CURRENT PRACTICES IN CARDIAC REHABILITATION: IMPLICATIONS FOR SCOPE OF REHABILITATION AND ASSESSMENT OF FUNCTIONAL CAPACITY

LIEZEL ANN DREYER

CURRENT PRACTICES IN CARDIAC REHABILITATION: IMPLICATIONS FOR SCOPE OF REHABILITATION AND ASSESSMENT OF FUNCTIONAL CAPACITY

Thesis submitted in fulfilment of the degree of Master of Science in Medicine

Submitted by Liezel Ann Dreyer

BSc(Med)(Hons)Exercise Science(Biokinetics), BA(HMS).

Supervised by Professor Wayne Derman

MRC/UCT RESEARCH UNIT FOR EXERCISE SCIENCE AND SPORTS MEDICINE,

DEPARTMENT OF HUMAN BIOLOGY, FACULTY OF HEALTH SCIENCES,

UNIVERSITY OF CAPE TOWN

June 2004

DEDICATION

For my Dad… whose sanguine spirit turned every firefly into a star.

ACKNOWLEDGEMENTS

There are a number of people to whom I owe a great amount of gratitude –

My family – Through your constant and unconditional support you have instilled in me a self-belief that ultimately enabled me to complete this thesis. Words do not do justice to my appreciation.

Professor Wayne Derman, I have valued your encouragement, guidance and wisdom during my research. It has been a privilege working with you the last 7 years.

My colleagues at BODY iQ for your understanding and support during the final stages of this thesis. Thank you creating such an exciting and challenging workplace! Most of all, thank you for your friendship.

The research described in this thesis would not have been possible without the excellent cooperation of the ***patients*** who participated in the studies. My thanks to you all.

To all ***staff at the Sports Medicine Practice*** for your help in accessing patients' medical data and with exercise testing.

Professor Mike Lambert, for help with statistical analysis.

Finally, to the anonymous ***external examiners*** for their time, effort and expertise in reviewing this thesis.

DECLARATION

I, *Liezel Ann Dreyer*, hereby declare that the experiments presented in this thesis were conceived and executed by myself and, apart from the normal guidance by my supervisor, I have received no assistance. Neither the substance nor any part of this thesis has been submitted in the past, or is being, or is to be submitted for a degree in the University or any other university. I hereby grant the University of Cape Town free license to reproduce this thesis in part or whole, for the purpose of research.

Signature: Signed by candidate

Date: 8 June 2004

PUBLICATIONS AND PRESENTATIONS

The work described in this thesis has been **published** in the following journals in abstract form:

Is the 6-minute walk test an acceptable measure of progression in cardiac rehabilitation programmes? Derman EW, Dreyer LA, Schwellnus MP, Noakes TD. Med Sci Sports Exerc 2001;33(5) (supp) S319.

Physiological and medical profiles of patients attending cardiac risk factor reduction and reversal programmes: implications for staffing and equipment. Dreyer LEA, Derman EW, Schwellnus MP, Noakes TD. Med Sci Sports Exerc 2001;33(5) (supp), S319.

Exercise Stress Testing underestimates improvements in functional capacity in patients on cardiac rehabilitation programmes. Derman EW, Dreyer LA, Schwellnus MP, Noakes TD. Med Sci Sports Exerc 2002;34(5) (supp) S303.

These papers were **presented** at the following conferences:
South African Sports Medicine Conference. Johannesburg, Gauteng, South Africa, 1998.
American College of Sports Medicine Conference. Baltimore, Maryland, USA, 2001.
American College of Sports Medicine Conference. St Louis, Missouri, USA, 2002.

ABSTRACT

The benefits of structured rehabilitation programmes for patients with coronary artery disease (CAD) are well recognised. In addition, patients with severe and complicated cardiac disease are now also deriving benefit from comprehensive cardiac rehabilitation programmes. Such programmes include supervised exercise training, education, nutritional strategies, counselling and behavioural intervention. Physical activity is also being included in the rehabilitation of patients with other chronic diseases of lifestyle. An observation from the Cardiac Rehabilitation Programme at the Sports Science Institute is that patients attending the programme for rehabilitation of a cardiac condition, often also present with additional co-morbidities and musculo-skeletal injuries. Thus the aim of the first chapter of this thesis was to profile patients attending the Cardiac Rehabilitation Programme at the Sports Science Institute of South Africa.

This descriptive retrospective analysis evaluated the medical records of 313 patients, who entered the programme during the period of January 1996 to August 2000. Of the total population, 80% had documented CAD. The remaining 20% of the total population, attended the programme for rehabilitation of another chronic lifestyle disease. Of the group of patients presenting with CAD, only 31% presented with CAD as the sole disorder, 14% presented with CAD and another chronic lifestyle disease, 26% with CAD and a chronic musculo-skeletal injury, and a last group of 14% required rehabilitation for CAD plus another co-morbidity and a musculo-skeletal injury. Furthermore, 11% presented with two or more risk factors, attending the programme for primary prevention of CAD only, whilst 6% attended the programme for primary prevention and the rehabilitation of another chronic disease.

Musculo-skeletal rehabilitation was required in 57% of the total population. Of the total 286 musculo-skeletal injuries noted, back injuries were the most common musculo-skeletal condition (49%) with grade I motion segment abnormality the most common back injury (63% of back injuries). Other common injuries included knee injuries (18%); shoulder injuries (13%) and hip injuries (7%). These findings suggest that (1) the focus of cardiac rehabilitation programmes should be shifted to 'chronic disease' rehabilitation; and (2) as previous musculo-skeletal injury is so common, staff who possess musculo-skeletal rehabilitation skills should be employed in such programmes. Indeed, we suggest that lumbar "prehabilitation" be taught to all patients enrolled in the programme. These factors may necessitate an evaluation of the current status of cardiac rehabilitation programmes in general, including provisions for musculo-skeletal rehabilitation,

variety in exercise forms, adequate supervision, the necessary testing and exercise equipment, and adequate reimbursement by medical aid schemes.

The final two chapters were designed to examine the methods of functional capacity assessment in cardiac rehabilitation.

The 6-minute walk test is a standard measure of functional capacity for patients attending cardiac rehabilitation programmes. This test has been shown to be valid and reliable for monitoring progress of patients with exercise intolerance and low functional capacity in phase I and II rehabilitation programmes. It is however still used to monitor the functional capacity of patients in phase III (outpatient maintenance) or more vigorous cardiac rehabilitation programmes. This study examined 10 patients with cardiac disease, (mean age 54.6±7 yrs), who attended cardiac rehabilitation and were participating in high-intensity exercise training 3 times per week. All subjects undertook the traditional 6-minute walk test (TWT) at 12-week intervals to measure progress during the exercise programme. During the second part of the trial at 9 months, subjects performed 2 tests in random order separated by a 30 minute rest period, namely: (1) a TWT and (2) a 6-minute "unrestricted motion" test (ULT) around a 135m indoor gymnasium track. Distances recorded during the initial TWT's, and those repeated at 12-week intervals were compared to determine the percentage of improvement over time. Although the distance covered during the TWT tended to increase from 0 to 6 months, there was no statistically significant difference between distance covered at 0 months and 3 months (695.7 ± 60.8m vs. 744.0 ± 75.1m), or 0 months and 6 months (695.7 ± 60.8m vs. 772.9 ± 74.2m). Furthermore, no significant difference was found in distance covered at time periods 3 to 6 months (744.0 ± 75.1m vs. 772.9 ± 74.2m) and 6 to 9 months (772.9 ± 74.2m vs. 806.7 ± 86.5m). However, the distance covered during the TWT at 9 months was significantly greater than the initial TWT distance ($p<0.05$). A significant difference was found between the distance covered during the ULT and each TWT performed at 0 months, 3 months, 6 months and 9 months ($p<0.0002$). Of significance however, is the discrepancy in the improvement in functional capacity shown by the TWT (16%), and the ULT (56%) at 9 months. Whilst both tests at 9 months are statistically different to baseline distance covered, a mean 35% (278.2m) discrepancy in reporting functional capacity is found. It seems that the TWT does not accurately reflect changes in functional capacity in patients who are accustomed to higher intensity exercise. Indeed, the results might mask significant progress in the programme. Thus it is questionable whether the TWT is an accurate measure of exercise capacity to be used in stage III of exercise rehabilitation. We therefore suggest that the "unrestricted locomotion test" be used to monitor functional capacity in phase III cardiac rehabilitation programmes.

In the fourth chapter of this thesis, changes in functional capacity achieved during routine exercise stress tests (EST) were examined. We observed that patients who regularly participate in cardiac rehabilitation, experience improvements in functional capacity far greater than is shown in their TWT or routine EST performed by their cardiologists. EST is currently used to assess patient safety and determine functional capacity in patients participating in cardiac rehabilitation programmes. The aim of this study was to compare changes in functional capacity during routine EST and a 6-minute ULT around a 135m indoor gymnasium track. 7 patients (average age 50.8 ± 3.0 years) with stable cardiac disease and who had undergone baseline EST using the Bruce protocol were recruited for this study. Subjects undertook the TWT at 0 and 9 months, and the ULT at 9 months as described in Chapter Three. Routine EST results at 0 months and 9 months were obtained from each patient's cardiologist. Average total time during the baseline EST was 7:27 ± 2:33 seconds. Subjects achieved a peak heart rate (HR) of 142 ± 20 bpm during this test. At 9 months the EST time significantly increased to 9:54 ± 2:52 min ($p<0.05$) which translates into a 31% improvement in total treadmill time. Peak HR increased to 152 ± 10 bpm, but this change was not significantly different from baseline. In contrast, the distance covered during the TWT at 0 months and the ULT at 9 months showed a 61% change in FC ($p<0.0002$). This test therefore yielded superior performance in patients with high baseline functional capacity.

A further aim of this study was to assess the safety of the ULT compared to the EST. Results showed that the maximum heart rates achieved were not significantly different during the TWT and EST at 0 months. Heart rates were significantly higher during the EST at 9 months compared to the TWT. Of importance, is that there was no significant difference in heart rates achieved during the ULT and EST at 9 months. Thus one could conclude that subjects were performing the ULT within the same safe heart rate limits as the EST. It also may be deducted that the TWT is an appropriate test to perform at initiation of cardiac rehabilitation, but may not reflect (1) functional capacity or (2) heart rates that patients are capable of achieving at later phases of cardiac rehabilitation.

The results of this thesis therefore confirms that patients with varying disease profiles are attending our programme. These results have implications for the staffing and equipment of such programmes, and justify the shift from "cardiac rehabilitation" to "chronic disease" programmes.

Secondly, it seems that traditional methods of functional capacity assessment including the traditional 6-minute walk test and routine exercise stress testing are relevant in assessing safety to exercise and functional capacity in earlier phases of cardiac rehabilitation, but do perhaps not accurately reflect the improvements experienced by patients in phase III and IV programmes. Therefore, we suggest that the ULT be used as a more accurate test of functional capacity in later phases of cardiac rehabilitation.

TABLE OF CONTENTS

A REVIEW OF THE LITERATURE

INTRODUCTION

The World Health Organisation (WHO) considers cardiovascular diseases the world's leading cause of mortality, claiming 12 million lives per year, a staggering quarter of the total number of deaths worldwide (available at URL: http://www.who.int/mediacentre/releases/pr83/en. Accessed 15 October 2003). Furthermore, the WHO Report (2002) shows for the first time that most of the global burden due to cardiovascular disease is found in developing countries.

Although the prevalence of chronic diseases is declining in industrialised, developed countries including the United States of America, Western Europe and Australia, these diseases pose an increasing threat in poorer, developing countries such as Africa, Asia and Latin America (Digenio 1993). South African statistics are particularly alarming. After HIV/AIDS (30%), cardiovascular disease (16.6%) was the leading cause of death in 2000 (Bradshaw et al. 2003).

These chronic conditions pose economic challenges to patients, families and the sustainability of health care systems. Furthermore, if no action is taken to improve the global cardiovascular health, the WHO estimates that by the year 2020, 25% more healthy life years will be lost to this disease (available at URL: http://www.who.int/mediacentre/releases/pr83/en. Accessed 15 October 2003). More than 50% of worldwide annual deaths can be prevented by a combination of simple, cost effective national efforts, and individual action aggressively targeting the established major risk factors (hypertension, high cholesterol, overweight, physical inactivity and cigarette smoking). The prevention of subsequent cardiac events and maintenance of cardiac and physical function is therefore a major challenge to our health care system.

PRIMARY PREVENTION OF CORONARY ARTERY DISEASE (CAD)

It is widely accepted that a sedentary lifestyle is a major risk factor for developing chronic cardiac and other lifestyle related diseases. Pioneers including Ralph Paffenbarger have spent the last few decades determining the quantity and quality of physical activity required for good health and prevention of chronic diseases of lifestyle. In a study of college alumni, the risk of death was diminished with an increase in physical activity levels from 500 to 3500 kcal per week (Paffenbarger et al. 1986). Similarly, the American College of Sports Medicine states that lower levels of physical activity may reduce the risk of developing certain chronic degenerative

CHAPTER ONE

REVIEW OF THE LITERATURE

A REVIEW OF THE LITERATURE

INTRODUCTION

The World Health Organisation (WHO) considers cardiovascular diseases the world's leading cause of mortality, claiming 12 million lives per year, a staggering quarter of the total number of deaths worldwide (available at URL: http://www.who.int/mediacentre/releases/pr83/en. Accessed 15 October 2003). Furthermore, the WHO Report (2002) shows for the first time that most of the global burden due to cardiovascular disease is found in developing countries.

Although the prevalence of chronic diseases is declining in industrialised, developed countries including the United States of America, Western Europe and Australia, these diseases pose an increasing threat in poorer, developing countries such as Africa, Asia and Latin America (Digenio 1993). South African statistics are particularly alarming. After HIV/AIDS (30%), cardiovascular disease (16.6%) was the leading cause of death in 2000 (Bradshaw et al. 2003).

These chronic conditions pose economic challenges to patients, families and the sustainability of health care systems. Furthermore, if no action is taken to improve the global cardiovascular health, the WHO estimates that by the year 2020, 25% more healthy life years will be lost to this disease (available at URL: http://www.who.int/mediacentre/releases/pr83/en. Accessed 15 October 2003). More than 50% of worldwide annual deaths can be prevented by a combination of simple, cost effective national efforts, and individual action aggressively targeting the established major risk factors (hypertension, high cholesterol, overweight, physical inactivity and cigarette smoking). The prevention of subsequent cardiac events and maintenance of cardiac and physical function is therefore a major challenge to our health care system.

PRIMARY PREVENTION OF CORONARY ARTERY DISEASE (CAD)

It is widely accepted that a sedentary lifestyle is a major risk factor for developing chronic cardiac and other lifestyle related diseases. Pioneers including Ralph Paffenbarger have spent the last few decades determining the quantity and quality of physical activity required for good health and prevention of chronic diseases of lifestyle. In a study of college alumni, the risk of death was diminished with an increase in physical activity levels from 500 to 3500 kcal per week (Paffenbarger et al. 1986). Similarly, the American College of Sports Medicine states that lower levels of physical activity may reduce the risk of developing certain chronic degenerative diseases and improve metabolic fitness, but may not necessarily improve overall aerobic capacity or maximal oxygen uptake during exercise (VO_{2max}) (ACSM,1990). Thus there seems to be a distinction between physical activity for health and the prevention of chronic diseases of lifestyle, and physical activity for fitness and performance. In addition, it seems that the lower the baseline level of activity the greater the change in selected health-related benefits with even a minimal increase in physical activity is achieved (Haskell 1994).

Historically, many of these chronic diseases and their associated risk factors were treated mainly with drugs. However, the evidence supporting the benefits of exercise in the prevention of chronic disease development lead to the formation of structured primary prevention programmes. Such programmes for patients with risk factors for CAD (including hypertension, hypercholesterolaemia, smoking, physical inactivity, stress and obesity) have been shown to be more cost-effective than treatment programmes based singularly on medical management (Digenio 1993). This is particularly relevant in South Africa, where preventative medicine is still not fully incorporated into our health care system. Community based programmes are in a unique position to develop such primary prevention strategies.

Other non-pharmacological interventions have also been shown to be effective in secondary prevention programmes. These include smoking cessation, weight and stress management and physical exercise components (Singh et al. 1992; Ornish et al. 1998). In comparison with pharmacological interventions, these have been shown to be less costly, however their success is dependant on patient compliance and long-term behaviour change.

These individual components are now incorporated into formal cardiac rehabilitation programmes. It's evolution as a discipline within cardiology and sports medicine is worthwhile exploring.

HISTORICAL OVERVIEW OF CARDIAC REHABILITATION PROGRAMMES

The potential benefit of more vigorous exercise in patients with CAD was initially documented by Herberden who observed that one of his patients was "nearly cured" after performing physical activity (sawing wood) for 30 minutes each day over a 6-month period (Herberden et al. 1961). However, it took a number of years for these benefits to be formally implemented into cardiac care programmes.

Prior to the 1930's, patients were confined to a 2-month period of bedrest after myocardial infarction (MI). It was thought that physical activity would lead to the formation of ventricular aneurysm, heart failure, cardiac rupture or sudden death. In the late 1930's, this period was shortened to 6-8 weeks (Mallory et al. 1939). Patients were advised to avoid any strenuous activity (including stair climbing) for prolonged periods, and sometimes indefinitely. It was rare for a patient to return to a normal lifestyle and restore his/her vocational status.

By the early 1950's, Levine and Lown showed the benefits of armchair exercises compared to extended bed rest (Levine et al. 1952). Most patients in their study were sitting in a chair for up to 2 hours on their first day of hospitalisation and this time was gradually increased during their stay in hospital. Discharge time was 4 weeks for nearly all patients. There were no complications associated with the addition of physical activity. Indeed, mortality rates were lower in this group compared to the control group who had been subjected to bed rest only. By 1956, early ambulation was prescribed within 14 days of the acute MI (Brummer et al. 1956).

Clinicians gradually realised the benefits of early ambulation in offsetting the detrimental effects of de-adaptation, disability and medical complications associated with prolonged periods of bed rest. Consequently, the length of hospitalisation decreased. Currently, it is estimated that most patients remain in hospital for 3-5 days (Newby et al. 2000).

Concern about the safety of unsupervised exercise after discharge, lead to the formalization of phase I, or in-patient cardiac rehabilitation programmes, supervised by unit nursing staff but sometimes involving rehabilitation teams. These programmes catered mainly for low-risk coronary patients but evolved to accommodate additional risk reduction interventions for a broader cardiac patient population, and focused almost exclusively on exercise training.

MODERN-DAY CARDIAC REHABILITATION

Whereas early cardiac rehabilitation focused on simple lifestyle modification primarily through exercise conditioning, modern cardiac care includes an array of costly medical and surgical interventions designed to correct disease pathogenesis and rehabilitate the patient back into a healthy life. Although these technical procedures and advances are successful, they fail to address underlying causes of disease development caused by a sedentary, unhealthy lifestyle.

The contemporary approach to secondary prevention cardiac rehabilitation is characterised by wide-ranging long-term services, involving medical evaluation, medically supervised exercise, cardiac risk factor modification, patient education, dietary-, counselling and other behavioural interventions (Wenger et al. 1995). The WHO defines cardiac rehabilitation as "the sum of activities required to influence favourably the underlying cause of disease, as well as the best possible physical, mental and social conditions, so that they may, by their own efforts preserve or resume when lost, as normal a place as possible in the community. Rehabilitation cannot be regarded as an isolated form of therapy but must be integrated with the whole treatment of which it forms only one facet" (WHO, 1993).

Essential components of a cardiac rehabilitation programme include an initial medical evaluation by a medical practitioner for risk stratification, medically supervised or directed exercise training, risk factor modification, medical surveillance/emergency support, dietary intervention and psychosocial/vocational counselling (Franklin et al. 1998, Balady et al. 2000).

PHYSICAL ACTIVITY AS A THERAPY FOR PATIENTS WITH CARDIOVASCULAR DISEASE

Several studies have addressed the relationship between physical activity and secondary prevention of coronary artery disease. The major findings of these studies are documented in Table 1.1.

Table 1.1. Selected studies addressing physical activity in secondary prevention of CAD and its' related conditions.

Reference	Study Design	Research Question	Main Findings and Conclusion
O'Connor et al. 1989	• Review of 22 RCT's • n = 4554 • TP: 3 yrs	Does this pooled data reflect significant benefits for MI patients participating in cardiac rehabilitation programmes?	• Total mortality, cardiovascular mortality and fatal re-infarction were reduced after 3yrs. • Odds Ratios were decreased for sudden death, but only at 1 year. • No differences between groups for non-fatal re-infarctions.
Hambrecht et al. 1993	• RCT • n = 62 • TP: 12 months	What are the effects of physical activity and a low fat diet on fitness and progression of coronary atherosclerosis in patients with CHD?	• Positive effect on regression of coronary artery stenosis (25% vs. 6% in experimental and control groups respectively; p<0.001). • Preventive effect on progression of coronary artery stenosis (10% vs. 45% in experimental and control groups respectively; p<0.001).
Lavie et al. 1994	• Cohort • n = 288	Benefits of CR and exercise training in CHD patients with high baseline levels of functional capacity compared to those with low baseline levels.	• High baseline group showed significant improvements in TG, LDL and exercise capacity after training. • The improvement in LDL was greater in this group in comparison to low baseline level patients. • Improvement in exercise capacity was less than in patients with low baseline levels.
Lavie et al. 1995	• Cohort • n = 458 • TP: 3-4 months	Effects of CR and exercise training on exercise capacity, behavioural characteristics and HRQOL in elderly patients (≥65 years) with CHD.	• Modest improvements in blood lipids, obesity indices, behavioural characteristics and QOL parameters. • Marked improvement in exercise capacity and mental health. These improvements are greater than those observed in younger patients.
Lavie et al. 1995	• Cohort • n=458 (83 women; 375 men) • TP: 3-4 months	Effects of CR and exercise training in women with CHD vs. men with CHD.	• Significant improvement in exercise capacity. • No significant change in BMI and lipids. • All improvements similar between men and women, but women's baselines measurements are lower.
Joliffe et al.	• Meta-	Effects of "exercise only",	• "Exercise only" and

2000	analysis of RCT's • n = 7683 • TP: >6 months	'comprehensive rehabilitation" and "usual care" of patients with CHD.	"comprehensive rehabilitation" reduce all-cause mortality. • Greater reduction with "exercise only" group compared to "usual care" group. • "Exercise only" and "comprehensive rehabilitation" reduce total cardiac mortality (31% and 26% respectively) compared to "usual care" group. • Therefore, exercise is effective in reducing cardiac death. • Limitation: Subjects are predominantly male, middle-aged and low risk.
Wannamethee et al. 2001	• Review paper	Effect of physical activity on CVD and CVA.	• Dose-response relationship between physical activity and CVD. • Physical activity is associated with a lower risk of cerebrovascular accident.
Cheng et al. 2002	• Review paper	Modifying risk factors in symptomatic CHD patients.	• Evidence-based strategy in reducing risk for CVD through modification of major, independent risk factors.

Abbreviations: RCT=Randomised Controlled Trials; TP=Time period; MI=Myocardial Infarction; CHD=Coronary heart disease; CR=Cardiac Rehabilitation; TG = Triglycerides; LDL=Low Density Lipoprotein; HRQOL=Health Related Quality of Life; QOL=Quality of Life; BMI=Body Mass Index; CVD=Cardiovascular disease; CVA=cerebrovascular accident.

