0	1	2	3	4	5
20. making it difficult for you to concentrate or remember things?	0	1	2	3	4	5
21. making you feel depressed?	0	1	2	3	4	5

APPENDIX H:

MEDICAL OUTCOME SURVEY SHORT FORM-36

THE MOS 36-ITEM SHORT-FORM HEALTH SURVEY (SF-36)

INSTRUCTIONS: This survey asks for your views about your health. This information will help keep track of how you feel and how well you are able to do your usual activities.

Answer every question by marking the answer as indicated. If you are unsure about how to answer a question, please give the best answer you can.

---

1. In general, would you say your health is: (circle one)

Excellent 1

Very good 2

Good 3

Fair 4

Poor 5

2. Compared to one year ago, how would you rate your health in general now? (circle one)

Much better now than one year ago 1

Somewhat better now than one year ago . . 2

About the same as one year ago 3

Somewhat worse now than one year ago . 4

Much worse now than one year ago 5

3. The following items are about activities you might do during a typical day. Does your health now limit you in these activities? If so, how much?

(circle one number on each line)

	yes, limited a lot	**yes, limited a little**	**no, not limited at all**
a. **Vigorous activities**, such as running, lifting heavy objects, participating in strenuous sports	1	2	3
b. **Moderate activities**, such as moving a table, pushing a vacuum cleaner, bowling, or playing golf	1	2	3
c. Lifting or carrying groceries	1	2	3
d. Climbing **several** flight of stairs	1	2	3
e. Climbing **one** flight of stairs	1	2	3
f. Bending, kneeling, or stooping	1	2	3
g. Walking **more than a mile**	1	2	3
h. Walking **several blocks**	1	2	3
i. Walking **one block**	1	2	3
j. Bathing or dressing yourself	1	2	3

4. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of your physical health?

(circle one number on each line)

	YES	**NO**
a. Cut down the **amount of time** you spent on work or other activities	1	2
b. **Accomplished less** than you would like	1	2
c. Were limited in the **kind** of work or other activities	1	2
d. Had **difficulty** performing the work or other activities (for example, it took extra effort)	1	2

5. During the past 4 weeks, have you had any of the following problems with your work or other regular daily activities as a result of any emotional problems (such as feeling depressed or anxious)?

(circle one number on each line)

	YES	NO
a. Cut down the **amount of time** you spent on work or other activities	1	2
b. **Accomplished less** than you would like	1	2
c. Didn't do work or other activities as **carefully** as usual	1	2

6. During the past 4 weeks, to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbours, or groups?

(circle one)

Not at all 1

Slightly 2

Moderately 3

Quite a bit 4

Extremely 5

7. How much bodily pain have you had during the past 4 weeks?

(circle one)

None 1

Very mild 2

Mild 3

Moderate 4

Severe 5

Very severe 6

8. During the past 4 weeks, how much did pain interfere with your normal work (including both work outside the home and housework)? (circle one)

Not at all 1

A little bit 2

Moderately 3

Quite a bit 4

Extremely 5

9. These questions are about how you feel and how things have been with you during the past 4 weeks. For each question, please give the one answer that comes closest to the way you have been feeling. How much of the time during the past 4 weeks:

(circle one number on each line)

	All of the Time	Most of the Time	A good Bit of the Time	Some of the Time	A Little of the Time	None of the Time
a. Did you feel full of pep?	1	2	3	4	5	6
b. Have you been a very nervous person?	1	2	3	4	5	6
c. Have you felt so down in the dumps that nothing could cheer your up?	1	2	3	4	5	6
d. Have you felt calm and peaceful?	1	2	3	4	5	6
e. Did you have a lot of energy?	1	2	3	4	5	6
f. Have you felt downhearted and blue?	1	2	3	4	5	6
g. Did you feel worn out?	1	2	3	4	5	6
h. Have you been a happy person?	1	2	3	4	5	6
i. Did you feel tired?	1	2	3	4	5	6

10. During the past 4 weeks, how much of the time has your physical health or emotional problems interfered with your social activities (like visiting with friends, relatives, etc.)?