EXERCISE PRESCRIPTION IN CARDIAC REHABILITATION PROGRAMMES

Exercise training is now integral in the modern comprehensive care plan for patients with cardiovascular disease. Traditionally, standard and generic exercise prescriptions were provided for all patients with CAD. In contrast, individualised exercise programmes are presently prescribed based on patients' clinical profile, including risk factors, age and functional status (Ades 2001). This patient-centric approach to cardiac rehabilitation enhances patient compliance and encourages patients to take ownership of their rehabilitation process.

Traditional programmes focused on two to four, 30-45 minute exercise sessions per week for a 12-week period. Exercise was prescribed at a moderate-to-high intensity (65-85% of the maximum heart rate), with walking or stationary cycling being the preferred choice of cardiovascular activity. This type of exercise regimen results in a low caloric energy expenditure (approximately 170 to 183 kcal per session) (Savage et al. 2000), and may explain the unpronounced effect of exercise on body weight and other cardiac risk factors. Later studies demonstrated the benefits of a high caloric exercise training programme (60-90 minute session, 5-7 days per week at a relatively low intensity of 50-60% of peak VO_2) in promoting weight loss and positively influencing cardiac risk factors in overweight coronary patients (Mertens et al. 1998; Savage et al. 2003).

More recent research has pointed to the benefits of high intensity exercise programmes. Hagberg et al. (1991), found an increase in myocardial oxygenation after 1 year of high-intensity exercise. They suggest that the benefits of cardiac rehabilitation are not only due to peripheral adaptations, but also to changes that occur in the myocardium itself. This does not imply that all patients should be encouraged to participate in high-intensity exercise. However, patients with CAD may be capable of performing higher intensity exercise than what we previously thought "physiologically possible".

At the Cardiac Rehabilitation Programme at the Sports Science Institute of South Africa, we have found two distinct groups of patients – those who demonstrate superior exercise capacity and the ability to adapt at an advanced level of high intensity strength and endurance training and partake in competitive sporting events (referred to as "cardiac athletes"), and those who seem to be able to exercise only at a moderate intensity. Dreyer et al. (2000) studied this group to create a physiological profile and to identify the possible physiological and other factors that might help explain the variance in response to cardiac rehabilitation. Results from this study demonstrated that multiple complex factors (including superior exercise capacity, less profound smoking history, higher levels of habitual physical activity, fewer perceived barriers to action, lower serum cholesterol, greater cardiovascular efficiency) besides residual left ventricular function may influence levels of fitness achieved by cardiac patients during a rehabilitation program (Dreyer et al. 2000, Honours thesis). These results emphasise the importance of identifying sub-groups of responders and adjusting exercise prescription accordingly.

Previous research has suggested that an energy expenditure of between 1000 kcal and 1500 kcal per week is sufficient for health benefits. A recent study showed that 72% of the patients attending cardiac rehabilitation accumulated 1000 kcal and 43% accumulated 1500 kcal and through cardiac rehabilitation, physical activity and leisure time activity (Schairer et al. 2003). A minimum of 1600 kcal per week of leisure time physical activity may halt the progression of CAD whilst regression thereof may be achieved with weekly energy expenditure of 2200 kcal per week (Franklin et al. 2003). Furthermore, not all of the positive effects of exercise can be attributed to a chronic metabolic adaptation over time. It seems that the acute effect of a recent training bout contributes to the protective effect of exercise (Thompson et al. 2003). These findings suggest that stable patients should participate in leisure time physical activity in addition to that performed as part of their cardiac rehabilitation programme so that they achieve a daily exercise session of 30 minutes of moderate to vigorous physical activity.

Brisk walking has been shown to be sufficient to achieve cardio-respiratory and health benefits (Quell et al. 2002). In this study most patients besides the highly fit patients reached a target heart rate of more than or equal to 70% of their symptom limited heart rate (determined via an EST) during brisk walking. This has important implications for programmes that do not have a variety of cardiovascular equipment available.

Other modes of training in cardiac rehabilitation programmes have been investigated. There has been concern regarding the safety of resistance training in the cardiac population, especially in patients with congestive heart failure (CHF), as there is the potential for a high afterload to have a negative impact on left ventricular function (Karlsdottie et al. 2002). However, resistance training studies have shown to be safe and effective in clinically stable patients (Franklin et al. 2003) resulting in an increase in skeletal muscle mass (Ades et al. 1999_a) and muscular strength, a reduction in body fat and preservation of physical function (Pierson et al. 2001). Furthermore, left ventricular function seems to remain stable during moderate intensity resistance training in CHF patients, confirming the safety of this form of therapy (Karlsdottie et al. 2002).

A recent study demonstrated the benefits of resistance training on physical performance in elderly and disabled female cardiac patients (Ades et al. 2003). The women in this study improved their physical capacity over a wide range of household activities. These results have particular importance in older patients who often present with severe deconditioning and disability as a result of disease or co-morbidities. The inclusion of resistance training may lead to an increased ability to perform daily living activities and therefore prolong independence for as long as possible.

PHYSIOLOGICAL ADAPTATIONS TO EXERCISE TRAINING IN PATIENTS WITH CAD

Patients with CAD who attend cardiac rehabilitation have shown an increase in exercise capacity, and an increase in measured and estimated maximal oxygen uptake (Wenger et al. 1995; Maines et al. 1997). Patients also report an improved ability to perform activities of daily living including climbing stairs and carrying groceries (Ades et al. 1999$_a$).

Patients who are more sedentary at baseline seem to experience a greater improvement in exercise tolerance with an increase in physical activity compared to their counterparts with higher baseline capacity (Hammond et al. 1985). However, exercise does show positive effects on exercise tolerance and selected risk factors, even in patients with higher levels of baseline physical activity (Lavie et al. 1994).

The mechanism by which these adaptations occur, is still unclear. Results of early studies, most of which incorporated moderate-intensity activities, lead to the general belief that the benefits of cardiac rehabilitation were due mainly to changes in the periphery. However, the possibility that exercise might also exert a beneficial effect on the coronary blood flow to potentially underperfused myocardium muscle has been investigated. Results of a study on dogs, suggest that exercise training positively influences coronary collateral function and quality that would stimulate transport to underperfused regions in the heart (Heaton et al. 1978). Belardinelli et al. (1999) suggested that enhanced myocardial perfusion plays a role in post-training improvements in functional capacity in patients with chronic heart failure. It has been established that myocardial ischaemia is the most potent trigger for the development of collateral vessels. As it is not desirable to subject any patient to increased periods of myocardial ischaemia for the sake of promoting collateral growth, exercise presents the best practical method of inducing temporary bouts of myocardial ischemia through increased oxygen demand (Kavanagh, 1989).

Post-exercise adaptations in patients with CAD include a reduction in heart rate (HR) (Detry et al. 1971) and blood pressure (BP) for any given sub-maximal workload (Hertanu et al. 1986).

This results in a lower rate-pressure product (RPP) (a non-invasive index of myocardial oxygen demand at any workload), from light to vigorous activity. This adaptation is especially beneficial for patients with coronary artery narrowing, as it results in a more favourable balance between myocardial oxygen demand and supply during exercise.

Certain authors did not find any changes in stroke volume and cardiac output after cardiac rehabilitation both at rest and during submaximal exercise (Detry et al. 1971). In contrast, others have found an increase stroke volume and cardiac output in patients without angina, and a decrease in patients with angina after exercise (Froelicher et al. 1984).

Some studies have shown improved left ventricular function, and ventricular size and remodelling in MI patients participating in exercise training (Giannussi et al. 1993). Conversely, others have reported no improvement in left ventricular function in patients with CAD (Letac et al. 1977; Cobb et al. 1982).

The left ventricle (LV) responds to isotonic exercise through an increase in stroke volume at rest and during exercise. The mechanism of this response is still a subject of investigation. It seems that it may be mediated by an increase in end-diastolic volume (as per the Frank-Starling effect) or through changes in the contractile state of the heart. Some authors have found exercise to be associated with an increase in stroke volume through an enhanced contractile state (Stein et al. 1980).

It has been suggested that exercise training may cause alterations in the vascular beds of the coronary vasculature leading to improved capacity to transport nutrients and waste products (Eshani et al. 1981; Ekelund et al. 1988). Animal studies have suggested that this adaptation is related to an increase in coronary blood flow capacity and coronary capillary diffusion (Laughlin 1985; Laughlin et al. 1989) but further research is required to confirm this finding in human studies.

Furthermore, it is also thought that the cardioprotective effect of exercise is related to its effect on the endothelium. Research suggests that physical training corrects endothelial dysfunction and results in an improved exercise capacity in patients with chronic heart failure (Hambrecht et al. 1998). A recent study by the same authors showed that 10-minute stationary bicycling sessions, 6 times per week for a 4-week period, at 80% of maximum heart rate, has a positive influence on the endothelium-dependant vasodilatation of coronary arteries (Hambrecht et al. 2000).

DIETARY INTERVENTION IN CARDIAC REHABILITATION PROGRAMMES

The relationship between dietary manipulation and cardiac protection has lead to the inclusion of a dietary intervention component in comprehensive cardiac rehabilitation. Three studies in this area deserve to be mentioned.

In 1970, Leren described the Oslo diet-heart study. Patients were advised to decrease the intake of saturated fat and increase polyunsaturated fat in an attempt to decrease total blood cholesterol concentrations (Leren 1970). A 23% reduction in subsequent coronary events was reported with no impact on overall patient survival.

In the diet and reinfaction trial (DART), MI survivors were advised to reduce their fat intake, increase the ratio of polyunsaturated- to unsaturated fat, and increase fatty fish and fibre intake. Subjects who were advised to increase fatty fish showed a 28% reduction in all-cause mortality after 2 years compared to the control group who received no advice (Burr et al. 1989).

The Lyon Diet Heart Study, investigated the benefits of a Mediterranean-type diet on subsequent coronary events and overall mortality in patients after MI (De Lorgeril et al. 1994). In comparison to the control group, the experimental groups' diet was high in the n-3 long-chain fatty acids precursor (alpha linolenic acid), contained more vegetables and bread, fruits at least once a day, less red meat (more poultry), and butter and cream were replaced with margarine high in alpha linolenic acid. A reduction in coronary events and cardiac death in the region of 70% was achieved.

Combining the results of these studies, and outlined in a recent publication, it is advised that patients with CAD should reduce total fat intake to 30% or less of total energy intake, reduce saturated fat to one third of total fat and partially replace these by unsaturated fats, reduce cholesterol to less than 300mg per day, and increase omega-3 fat intake (from fishgrapeseed oil), increase the intake of fruits and vegetables and control salt or alcohol use (Wood et al. 1998).

However, there is a need for more studies to be conducted in this area. Specifically, whilst these studies showed positive results in developed countries, more research is required to establish the effects of dietary changes more appropriate for low and middle-income countries where national poverty and household budgets are not able to cater for the food types prescribed in the above diets.

PSYCHOLOGICAL INTERVENTION IN CARDIAC REHABILITATION PROGRAMMES

Psychological interventions either as a standard component of cardiac rehabilitation or as a stand-alone intervention have been reported to have a positive effect on coronary risk factors, and have resulted in significant improvements in psychosocial well-being and a reduced mortality and morbidity.

Many of the complications experienced by people who develop heart disease are not due to physical illness, but are related to anxiety and depression issues surrounding their health (Poston et al. 2003). The positive effects of counselling and education in conjunction with exercise training have been shown in the following groups: MI, coronary artery bypass graft (CABG) and CAD patients (Oldridge et al. 1991_b; Maines et al. 1997), obesity (Lavie et al. 1996), depression (Milani et al. 1996) and elderly women (Lavie et al. 1993).

Anxiety and Depression

Significant morbidities including reduced functional capacity, blood lipid abnormalities, smoking, higher levels of anxiety, hostility, bodily pain and reduced QOL have been associated with depression (Milani et al. 1996).

Measures of anxiety and depression, emotional stress, lack of self-confidence, depression and social isolation are all positively influenced by cardiac rehabilitation (Oldridge et al. 1991_b; Schuler et al. 1992; Lindin et al. 1996; Milani et al. 1996; Maines et al. 1997). These studies suggest that the higher the levels of distress on initiation of a cardiac rehabilitation programme, the greater the degree of improvement during the programme.

Furthermore, depression and lack of social support have been linked to increased risk of post-MI mortality at 1 year and 5 years (Frasure-Smith et al. 2000; Lespérance et al. 2002). These patients were less likely to have close friends, more likely to be unmarried and living alone. Assessment of patients on entry to cardiac rehabilitation programmes should include questions related to typical social networks, and clinicians should be alerted to combinations of depression and poor support structures. This will facilitate the identification of potential problem areas that can be supported through psychological intervention.

Quality of Life

The success of a cardiac rehabilitation programme needs to be judged not only in terms of its effect on mortality and morbidity, but also in terms of a patients' perception of his/her well-being and health-related quality of life (QOL). QOL is most commonly measured by questionnaires and interviews and covers areas specific to physical function including experiences of pain, fatigue and disability, psychological and emotional well-being and social function (Garratt et al. 2002).

There is uncertainty whether cardiac rehabilitation has a quantifiable effect on measures of QOL. From practical observation, most patients enjoy and value their rehabilitation programme. A study by Oldridge et al. (1991$_b$) showed no difference in disease-specific and health-related measures of QOL in low-risk patients who underwent rehabilitation compared to a control group who received usual care at 12 months. However, at 8 weeks, the intervention group showed small, but significant improvements in QOL and anxiety. The authors concluded that shorter periods of cardiac rehabilitation have little lasting effect on QOL of patients who are moderately depressed or anxious. Other studies have shown improvements in QOL after cardiac rehabilitation (Dugmore et al. 1999; Gardner et al. 2003). A recent study showed improved health-related QOL outcomes for patients participating in 13 weeks of cardiac rehabilitation (Lavorato et al. 2003). Patients showed significant improvements in six of the eight categories of the Medical Outcomes Survey - Short Form 36 (SF-16) (Ware, 1997) and in particular, in physical functioning and vitality.

The group of patients who most benefit from cardiac rehabilitation are high-risk patients (Sullivan et al. 1989). Even modest improvements in their functional limitations as a result of their disease may have a positive effect on their perceived QOL. One can therefore argue that low risk patients (such as the subjects in Oldridge's study) would possibly recover to their before-event functional status regardless of whether or not they engage in cardiac rehabilitation. Paradoxically, the group of patients who benefit most from rehabilitation (very sick, elderly, women, high-risk and sedentary patients) were excluded from traditional programmes. Therefore further research is required which includes these subgroups of the cardiac rehabilitation population, to gain an accurate understanding of the effects of cardiac rehabilitation on QOL.

Back-to-work status

There is also discrepancy in the literature regarding the benefits of cardiac rehabilitation on a patients' work status. A planned rehabilitation programme, which is aimed at the whole individual in his or her social setting and not just at the cardiac condition in isolation, seems to facilitate early return to work (Schiller et al. 1976; Hertanu et al. 1986). In contrast, Bengtsson et al. (1983) found no difference in the rate of return to work between controls and a group of patients participating in regular rehabilitation classes. Perk et al. (1990) showed similar results in a group of post-CABG patients undergoing cardiac rehabilitation.

A possible reason for this discrepancy is that in the new world of work, mechanisation of many jobs has resulted in less demanding physical conditioning necessary for employment. As a result, cardiovascular fitness is not as important a determinant of readiness for return to work, as cardiac function. Economic conditions, various non-medical and psychosocial variables, employer stereotypes and the availability of pension funds seem to have a greater bearing on return-to-work figures than functional capacity after a cardiac event.

Patient Education

Patients view physicians (as opposed to nurses or other health professionals) as the more credible authority of information to restore and maintain their health (Karlik et al. 1987). In addition, participation in and compliance with cardiac rehabilitation seems to be enhanced when patients are physician referred (Wilhelmsen et al. 1975; Yates et al. 2003). This experience provides both challenges and opportunities for chronic disease risk reduction and reversal programmes in non-hospital settings. Doctors are often the first point of contact after a serious cardiac event. Whilst the benefits of risk reduction are recognised, the reality is that doctors are often too busy to educate patients on the importance of lifestyle modification and risk reduction. This "treatment gap" remains a continual obstacle to the success of risk reduction interventions. Therefore, it is then essential for formal cardiac rehabilitation programmes to include structured educational processes to guide and advise patients regarding physical, dietary and emotional issues. Single-concept learning, where one aspect of lifestyle management is promoted at a time, is often more successful than inundating a patient with copious amounts of information, most of which does not get retained.

Whereas these methods are being implemented in larger, more advanced and financially viable programmes, the reality in poorer countries is that many programmes are operating with diminished resources, both professionally and financially. Health professionals in such programmes often wear a number of hats, providing advice and services in areas that are beyond the scope of their expertise in risk reduction. As a result, they may need to limit their focus to those interventions that show immediate results, and cannot afford to offer those that have been shown to be beneficial, that are of a more long-term nature (i.e. behavioural intervention).

PHARMACOLOGICAL INTERVENTION

Despite advances in interventions that prevent the recurrence of re-infarction, it is still true that cardiovascular risk factors are being controlled sub-optimally, and that drugs including antiplatelet-, lipid-lowering- and β-blocking agents are being under-prescribed in patients with CAD. However, the impact of pharmacological intervention on survival and recurrent infarctions and cost effectiveness remain uncertain (McAlister et al. 2001).

CLINICAL OUTCOMES OF CARDIAC REHABILITATION

The success of a CAD therapeutic intervention can be measured by its' effect on the following: mortality, morbidity, improvement in symptoms and functional capacity and exercise tolerance (Ades et al. 2000). These outcomes can all be directly appreciated by the patient and should therefore be considered essential in all cardiac rehabilitation programmes.

Cardiovascular Symptoms

Patients with CAD most commonly present with the symptoms of stable exertional angina including shortness of breath and fatigue. Research shows evidence for the improvement of cardiovascular symptoms with exercise, including angina pectoris in patients with CAD, and symptoms of heart failure in patients with LV systolic dysfunction (Redwood et al. 1972; Letac et al. 1977; Lee et al. 1988; Verani et al. 1981). Improvements in dyspnoea and fatigue have been shown in patients with stable chronic heart failure after engaging in long-term moderate intensity exercise training (Belardinelli et al. 1999).

Coronary Risk Factors

The Stanford Coronary Risk Intervention Project (SCRIP) showed that intensive multi-factor risk reduction resulted in a reduction in the rate of coronary atherosclerosis progression and cardiac events in both men and women (Haskell et al. 1994). In this trial, 300 men and women, (mean age 56±7.4 years) with coronary atherosclerosis were randomly assigned to a group that either received usual care from their physicians, or to the intervention group that received multifactor risk reduction. The latter group received individualised programmes with low-fat and cholesterol diets, exercise programmes, weight loss, smoking cessation and lipid lowering medication. The intervention group showed highly significant improvements in risk factors including LDL, HDL, plasma TG, apolipoprotein B and exercise capacity. Furthermore, hospitalisation for this group was decreased for both cardiac and non-cardiac events.

Serum Lipid Profiles

Epidemiological studies have shown a strong positive correlation between increased cardiovascular risk and elevated total serum cholesterol, increased low-density lipoprotein (LDL) cholesterol and low high-density lipoprotein (HDL) cholesterol (Law et al. 1998). Furthermore, it is estimated that elevated serum cholesterol concentrations cause approximately one third of coronary artery disease world-wide (available at URL: http://www.who.int/mediacentre/releases/pr83/en. Accessed 15 October 2003). The relationship between elevated triglyceride (TG) concentrations and cardiovascular risk is more difficult to determine and remains controversial. However it seems that there may be a positive relationship between cardiovascular risk and high TG concentrations (Ginsberg et al. 1997).

The evidence suggests that an aggressive approach to the reduction of elevated LDL cholesterol in patients with CHD is beneficial. The intensity of the risk reduction should be tailored to the patients' risk (NCEP Guidelines, 2001). The combination of regular assessments of blood lipids, aggressive lipid-lowering therapy and regular consultation with the primary care physician seems to triple the compliance to drug therapy and significantly reduces LDL cholesterol concentrations (Ades et al. 1999_b). It is therefore imperative that cardiac rehabilitation programmes include regular assessments of blood lipid concentrations, provide nutritional counselling and are involved in the supervision of drug therapy.

Regular vigorous endurance-type training shows favourable changes in blood lipid profiles (HDL cholesterol, TG concentrations, total:HDL cholesterol ratio, and to a lesser degree LDL cholesterol) of patients with CAD (Hartung et al. 1981; Brubaker et al. 1996). These changes are more pronounced when exercise training, education and dietary modification are applied in combination (Ornish et al. 1990; Schuler et al. 1992).

Despite recommendations by the National Cholesterol Education Programme (2001), recent studies have shown that less than a third of patients with coronary heart disease have LDL cholesterol concentrations of < 2.59 mmol/l (McBride et al. 1998). Indeed, only 42% of patients attending cardiac rehabilitation programmes have LDL concentrations at goal value (Wyman et al. 2002). European research in the area of CAD prevention and reversal states that the lipid goal for patients with CAD should be achieving a total cholesterol below 5.0 mmol/l and an LDL less than 3.0 mmol/l (Wood et al. 1998). If lifestyle changes fail to control these values, drug therapy is advised. HMG CO-A reductase inhibitors (statins) are the drugs of choice in lipid management as these lipid lowering agents have the strongest evidence in reducing morbidity and morbidity in CAD patients.

Body Weight and Body Composition

Obesity is a significant independent predictor of cardiovascular disease in both men and women (Hubert et al. 1983). Furthermore, in excess of 75% of the cardiac rehabilitation population is overweight (BMI >25) (Brochu et al. 2000; Bader et al. 2001). These studies also showed that compared to a control group who did not have CAD, obese subjects were younger and had a greater risk factor profile (higher prevalence of diabetes mellitus and hypertension, larger waist circumference, lower exercise capacity and lower HDL concentrations). Obesity also has implications for the diagnosis of other conditions. Hubert et al. (1983) found that intermittent claudication may be under diagnosed in heavier patients who are unable to walk or exercise sufficiently to elicit claudication symptoms.

Although there is ample research to suggest that a loss of weight and body fat results in improved blood pressure, measures of insulin resistance, blood lipid concentrations and clotting abnormalities (Calles-Escabdon et al. 1996; Lavie et al. 1996), there is no evidence that weight reduction has a positive effect on secondary coronary events in cardiac patients.

The effect of an exercise-only regimen shows minimal and inconsistent results on weight reduction in cardiac rehabilitation programmes (Lavie et al. 1996; Brochu et al. 2000). In contrast, there is a much greater decrease in BMI when significant nutritional and dietary intervention is coupled with exercise training (Ornish et al. 1990; Schuler et al. 1992; Savage et al. 2002).

In light of these findings, obesity should be treated aggressively through exercise and comprehensive lifestyle modification in cardiac rehabilitation programmes. A realistic goal should be set between the clinician and patient, but an average weight loss per week is 0.5 to 1kg until the goal weight has been reached (Wood et al. 1998).

Diabetes Mellitus

Decreased insulin levels and abnormal carbohydrate metabolism are independent risk factors for the development of CAD. Research shows that patients with adult-onset diabetes (type I or type II diabetes) account for up to 16-46% of the population in cardiac rehabilitation programmes (Cannistra et al. 1992; Cannistra et al. 1995). Furthermore, CAD is the ultimate cause of death in more than 50% of diabetic patients, and often presents as silent myocardial ischaemia (Langer et al. 1991). Patients with type II diabetes often present with additional modifiable risk factors and co-morbidities including increased LDL concentrations, decreased HDL concentrations, raised blood pressure, smoking, obesity and clotting abnormalities (Turner et al. 1998).

A combination of weight loss and exercise has been shown to have a favourable influence on reducing insulin requirements and gaining tighter control of blood glucose concentrations. (Horton et al. 1988). Furthermore, higher-intensity exercise programmes have a positive influence on plasma lipoprotein-lipids, glucose tolerance and insulin sensitivity, all of which affect the rate of atherogenesis (Hagberg 1991). With reference to a previous section in this review, the promotion of higher-intensity exercise programmes in chronic disease seems to produce more favourable results than exercise of light or moderate intensity.

Hypertension

Hypertension is an established risk factor for the development and progression of chronic diseases of lifestyle including CAD, cerebrovascular disease, renovascular disease and heart failure (Levy et al. 1996). It is estimated that high blood pressure alone causes 50% of CAD globally (available at URL: http://www.who.int/mediacentre/releases/pr83/en. Accessed 15 October 2003). Consequently the management of blood pressure is an important component in any cardiac rehabilitation programme.

Yet, there is discrepancy in the literature regarding the effects of cardiac rehabilitation and dietary modification on blood pressure in cardiac patients. Some studies found that exercise training in hypertensive and normotensive patients leads to a modest decrease in blood pressure both at rest and during submaximal exercise (Blumenthal et al. 1991), whereas others found significant decreases in systolic and diastolic blood pressure respectively (Haskell et al. 1994). These discrepancies may be due to the confounding effects of additional advice given to hypertensive patients including sodium restriction, moderation or abstinence from alcohol and the use of anti-hypertensive medications.

It seems that exercise training as a sole intervention has inconsistent effects on lowering blood pressure, and therefore multifactorial cardiac rehabilitation that includes dietary intervention and pharmacological therapies should be applied.

Smoking

Tobacco smoking has been reported to cause 20% of coronary artery disease universally (available at URL: http://www.who.int/mediacentre/releases/pr83/en. Accessed 15 October

Teaching patient behavioural skills for coping with high-risk situations, providing relaxation training, selectively prescribing bupropion or nicotine supplements, and maintaining long-term contact with patients are strategies that should be included in a smoking cessation component of a cardiac rehabilitation programme (Ades, 2001). These strategies have been shown to reduce smoking by 17-26% and can prevent its relapse (Heller et al. 1993). Once more, incorporating a patients' readiness to change their smoking habit or quit smoking altogether into the approach may give rise to more successful results.

Morbidity and Mortality

Studies by Oldridge et al. (1989) and O'Connor et al. (1989), report an overall 20-25% reduction in mortality after cardiac rehabilitation compared to control patients over a 3-year and 1-year follow up period respectively. This mortality reduction is similar in magnitude to those reported with the use of beta-blocking drugs after MI or the use of angiotensin converting enzyme inhibitors in patients with left ventricular systolic dysfunction and heart failure.

The overall contribution to this reduction in mortality after cardiac rehabilitation is multi-factorial. Positive changes in psychological profiles (Frasure-Smith et al. 2000), lipid profiles (Redwood et al. 1972; Ades et al. 1999_a), endothelium-mediated coronary vasodilation (Hambrecht et al. 2000; Schahinger et al. 2000), fibrinolysis (Stratton et al. 1991), autonomic tone and heart rate recovery post exercise (Malfatoo et al. 1998; Tiukinhoy et al. 2003) may all contribute.

Furthermore, mortality rates after MI improved drastically with the introduction of intravascular thrombolysis in the 1980's (Muller et al. 1990). As a result, more patients survive MI's and are left with variable amounts of healthy myocardium. This means that patients who might previously have died after a cardiac event are now being referred to rehabilitation programmes as high-risk patients and will require aggressive risk factor modification to halt or reverse the progression of their coronary artery disease. These changes will inevitably have a huge impact on health care expenditure and utilisation. This might also be an additional reason the efforts of cardiac rehabilitation are not translated into clear positive outcomes.

In view of the decrease in overall cardiovascular mortality, a decrease in morbidity is to be expected. These include nonfatal MI's and other acute coronary syndromes and symptoms that result in cardiac hospitalisations. However, there seems to be incongruency in the literature regarding morbidity outcomes after cardiac rehabilitation. Some studies show no decrease in the recurrence of non-fatal myocardial infarctions compared to control groups (Oldridge et al. 1988_b; O'Connor et al 1989) whilst others show a significant decrease in morbidity (Dugmore et al. 1999) and the recurrence of MI's over 5 years (Hedback et al. 1993) after cardiac rehabilitation.

As most of these trials were conducted before the use of thrombolytic and beta-blocking agents in the treatment of MI, it is unclear whether the effects of exercise on the overall cardiovascular mortality rates will be of the same magnitude as previously described (Balady et al. 2000). Furthermore, most of these trials are limited to predominately male, middle-aged and low risk patients. Therefore, a subset of patients who would have benefited from cardiac rehabilitation (i.e. women, high-risk and elderly patients) was excluded from these studies. Available data on the benefits of cardiac rehabilitation in these populations will be discussed in a subsequent section of this review. Suffice to say that the true benefit of cardiac rehabilitation in reducing morbidity and mortality will only be obvious when data is available from a more inclusive study group.

SAFETY AND RISKS OF CARDIAC REHABILITATION

Exercise can both protect against, and provoke sudden death (Albert et al. 2000). In particular, young, highly motivated patients that frequently exceed their prescribed training heart rates during structured exercise but also whilst exercising on their own, are at increased risk of cardiac arrest (Schuler et al. 1992). Some research has found that even low-intensity exercise training and testing may be harmful in patients recovering from anterior transmural myocardial infarction (Jugdutt et al. 1998). However, whereas sudden death from cardiac causes often occurs during or just after physical exertion (Siscovick et al. 1984; Maron et al. 1996), it has been shown that cardiac rehabilitation in a supervised setting is extremely safe. Haskell (1978) estimated a mortality rate of 1 death per 116,402 patient-hours from a multi-centre report of 30 programmes. A larger study showed a cardiac arrest rate of 1 per 111,996 patient-hours, a non-fatal MI rate of 1 per 293,990 patient-hours and a mortality rate of 1 per 783,972 patient-hours (Van Camp et al. 1986).

The beneficial effects of exercise in both the healthy and diseased population do thus not come without risks (Haskell 1994). However, it is reasonable to conclude that the transient risks of primary cardiac arrest are outweighed by the overall cardiovascular benefits of exercise (Siscovick et al. 1984).

Certain precautions can be taken to enhance patient safety during exercise. These include proper pre-exercise screening, adequate medical supervision during exercise, careful attention to physical signs and symptoms during exercise, availability of and easy access to emergency equipment and hospitalisation. Furthermore, Haskell (1987) showed that of the 61 fatal and non-fatal complications, 44 developed during the warm-up or cool-down phase. The use of continuous electrocardiographic (ECG) monitoring during exercise was also associated with a significantly lower rate of fatal complications in this trial. This is especially important in moderate- to high-risk patients. In most cases, myocardial ischaemia and ventricular fibrillation can be avoided by close supervision and monitoring during exercise, and ensuring adequate warm-up and cool-down periods.

The use of monitoring procedures such as heart rate monitoring (either via palpation or watch-type heart rate monitors) is becoming more popular in cardiac rehabilitation programmes. Indeed, all new patients on our programme, are issued with a heart rate monitor to use during their first ten formal exercise sessions, and are thereafter encouraged to acquire one of their own for further use. Educating patients on the importance of training within a safe heart rate zone ensures that these principles can be applied to recreational activities.

RISK STRATIFICATION

Risk stratification of patients who initiate cardiac rehabilitation is important for 2 main reasons. Firstly, patients who are rated moderate- to high-risk, can be selected for more intensive monitoring, pharmacotherapy, or referred for surgery or interventional cardiac catheritisation. Alternatively, low-risk patients can be spared surgery and be encouraged to resume work and activities of daily living sooner (Franklin et al. 1998).

Three factors determine the prognosis, and risk of future events after MI: the amount of residual myocardium at risk, the extent of left ventricular dysfunction and the arrhythmic potential of the heart (DeBusk et al. 1986; Pashkow, 1993).

Exercise stress testing aids in identifying patients who are at risk of developing ischaemia during exercise and might need revascularisation (Krone et al. 1985). In addition, low-level in-hospital exercise testing optimises the discharge process (Topol et al. 1987) and is an accurate predictor of subsequent coronary events (Starling et al. 1981).

Risk stratification, in conjunction with clinical judgement provide guidelines for patient management throughout a programme. It is thus integral to the management of cardiac patients regardless of whether they initiate rehabilitation or not (Krone et al. 1992).

PHASES OF CARDIAC REHABILITATION

There has been some confusion regarding terminology of the phases of cardiac rehabilitation. Cardiac rehabilitation programmes are designed to progress patients through the following phases (Franklin et al. 1998):

Phase I

This phase is generally known as the "in-hospital" period, which has decreased dramatically from the traditional four to six weeks, to four to seven days. Individualised rehabilitation is primarily education- and exercise-orientated. Referral is mainly physician-directed and usually includes information about patients' medical history, needs, goals and expected outcomes.

Phase II

Following hospital discharge (as early as one or two days post-discharge, and within three weeks thereafter), a phase II programme consists of an initial outpatient exercise intervention phase of approximately 12 weeks.

Phase III

The next three to six months are typically classified as a phase III, exercise maintenance programme, including continued encouragement of lifestyle modification.

Phase IV

This constitutes an indefinite period of maintenance of positive lifestyle behaviours achieved whilst attending the cardiac rehabilitation programme.

DURATION OF CARDIAC REHABILITATION PROGRAMMES

Improvements in functional capacity, blood lipids, body composition and other cardiovascular disease risk factors have been noted in patients who attend rehabilitation programmes for at least a limited period of 3 months (Brubaker et al. 1996). These authors noted greater efficacy in changing these parameters in an extended-length programme of longer than 1 year. Whilst physical activity and physical function peaked at 3 months and maintained at programme completion, psychological improvements were noted after the traditional 12-week rehabilitation period (Morrin 2000). In Oldridge's study, the effects of a 20-25% reduction in mortality were evidently influenced if the rehabilitation period was greater than the usual 8-12 weeks (Oldridge et al. 1983).

The results of the Lifestyle Heart Trial (Ornish et al. 1990) (involving a low-fat vegetarian diet, stress management techniques and individually prescribed exercise) showed that a group of heterogeneous patients with CAD, could make comprehensive lifestyle modifications, and maintain them for at least 1 year outside hospital. They concluded that these vigorous lifestyle changes may begin to reverse coronary atherosclerosis in the same period of time. A recent study suggests that patients who attended a Phase III maintenance programme or an extended Phase II programme were more likely to maintain exercise behaviours after 12 months (Bock et al. 2003).

In South Africa, the length of participation in cardiac rehabilitation programmes for patients is currently limited by medical aid schemes to 36 sessions or 12 weeks. Some schemes will then further aid patients in attending a maintenance phase for a subsequent 12 weeks. Alternatively, patients may exit the formal outpatient programme after phase II, (for schedule conflicts or financial reasons), with the goal of maintaining adequate health behaviours without any formal support. However, chronic medical conditions are by definition lengthy and require continuity of care. Furthermore, structured follow-up procedures and long-term management systems to ensure positive outcomes are often not in practise. In such a short time period, patients are often not educated sufficiently or empowered to manage their condition. Changes in risk factors are not often seen in this short time, and therefore the results of short duration cardiac rehabilitation are not as impressive compared to the results of programmes of longer duration.

CARDIAC REHABILITATION IN SPECIAL POPULATIONS:

Whilst there is research showing the benefits of cardiac rehabilitation in young, male subjects, the female and elderly populations have not been as well studied.

Women

Although the risk of MI in women younger than 45 years is relatively low, there is an age-related increase in risk so that over 65 years, the risk is almost equal to that of a man of the same age. As it has been suggested that women experience higher post-infarction morbidity and mortality compared to men, cardiac rehabilitation in women (and research in this area) is becoming critical (Cannistra et al. 1992; Balady et al. 2000). Whilst the benefits of cardiac rehabilitation have been well documented in men, little data are available on the benefits of such programmes in women. Of all randomised clinical trials, in which 4500 patients were evaluated, only 3% were women (O'Connor et al. 1989).

Nevertheless, one study found that although women had a greater coronary risk factor profile (hypertension, diabetes mellitus, higher total serum cholesterol values) than the men on the programme, they demonstrated a similar 30% improvement in their peak functional capacity after 12 weeks of training (Cannistra et al. 1992). In this study, younger women (< 50 years) and those who smoked, and men with a positive family history, who smoked and had home stress were less likely to complete the programme. Furthermore, black women tend to have exercise modifications (Gallagher et al. 2003). More research in this area is required to understand why women are missing from our programmes and what can be done to make programmes more appealing and accessible to them.

Elderly

Exercise training can attenuate the deterioration of peak functional capacity, which declines naturally with age. Unfortunately, most studies in cardiac rehabilitation exclude individuals older than 65 - 70 years. However, in a study by Lavie et al (1993), a group of elderly patients (≥ 65 years) demonstrated improvements in exercise capacity, obesity indexes and lipids similar to that of their younger counterparts (≤ 65 years). Similarly, Rejeski et al. (2002) showed that exercise resulted in improvements in physical function (measured by a six minute walk test), with lower functioning men showing the greatest improvement.

Whilst older patients that have suffered cardiac events are less fit, they may experience a similar increase in functional capacity as their younger counterparts participating in exercise training (Ades et al. 1990). Improvements in functional capacity (measured in MET's) of 34% - 53% after 12 weeks of training in the older population have been reported (Williams et al. 1985; Lavie et al. 1993).

Older adults who have lower baseline functional capacity and subsequent risk for cardiac morbidity and mortality seem to derive the greatest benefit from cardiac rehabilitation (Rejeski et al. 2002). This benefit was enhanced when traditional exercise therapy was coupled with regular group-mediated counselling sessions, aimed at promoting independence and confidence and thus resulting in greater compliance to cardiac rehabilitation.

These data emphasise the need for women and the elderly with coronary heart disease to be referred to and encouraged to participate in cardiac rehabilitation programmes.

MEASUREMENT OF IMPROVEMENT IN PHYSICAL CAPACITY DURING CARDIAC REHABILITATION

Identification of patients who are at risk for sudden death during exercise is an important goal of exercise testing (Zabel et al. 2002). Furthermore, assessing functional capacity is important

These data emphasise the need for women and the elderly with coronary heart disease to be referred to and encouraged to participate in cardiac rehabilitation programmes.

MEASUREMENT OF IMPROVEMENT IN PHYSICAL CAPACITY DURING CARDIAC REHABILITATION

Identification of patients who are at risk for sudden death during exercise is an important goal of exercise testing (Zabel et al. 2002). Furthermore, assessing functional capacity is important in evaluating a cardiac patient's prognosis and responsiveness to therapy (Weisman et al. 2001).

Measures of functional capacity in Cardiac Rehabilitation Programmes are used to stratify risk and determine safe levels of exercise prescription, assess programme efficacy, educate and motivate patients, and to answer specific research questions. The most common current testing procedures include exercise stress testing using a treadmill or cycle ergometer, and the 6-minute walk test.

Stress Electrocardiography

Non-invasive tests such as the exercise stress test (EST), detect myocardial ischaemia and left ventricular dysfunction as a result of chronic CAD (DeBusk 1989; Smith et al. 2000). Further goals of the EST are to assess functional capacity as a guide to further medical management or adjustment of exercise prescriptions.

Although a number of different types of ergometers can be used for testing, the cycle and treadmill are most commonly used. The protocol should generally involve large muscle groups, and should be tolerated by the population being tested (McKelvie et al. 1989). The results of an exercise test are influenced by a number of factors including patient selection, timing and mode of the exercise test, test endpoint and cardiac medications.

Traditional indices that are noted during treadmill testing include peak HR achieved, BP response to graded exercise, ST segment changes, arrhythmias, exercise capacity, and any abnormal cardiovascular symptoms including angina pectoris, shortness of breath and undue fatigue (DeBusk et al. 1989).

Peak treadmill workload (calculated in METs) is conversely related to the extent of cardiac abnormality and disease. One MET is a measure of energy expenditure and is equivalent to an oxygen uptake of 3.5ml.kg^{-1}.min^{-1}. The inability to complete a 4-MET workload reflects severe left ventricular dysfunction and indicates poor prognosis (DeBusk 1989). Exercise capacity has been shown to be an independent predictor of all-cause and cardiovascular mortality in patients who are able to perform maximal tests to exhaustion (Vanhees et al. 1994; Myers et al. 2002).

The use of the EST in screening for CAD in asymptomatic persons is not warranted (Smith et al. 2000). However, in this statement by the AHA, exercise testing is deemed useful in targeting risk factors and evaluating the cause of myocardial ischaemia in asymptomatic men who are over the age of 40 years and have cardiovascular risk factors. The detection of myocardial ischaemia is often dependant on the prevalence of underlying disease, specifically flow-limiting coronary stenosis. However, if screening is done in asymptomatic patients, many positive tests are regarded as false-positives. This questions the relevance of exercise testing in patients with a low prevalence of disease (Smith et al. 2000).

Exercise-induced ST segment depression is frequently seen in patients with CAD, and is associated with myocardial ischaemia (Michaelides et al. 1998). In patients who have undergone percutaneous transluminal coronary angioplasty (PTCA), stress testing at 3 months revealed ST-segment changes in other leads in the absence of restenosis, resulting in a false-positive result (Michaelides et al. 1998). The significance of exercise testing in this context is not clear. Stress testing has been shown to be valuable in assessing the prognosis of patients with acute MI. Patients who are able to undergo testing within a 3-week period of their MI have a mortality rate of between one third and one sixth of patients who are unable to undergo testing as a result of unstable angina and heart failure (DeBusk et al. 1989).

In practice, patients undergo exercise stress testing at hospital discharge, where protocols of arbitrary target heart rates of between 120-140 bpm are often used (Schlant et al. 1986). Alternatively, patients undergo testing under the supervision of their cardiologist or physician before joining a rehabilitation programme. Exercise stress testing enables cardiologists to confirm their diagnosis, and to make or change decisions regarding further interventions, for example coronary angiography (Bobbio et al. 1993). These results are used by programme staff in the programme design to ensure it is individualised and safe. Whereas these results provide an accurate indication of safe limits for exercise, it is questionable whether patients' true functional capacity is accurately reflected. In our experience, exercise intensity is often under prescribed based on these results. To this end it is essential to distinguish between heart rate- and symptom-limited exercise testing as this has a direct bearing on the information used for exercise prescription. This question will be investigated in a subsequent section of this thesis.

The safety of performing exercise testing has been documented. The risk of sudden death, nonfatal MI, and serious arrhythmias, was 51 per 10 000, 3.6 per 10 000 and 4.8 per 10 000 tests performed respectively in a group of patients with CAD (Stuart et al. 1980). However, this risk is largely limited to patients who have left ventricular dysfunction or myocardial ischaemia. Patients are often symptom limited long before the set heart rate target has been reached. In patients with MI, exercise testing 3 days after onset has been shown to be safe and predictive of in-hospital clinical outcomes (Topol et al. 1987).

However, the EST is a laboratory test and its clinical relevance has been questioned in a number of studies (Francis et al. 1994; Walsh et al. 1995). Silent CAD is unpredictable and has lead to many physicians using exercise electrocardiography to screen for the disease (Sox et al. 1989). Whilst the exercise ECG has clinical relevance in the diagnosis of disease (Smith et al. 2000), it's practical application in the prescription of exercise is questionable. Certainly in patients attending programmes of higher intensity (for example Phase III patients), the use of the exercise ECG for exercise prescription needs to be re-visited. This resulted in the development of various corridor walk tests, all designed to assess exercise capacity in a more natural way (Staniforth et al. 1998).

6- minute walk test

The 6-minute walk test is a standard measure of functional capacity for patients attending cardiac and pulmonary rehabilitation programmes (Gyuatt et al. 1985; Wright et al. 2001). Research has confirmed the value of the 6-minute walk test in various chronic disease conditions. It is a reliable assessment tool in patients with peripheral occlusive arterial disease (POAD) (Montgomery et al. 1998). Furthermore, it is a simple, inexpensive yet practical test of functional capacity with good correlation with bicycle and treadmill ergometry for patients with pacemakers (Langenfeld et al. 1990). In heart failure, it has been shown to be highly reproducible (O'Keeffe et al. 1998; Demers et al. 2001) and an accurate measure of variations in functional capacity produced by pharmacological interventions (Gualeni et al. 1998). It has also been reported to predict peak oxygen uptake and survival (Cahalin et al. 1996; Roul et al. 1998), mortality and hospitalisation in patients with advanced congestive heart failure (Shah et al. 2001).

The validity of this test in earlier phases of cardiac rehabilitation and severe disease states is therefore well recognised. However, the use of this test has not been studied in later phases of cardiac rehabilitation. It is questionable whether this test is accurate in assessing functional capacity in patients who are accustomed to higher intensity exercise. This question will be addressed in the third chapter of this thesis.

COMPLIANCE TO CARDIAC REHABILITATION SERVICES

Long-term adherence and compliance to lifestyle modification strategies is vital in the improvement of patient outcomes. Results from a South African study showed that physical work capacity and coronary risk factors only improved in those patients who attended cardiac rehabilitation regularly (Digenio et al. 1991). Unfortunately, only half or less of those who initiate health-related behaviours will continue (Franklin et al. 1997).

Compliance to cardiac rehabilitation is typically considered to decrease over time. In a review by Oldridge (1991_a), he describes adherence rates for cardiac rehabilitation programmes to generally exceed 80% for the first 6 months, fall to 70% at 12 months and 35-60% at 2 to 4 years. In contrast, at 1 year, there is a 64% compliance rate for anti-hypertensive medication (Dunbar-Jacob et al. 1991) and 82% for lipid-lowering agents (Kruse 1991). Little is known about compliance to other interventions including nutritional counselling aimed specifically at weight loss and blood lipid control, but it is thought to be poor.

In order to encourage enrollment in cardiac rehabilitation programmes, it is essential to understand the perceptions of patients who comply and those who don't. Table 1.2 shows the factors that are related to high patient dropout that are either avoidable or unavoidable

(Oldridge 1991a). Results from previous a previous study by Oldridge et al. (1990) showed that approximately 40% of dropouts occurred for avoidable reasons, and 60% for unavoidable.

Table 1.2. Factors related to high dropout rates in patients attending cardiac rehabilitation programmes.

Factor	Avoidable	Un-avoidable
Patient Characteristics		
Smoker	•	
Overweight	•	
Low self-motivation	•	
Habitual physical activity	•	
Lack of interest in the programme	•	•
Programme Characteristics		
Type (individual/group)	•	
Unfriendly/Unhelpful staff members	•	
Inconvenient location	•	
Inconvenient time	•	•
Other		
Symptoms	•	•
Medical factors		•
Lack of support from family spouse or family	•	•
Job-related factors (blue collar employment)	•	•

Patient motivation to maintain healthy behaviour change and belief in the benefits of exercise has a direct influence on overall compliance (Andrew et al. 1981). Patient involvement in their rehabilitation and feedback on their expectations of progress, programme performance and personal outcomes is vital and may have a positive effect on dropout rates. Furthermore, as primary and secondary prevention programmes yet need to prove their cost-effectiveness, it is essential that patients' participation in these programmes is optimised and compliance enhancing programmes developed (Oldridge 1991a).