(circle one)

All of the time 1

Most of the time 2

Some of the time 3

A little of the time 4

None of the time 5

11. How TRUE or FALSE is each of the following statements for you?

(circle one number on each line)

	Definitely True	**Mostly True**	**Don't Know**	**Mostly False**	**Definitely False**
a. I seem to get sick a little easier than other people	1	2	3	4	5
b. I am as healthy as anybody I know	1	2	3	4	5
c. I expect my health to get worse	1	2	3	4	5
d. My health is excellent	1	2	3	4	5

APPENDIX I:

STANDARD GAMBLE UTILITY QUESTIONNAIRE

STANDARD GAMBLE

Instructions: The next questionnaire is somewhat of a fantasy or a game. Nevertheless, we hope that it will give us some idea of how you feel about your present health state. The questionnaire will present a choice between you present health state and the possibility of either returning to excellent health or immediate death.

When you are answering the questions, I would like you to keep in mind how you have been feeling during the last two weeks. In particular, I'd like to consider how much shortness of breath, tiredness, and leg fatigue you have had during the last two weeks, how limited in your activities you have been and how you have been feeling emotionally.

In this section, you will be asked to make a series of choices between two options. If you think the two options are equal, tell me and I will mark your answer accordingly. In order to make the task easier to understand, we will use an aid similar to a game board. We call this a chance board **[INDICATE CHANCE BOARD]** because it indicates a chance or probability of a certain event occurring. As you can see, the top part of the board is labelled Choice A **[POINT FINGER AT "CHOICE A"]**. The bottom part is labelled Choice B **[POINT FINGER AT "CHOICE B"]**. Choice B is fairly simple because it is your health during the last tow weeks and in the event that you choose this option, you will be certain to continue in your present health state. If something is certain, it is equal to a 100 percent chance or probability. However, Choice A is a little more complex because if it is chosen, there are two possible results; excellent health or immediate death **[INDICATE EACH]**. The chances of each of these results occurring are indicated by the numbers appearing above each result and the size of the matching colours in the circle between the numbers **[POINT TO CIRCLE]**.

To make these ideas a little clearer, let me run through an example. Let us assume that you have the option of taking a drug/having surgery that can cure your heart condition, but there is a risk of death associated with it. You now have two choices, Choice A and Choice B. **[POINT TO CHOICE A AND THEN TO CHOICE B]**

Choice A **[AGAIN, POINT TO CHOICE A]** represents the drug, which has a 90% chance **[POINT TO 90 AND PINK AREA OF CIRCLE]** of full recovery to excellent health **[POINT TO EXCELLENT HEALTH SQUARE]**. However, in this example, there is also a 10% chance **[POINT TO 10 AND BLUE AREA OF CIRCLE]** that you will die due to side effects of the drug **[POINT TO BLUE IMMEDIATE DEATH SQUARE]**.

Your second choice, Choice B **[POINT TO CHOICE B]** is to remain in your present health state for the rest of your life **[POINT TO B SECTION]**. So, Choice B represents no drug, but you can be 100% certain that, for the rest of your life, you will feel the way you have during the last two weeks.

Do you have any questions?

ELICITING UTILITY OF PATIENTS' HEALTH STATE: We will now do the questionnaire in which we give you the choice between your current health state and the possibility of either being completely well or dying. remember that when you make your choice, you should focus on the way you have been feeling during the last two weeks. You should particularly consider as well as how bad your leg fatigue has been; how much shortness of breath and tiredness you have had, as well as how limited you have been and how you have been feeling emotionally. Also, remember that we want you to answer as if you will live for **[15 years for those over**

65, 20 years for those between 60 and 65, 25 years for those under 65], either in your present health state or in excellent health. In Choice A, excellent health will be represented by the square in the top left hand pocket and immediate death by the blue square int he right hand pocket. Your present health state is represented by the green square in the bottom.

[SET WHEEL TO 100/0]

As you can see, Choice A is now a 100 percent chance of excellent health and zero chance of death. Choice B is 100 percent chance of remaining in the health state you have been in during the last two weeks. If you had to pick between Choice A and Choice B, I assume that you would pick Choice A; is that correct?

[IF NO, ASK WHY AND RECORD RESPONSE VERBATIM; SCORE AS ? ON ANSWER SHEET; IF YES, MOVE WHEEL TO 10/90 AND CONTINUE]

Now I've changed Choice A to show that there is a 10% chance of excellent health and a 90% chance of death. choice B is still a 100% chance of your current health state. Would you pick A or B now? Remember, you can also decide that the two options are equal.