Recent research showed the value of incorporating a patients' readiness to change in the prescription of lifestyle modification (Prochaska 1993). This approach describes 6 stages a patient might go through when considering change (pre-contemplation, contemplation, preparation, action, maintenance, and termination). Outcomes are improved when rehabilitation and education is guided by the stage of change a patient may be at for each individual intervention component (weight loss, exercise, smoking cessation and stress management). In this model, patients focus only on those areas they feel ready to deal with. It would then follow that programmes incorporating this approach show more successful results. These interventions are now incorporated into modern-day primary prevention as well as secondary prevention programmes (e.g. cardiac rehabilitation programmes).

Programmes of longer duration have been shown to have higher rates of dropout (Gillum et al. 1974). In conclusion, it would be beneficial to identify patients who are likely to dropout early (Oldridge et al. 1983), and practitioners and exercise specialists should be trained to recognise patients who do not seem enthusiastic about their programme, or who seem unduly fatigued by either their work, or the exercise programme (Andrew et al. 1981). It is thus essential to implement proactive compliance-enhancing strategies in an effort to encourage long-term participation in cardiac rehabilitation programmes.

COST-EFFECTIVENESS OF CARDIAC REHABILITATION

Cost-effectiveness is a measure of the efficiency with which financial resources are translated into health outcomes (for example, longevity) (Sox et al. 1989). Whereas the benefits and relatively low risks of cardiac rehabilitation programmes have been shown, the cost-efficacy of such programmes is still questioned.

Although the data are limited, cardiac rehabilitation programmes have been shown to be cost-effective with a direct saving to patients, the community and medical aid schemes (Levin et al; 1991, Oldridge et al. 1993). Furthermore, cardiac rehabilitation has been shown to predict lower cardiac-related re-hospitalisation costs in post-coronary event patients, lessen the need for chronic medications, and result in patients returning to work in shorter periods of time with resultant diminished costs for sick leave (Hedback et al. 1987; Levin et al. 1991; Ades et al. 1992).

In a Swedish study, the cost for cardiac rehabilitation was offset by the lower rates of hospitalisation and increased work productivity, resulting in a 5-year cost-saving to the Swedish health-care system of $12,000 per patient (Levin et al. 1991). Similarly, a study by Oldridge et al. (1993), expressed the cost-effectiveness of cardiac rehabilitation for post MI patients, adjusted for quality of life, as $9,200 per year of life saved in the United States of America.

The cost-efficacy of cardiac rehabilitation compares favourably with the other forms of preventative measures prescribed in cardiology (e.g. CABG). Rehabilitation has been shown to be more cost-effective than the use of Captopril for hypertension or Lovastatin for hypercholesterolaemia, but compares less favourably with smoking cessation or the use of Aspirin and β-blockers after acute MI. Despite these data, third parties are still withholding support of cardiac rehabilitation services in many cases, thus limiting its accessibility to patients.

CARDIAC REHABILITATION – STATUS QUO

Community-based projects and services are often under-valued and under-utilised. Intervention programmes can be provided through comprehensive and established cardiac rehabilitation programmes or in low resource settings as part of clinic-based medical management. Friedman et al. (1997) published a report showing excellent compliance rates (90%) and improvements in submaximal work capacity and risk factors in indigent patients participating in a small cardiac rehabilitation programme. The authors ascribe their success to an individualised, personal approach as opposed to more clinical, impersonal ambiences in larger, more affluent centres.

Accessibility to these programmes is still a major concern with only a certain portion of the eligible population able to benefit from regular exercise training intervention. Group and home-based programmes, and new advances in electronic communication and medicine technology have increased accessibility to rehabilitation services. Furthermore, these programmes have shown improved patient-physician communication and benefits in preventive care, cardiovascular disease and in low risk CABG patients, either independently or in conjunction with cardiac rehabilitation (Balas et al. 1997; Arthur et al. 2002; Southard et al. 2003).

Exciting new developments in this field include INTER$_x$VENT, which is a comprehensive cardiovascular risk reduction programme that has addressed many of the barriers to participation to other such programmes. In their model, patients have the option of joining formal cardiac rehabilitation programmes, or attending either a 12- or 52 week community based risk reduction programme at easily accessible sites including shopping malls, hospitals, doctor's surgeries and fitness facilities. Patients are guided and mentored during their scheduled sessions by health care professionals including doctors, nurses, exercise physiologists, physiotherapists and dieticians. This programme makes use of various modalities, including the Internet, audiocassettes, home based learning or one-on-one mentoring in a comprehensive approach to risk reduction with the emphasis on long-term lifestyle behaviour. This less costly approach showed significant improvements in systolic and diastolic blood pressure, LDL cholesterol, triglycerides, VO_{2max} and weight from baseline measures. The changes in total cholesterol were significantly greater compared to those achieved in a conventional phase 2 cardiac rehabilitation programme (Gordon et al. 2000). The programme has been shown effective in a number of population groups including males, females, different ethnic groups, healthy individuals and those with diabetes mellitus, stroke and CAD (Gordon et al. 2000).

SUMMARY OF LITERATURE REVIEW AND AIM OF THIS THESIS

Chronic disease risk reduction and reversal as both primary and secondary prevention approaches has become imperative in combating CAD that is claiming millions of lives throughout the world. Idealistically, cardiac rehabilitation programmes are the perfect dispensing depots for such services. However, there are certain limitations to cardiac rehabilitation programmes (as we know them), which may explain the lack of convincing benefits to such interventions, many of which have been discussed earlier in this review.

Firstly, compliance with cardiac rehabilitation programmes remains remarkably low (Oldridge et al. 1988_a), with only 10-47% of eligible patients participating in formal programmes (Wenger et al. 1995; Thomas et al. 1996; Evenson et al. 1998). It is therefore essential that health care professionals involved in cardiac rehabilitation constantly re-evaluate whether programme goals are being met. Furthermore, more innovative approaches should be investigated to ensure that these services are accessible to a greater percentage of the population.

Secondly, standard 12-week cardiac rehabilitation programmes may not be of sufficient duration to effectively treat CAD, which is a more chronic affliction.

Thirdly, most cardiac rehabilitation programmes are still focusing primarily on exercise training only, and patients are not receiving adequate input in additional areas of lifestyle modification including dietary intervention, stress management and behavioural counselling. From this review of the literature, it is clear that exercise training alone has only a modest effect on recognised risk factors.

Fourthly, one of the challenges facing cardiac rehabilitation programmes is the shift in the global disease burden from single-disease to multiple chronic conditions. With medical advances, patients' hospital stay is decreasing, and older, sicker patients are entering cardiac rehabilitation programmes. The aim of **Chapter Two** of this thesis is to assess the multi-disease profile of patients who attended the Cardiac Rehabilitation Programme at the Sports Science Institute of South Africa from January 1996 to August 2000. This chapter will document medical and demographical characteristics, musculo-skeletal injuries and medication use. It is important to understand the full impact that this "new" patient profile in our programmes will have on programme structure including staffing and equipment.

To quantify improvements in physical activity in patients attending cardiac rehabilitation programmes, exercise tests are used. At present, the six minute walk test and the exercise stress test are most commonly used. From this literature review, it is clear that both of these tests have limitations in certain phases of cardiac rehabilitation. In particular, it seems that the six minute walk tests' accuracy in portraying true functional capacity in later phases of cardiac rehabilitation is questioned. **Chapter Three** of this thesis will address the use of this traditional test vs. the "Unrestricted Locomotion Test" (ULT) where patients are instructed to cover as much distance as they can in 6 minutes, and are allowed to run if they wish.

Chapter 4 will assess the safety of the ULT vs. the standard measure of safety in exercise prescription in patients attending cardiac rehabilitation, the stress ECG.

The results of this study will contribute to the understanding of:

- The patient profile of patients attending cardiac rehabilitation programmes and it's effects on equipment and staffing requirements.
- Accurately assessing functional capacity during participation in phase III cardiac rehabilitation programmes.

CHAPTER TWO

PHYSIOLOGICAL AND MEDICAL PROFILES OF PATIENTS ATTENDING CARDIAC RISK FACTOR REDUCTION AND REVERSAL PROGRAMMES: IMPLICATIONS FOR STAFFING AND EQUIPMENT.

INTRODUCTION

The delivery of cardiac rehabilitation services has undergone much transformation during the last 3 decades. Early cardiac rehabilitation programmes catered mostly for those who had recovered from uncomplicated MI (De Busk et al. 1979; Kallio et al. 1979; Hung et al. 1984). Contemporary programmes include patients recovering from complicated MI (Jugdutt et al. 1988), and those who are recovering from procedures such as coronary artery bypass graft (CABG), percutaneous transluminal coronary angioplasty (PTCA) and other forms of coronary revascularisation (Heath et al. 1987; Ben-Ari et al. 1989; Schuler et al. 1992). Furthermore, many patients who have severe and complicated cardiac illness, including cardiac failure, are now deriving benefit from comprehensive rehabilitative cardiac care, which comprises supervised exercise training, education, nutritional strategies, counselling and behavioural intervention. Such programmes throughout the world are termed "Cardiac Rehabilitation Programmes", and are modelled on cardiovascular disease rehabilitation requirements.

Physical activity is also being included in the treatment plan for patients with other chronic lifestyle diseases including chronic obstructive pulmonary disease (COPD), chronic renal failure, osteoporosis, diabetes mellitus, peripheral vascular disease (PVD), arthritis, cancer, fibromyalgia and chronic fatigue syndrome (American College of Sports Medicine: Exercise Management in Patients with Chronic Disease). Conventional "cardiac" rehabilitation programmes, however, would not have catered for patients with other chronic co-morbidities. This would have important implications for the staffing and equipment of these "chronic disease" rehabilitation programmes. For example, the exercise rehabilitation of a patient with COPD involves several different facets. In adjunct to a personalised exercise regimen, specific breathing techniques using methods including pursed lip breathing which slow the respiratory rate should be taught. Oxygen should be administered to severely restricted patients. Oxygen saturation measuring devices are essential, and patients are encouraged to measure their oxygen saturation at different stages throughout their exercise sessions.

The recommended mode of exercise training for patients with rheumatoid- and osteo-arthritis is non-weight bearing, low impact activities, where the load on the joints is reduced. In contrast, patients with osteoporosis are encouraged to engage in resistance training and weight bearing exercise, as it is now accepted that strength training contributes to the conservation of bone loss in these patients. Diabetic patients should be educated on the effects of the interaction of timing of their exercise training and medication regimens. Equipment should be available for patients to monitor their blood glucose concentrations before and after exercise. In addition, given the elderly population entering these programmes, a large proportion of patients require rehabilitation for musculo-skeletal injuries (American College of Sports Medicine: Exercise Management in Patients with Chronic Disease). Yet the extent of these co-morbidities in cardiac rehabilitation programmes has not yet previously been documented.

Furthermore, the number of individuals who become chronically affected and debilitated by additional chronic diseases of lifestyle such as chronic obstructive pulmonary disease (COPD), chronic renal failure, diabetes mellitus and peripheral vascular disease (PVD), and who have cardiovascular disease and a major co-morbidity is increasing (Digenio 1993). Indeed, an observation at the Cardiac Rehabilitation Programme at the Sports Science Institute of South Africa in Cape Town is that patients often present with co-morbidities in addition to their core cardiovascular disease concerns that need medical consideration when prescribing exercise.

AIM

Accordingly, the aim of the first chapter of this thesis is to determine the disease profile of patients attending the Cardiac Rehabilitation Programme at the Sports Science Institute of South Africa in Cape Town. This is a medically supervised exercise rehabilitation programme, which caters for patients with chronic cardiac disease.

SUBJECTS AND METHODS

A retrospective review of medical records and interviews was conducted on all patients who had been referred to the Cardiac Rehabilitation Programme at the Sports Science Institute of South Africa, between January 1996 and August 2000.

The purpose and risks involved in the study were outlined to patients in an informed consent form before initiating cardiac rehabilitation. The study was approved by the Ethics and Research Committee of the Faculty of Medicine at the University of Cape Town.

The initial evaluation of all patients consisted of a consultation with a medical doctor, which includes a thorough medical history, a physical examination and biomechanical evaluation to identify any musculo-skeletal abnormalities that require medical attention and consideration in the prescription of exercise. An effort electrocardiogram and/or lung function test is performed if required.

The second visit to the rehabilitation centre comprised an assessment of risk factors (blood pressure, finger-prick cholesterol concentration, heart rate), a test of functional capacity (evaluated by the 6-minute walk test) and body composition (BMI, % body fat, waist and hip girth measurements).

STUDY POPULATION

313 patients were enrolled into the rehabilitation programme during the specified time. These patients represent a cross-section of age, gender, race and ethnic groups, and medically referred and self-referred patients.

DATA COLLECTION

All initial medical examinations and testing of functional capacity were conducted at the Sports Science Institute of South Africa. Clinical and demographic data extracted from the medical assessment included:

1. Demographic data

i. Age on entry to the programme.

2. Anthropometrical analysis of body composition

On the first visit, height (to the nearest 0.5cm) and weight (to the nearest 100g) were measured using a Seca (Model 708) scale with a calibrated ruler. BMI was then calculated by dividing body weight in kilograms by height in metres squared (kg/m^2). Waist and hip circumference were measured with a tape measure.

The thickness of the right triceps, biceps, subscapular and supra-iliac skinfolds were measured. The mean of the three skinfold measurements at each site was calculated and the equivalent fat content was determined as a percentage of the body mass according to the method of Durnin and Womersly (1974).

3. Assessment of functional capacity using the 6-minute walk

Patients performed a 6-minute walk test to determine maximum distance covered (meters) and peak heart rate (bpm). Subjects were instructed to cover as much distance as possible by walking around a 135-metre indoor rubber track in six minutes. During the test, patients were aware of the time to completion.

4. **Medical profiles**

From the review of patients' medical files, the documented disease states were determined and categorised as follows:

Documented coronary artery disease (CAD) only - (CAD).

This group comprised patients who attended the programme for rehabilitation of CAD only.

CAD and the presence of another chronic disease - (CAD+CD)

This group required medical and exercise intervention for an additional chronic disease in addition to the patients' chronic cardiac considerations. Chronic Diseases include diabetes mellitus (non-insulin- and insulin-dependant diabetes), COPD, asthma, cystic fibrosis, cancer, osteoporosis, fibromyalgia and chronic fatigue syndrome, renal failure, neuromuscular disorders, clinical depression, cerebrovascular accident (CVA) and peripheral vascular disease (PVD).

CAD and a diagnosed musculo-skeletal injury requiring rehabilitation - (CAD+M).

A musculo-skeletal injury was documented if the patient presented with a musculo-skeletal condition, which would require specific rehabilitation as directed by the sports physician who assessed the patient on entry into the programme. Injuries are classified into joint categories by anatomical location.

CAD, another chronic disease and a musculo-skeletal injury - (CAD+CD+M)

This group of patients had CAD as their main medical consideration, but also required specific medical advice and rehabilitation for another co-morbidity and a musculo-skeletal injury.

Primary prevention of CAD only - (PP).

This constituted a group of patients with two or more risk factors for CAD. These included hypertension (> 140/90 mmHg), hypercholesterolaemia (>5 mmol/l), obesity (BMI >25), physical inactivity, smoking, age (males >55 years and females >45 years) and a family history of CAD.

Primary prevention and another chronic disease - (PP+CD).

Patients who attended the programme primarily for the rehabilitation of another chronic disease, but also presented with risk factors for CAD (as described above) requiring medical attention, were placed in this category.

Chronic disease (excluding CAD) only (CD).

This group constituted patients seeking rehabilitation for a chronic disease other than CAD.

4. Surgical interventions

Revascularisation and other coronary surgical procedures were documented. These included: CABG, PTCA with or without stent, valve replacement or repair, endarterectomy and implantation of cardio-defibrillator.

5. Medications

A medication inventory was compiled for all patients entering the programme.

6. Musculo-skeletal injuries

An injury was defined as a musculo-skeletal complaint leading the patient to seek medical advice in this regard. These chronic or acute musculo-skeletal injuries as assessed by the medical doctor, were classified into joint categories, and then further sub-categorised into specific joint injuries based on anatomical location.

OA and RA are well-recognised chronic degenerative joint disease states, but present mostly as patients complaining of pain of the large weight-bearing joints and resultant deformity and limitation of movement. Thus they have been included as injury during classification.

STATISTICAL ANALYSIS

Descriptive statistics were carried out on all test results. Results are expressed as means ± standard deviation (SD), and as percentages of the relevant group, rounded off to the nearest one decimal point.

RESULTS

Gender distribution of patients on the programme

Table 2.1 shows the number of men and women who were enrolled consecutively into the programme.

Table 2.1: Number of men and women participating in the Cardiac Rehabilitation Programme at the Sports Science Institute of South Africa.

	n	% of total population
Total number of patients	313	100
Males	238	76
Females	75	24

313 patients were evaluated. Male participants constituted 76% and females 24% of the total programme population.

Subject characteristics on entry to the programme

Subject characteristics are listed in Table 2.2. All values are expressed as means ± standard deviations (SD).

Table 2.2: Characteristics of the patients attending the Cardiac Rehabilitation Programme at the Sports Science Institute of South Africa.

	Total	Females	Males
Average age (yrs)	56.9 ± 11.0	55.6 ± 13.0	57.3 ± 11.0
Height (cm)	169.4 ± 22.0	163.3 ± 6.7	174.1 ± 7.4
Weight (kg)	83.8 ± 8.0	72.6 ± 15.9	86.5 ± 16.9
BMI	29.3 ± 20.0	27.3 ± 6.0	28.5 ± 5.6
Waist circumference (cm)	99.7 ± 14.3	92.4 ± 15.0	102.6 ± 13.2
Hip circumference (cm)	105.7 ± 11.2	106.8 ± 12.0	206.0 ± 10.4
Waist:hip ratio	0.9 ± 0.1	0.9 ± 0.1	0.98 ± .01
Body fat %	28.8 ± 6.5	33.7 ± 6.7	27.5 ± 6.0
Resting heart rate (bpm)	72.0 ± 13.0	73.0 ± 13.0	71.0 ± 13.0
Resting systolic blood pressure (mmHg)	136.0 ± 18.0	134.0 ± 18.0	138.0 ± 18.0
Resting diastolic blood pressure (mmHg)	84.0 ± 11.0	82.0 ± 9.0	85.0 ± 11.0
6 minute walk distance (m)	569.3 ± 110.0	530.7 ± 103.3	574.9 ± 114.9
Heart rate at termination of test	104.0 ± 23.0	207.0 ± 23.0	101.0 ± 22.4
Fingerprick cholesterol (mmol/l)	5.0 ± 1.1	5.0 ± 1.0	5.0 ± 1.2
Fingerprick glucose (mmol/l) (diabetic patients only)	10.5 ± 3.9	9.8 ± 2.0	10.3 ± 3.7

*Values are shown as mean ± standard deviations (SD).

The age of male and female participants was not significantly different, with the male participants only slightly older. The risk profile of the group showed a raised BMI and waist:hip ratio, normal blood pressure and cholesterol concentrations and elevated glucose values for the group of diabetic patients.

Medical profiles

Initial analysis of medical profiles involved classifying patients as those presenting with CAD (alone, or in conjunction with another chronic disease), or those who have a chronic disease only. Data are shown in Table 2.3.

Table 2.3: Medical profiles of all patients attending the Cardiac Rehabilitation Programme (n=313).

Category	n	% of total programme population
CAD	251	80.2
CD only	62	19.8

Abbreviations: CAD = Coronary Artery Disease; CD = Chronic Disease.

Patients with documented CAD (n = 251) constituted 80.2% of the total programme population. The remainder of the group (n = 62) presented with another chronic disease requiring rehabilitation. These two groups are further analysed in Tables 2.4 and 2.7.

Profile analysis of patients with CAD

The profiles of patients with documented CAD were further analysed to determine the composition of this group. These results are shown in Table 2.4.

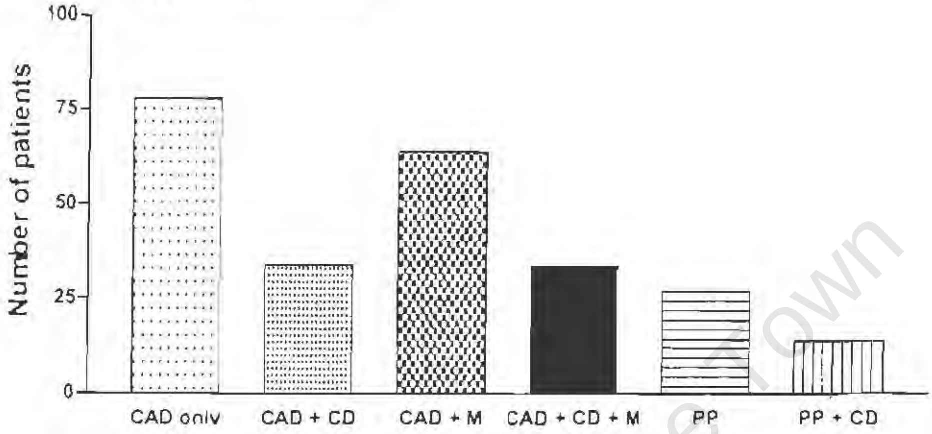
Table 2.4: Profiles of patients with documented CAD for secondary prevention, or risk factors for CAD requiring primary prevention (n = 251).

	n	% of total programme population	% of CAD population
CAD only	78	24.9	31.1
CAD + M	64	20.4	25.5
CAD + CD	34	10.9	13.5
CAD + CD + M	34	10.9	13.5
PP	27	8.6	10.8
PP + CD	14	4.5	5.6

Abbreviations: CAD = Coronary Artery Disease; CAD + CD = CAD and a chronic disease; CAD + M = CAD and a musculo-skeletal injury; CAD + CD + M = CAD, another chronic disease and a musculo-skeletal injury; PP = Primary prevention of CAD only; PP + CD = Primary prevention of CAD and another chronic disease; CD = Chronic disease only.

Only 25% of the total programme population presented with CAD only, whilst patients with CAD and an additional co-morbidity, and those with CAD requiring rehabilitation for a musculo-skeletal injury represented 11% and 20% of all participants respectively. These data are displayed graphically in Figure 2.1.

Figure 2.1: Profiles of patients with documented CAD for secondary prevention, or risk factors for CAD requiring primary prevention (n = 251).



Abbreviations: CAD = Coronary Artery Disease; CAD + CD = CAD and a chronic disease; CAD + M = CAD and a musculo-skeletal injury; CAD + CD + M = CAD, another chronic disease and a musculo-skeletal injury; PP = Primary prevention of CAD only; PP + CD = Primary prevention of CAD and another chronic disease; CD = Chronic disease only.

The profiles of patients who had either documented cardiac disease, or required rehabilitation to prevent the development thereof, were further analysed. These data are displayed in Table 2.5.

Table 2.5: Analysis of cardiovascular disease and associated conditions for secondary prevention documentation (n=284).

Condition	n	% of cardiovascular conditions
Diagnosed CAD	161	56.7
Chronic stable angina	42	14.7
Primary prevention only	28	9.8
Arrhythmia	16	5.6
Primary prevention + other chronic disease	12	4.2
Ischaemic cardiomyopathy	9	3.2
Valvular disease	5	1.8
Chronic congestive cardiac failure	4	1.4
Atrial septum defect	2	0.7
Cardiac hypertrophy	2	0.7

Myocarditis	1	0.4
Ventricular dysplasia	1	0.4
Neurocardiogenic syncope	1	0.4

Abbreviations: CAD = Coronary Artery Disease.

251 patients had documented CAD that required either secondary prevention, or had risk factors for CAD requiring primary prevention. The total number of CAD conditions is higher than the number of patients (n = 84) as some patients presented with more than one cardiac condition. Traditionally, only low risk patients with CAD or post MI were thought eligible for cardiac rehabilitation. These results show that higher risk patients with arrhythmia and ischaemic cardiomyopathy are also presently attending the rehabilitation programme.

Surgical interventions

Revascularisation and other coronary surgical procedures undergone by the group of patients with CAD are listed in Table 2.6.

Table 2.6: Analysis of all revascularisation and other coronary surgical procedures (n=184).

Interventions	n	% of all interventions
CABG	72	39.1
PTCA	58	31.5
PTCA + stent insertion	35	19.1
Pacemaker insertion	8	4.4
Valve replacement	4	2.2
Valve repair	3	1.6
Cardioversion	2	1.1
Endarterectomy	1	0.5
Implantation of cardio-defibrillator	1	0.5

Abbreviations: PTCA = percutaneous transluminal coronary angioplasty; CABG = coronary artery bypass graft.

161 patients required cardiovascular surgery. A total of 184 surgeries were documented, with some patients undergoing multiple surgical procedures. CABG and balloon angioplasty were the most common procedures performed in this group.

Analysis of chronic diseases profiles

The identified chronic diseases requiring additional medical intervention are listed in Table 2.7.

Table 2.7: Analysis of all documented chronic diseases of lifestyle (n=175).

Chronic Disease of Lifestyle	n	% of all chronic diseases
Metabolic Diseases	49	28.0
IDDM (Type I)	6	
NIDDM (Type II)	43	
Respiratory Diseases	38	21.7
COPD	27	
Asthma	10	
CF	1	
Neurological Disorders	26	14.9
Neuromuscular disorder	1	
Depression	8	
CVA	12	
Bell's Palsy	1	
Polio	2	
Muscular Dystrophy	1	
MS	1	
Rheumatological Disorders	20	11.4
Fibromyalgia/CFS	20	
Vascular Diseases	14	8.0
PVD	14	
Musculo-skeletal Diseases	12	6.9
Osteoporosis	12	
Neoplastic Disorders	11	6.3
Cancer	11	
Immunological Disorders	2	1.1
Autoimmune disease	1	
SLE	1	
Infection	2	1.1
HIV	1	
Cystitis	1	
Renal Diseases	1	0.6
Renal failure	1	

Abbreviations: IDDM = Insulin dependant diabetes mellitus; NIDDM = Non-insulin dependant diabetes mellitus; COPD = chronic obstructive pulmonary disease; CF = cystic fibrosis; CFS = chronic fatigue syndrome; HIV = human immunodeficiency virus; SLE = Systemic lupus erythematosus; CVA = Cerebrovascular accident; MS = Multiple Sclerosis; PVD = Peripheral Vascular Disease)

As previously stated, 20% (62 patients) of the total programme population attended our programme for chronic disease rehabilitation only. The above table lists all co-morbid conditions including the 20% "chronic disease only" group, but also those noted in the secondary and primary cardiac prevention group. Diabetes Mellitus, (particularly Type II diabetes), and respiratory disease, were the most common chronic diseases noted.

MEDICATIONS

A medication inventory was compiled of all medication taken by patients on the programme. These data are shown in Table 2.8.

Table 2.8: Medication taken by all patients attending the Cardiac Rehabilitation Programme.

DESCRIPTION	CLASS	Total per class	GENERIC NAME	Total per generic
CARDIOVASCULAR SYSTEM				
Cardiac glycosides	Digitalis	10	Digitalis	10
Anti-arrhythmics	Anti-arrhythmics	5	Amiodarone	5
Anti-hypertensives	Alpha-blockers	3	Doxazin	3
	Beta-blockers	113	Acebutalol	18
			Atenolol	68
			Betaxolol	2
			Bisoprolol	14
			Levobunalol	1
			Metoprolol	2
			Nadolol	2
			Propanolol	3
			Sotalol	3
	Alpha- & Beta-blockers	7	Carvedilol	7
	Sympathetic nervous blockers	1	Reserpine	1
	Calcium-channel blockers	45	Amlodipine besylate	17
			Diltiazem	11
			Felodipine	1
			Isradipine	5
			Nifedipine	2
			Nisoldipine	2
			Verapimil	7
	ACE-inhibitors	78	Benazapril	1
			Captopril	6
			Cilazapril	1
			Enalopril	13
			Fosinopril	1
			Lisinopril	7
			Perindopril	27
			Quinapril	6
			Ramipril	14
			Trandalopril	1
			Valsartin	1
	Angiotensin receptor antagonists	8	Ibresartan	1
			Losartan	7
	Potassium-sparing	(36)	Amiloride	4
	diuretics	6		
			Bumetanide	1
			Spironolactone	1
	Loop diuretics	17	Furosemide	17
	Thiazide diuretics	13	Hydro-chlorothiazide	2
			Mefruside	3
			Indapamide	7
			Tamsulosin	1
	ACE- & Calcium-channel blockers	2	Verapamil + Trandolapril	2
	ACE-inhibitor & Diuretics	3	Lisinopril + Diuretic	3
	ACE-inhibitor & Diuretics	1	Quinapril + Diuretic	1
	Beta-blocker & Diuretics	3	Atenolol + Chlorthalidone	3
Anti-anginal agents	Organic nitrates	20	Glyceral Trinitrate	6
			Isosorbide dinitrate	3

			Isosorbide mononitrate	11
Platelet aggregation inhibitors	Anti-coagulants	194	Aspirin	131
			Dipyridamole	2
			Ecotrin	39
			Heparin	1
			Warfarin Sodium	21
Hipolipidaemic agents	Statins	(136) 133	Atorvastatin	74
			Fluvastatin	11
			Simvastatin	43
			Pravastatin	5
	Fibrates	3	Bezafibrate	2
			Fenofibrate	1
RESPIRATORY SYSTEM				
Bronchodilators	Sympatho-mimetics	21	Salbutamol	5
			Fenoterol	6
			Terbutaline	1
			Formoterol	3
			Salmeterol	6
	Methylxanthines & combinations	1	Aminophylline	1
	Combinations	1	Salbutamol + Ipratropium bromide	1
Glucocorticoids	Glucocorticoids	20	Beclomethasone dipropionate	6
			Budesonide	11
			Fluticasone propionate	3
Nebulisers	Combinations	1	Berotec + Atrovent Nebuliser	1
CENTRAL NERVOUS SYSTEM				
Sedative hypnotics	Benzodiazepines	1	Triazolam	1
Anxiolytics	Benzodiazepines	11	Alprazolam	4
			Bromazepam	1
			Prazepam	1
			Zopiclone	5
Anti-depressants	Tricyclics	3	Dothiepin	3
	Other	13	Sulpiride	1
			Mirtazopine	1
			Nefazodone	2
			Amitryptiline	7
			Imipramine	2
	Selective mono-amine oxidase inhibitors	1	Moclobemide	1
	Selective serotonin re-uptake inhibitors	7	Fluoxetine	4
			Setraline hydrochloride	1
			Paroxetine	2
	Lithium	2	Lithium carbonate	2
Anti-psychotics	Other	1	Olanzaprine	1
ENDOCRINE SYSTEM				
Anti-diabetic agents	Insulins	6	Biosynthetic human isophane insulin	2
			Biphasic biosynthetic human premixed insulin	2
			Biosynthetic human regular/soluble insulin	2
	Oral agents	35	Gliclazide	10
			Glibenclamide	8
			Glimepiride	2
			Glipizide	2
			Metformin	17
Thyroid	Thyroid	7	Thyroxine	7
Corticosteroids	Corticosteroids	8	Prednisone	5
			Triamcinolone acetonide	1
			Cortisone	2
Sex hormones	Oestrogens	9	Conjugated oestrogens	7
			Estradiol	1
			Oestradiol	1

	Combinations	3	Oestradiol valerate	1
			Progesterone & oestrogen combination	2
	Other	1	Tibolone	1
Contraceptive agents	Contraceptive agents	1	Ethyril Oestradiol	1
GASTROINTESTINAL TRACT				
GIT	Proton pump inhibitor	5	Lansoprazole	3
			Pantoprazole	1
			Omeprazole	1
	Urinary alkilizer	1	Sodium bicarbonate	1
	Amino-salicylate	1	Mesalazine	1
	Minerals & electrolytes	1	Potassium chloride	1
	Laxative	1	Psyllum hydrophilic mucillois	1
	Histamine-2 receptor antagonist	2	Ranitdine	2
	Digestants	1	Pancreatin	1
	Other	1	Sulphasalazine	1
Liver, gall bladder & bile	Liver dysfunction	1	Silymarin	1
MUSCULO-SKELETAL SYSTEM				
Anti-gout agents	Anti-gout agents	20	Allopurinol	15
			Allopurinol & Bensbromarone	2
			Colchicine	3
NSAIDS	COX inhibitors	8	Diclofenac	1
			Naproxen	1
			Piroxicam	1
			Sulindac	1
			Mefenamic acid	2
			Indomericin	2
	Selective COX-2 inhibitors	1	Celecoxib	1
Analgesics & Antipyretics	Analgesic	6	Paracetamol	6
OSTEOPOROSIS				
Drugs affecting bone mineralisation	Bisphosphonates	5	Alendronate	4
			Etidronate disodium	1
	Minerals & electrolytes	1	Sandoz Calcium Forte	1
CANCER				
Cytostatic agents	Cytotoxic agents	3	Methotrexate	1
			Docetaxel	2
ANTI-VIRALS FOR SYSTEMIC USE				
Anti-microbials	Anti-viral agents	4	Indinavir	1
			Ornelesc	1
			Ritanovir	1
			Zelitrex	1
AUTOCOIDS				
Autocoids	Anti-histamines	1	Cetirizine	1
	Decongestants	2	Loratatine	1
			Mistabron	1
OPTHALMICS				
Opthalmics	Occular hypertension	1	Dorzolamide	1
	Glaucoma	1	Pilocarpine	1
OTHERS				
Immunological	Immuno-suppressant	1	Cyclosporin	1
Others	Smoking cessation	1	Nicotine	1
	Motor Neuron Disease	1	Riluzole	1

Abbreviations: ACE = Angiotensin converting enzyme; COPD = Chronic obstructive pulmonary disease; GIT = Gastro-intestinal tract; NSAID = Non-steroidal anti-inflammatory; COX = Cyclo-oxygenase inhibiotor; COX 2 = Specific cyclo-oxygenase-2 inhibitor; HRT = Hormone replacement therapy

The most common drugs ingested are anti-coagulants (aspirin) (194 patients), lipid lowering agents (136 patients), beta-blockers (113 patients) and ACE-inhibitors (78 patients). Only 18 patients on the programme were not taking any medication.

Combinations of drugs are often prescribed to target multiple cardiac risk factors or other co-morbid conditions. The regimens of medication usage taken by patients in our sample are detailed in Table 2.9.

Table 2.9: Combinations of medication ingested by patients participating in the Cardiac Rehabilitation Programme at the Sports Science Institute of South Africa (n=241).

GROUP	n	% of all combinations
Beta-blocker + Diuretic	3	1.2
Beta-blocker + Calcium-channel blocker	5	2.1
Beta-blocker + Nitrate	1	0.4
Beta-blocker + ACE-inhibitor	8	3.3
Beta-blocker + Lipid lowering drugs	40	16.6
Beta-blocker only	20	8.3
Beta-blocker + Alpha-blocker	1	0.4
Alpha-blocker only	1	0.4
ACE-inhibitor + Calcium-channel blocker	4	1.7
ACE-inhibitor + Diuretic	14	5.8
ACE-inhibitor + Lipid lowering drugs	13	5.4
ACE-inhibitor only	22	9.1
Calcium-channel blocker + Diuretic	1	0.4
Calcium-channel blocker + Lipid lowering drugs	6	2.5
Calcium-channel blocker + Nitrates	1	0.4
Calcium-channel blocker only	7	2.9
Diuretic + Nitrate	1	0.4
Diuretic only	3	1.2
Lipid lowering drugs + Nitrate	1	0.4
Lipid lowering drugs only	33	13.7
Nitrates only	2	0.8
Beta-blocker + Calcium-channel blocker + Lipid lowering drugs + Nitrate	2	0.8
Beta-blocker + Calcium-channel blocker + Lipid lowering drugs	8	3.3
Beta-blocker + Calcium-channel blocker + Diuretic + Lipid lowering drugs	1	0.4
Beta-blocker + Lipid lowering drugs + Nitrate	4	1.7
Beta-blocker + Diuretic + Lipid lowering drugs	1	0.4
Beta-blocker + Lipid lowering drugs + Alpha-blocker	1	0.4
ACE-inhibitor + Beta-blocker + Lipid lowering drugs	12	5.0
ACE-inhibitor + Diuretic + Lipid lowering drugs	1	0.4
ACE-inhibitor+ Beta-blocker + Calcium-channel blocker + Lipid lowering drugs	2	0.8
ACE-inhibitor + Calcium-channel blocker + Diuretic	2	0.8
ACE-inhibitor + Lipid lowering drugs + Nitrate	1	0.4
ACE-inhibitor + Beta-blocker + Diuretic + Lipid lowering drugs	2	0.8
ACE-inhibitor + Calcium-channel blocker + Lipid lowering drugs	2	0.8
ACE-inhibitor + Beta-blocker + Diuretic	1	0.4
ACE-inhibitor + Diuretic + Nitrate	1	0.4
ACE-inhibitor + Beta-blocker + Diuretic + (Alpha- + Beta-blocker)	1	0.4
ACE-inhibitor + Diuretic + (Alpha- + Beta-blocker)	1	0.4
ACE-inhibitor + Diuretic + Lipid lowering drugs + (Alpha- + Beta-blocker)	1	0.4
ACE-inhibitor + Diuretic + (Alpha- + Beta-blocker)	2	0.8
ACE-inhibitor + (Alpha- + Beta-blocker)	1	0.4
Calcium-channel blocker + Diuretic + Lipid lowering drugs	1	0.4
Calcium-channel blocker + Lipid lowering drugs + Nitrate	1	0.4
Calcium-channel blocker + Diuretic + Nitrate	1	0.4

Diuretic + Lipid lowering drugs + Nitrate	1	0.4
Diuretic + (ACE-inhibitor + Calcium-channel blocker) + Alpha-agonist	1	0.4
Nitrate + (ACE-inhibitor + Calcium-channel blocker)	1	0.4

Abbreviations: ACE = Angiotensin converting enzyme; COPD = Chronic obstructive pulmonary disease; GIT = Gastro-intestinal tract; NSAID = Non-steroidal anti-inflammatory; COX = Cyclo-oxygenase inhibiotor; COX 2 = Specific cyclo-oxygenase-2 inhibitor; HRT = Hormone replacement therapy

The most common medication groupings are beta-blocker and lipid lowering agents (n=40) and ACE-inhibitors and lipid lowering agents (n=13). 33 patients ingested lipid lowering medication only, whilst 20 patients ingested beta-blockers only and 22 patients were taking ACE-inhibitors only.

Musculo-skeletal injuries:

A total of 178 patients (57% of the total programme population) required rehabilitation for one or more musculo-skeletal injuries. Diagnosed musculo-skeletal injuries on entry to the programme are classified by anatomical location in Table 2.10.

Table 2.10: Classification of musculo-skeletal injuries by anatomical location (n=286).

Joint	n	% of total injuries
Cervical and Thoraco-lumbar Spine	141	49.3
Knee	52	18.2
Shoulder	37	12.9
Hip	21	7.4
Ankle/foot	17	6.0
Hand	9	3.1
Lower leg	5	1.7
Elbow	4	1.4

49% of the injuries noted were classified as cervical and thoraco-lumbar injuries.

Subsequent analyses of each anatomical locations' associated injuries, are described in Tables 2.11 to 2.18.

Table 2.11: Analysis of cervical and thoraco-lumbar injuries requiring medical advice and musculo-skeletal rehabilitation as part of the comprehensive disease management programme (n=141).

Specific cervical and thoraco-lumbar injuries	n	% of total back injuries
Grade I motion segment abnormality	89	63.1
Grade II motion segment abnormality	16	11.4
Cervical spondylosis	14	9.9
Post laminectomy	6	4.4
Vertebral fracture	4	2.8
Lumbar skeletal muscle spasm	3	2.1
Spondylolysis	2	1.4
Spondylolisthesis	2	1.4
RA	2	1.4
OA	1	0.7
Cervical disc lesion	1	0.7
Sheuerrman's disease	1	0.7

Abbreviations: RA = rheumatoid arthritis; OA = osteo-arthritis.

Table 2.12: Analysis of knee injuries requiring medical advice and musculo-skeletal rehabilitation as part of the comprehensive disease management programme (n=52).

Specific knee injuries	n	% of total knee injuries
Patellar femoral pain	17	32.7
Post menisectomy	15	28.9
OA	9	17.3
Post arthroscopy	3	5.8
Post ACL reconstruction	3	5.8
Post knee replacement	2	3.8
Post MCL reconstruction	1	1.9
Post tibial osteotomy	1	1.9
RA	1	1.9

Abbreviations: ACL = anterior cruciate ligament, MCL = medial collateral ligament; OA = osteo-arthritis; RA = rheumatoid arthritis

Table 2.13: Analysis of shoulder injuries requiring medical advice and musculo-skeletal rehabilitation as part of the comprehensive disease management programme (n=37).

Specific shoulder injury	n	% of total shoulder injuries
Rotator cuff injury	25	67.6
Glenohumeral OA	5	13.5
Frozen shoulder	5	13.5
Post acromioplasty	1	2.7
AC joint injury	1	2.7

Abbreviations: AC joint = acromioclavicular joint; OA = osteo-arthritis.

Table 2.14: Analysis of hip injuries requiring medical advice and musculo-skeletal rehabilitation as part of the comprehensive disease management programme (n=21).

Specific hip injuries	n	% of total hip injuries
OA	14	66.7
Hamstring injury	3	14.2
RA	2	9.5
Post hip replacement	1	4.8
Gluteus medius amputation	1	4.8

Abbreviations: RA = rheumatoid arthritis; OA = osteo-arthritis.

Table 2.15: Analysis of ankle/foot injuries requiring medical advice and musculo-skeletal rehabilitation as part of the comprehensive disease management programme (n=17).

Specific ankle/foot injuries	n	% of total ankle/foot injuries
Post ankle sprain	8	47.1
Post achilles rupture and repair	5	29.4
Achilles tendinopathy	3	17.6
OA	1	5.9

Abbreviations: OA = osteo-arthritis.

Table 2.16: Analysis of hand/finger injuries requiring medical advice and musculo-skeletal rehabilitation as part of the comprehensive disease management programme (n=9).

Specific hand/finger injuries	n	% of total hand/finger injuries
OA	3	33.3
RA	3	33.3
Post wrist tendon surgery	3	33.3

Abbreviations: RA = rheumatoid arthritis; OA = osteo-arthritis.

Table 2.17: Analysis of elbow injuries requiring medical advice and musculo-skeletal rehabilitation as part of the comprehensive disease management programme (n=4).

Specific elbow injuries	n	% of total elbow injuries
Medial epicondylopathy	3	75.0
Lateral epicondylopathy	1	25.0

Table 2.18: Analysis of lower leg injuries requiring medical advice and musculo-skeletal rehabilitation as part of the comprehensive disease management programme (n=5).

Specific lower leg injuries	n	% of total lower leg injuries
Gastrocnemius/soleus tear	1	20
Tibial periostalgia	1	20
Tibia fracture	1	20
Other	2	40

Diverse musculo-skeletal injuries were noted in all joints. Grade i motion segment abnormality is the most common cervical and thoraco-lumbar injury (89 patients). The most common knee injury requiring rehabilitation was patellar femoral pain (n=17), whilst nearly as many patients required rehabilitation post menisectomy (n=15). Ankle sprains, diagnosed by the physician on entry to programme, were present in 8 patients, and the most common shoulder injury was rotator cuff damage (n=25). OA of the hip was present in 14 patients, and OA and RA was the most common hand/finger injury. Only 2 categories of elbow injuries were noted namely lateral and medial epicondylopathy. Lower leg injuries were not very common, with only 5 patients requiring rehabilitation.

DISCUSSION

With changes in the early care of cardiovascular patients, has come a shift and advancement in the rehabilitation of these patients. As only 10-47% of eligible patients currently participate in formal programmes of cardiac rehabilitation programmes (Wenger et al. 1995; Thomas et al. 1996; Evenson et al. 1998), the challenge for future rehabilitation programmes lies in developing strategies to make services accessible to all patients requiring medically directed and supervised exercise training as part of a multi-faceted treatment plan.

To this end, collecting and analysing data on patient disease profiles and the subsequent impacts on programme construction, is central in setting new standards and guidelines for the future practice of cardiac rehabilitation. Rehabilitation programmes need to service patients' individual medical profile by means of a holistic approach to their management.

Thus, the aim of this chapter was to determine disease profiles of patients attending the Cardiac Risk Reduction and Reversal Programme at the Sports Science Institute of South Africa, Cape Town.

80.2% of the total study population had documented coronary artery disease (CAD), whilst the remaining 19.8% attended the rehabilitation programme for another chronic lifestyle disease.

Analysis of the profiles of the CAD patients reveals that there is a relatively small group of patients presenting with CAD only (31%). 25% of the group required rehabilitation for CAD and a chronic musculo-skeletal injury. A further 14% presented with CAD and additional co-morbid conditions. Patients who had CAD, plus another chronic disease and a musculo-skeletal injury represented 14% of the group. Lastly, 11% attended the programme for primary prevention of CAD only, and 6% attended the programme for primary prevention and the rehabilitation of another chronic disease.

Thus, the first important finding of this study is the high prevalence of additional co-morbidities in patients attending cardiac rehabilitation. Traditional rehabilitation programmes focused on single disease management (e.g. for CAD only). The results from this study highlight the need for implementation of multiple disease and injury rehabilitation as a standard service offered to patients enrolled in cardiac rehabilitation programmes. This concept is supported by recent research suggesting that rehabilitation programmes adopt a multi-disciplinary approach to multi-disease management (McAlistair et al. 2001).

These results have a significant impact on exercise prescription in cardiac rehabilitation. Typically, walking and cycling programmes at moderate-to-high intensity, 2-4 times per week for 30-45 minutes per session, have been prescribed for cardiac patients (Ades 2001). It has been documented that this low caloric energy expenditure (270-183 kcal per session) may not have the desired effect on risk factors, specifically body weight and related factors including insulin resistance, hypertension and hyperlipidemia (Schairer et al. 1998, Savage et al. 2000). A recent publication by Haskell et al. (2001) showed that the required dose of exercise prescribed may vary based on different desired outcomes. For example, to achieve a significant reduction in blood pressure, an estimated 1200 kcal/wk dose of exercise is needed. To treat insulin resistance however, a dose of 1800 kcal/wk is necessary. The prescription of exercise including the mode, frequency, intensity and duration, appears to be specific to the nature of each disease. Therefore, knowledge of exercise prescription in various lifestyle-related diseases is essential for any staff member of a rehabilitation programme. This ensures that patients exercise at an intensity which relates to their clinical and demographic characteristics, and which is sufficient to illicit positive changes in respective disease parameters.

The second important finding of this study is the low percentage of patients attending the programme for primary prevention of CAD. This may be due to the cost of the programme and failure of the medical aid groups to adequately reimburse these services.