[IF INDIFFERENT, SCORE 0.10 AS UTILITY
IF A ASK, ' DO YOU MEAN YOU WOULD PREFER TO HAVE A 90 PERCENT CHANCE OF EXCELLENT HEALTH RATHER THAN LIVING IN THE HEALTH STATE YOU HAVE BEEN IN DURING THE LAST TWO WEEKS?' IF "NO", REPEAT CHOICES SHOWN ON BOARD. IF "YES", SCORE 0.05 AS UTILITY AND THANK RESPONDENT.

IF B, MOVE WHEEL TO 90/10 AND CONTINUE]

The board no shows Choice A to be a 90% chance of excellent health with a 10 % chance of dying and Choice B remains as your health state during the last two weeks. Which would you prefer? Remember, you can also decide if the two options are equal.

[IF INDIFFERENT, SCORE 0.90 AS UTILITY
IF A, MOVE WHEEL TO 20/80 AND CONTINUE
IF B, SCORE UTILITY AS 0.95 AND THANK RESPONDENT]

The board no shows Choice A to be a 20% chance of excellent health with a 80 % chance of dying and Choice B remains as your health state during the last two weeks. Which would you prefer? Remember, you can also decide if the two options are equal.

[IF INDIFFERENT, SCORE 0.20 AS UTILITY
IF A, SCORE UTILITY AS 0.15 AND THANK RESPONDENT.
IF B, MOVE WHEEL TO 80/20 AND CONTINUE]

The board no shows Choice A to be a 80% chance of excellent health with a 20 % chance of dying and Choice B remains as your health state during the last two weeks. Which would you prefer? Remember, you can also decide if the two options are equal.

[IF INDIFFERENT, SCORE 0.80 AS UTILITY

IF A, MOVE WHEEL TO 30/70 AND CONTINUE
IF B, SCORE UTILITY AS 0.85 AND THANK RESPONDENT]

The board no shows Choice A to be a 30% chance of excellent health with a 70 % chance of dying and Choice B remains as your health state during the last two weeks. Which would you prefer? Remember, you can also decide if the two options are equal.

[IF INDIFFERENT, SCORE 0.30 AS UTILITY
IF A, SCORE UTILITY AS 0.25 AND THANK RESPONDENT.
IF B, MOVE WHEEL TO 70/30 AND CONTINUE]

The board no shows Choice A to be a 70% chance of excellent health with a 30 % chance of dying and Choice B remains as your health state during the last two weeks. Which would you prefer? Remember, you can also decide if the two options are equal.

[IF INDIFFERENT, SCORE 0.70 AS UTILITY
IF A, MOVE WHEEL TO 40/60 AND CONTINUE
IF B, SCORE UTILITY AS 0.75 AND THANK RESPONDENT]

The board no shows Choice A to be a 40% chance of excellent health with a 60 % chance of dying and Choice B remains as your health state during the last two weeks. Which would you prefer? Remember, you can also decide if the two options are equal.

[IF INDIFFERENT, SCORE 0.40 AS UTILITY
IF A, SCORE UTILITY AS 0.35 AND THANK RESPONDENT.
IF B, MOVE WHEEL TO 60/40 AND CONTINUE]

The board no shows Choice A to be a 60% chance of excellent health with a 40 % chance of dying and Choice B remains as your health state during the last two weeks. Which would you prefer? Remember, you can also decide if the two options are equal.

[IF INDIFFERENT, SCORE 0.60 AS UTILITY
IF A, MOVE WHEEL TO 50/50 AND CONTINUE
IF B, SCORE UTILITY AS 0.65 AND THANK RESPONDENT]

The board no shows Choice A to be a 50% chance of excellent health with a 50 % chance of dying and Choice B remains as your health state during the last two weeks. Which would you prefer? Remember, you can also decide if the two options are equal.

[IF INDIFFERENT, SCORE 0.50 AS UTILITY
IF A, SCORE UTILITY AS 0.45 AND THANK RESPONDENT
IF B, SCORE UTILITY AS 0.55 AND THANK RESPONDENT]