The third important finding was the high occurrence of musculo-skeletal injuries in this group undertaking rehabilitation. 57% of the total programme population required musculo-skeletal rehabilitation. Cervical and thoraco-lumbar injuries were the most common musculo-skeletal condition (49%) with grade I motion segment abnormality of the lumbar spine being the most common back injury (63%). Other common injuries included knee injuries (18%); shoulder injuries (13%) and hip injuries (7%).

As previous musculo-skeletal injury is extremely common, staff with the necessary expertise should be employed in such programmes. The high prevalence of mechanical low back pain is perhaps not surprising, but may emphasise an opportunity to incorporate rehabilitation techniques into cardiac rehabilitation programmes. Indeed, we suggest that lumbar "prehabilitation" be taught to all patients enrolled in cardiac rehabilitation programmes. To this end, we have incorporated a rehabilitation directed strength training course for all new patients on our programme, focusing on core stability and injury prevention.

The variety in disease profiles of patients attending cardiac rehabilitation has an impact on the various drug regimens of these patients. On analysis, the most common medication regimen was the combination of aspirin, beta-blocking drugs and lipid lowering agents. This is in accordance with standard practice of cardiovascular disease management. Furthermore, the most common group of lipid lowering drug were hydroxy-3-methyl-glutaryl-coenzyme A (HMG-CoA) reductase (statins). Statin-induced myopathy, in the form of musculo-skeletal pain and/or creatine phosphokinase elevation, is the most serious and commonly seen side effect of users of this family of drugs (Sinzinger, 1999; Boger, 2001). The main musculo-skeletal abnormalities are muscle pain and weakness, tendinopathy and a few cases of drug-induced systemic lupus erothematosis (SLE) (Chazerain et al., 2001). When statins are prescribed in combination with other drugs that inhibit the metabolism of agents in the liver, these side-effects (especially myopathy) occur more frequently (Boger, 2001). Therefore, when rehabilitating patients in an exercise setting a thorough knowledge of such agents is important to ensure that possible side-effects may be identified and possibly minimised.

In a multi-disease rehabilitation programme, diverse drug therapy regimens may complicate the exercise prescription. Therefore it is essential that health professionals providing these services are aware of the effects of medication on the ability to exercise and should be familiar with the possible interaction of different combinations of drugs (i.e. beta-blockade and lipid-lowering agents). Furthermore, as target levels of blood pressure and lipids are hardly reached even in cardiac rehabilitation programmes, it is the responsibility of the programme staff to assist the physicians in monitoring the efficacy of the prescribed pharmacological programme in the treatment of hypertension, hyperlipidemia and diabetes.

Cardiac rehabilitation programmes are traditionally thought of as being costly and have therefore had little financial support from the medical aid industry. However, research has shown cardiac rehabilitation to be an effective intervention for patients with CAD (Wenger et al., 1995). Whereas the majority of literature describes the efficacy of cardiac rehabilitation in patients with MI, there is a growing body of evidence that cardiac rehabilitation is effective in patients with angina, heart failure, CABG, PTCA and heart transplantation (Wenger et al. 1995). Survival benefits of 20-24% have previously been demonstrated in cardiac rehabilitation participation of patients with MI (O'Connor et al. 1989; Oldridge et al. 1988_b). However most of these trials were mainly based on exercise interventions. When these "usual care" trials were compared to trials that incorporate multi-disciplinary interventions, the treatment effects were not as impressive (McAlistair et al. 2001). Several reasons have been proposed for these results including labelling patients as having a single disease for a management programme. This may lead to sub optimal care of their co-morbid conditions and would therefore not impact on the all-cause mortality (McAlistair et al. 2001; Redelmeier et al. 1998).

There is paucity of data regarding economic factors from which to determine the efficiency of cardiac rehabilitation (i.e. determining life-years gained or years of life saved) (Oldridge 1998). Limited results from 8 trials suggest that cardiac rehabilitation is indeed cost-effective (Levin et al. 1991; Ades et al. 1992; Edwards et al. 1993; Bondestam et al. 1995; Allison et al. 1995;

DeBusk et al. 1985; Oldridge et al. 1993; Ades et al. 1997). However, as varying intensities, different study designs and data collection techniques were utilised in these 8 studies, it is difficult to conclude from these data that the programmes are in fact cost-effective (McAlister et al. 2001). Cardiac rehabilitation programmes have not yet been subjected to extensive economic evaluation, although traditional programmes are thought to be cost-effective.

In the absence of true patient disease profiles, drawing valid conclusions on cost-efficacy may be inaccurate. A recent publication by Oldridge et al. (2001), suggests that the high prevalence of cardiovascular and metabolic co-morbid conditions in middle and older-age adults should be taken into consideration when investigating cost-efficacy of cardiac rehabilitation programmes. The findings of this chapter show that only 31% of the total programme population required rehabilitation for a cardiac condition only. Disregarding the other patients' disease states and rehabilitation needs, would result in an inaccurate reflection of the programme population profile and possible biased outcomes and applications. Modern "chronic disease" rehabilitation programmes therefore, have the potential to provide more relevant data for cost-efficacy studies and secondly, can be more cost-effective by addressing multiple medical concerns in addition to CAD factors.

Another important finding of this chapter is the small proportion of women (24%) participating in this cardiac rehabilitation programme. This is in accordance with research showing low rates of enrollment of women into phase II cardiac rehabilitation programmes. A number of studies suggest that women may be missing from our programmes for reasons including older age (despite similar disease profiles), lower physician recommendation, enrollment, resources such as transport and distance to travel, and lastly, patient preference (i.e. women not wanting to exercise) (Ades et al. 1992; Benz Scott et al. 2002). As discussed in Chapter One, much of the knowledge about women and cardiac rehabilitation has been extrapolated from studies performed on younger males. Ades et al. (1992) showed that maximal exercise capacity increased similarly in both male and female cardiac patients, suggesting that women gain similar benefits from cardiac rehabilitation than their male counterparts. As physician referral remains the most powerful predictor of cardiac rehabilitation participation in older patients (Ades et al. 1992), it is essential that physicians adequately counsel and refer women to cardiac rehabilitation programmes. The results of our study did not provide insight as to the reasons for the low number of female participants.

With the varying needs of patients with different chronic diseases, it is imperative that staffing with the necessary expertise in exercise training and prescription in these conditions are employed in similar programmes. Furthermore, knowledge of final phase musculo-skeletal rehabilitation techniques and of the effects and side-effects of commonly used medications is essential. Similarly, the programme should have the necessary testing and emergency equipment to cater for the different chronic disease populations, e.g. cardiac disease, COPD, diabetes mellitus and arthritis. It seems that a shift in the focus of traditional cardiac rehabilitation is necessary to accommodate for the changing disease profiles of patients enrolling in these programmes. Indeed the name of our programme has subsequently changed from "The Cardiac Rehabilitation Programme" to "The Chronic Disease Risk Reduction and Reversal Programme".

These factors may necessitate an evaluation of the current status of cardiac rehabilitation programmes in general, including provisions for musculo-skeletal rehabilitation, variety in exercise modalities, adequate supervision and the necessary testing and exercise equipment, and reimbursement by medical aid schemes. The role of the Biokineticist, a speciality in South Africa focusing on the rehabilitation of both healthy individuals and special needs populations, is particularly important in the new generation cardiac or chronic disease rehabilitation programmes. Such individuals are trained in instructing patients on musculo-skeletal rehabilitation and chronic disease modification by using exercise as the cornerstone of their approach.

In conclusion, the arguments presented in this chapter must be advanced to health care funders to support the reimbursement of modern "chronic disease rehabilitation", which incorporates not only rehabilitation of patients' major cardiovascular disease, but essentially treats the patients in a holistic manner in an attempt to provide multi-disease management. This will ultimately in all likelihood result in a direct cost-saving to the health care funder. Furthermore, as the impact of co-morbid chronic diseases has not been taken into consideration previously, the cost efficacy of cardiac rehabilitation needs to be re-calculated.

CHAPTER THREE

EVALUATION OF FUNCTIONAL CAPACITY DURING CARDIAC REHABILITATION

IS THE SIX-MINUTE WALK TEST AN ACCEPTABLE MEASURE OF FUNCTIONAL CAPACITY IN PHASE III CARDIAC REHABILITATION PROGRAMMES?

INTRODUCTION

Exercise testing is a useful tool when assessing physical fitness, determining functional capacity, defining patient prognosis, developing a safe and effective exercise prescription and guiding and monitoring the efficacy of a rehabilitation programme (White et al. 2001).

As both programme and patient progress in phase II cardiac rehabilitation is based on outcome measures including improvement in functional capacity, it is important that the tests used are accurate. Patient motivation has a direct influence on overall compliance to the cardiac rehabilitation programme and, as dropout rates in cardiac rehabilitation programmes are high, efforts need to be made to improve compliance to ensure patients derive maximum benefit from such programmes. Patient involvement in their rehabilitation process and feedback regarding progress, programme performance and personal outcomes is vital. In this regard, results from functional capacity testing and risk factor re-assessments should be used to motivate patients to commit further to their rehabilitation programmes.

Exercise testing is also necessary to adjust the programme type and intensity for patients progressing from one phase of cardiac rehabilitation to the next. Normally, exercise prescription is based on the results of a symptom-limited exercise stress test (EST), where the exercise target heart rate is set at a percentage of the maximum heart rate achieved during a symptom-limited test (ACSM's Guidelines for Exercise Testing and Prescription, 2000). However, it is not always financially or logistically possible for patients to undergo EST at regular intervals. Therefore, whilst patients' may experience an increase in fitness and functional capacity during cardiac rehabilitation, their exercise programmes may only get adjusted after they perform an EST at intermittent intervals. Inexpensive, practical and easy to administer tests are therefore very useful in both assessing functional capacity and guiding the exercise prescription.

A number of sub-maximal exercise tests of functional capacity have been identified as accurate and reliable in cardiac rehabilitation. These include the 6-minute walk test, the shuttle-walk test, the 12-minute walk test, and the exercise stress test (Weisman et al. 2001; Morales et al. 2000). As the 6-minute walk test is most widely advocated, and is indeed the measure of functional capacity used in our programme, this chapter will focus on its relevance to a phase II cardiac rehabilitation population.

As discussed in Chapter One, the validity of the 6-minute walk test in earlier phases of cardiac rehabilitation and severe disease states has been established (Gyuatt et al. 1985; Wright et al. 2001). However, the use of the 6-minute walk test in later phases of cardiac rehabilitation is not as well researched. It is our experience that many patients in phase III and IV cardiac rehabilitation are able to tolerate higher exercise intensities and even participate in competitive running and cycling events. Yet, this improvement in exercise tolerance is not apparent when one considers the results of their 6-minute walk tests at 12-weekly intervals. In addition, we have noted that during follow-up interviews, patients are concerned that the results of their 6-minute walk tests do not adequately reflect their perceived functional improvement on the programme. Thus, it is questionable whether this test is an accurate measure of exercise tolerance and capacity to be used in later stages of exercise rehabilitation.

Most patients in our phase III programme are regularly participating in running activities as part of their normal rehabilitation classes. As we felt that the 6-minute walk test was potentially not adequately reflecting changes in functional capacity in patients attending phase III and IV cardiac rehabilitation, we introduced an additional test where patients were allowed to walk, jog or run for the duration of the 6-minute test. We termed this test the "unrestricted locomotion test" (ULT).

AIM

The aim of this chapter was to determine if the traditional 6-minute walk test (TWT) is an acceptable measure of functional capacity in phase III cardiac rehabilitation.

A secondary aim of this chapter was to compare the changes in functional capacity reflected in the TWT and an unrestricted locomotion test (ULT) during a period of 9 months of cardiac rehabilitation.

SUBJECTS AND METHODS

10 male patients (mean age 54.6 $\pm$ 7.0 years) with stable cardiac disease attending the Cardiac Rehabilitation Programme at the Sports Science Institute were recruited for this study. Subjects were excluded if they had silent ischaemia during their previous exercise stress test, or developed any new cardiovascular symptoms including angina, dangerous arrhythmia, or any serious orthopaedic injury during the study period.

During the first part of the trial, subjects were asked to undertake the TWT at baseline, 3 months and 6 months of a standard cardiac rehabilitation programme.

The second part of the trial took the format of a randomised crossover trial where patients completed both the TWT and ULT at 9 months. The tests were conducted on the same day and separated by a 30-minute rest period.

Subjects did not perform the ULT at baseline, 3 months and 6 months, as we were concerned that patients may exceed their maximum target heart rates in these early phases of the programme. Whilst safety is still an important factor to consider in later phases of cardiac rehabilitation, patients are able to perform activities of higher intensity as a result of the positive adaptations to cardiac rehabilitation. We therefore felt it safe to incorporate the ULT as a test of functional capacity at 9 months, provided patients regularly participated in higher intensity classes as described below.

All tests were conducted at the Sports Science Institute of South Africa during patients' cardiac rehabilitation classes. All subjects signed informed consent to participation in the study and were allowed to withdraw from the study at any point. This study was approved by the Ethics and Research Committee of the Faculty of Medicine at the University of Cape Town.

EXERCISE PROTOCOLS

All patients attended at least two exercise sessions per week during the study period. A typical session consisted of approximately 10 minutes warm-up, followed by 30-40 minutes of cardiovascular exercise (e.g. cycling, light jogging or walking), resistance training, and a 10-minute cool-down and stretching period. By the time patients entered phase III, they were accustomed to higher intensity cardiovascular training, and were participating in super circuit classes which entail activities including running and resistance training on a regular basis. Patients exercised at an intensity of 75-85% of their maximum heart rate as determined by a baseline symptom-limited exercise stress test (EST). Subjects were instructed to maintain this constant level of exercise training during the trial. No changes were made to their medication or other medical treatment throughout the trial.

WALKING PROTOCOLS

During the TWT, subjects were instructed to walk as fast as possible around a 135m indoor rubber track to determine maximum distance covered (m) and peak heart rate (bpm). During the ULT, subjects were instructed to cover as much distance as possible and were allowed to run or jog if they desired.

During both tests, the investigator recorded the number of laps covered. To standardise the protocol, subjects were not encouraged or motivated during either protocol (Guyatt et al. 1984). Throughout the tests, patients were aware of the time to completion. Peak heart rate was recorded by palpating the radial artery as the subject stopped the exercise test.

STATISTICAL ANALYSIS

Descriptive statistics were carried out on all test results. Results are expressed as means ± standard deviation (SD). All walk tests were compared using repeated ANOVA and Tukey HSD tests. Statistical significance was established at the $p<0.05$-confidence level. Improvement in distance covered at 12 weekly intervals, is expressed as a percentage, rounded off to the nearest one decimal point.

RESULTS

Subject characteristics on entry to the programme

Subject characteristics are listed in Table 3.1. All values are expressed as means ± standard deviations (SD).

Table 3.1: Characteristics of all patients on entry to the programme.

	Mean ± SD
Average age (yrs)	54.0 ± 7.0
Height (cm)	176.0 ± 7.8
Weight (kg)	77.0 ± 8.6
BMI	25.0 ± 2.9
Waist circumference (cm)	86.0 ± 12.8
Hip circumference (cm)	97.4 ± 10.4
Waist:hip ratio	0.9 ± 0.3

Abbreviations: BMI = Body Mass Index.

Compared to the risk profile of the total programme population described in Chapter Two, these 10 patients are slightly younger (54.0 ± 7.0 years vs. 56.9 ± 11.0 years), have a lower BMI (25.0 ± 2.9 vs. 29.3 ± 20.0) and waist:hip ratio (0.9 ± 0.3 vs. 1.3 6.1).

MEDICAL PROFILES

Patients' medical diagnoses are shown in Table 3.2.

Table 3.2: Medical profiles of all study participants.

Subject	Diagnosis
1	CAD, previous MI
2	CAD
3	CAD, previous MI
4	CAD
5	CAD, previous MI
6	Pacemaker; Arrhythmia
7	CAD
8	CAD; NIDDM
9	CAD, previous MI, CVA
10	CAD, previous MI

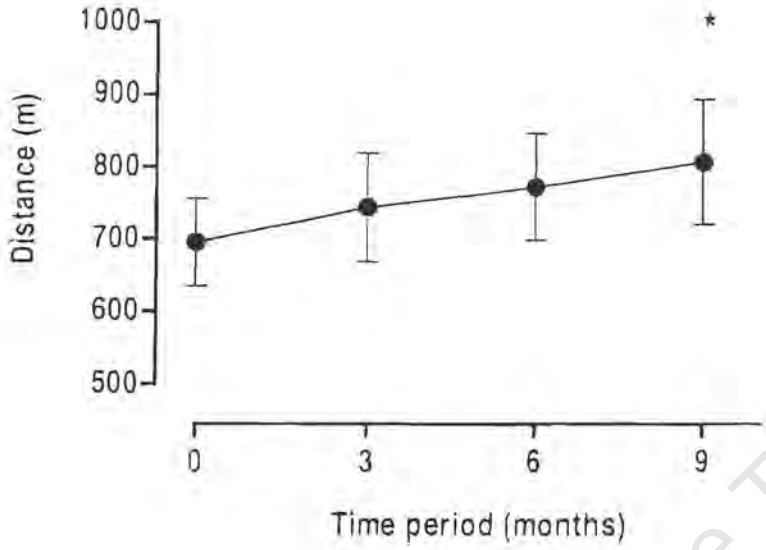
Abbreviations: MI = Myocardial Infarction; CAD = Coronary Artery Disease; NIDDM = Non-Insulin Dependant Diabetes Mellitus; CVA = Cerebrovascular Accident.

Disease histories included CAD only (n=3), CAD + previous MI (>6 months) (n=5), Arrhythmia (n=1), CAD + NIDDM (n=1).

Tests of Functional Capacity

Figure 3.1 shows the results of the comparative 6-minute walk tests performed at 3-monthly intervals. Values are shown as mean ± standard deviations (SD).

Figure 3.1: Distance covered (meters) during the traditional 6-minute walk tests at 0, 3, 6 and 9 months of cardiac rehabilitation. * = $p<0.05$ vs. distance covered at baseline.

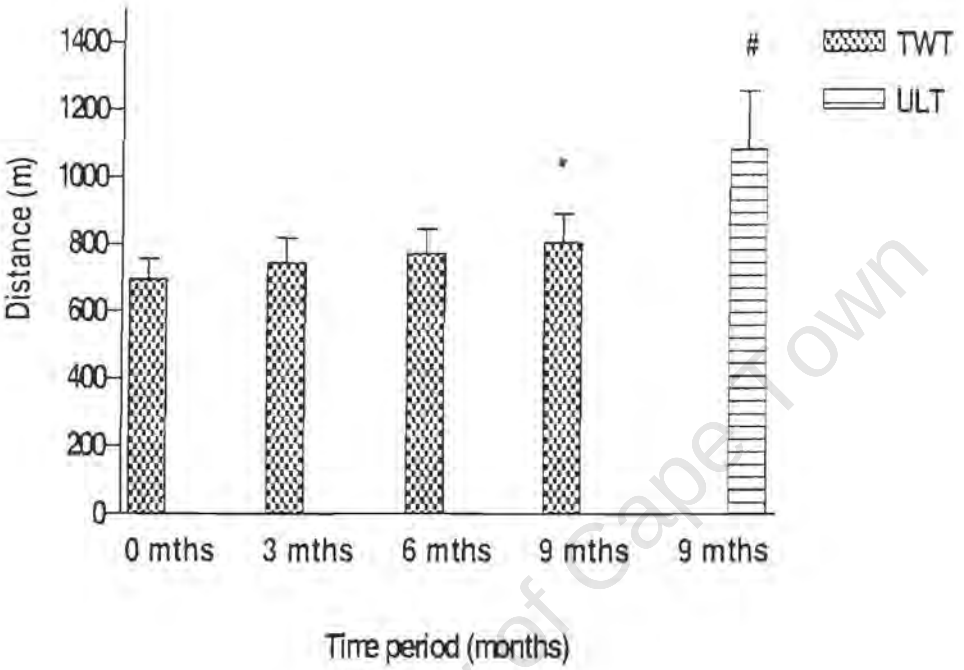


Although the distance covered during the TWT tended to increase from 0 to 6 months, there was no statistically significant difference between distance covered at 0 months and 3 months (695.7 ± 60.8m vs. 744.0 ± 75.1m), or 0 months and 6 months (695.7 ± 60.8m vs. 772.9 ± 74.2m). Furthermore, no significant difference was found in distance covered at time periods 3 to 6 months (744.0 ± 75.1m vs. 772.9 ± 74.2m) and 6 to 9 months (772.9 ± 74.2m vs. 806.7 ± 86.5m).

However, the distance covered at 9 months was significantly greater than the initial distance ($p<0.05$).

Figure 3.2 illustrates the comparison between the traditional walk test (TWT) performed at 3 monthly intervals, and the unrestricted locomotion tests (ULT) at 9 months.

Figure 3.2: Distance covered (meters) during the traditional 6-minute walk test at 0, 3, 6 and 9 months, and during the unrestricted locomotion test at 9 months. * = $p < 0.05$ vs. distance covered at baseline. # = $p < 0.0002$ vs. distance covered at baseline, 3 months, 6 months and 9 months.

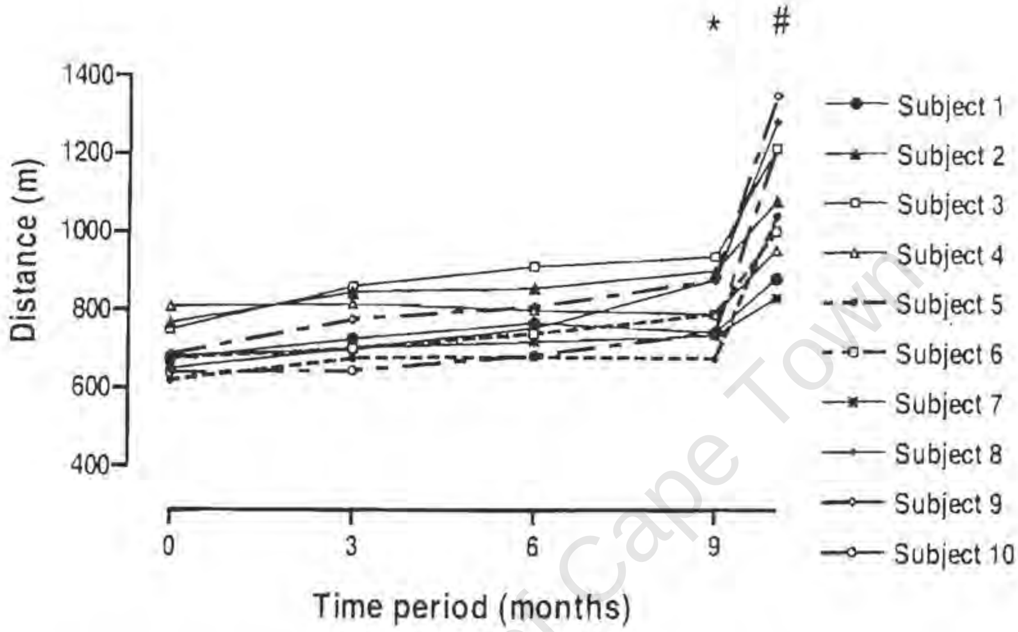


During the ULT at 9 months, all subjects jogged or ran for the full 6-minutes and completed the ULT without any CAD symptoms.

A significant difference was found between the ULT and each TWT performed at 0 months, 3 months, 6 months and 9 months ($p<0.0002$).

Distances covered by individual patients at each of the tests illustrated above are shown in Figure 3.3.

Figure 3.3: Individual distances covered (meters) during the traditional 6-minute walk test at 0, 6 and 9 months, and during the unrestricted locomotion test at 9 months. * = p<0.05 vs. distance covered at baseline; # = p<0.002 vs. distance covered at baseline, 3 months, 6 months and 9 months.



It is important to note the individual variance in improvement for each subject. Patients who perform the best at baseline are not necessarily those who perform the best after 9 months of cardiac rehabilitation.

The improvement in functional capacity at different time intervals is shown in Table 3.4.

Table 3.4: Improvement in distance covered (meters) between various time periods.

Test period	Difference in distance (m)	% Improvement between tests
0 – 3 months	48.3	7
3 – 6 months	28.9	4
6 – 9 months (TWT)	33.8	4
0 – 9 months (TWT)	111.0	16 *
0 – 9 months (ULT)	389.2	56 #
9 months TWT – 9 months ULT	278.2	35 #

Abbreviations: TWT = Traditional Walk Test; ULT = Unrestricted Locomotion Test. (*: p < 0.05; #: p < 0.0002)

A greater improvement is seen from 0-3 months (7%), compared with the slight increase in functional capacity from 3 to 6 months (4%), and 6 to 9 months (4%). However, there was no statistically significant difference between any of the TWT tests at the different time intervals. Once more, it is important to note individual differences in improvement.

Of significance however, is the discrepancy in the improvement in functional capacity shown by the TWT (16%), and the ULT (56%) at 9 months. Whilst both tests at 9 months are statistically different to baseline distance covered, a mean 35% (278.2m) discrepancy in reporting functional capacity is found. This suggests that there is considerable reserve, as one would expect in runners. Thus is it questionable whether the traditional 6-minute walk test is accurately conveying functional capacity at this later stage of cardiac rehabilitation.

DISCUSSION

It is well recognised that the prescription of exercise is an essential component of any cardiac rehabilitation and secondary prevention programme. The exercise prescription should be based on a recent exercise test that documents the cardiac patients' functional capacity and cardiac and haemodynamic response to exercise. Signs and symptoms associated with exertion should also be documented (Williams, 2001). The 6-minute walk test, originally designed to assess functional capacity in patients with COPD (Butland et al. 1982), is of particular value in assessing patients with more severe disease who may be too weak to tolerate maximal exercise testing (Miyamoto et al. 2000). The 6-minute walk test is also widely advocated as a simple, inexpensive and easily administered test of functional capacity that is better tolerated than treadmill tests (Montgomery et al. 1998). Furthermore, these tests may be more practical and related to activities of daily living than bicycle and treadmill ergometry (Guyatt et al. 1985; Lipkin et al. 1986; Langenfeld et al. 1990; Hendrican et al. 2000).

The first important finding of this chapter is that only small increments in improvement in functional capacity are demonstrated when using the 6-minute walk test at 12 weekly intervals during phase II, III and IV cardiac rehabilitation. Furthermore, it seems that there is a mismatch with the training intensity that patients are accustomed to and patients' perception of their functional capacity.

The second important finding of this chapter is that the ULT elicits a greater improvement in functional capacity compared to the TWT in phase III and IV patients. Therefore it is perhaps apparent that patients who are accustomed to higher intensity exercise are limited by other factors including biomechanical walking speed when performing the TWT. Despite the significant difference in distance covered using the TWT at 9 months compared to baseline measures, this gradient is shallow compared to the improvement in exercise training intensity and functional capacity reported by patients. The results of the TWT might therefore mask significant progress in functional capacity. This results in a "plateau" in performance and is not a true reflection of their present functional capacity as seen from the results of our study. Indeed, results mask significant progress in the programme.

It is important to distinguish the reasons for conducting a test of functional capacity. Firstly, the test can be performed in order to assess disease severity and baseline functional capacity – generally in phase I or in patients with intermediate to severe disease. Secondly, to assess improvement in functional capacity in patients who have a superior exercise tolerance and milder disease states. Thirdly, to design the initial programme, and appropriately adjust subsequent exercise programmes. This would have significant bearing on the type of test selected. From the results of this study, if improvement in functional capacity is the main objective, it seems that the ULT may be of more value and conveys a more accurate reflection of functional capacity than the TWT in phase III and IV cardiac rehabilitation.

The majority of research on the TWT has been conducted on patients with chronic airflow limitations and chronic heart failure (Guyett et al. 1985). As discussed in Chapter One, the use of this test in later phases of cardiac rehabilitation has not been established. From the results of our study, it may be concluded that the traditional 6-minute walk test is appropriate in assessing functional capacity in patients at the initiation of a phase I cardiac rehabilitation programme, but is not a very reliable test to report functional capacity in patients in a phase III programme who demonstrate greater exercise tolerance and who have participated in running.

Continually increasing and monitoring exercise caloric expenditure during cardiac rehabilitation remains a challenge in cardiac rehabilitation (Williams, 2001). These suggestions should be based on safe and accepted guidelines, and the results of an exercise test (i.e. the 6-minute walk test). However, if the test used does not reflect true functional capacity, it may result in exercise intensities that are lower than what the patient is capable of. This, in turn may result in less impressive overall improvements after cardiac rehabilitation. Furthermore, low self-motivation is a factor that is consistently associated with dropout of patients in supervised rehabilitation programmes (Oldridge, 1991_a). Positive re-enforcement of improvement in functional capacity may act as a compliance-enhancing strategy. A possible method of overcoming low-self motivation is to set goals that are adjusted at regular intervals during the programme. These results should be based on the results of exercise testing that accurately reflect functional capacity. As shown in our study, the unrestricted locomotion test yielded superior levels of functional capacity, and would therefore result in adjusting programmes to different, and possibly more realistic intensities.

The main goal when selecting an exercise protocol is to find a balance between an intensity that will not prematurely fatigue the subject, and at the same time allow the patient to reach a maximum power output (or effort) during the exercise test (McKelvie et al. 1989). The intensity of the test should be increased to a symptom-limited maximum. This procedure is safe provided standard contraindications to exercise testing, and termination criteria are strictly adhered to (ACSM's Guidelines for Exercise Testing and Prescription, 2000). The following criteria should be considered: the test should represent major functional fitness components; be able to detect physical changes due to training/exercise; be easy to administer and score, and reasonably quick to administer; require minimum equipment and space; be capable of being self- or partner administered in the home setting; be safe to perform without major medical risks (McKelvie et al. 1989). From the results of our study, the ULT meets these criteria.

In conclusion, the results of this chapter suggest that both the TWT and the ULT may be of practical use for smaller centres that do not have the financial resources to acquire traditional exercise stress ECG equipment. However, we suggest that the ULT be used in later stages of cardiac rehabilitation to monitor functional capacity accurately and to adjust exercise prescription accordingly.

Limitations of this study

As discussed previously, we did not include the ULT at baseline, 3 months and 6 months due to safety concerns. Based on the ACSM's Guidelines for Exercise Testing and prescription (2000), run tests might be inappropriate for sedentary individuals at risk for cardiovascular and musculo-skeletal complications. As we had not yet determined the safety of this novel test of functional capacity, we did not include it in earlier in the programme. The purpose of the next chapter of this thesis to evaluate the safety of the ULT compared with conventional exercise stress ECG testing.

CHAPTER FOUR

EXERCISE STRESS TESTING UNDERESTIMATES IMPROVEMENTS IN FUNCTIONAL CAPACITY IN PATIENTS ON CARDIAC REHABILITATION PROGRAMMES

INTRODUCTION

"Exercise testing should be conducted when it is anticipated that the results will affect patient management" (Rodgers et al. 2000). Regular assessments of functional capacity are therefore important to assess patient prognosis, disease progression, and to adjust exercise prescription.

As described in Chapter One, several studies have documented the benefits of exercise stress testing (EST) in the diagnosis of cardiac disease and assessment of safety during exercise. The results of stress testing are used to categorise patients into high-, moderate- and low-risk categories. Clinically these results can be used to gauge resumption of physical activity and return to work after a major cardiac event.

Current practice in the Cardiac Rehabilitation Programme at the Sports Science Institute of South Africa is for patients to be referred with an accompanying report of their EST performed by their cardiologists. Data from the test are often limited to the total treadmill time and stage of the protocol achieved, the heart rate at which the test was terminated and any signs or symptoms noted during the test. Programme staff use these results as a guideline to design a programme that is both safe and of a sufficient degree of difficulty to elicit positive responses to training. Based on ACSM Guidelines for Exercise Testing and Prescription (2000), target heart rates are generally set at 65-85% of the maximum heart rate achieved during the test.

Research shows that random target heart rates of between 120-140 bpm (Schlant et al. 1986), or a MET level of 5 (ACSM Guidelines for Exercise Testing and Prescription, 2000) are often used as termination criteria during testing rather than a patients' true functional capacity. Such submaximal exercise testing would be useful in determining adverse signs and symptoms that may be a preclusion to exercise, but may not indicate maximal functional capacity. Therefore, basing the exercise prescription on the results of such protocols might result in intensities that are lower than what patients are potentially capable of. It would therefore be questionable whether EST results should be used as the basis for exercise prescription.

In addition, it seems that patients assess their ability to perform various physical activities even before undergoing an EST, and may alter this perception post-test based on the results (Ewart et al. 1983). Not allowing the patient an opportunity to perform the exercise test to the best of their physical ability may therefore have important psychological effects.

Yet, to monitor safety, patients should undergo EST at regular intervals during their participation in a cardiac rehabilitation programme. However, it is our experience that often it is not financially or logistically possible for patients to undergo EST more than once per year. Depending on exercise tolerance, patients' training programmes should be updated every 1-3 weeks to maintain interest in the programme and instil a sense of progress at each update (ACSM Guidelines for Exercise Testing and Prescription, 2000). If EST were to be the measure of functional capacity by which to guide exercise programme revision, many patients would not be progressed at a sufficient and safe pace. The use of walking tests that are inexpensive, more easily administered tests and can be conducted at more regular intervals may therefore be more important tests of functional capacity in cardiac rehabilitation programmes where constant evaluation is necessitated.

In the previous chapter of this thesis, we showed that the 6-minute walk test tended to underestimate patients' true functional capacity, especially during later stages of cardiac rehabilitation. Indeed, patients who are accustomed to higher intensity exercise show better results in functional capacity when performing the unrestricted locomotion test during phase III and IV cardiac rehabilitation. We therefore recommended that the unrestricted locomotion test (ULT) be used as a more accurate measure of functional capacity in later stages of cardiac rehabilitation.

AIM

The first aim of this chapter was to compare changes in functional capacity (FC) noted during EST, the traditional 6-minute walk test (TWT) and 6-minute unrestricted locomotion test (ULT) at baseline and after 9 months of cardiac rehabilitation.

As safety during exercise testing is a major concern, the second aim of this chapter was to investigate whether patients perform both the EST and ULT within safe heart rate ranges.

SUBJECTS AND METHODS

7 patients (average age 50.8 ± 3.0 years) with stable cardiac disease and who had undergone baseline EST using the Bruce protocol were recruited for this study. All patients also participated in the study described in the previous chapter.

Subjects were excluded if they developed any new cardiovascular symptoms including angina or dangerous arrhythmia, silent ischaemia during exercise testing, or any serious orthopaedic injury during the study period.

Subjects undertook the TWT at 0 and 9 months, and the ULT at 9 months as described in Chapter Three. Routine EST results at 0 months and 9 months were obtained from each patient's cardiologist. The following data are provided by cardiologists and were extracted for evaluation: protocol used, time to completion (min:sec), stage of Bruce protocol achieved, peak METs achieved and maximum heart rate (bpm) achieved. No cardiac abnormalities including ischaemia or arrhythmia were reported as termination criteria.

Functional capacity was determined from the total treadmill time during the EST and distance covered during the TWT and ULT. Improvement in total treadmill time and distance covered is expressed as a percentage, rounded off to the nearest one decimal point. Maximum heart rates achieved during the TWT, ULT and the EST were compared at 0 and 9 months.

All tests were conducted at the Sports Science Institute of South Africa during patients' cardiac rehabilitation classes. All subjects signed informed consent to participation in the study and were allowed to withdraw from the study at any point. This study was approved by the Ethics and Research Committee of the Faculty of Medicine at the University of Cape Town.

STATISTICAL ANALYSIS

Descriptive statistics were carried out on all test results. Results are expressed as means ± standard deviation (SD). All walk tests were compared using repeated ANOVA and Tukey HSD tests. Total treadmill time during the EST was compared using T-Tests for dependant samples. Statistical significance was established at the $p<0.05$-confidence level. Improvement in functional capacity is expressed as a percentage, rounded off to the nearest one decimal point.

Correlations between the total treadmill time and the distance covered during the TWT and ULT were compared using the Pearson-Moment Correlation.

RESULTS

Subject characteristics on entry to the programme

Subject characteristics are listed in Table 4.1.

Table 4.1: Characteristics of all patients on entry to the programme (n=7).

	Mean ± SD
Average age (yrs)	50.8 ± 3.0
Height (cm)	174.5 ± 9.0
Weight (kg)	77.5 ± 9.0
BMI	25.4 ± 2.9
Waist circumference (cm)	84 ± 15.7
Hip circumference (cm)	94.7 ± 12.4
Waist:hip ratio	0.9 ± 0.4

Abbreviations: BMI = Body Mass Index. Values are shown as mean ± standard deviations (SD).

The average age of this group is slightly less than the 10 subjects studied in the previous chapter (50.8 ± 3.0 years vs. 54.0 ± 7.0 years), but they have similar BMI's (25.4 ± 2.9 vs. 25.0 ± 2.9) and waist:hip ratio's (0.9 ± 0.4 vs. 0.9 ± 0.3).

MEDICAL PROFILES

Patients' medical diagnoses are shown in Table 4.2.

Table 4.2: Medical profiles of all study participants.

Subject	Diagnosis
1	CAD, previous MI
2	CAD
3	CAD, previous MI
4	CAD, previous MI
5	Pacemaker; Arrhythmia
6	CAD; NIDDM
7	CAD, previous MI

Abbreviations: MI = Myocardial Infarction; CAD = Coronary Artery Disease; NIDDM = Non-Insulin Dependant Diabetes Mellitus.

Disease histories included CAD only (n=1), CAD + MI (>6 months) (n=4), Arrhythmia (n=1), CAD + NIDDM (n=1).

Tests of Functional Capacity

Exercise Stress Test (EST) Results

EST data are shown in Table 4.3. Total treadmill time (min:sec) is expressed as the time to completion of the graded EST. All subjects performed the EST using the Bruce protocol. Peak MET's and maximum heart rate (bpm) achieved were recorded on termination of the test.

Table 4.3: Data obtained from the Bruce protocol EST at 0 and 9 months (n=7).

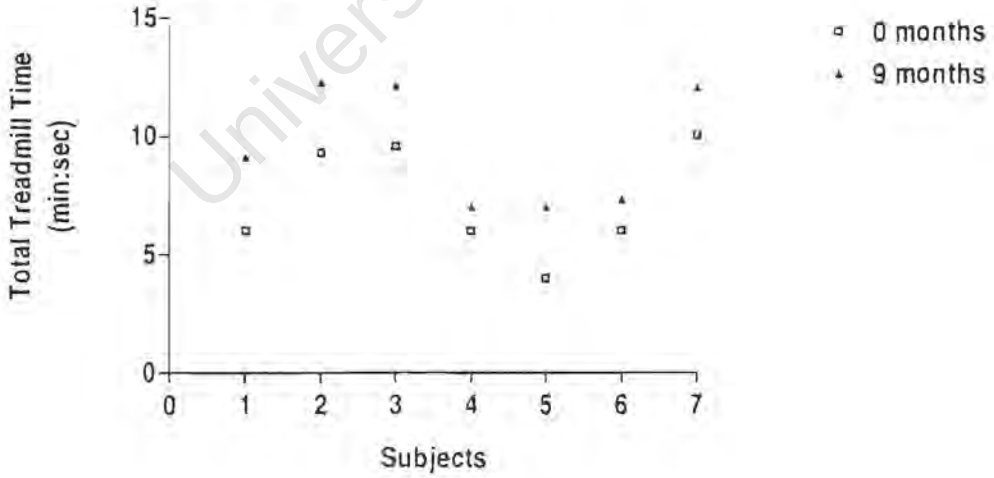
	Initial EST	9 month EST
Total treadmill time (min:sec)	7:27 ± 2:33	9:54 ± 2:52 *
Stage of Bruce protocol achieved	III	IV
Max MET achieved	9.5	13
Max heart rate achieved (bpm)	142 ± 20	152 ± 10

Abbreviations: EST=Exercise Stress Test; MET=Metabolic equivalent. Values are shown as mean ± standard deviations (SD). *: $p<0.05$.

There was a significant improvement in total treadmill time from 0 to 9 months (7:27 ± 2:33 min:sec vs. 9:54 ± 2.52 min:sec) ($p<0.05$). This translated into a 30.8% improvement in total treadmill time from 0 to 9 months.

The improvement in total treadmill time achieved by each subject is shown below in Figure 4.1.

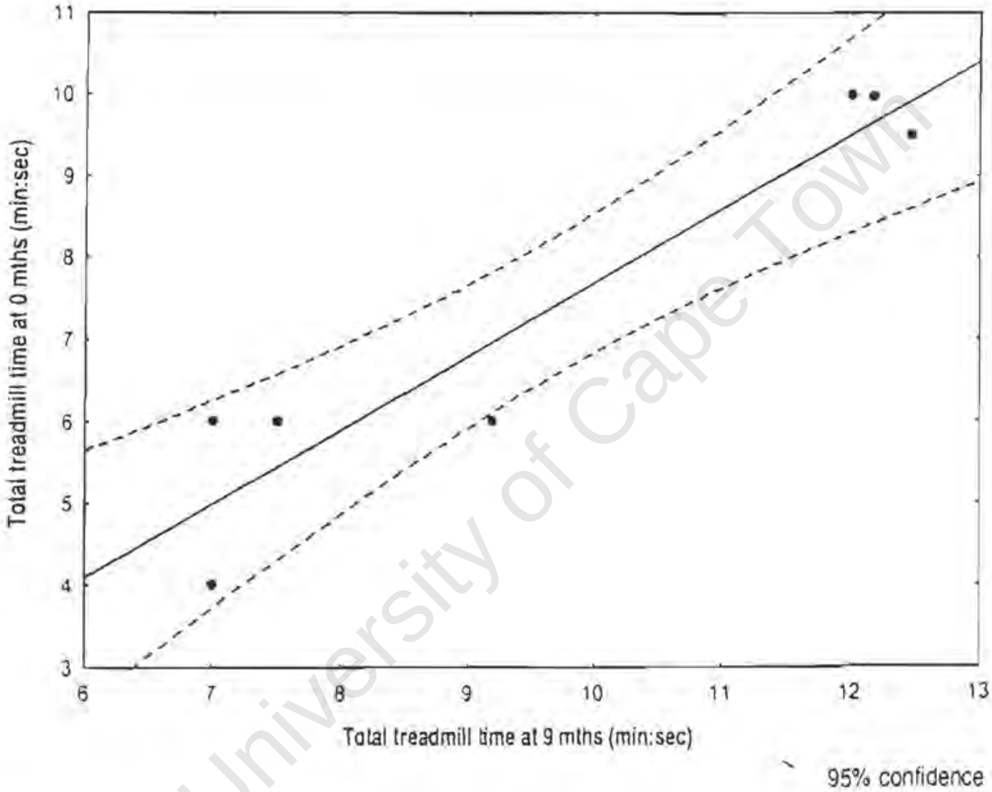
Figure 4.1: Improvement in total treadmill time during the Bruce protocol EST at 0 and 9 months for individual subjects.



As illustrated above, all subjects improved their total treadmill time after 9 months. This improvement however, was greater in some subjects (e.g. subject 5, 75%) than others (e.g. subject 4, 17%).

Figure 4.2 shows the correlation between the total treadmill time achieved during the EST at 0 and 9 months.

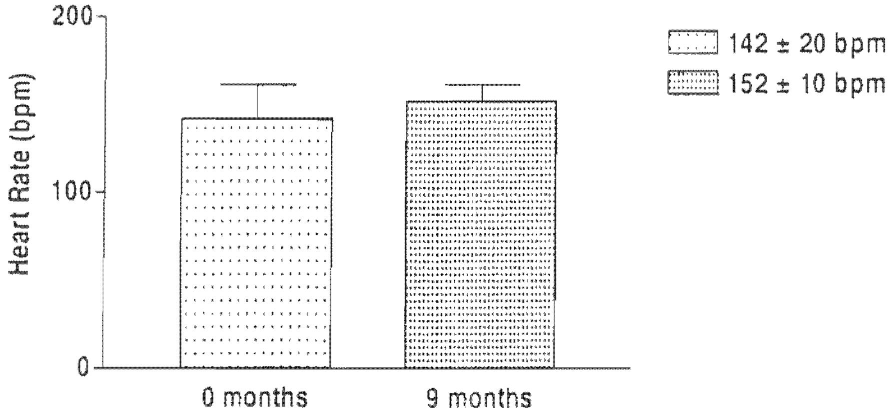
Figure 4.2: Correlation between total treadmill time (min:sec) during the EST at 0 months and 9 months (p<001; r=0.94).



There was a positive correlation between the total treadmill time achieved during the EST at 0 months and 9 months. Therefore patients who perform the best at 0 months, seem to perform the best at 9 months.

Maximum heart rates achieved during the EST at baseline and at 9 months are shown in Figure 4.3.

Figure 4.3: Maximum heart rate (bpm) achieved during the EST at 0 and 9 months of cardiac rehabilitation.



No significant difference was found between the maximum heart rate achieved during the EST using the Bruce protocol at 0 months and 9 months (p=0.24).

Traditional 6-minute walk test (TWT) and unrestricted locomotion test (ULT) results

Distance covered and peak heart rates achieved during the TWT at 0 and 9 months, and the ULT at 9 months, are listed in Table 4.4.

Table 4.4: A comparison of distance covered and maximum heart rates achieved during the TWT at 0 and 9 months, and during the ULT at 9 months.

Test	Distance (m)	Heart Rate (bpm)
TWT at 0 months	687.1 ± 54.1	121 ± 29
TWT at 9 months	809.3 ± 97.3 *	116 ± 26
ULT at 9 months	1102.2 ± 142.4 #	155 ± 9

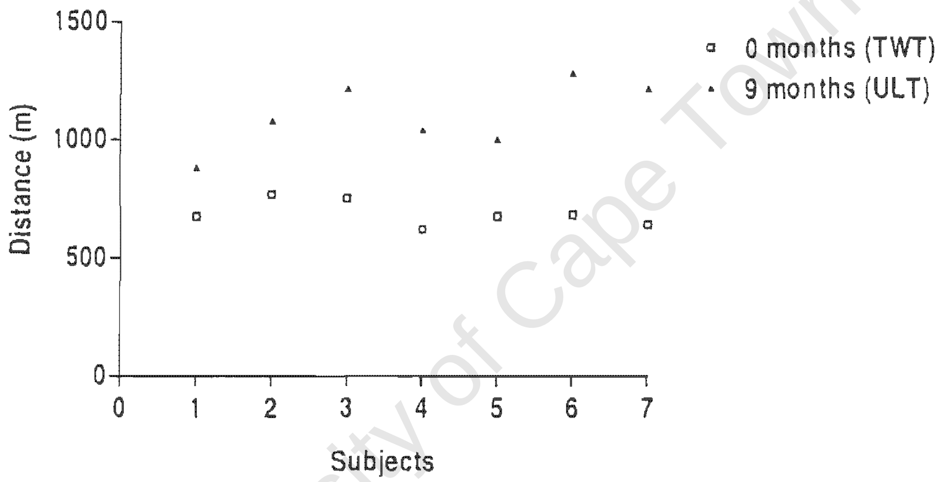
* = p<0.05 vs. distance covered during the TWT at 0 months; # = p<0.0002 vs. distance covered during the TWT at 0 months and 9 months.

The distance covered during the TWT at 9 months was significantly greater than the distance covered at baseline. Distance covered during the ULT was significantly greater than that covered during the TWT at both 0 and 9 months. Furthermore, an 18% improvement in functional capacity was shown in distance covered during the TWT at 0 months and at 9 months. In contrast, a 61% improvement is shown when the initial distance covered during the TWT is compared to the distance covered during the ULT at 9 months.

During the TWT at 0 months, patients achieved 85% of their symptom-limited heart rates during the EST. At 9 months, they achieved 76% of their symptom-limited heart rates during the TWT. Interestingly, at 9 months, when performing the ULT, there was no difference in the heart rates achieved during the EST and ULT.

The improvement in distance covered during the TWT at 0 months and the ULT at 9 months is shown in Figure 4.4.

Figure 4.4: Distance covered during the TWT (0 months) and ULT (9 months) for individual subjects.

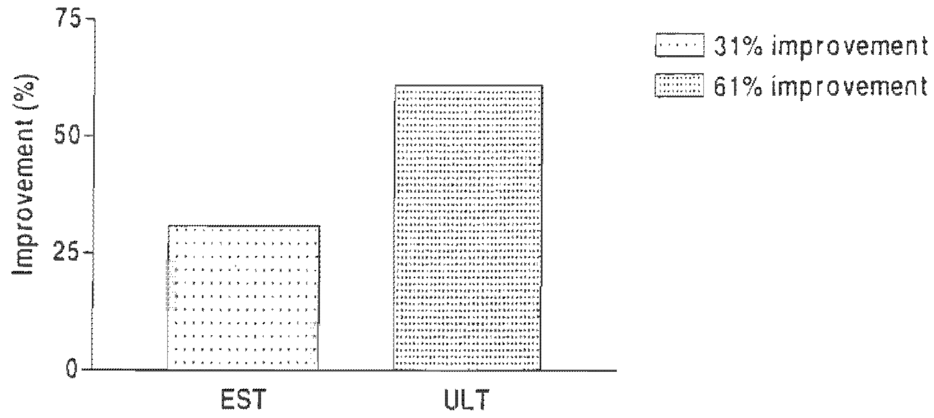


Each subject improved the distance covered at 9 months during the ULT. Again, the improvements varied with subject 1 showing far less an improvement (30%) than, for example, subject 7 (90%).

Improvement in functional capacity

Figure 4.5 shows the improvement in functional capacity shown in total treadmill time during the EST using the Bruce protocol at 0 and 9 months, and the total distance covered during the TWT at 0 months and the ULT at 9 months.

Figure 4.5: % Improvement in functional capacity shown by EST and ULT at 9 months.



The ULT elicited a much greater percentage improvement (61%) in functional capacity compared to that shown by the EST (31%).

Heart rates achieved during the EST, TWT and ULT

The maximum heart rates achieved during the TWT and EST at 0 months are displayed in Figure 4.6. Although there was a trend toward significance, the maximum heart rates achieved during the EST and TWT at initiation of cardiac rehabilitation were not significantly different (141.7 ±. 20 bpm vs. 121.1 ± 29 bpm; p=0.06).

Maximum heart rates during the TWT and EST at 9 months are shown in Figure 4.7. Significantly higher maximum heart rates were achieved during the EST than during the TWT at 9 months.

Figure 4.8 shows the maximum heart rates achieved during the ULT and EST at 9 months. No significant difference was found (152 ± 10 bpm vs. 155 ± 9 bpm; p=0.51).

Figure 4.9 shows the correlation between the maximum heart achieved during the TWT and EST at 0 months. No significant correlation was found. Similarly, no correlation was found between the maximum heart rates achieved during the ULT and EST at 9 months as shown in Figure 4.10.

Figure 4.6: Maximum heart rate (bpm) achieved during the EST and TWT at 0 months. p=0.06.

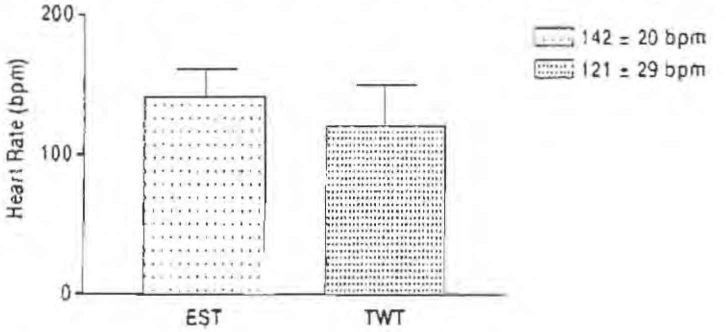


Figure 4.7: Maximum heart rate (bpm) achieved during the EST and TWT at 9 months. *: p <0.05 vs. heart rate during the TWT.

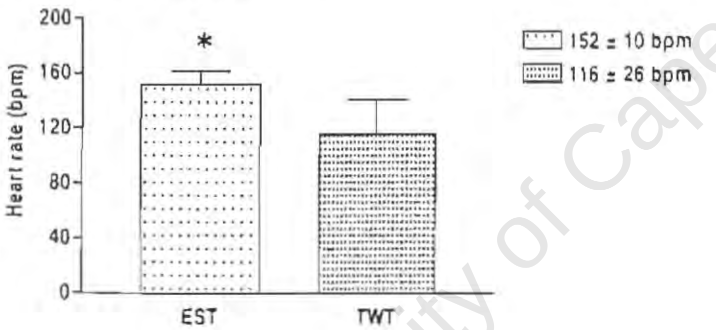


Figure 4.8: Maximum heart rate (bpm) achieved during the EST and ULT at 9 months.

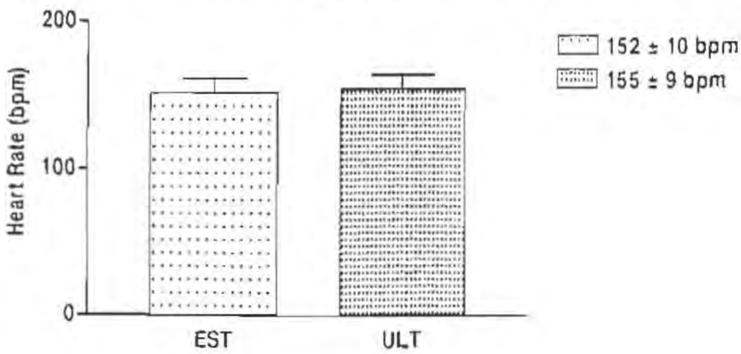


Figure 4.9: Correlation between maximum heart rate (bpm) achieved during the TWT and EST at 0 months (p=0.16; r=0.6).

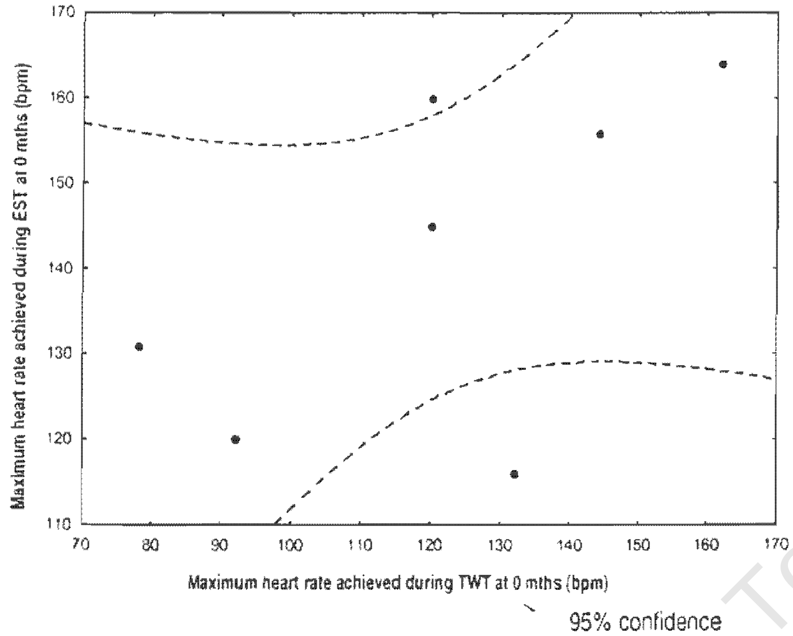
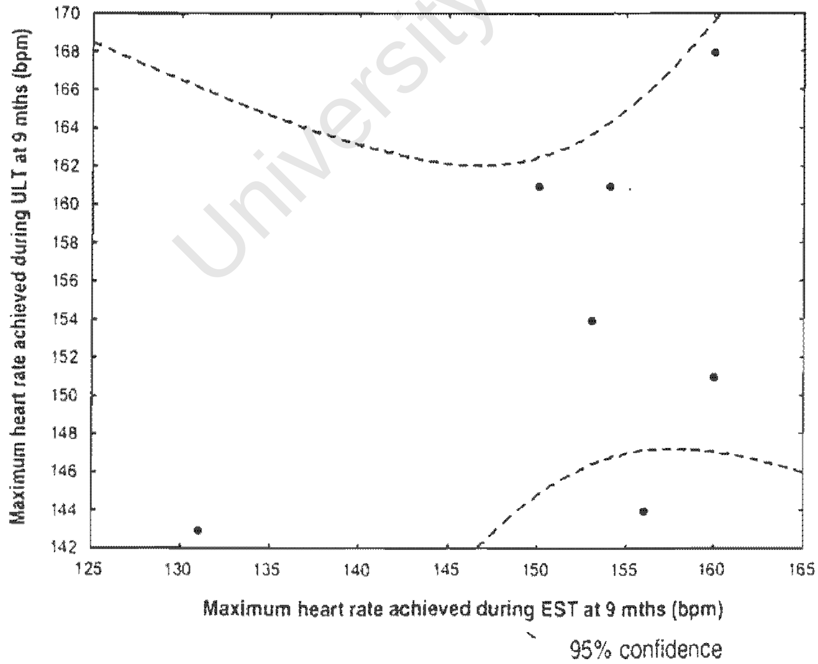


Figure 4.10: Correlation between maximum heart rate (bpm) achieved during the ULT and EST at 9 months (p=0.25; r=5).



DISCUSSION

In order to effectively monitor and track improvements in functional capacity, it is essential to use an exercise protocol that accurately measures true changes in functional capacity. We observed that patients who regularly participate in cardiac rehabilitation exercise training classes, experience improvements in functional capacity far greater than is shown by either the traditional 6-minute walk test and the conventional EST.

The first relevant finding of this study was that patients showed a greater improvement in functional capacity when performing the ULT (61%) compared to routine EST (31%) at 9 months of cardiac rehabilitation. It is important to note that subjects achieved an average 9 MET's during EST at 0 months, which would classify them as having a high baseline exercise tolerance. The results of the ULT therefore show superior performance in patients with high baseline exercise tolerances, despite underlying cardiovascular disease.

Furthermore, the variable response shown in improvement in functional capacity during both the EST and the walking protocols, suggests that individualised exercise prescription is important to ensure that patients are progressed through the various phases of cardiac rehabilitation at the adequate pace.

However, a possible limitation of this study may influence the interpretation. The EST records were obtained from routine visits by the patients to their cardiologists. It is not possible to be sure that the termination criteria used during these assessments were the same. Standard termination criteria include physical exhaustion, severe angina, ST–segment depression of more than 2 mm, hypotension of more than 20 mmHg, increase in blood pressure greater than 260/115 mmHg, signs of poor perfusion, complex arrhythmia, failure of heart rate to increase with increased exercise intensity or the patients' request (ACSM Guidelines for Exercise Testing and Prescription, 2000). However, many tests are terminated once the patient reaches a fair level of work or when the physician is satisfied that there are no cardiac abnormalities during exercise. Indeed, as described in the review of the literature in Chapter One, arbitrary target hearts rates of, for example, between 120-140 bpm are often used as termination criteria (Schlant et al. 1986). Yet, the EST results used in our study are representative of the results that are routinely provided by cardiologists when referring patients to cardiac rehabilitation programmes. We suggest that the intensities reached during routine practice EST is insufficient and cardiologists should be encouraged to perform tests of maximal functional capacity if the results are to be used in exercise prescription during cardiac rehabilitation. Indeed, the American College of Sports Medicine advocates that unless a patient shows any untoward signs and symptoms, they should be encouraged to give their best effort so that the maximal exercise tolerance can be determined accurately (ACSM Guidelines for Exercise Testing and Prescription, 2000). It is important to consider the purpose of the EST: Exercise tests can be performed to assess disease severity and prognosis, or to evaluate functional capacity. The findings of this chapter highlight the need to interpret routine EST results for exercise prescription with caution, especially at later stages of cardiac rehabilitation.

Our findings are supported by those of Hammond et al. (1985) who suggested that setting exercise prescriptions from the results of routine symptom-limited stress testing might result in too low exercise intensities. This may explain why results from cardiac rehabilitation are not as impressive as expected. Our results show that patients are able to endure intensity levels far greater than that achieved during routine EST. These results were achieved during the ULT, and are also evident on observation of patients during their normal cardiac rehabilitation classes. It follows then that perhaps the results of the ULT should be used as a more accurate indicator of the exercise intensity for patients attending later phases of cardiac rehabilitation.

The second important finding of this study was that significantly lower heart rates were achieved during the TWT compared to the EST at 9 months. This finding suggests that patients did not achieve the maximum heart rates they were capable of during the TWT, and that the TWT does not reflect true functional capacity in later phases of cardiac rehabilitation.

Thirdly, the heart rates achieved during the EST and ULT at 9 months were not significantly different. Therefore, patients did not exceed heart rates that were deemed "safe" by their cardiologists during the ULT. The ULT can therefore safely be undertaken by cardiac low-risk patients who regularly attend high intensity sessions and have no musculo-skeletal abnormalities that may be aggravated by unrestricted locomotion.

One of the limitations discussed in the previous chapter of this thesis was that subjects did not perform the ULT on initiation of the cardiac rehabilitation programme. In this chapter therefore we set out to investigate it's safety vs. more traditional indices of functional capacity including the EST and TWT. Whilst our study shows the safety of the ULT during phases III and IV cardiac rehabilitation, further research is necessary to prove it's safety in patients starting cardiac rehabilitation. Some authors have suggested that the design of an exercise testing protocol should match the expected abilities of the patients being tested (Staniforth et al. 1998). It may therefore be appropriate to select the type of test based on the peak METs achieved during the EST. Perhaps patients who achieve low levels of functional capacity should perform the TWT and those who achieve a high baseline functional capacity should be allowed to walk or jog during their exercise test.

A test that assesses both functional capacity and patient prognosis is more likely to be clinically useful than one that assesses patient prognosis alone (DeBusk 1989). From the results of our study, the ULT appears to be a more accurate test of functional capacity in phase III and IV cardiac rehabilitation. However, whereas many studies have shown the value of the 6-minute walk test in the diagnosis and prognosis of cardiac disease, further research should be conducted on the ULT to establish it as a recognised test of prognosis and functional capacity in later phases of cardiac rehabilitation.

In conclusion, the results of this study show that EST underestimates the improvement in functional capacity in patients participating in phase III and IV cardiac rehabilitation programmes. It is therefore suggested that all cardiac rehabilitation patients perform the ULT as a better measure of functional capacity. Whilst the EST is valuable in determining the safety of patients to exercise and to assess any new cardiac abnormalities, we suggest that exercise prescription should not be based solely on the results of the EST.

CHAPTER FIVE

SUMMARY AND CONCLUSIONS

SUMMARY

The aim of this thesis was firstly to characterise patients attending cardiac risk reduction and reversal programmes, and secondly to evaluate test of functional capacity during later phases of cardiac rehabilitation programmes.

The first study of this dissertation reported in **Chapter Two**, established that 80% of the patients attending the Cardiac Rehabilitation Programme at the Sports Science Institute of South Africa had documented CAD, and the remaining 20% attended the programme for rehabilitation of another co-morbidity. In addition, only 31% of the group of CAD patients presented with CAD only. The remainder of the group either required rehabilitation for musculo-skeletal injuries (most commonly grade I motion segment abnormality of the lumbar spine) or an additional co-morbidity in conjunction with their cardiac condition. This study also confirmed previous research that the number of female participants in cardiac rehabilitation programmes is much lower than the number of males participants.

The experiments reported in **Chapter Three** found that the traditional 6-minute walk test showed only small increments in improvement in functional capacity when performed at 12 weekly intervals during phase II, III and IV cardiac rehabilitation. Secondly, the unrestricted locomotion test elicits a greater improvement in functional capacity compared to the TWT in phase III and IV patients. The results of this study suggest that both the TWT and the ULT may be of practical use for smaller centres that do not have the financial resources to acquire traditional exercise stress ECG equipment. However, we suggest that the ULT be used in later stages of cardiac rehabilitation to monitor functional capacity accurately and to adjust exercise prescription accordingly.

In **Chapter Four**, the safety of the ULT was investigated by comparing the maximum heart rates achieved during this test and those achieved during routine exercise stress tests (EST). This study showed that the heart rates achieved during the ULT after 9 months of cardiac rehabilitation were not significantly different to the heart rates achieved during the EST at 9 months. Patients were therefore performing the test within safe heart rate limits. A further important finding of this study showed that the EST underestimates improvement in functional capacity compared to the percentage improvement shown by the ULT. It appears that both traditional walk indices and routine EST underestimate true functional capacity in patients who regularly participate in high intensity cardiac rehabilitation.

CONCLUSIONS

This thesis confirms that the traditional cardiac rehabilitation population is changing and now includes patients requiring medical intervention and rehabilitation for co-existing musculoskeletal injuries and additional co-morbidities. These findings have implications for staffing and equipment of such programmes, and should be considered to enable the holistic treatment of patients.

Secondly, the choice of test of functional capacity is important in ensuring that patients receive accurate feedback regarding their progress during participation in cardiac rehabilitation programmes. Reasons for performing such tests should guide one's choice – for example, if safety to perform exercise is the goal, the EST may be the best choice. However, if the accurate assessment of functional capacity is the aim, the TWT or ULT is advocated. These tests can also be used in community-based intervention programmes. It is our suggestion that patients participating in phase III and IV cardiac rehabilitation perform the ULT as a better measure of functional capacity, as the TWT may mask significant improvements in functional capacity.

CHAPTER SIX

REFERENCES

REFERENCES

Ades PA. Cardiac rehabilitation and secondary prevention of coronary heart disease. N Engl J Med 2001;345(12):892-902.

Ades PA, Coello CE. Effects of exercise and cardiac rehabilitation on cardiovascular outcomes. Medical Clinics of North America 2000; 84(1):251-265.

Ades PA, Grunveld MH. Cardiopulmonary exercise testing before and after conditioning in older coronary patients. Am Heart J 1990;120:585-589.

Ades PA, Huang D, Weaber SO. Cardiac rehabilitation participation predicts lower rehospitalization costs. Am Heart J 1992;123:916-921.

Ades PA, Maloney A, Savage P, Carhart RL Jr. Determinants of physical functioning in coronary patients: response to cardiac rehabilitation. Arch Intern Med 1999$_a$;159:2357-2360.

Ades PA, Savage PD, Elaine Cress M, Brochu M, Melinda Lee N, Poehlman ET. Resistance training on physical performance in older disabled female cardiac patients. Med Sci Sports Exerc. 2003;35(8):1265-70.

Ades PA, Savage PD, Poehlamn ET, Bruchu M, Fragnoli-Munn K, Carhhart RL Jr. Lipid lowering in the cardiac rehabilitation setting. J Cardiopulm Rehabil 1999$_b$;19:155-160.

Ades PA, Pashkow FJ, Nestor JR. Cost effectiveness of cardiac rehabilitation after myocardial infarction. J Cardiolpulm Rehabil 1997;17:222-231.

Albert CM, Mittleman MA, Chae CU, Lee I-M, Hennekens CH, Manson JE. Triggering of sudden death by vigorous exertion. N Engl J Med 2000; 328:538-545.

Allison TG, Williams DE, Miller TD, Patten CA, Bailey KR, Squires RW, Gau GT. Medical and economic costs of psychological distress in patients with coronary artery disease. Mayo Clin Proc 1995:70(8):734-742.

American College of Sports Medicine. The recommended quantity and quality of exercise for developing and maintaining fitness in healthy adults. Med Sci Sports Exerc 1990;22:265-274.

American College of Sports Medicine. ACSM's Exercise Management for persons with chronic diseases and disabilities. Durstine JL, Bloomquist LE, Figoni SF, Moore GE, Painter PL, Pitetti KH, Roberts SO, Pope CJ. Champaign IL: Human Kinetics, 1997.

American College of Sports Medicine. ACSM's guidelines for testing and prescription. Franklin BA, Whaley MH, Howley ET, Balady GJ, Berra KA, Golding LA, Gordon NF, Mahler DA, Myers JN, Sheldahl LM. 6th ed. Philadelphia: Lippincott Williams and Wilkins. 2000.

Andrew GM, Oldridge NB, Parker JO, Cunningham DA, Jones NL, Rechnitzer PA, Buck C, Kavanagh T, Shephard RJ, Sutton JR, McDonald W. Reasons for dropout from exercise programmes in post-coronary patients. Med Sci Sports Exerc 1981;13(3);164-168.

Arthur HM, Smith KM, Kodis J, McKelvie R. A controlled trial of hospital versus home-based exercise in cardiac patients. Med Sci Sports Exerc 2002;34(10):1554-50.

Bader DS, Maguire TE, Spahn CM, O'Malley CJ, Balady GJ. Clinical profile and outcomes of patients in cardiac rehabilitation stratified according to the National Heart, Lung and Blood Institute criteria. J Cardiopulm Rehabil 2001;21(4):210-217.

Balady GJ, Fletcher BJ, Froelicher ES, Hartley LH, Krauss RM, Oberman A, Pollock ML, Taylor CB. Cardiac Rehabilitation Programs. A statement for Healthcare Professionals from the American Heart Association. AHA Medical/Scientific Statement. Circulation 1994;90:1602-1610.

Balady GJ, Weiner DA. Physiology of exercise in normal and patients with coronary artery disease. In: Wenger NK, Hellerstein HK. Rehabilitation of the Coronary Patient. 3rd ed. New York, NY: Churchill Livingstone Inc, 1992:103-122

Balady GJ, Ades PA, Comoss P, Limacher M, Pina IL, Southard D, Williams MA, Bazzarre T. Core components of cardiac rehabilitation/secondary prevention programs: A statement for healthcare professionals from the American Heart Association and the American Association of Cardiovascular and Pulmonary Rehabilitation Writing Group. Circulation 2000;102(9):1069-1073.

Balas EA, Jaffrey F, Kuperman GJ, Austin Boren S, Brown GD, Pinciroli F, Mitchell JA. Electronic communication with patients: evaluation of distance medicine technology. JAMA 1997; 278(2):152-159.

Barry J, Mead K, Nabel EG, Rocco MB, Campbell S, Fenton T, Mudge GH Jr, Selwyn AP. Effect of smoking on the activity of ischaemic heart disease. JAMA 1989;261:398-402.

Belardinelli R, Georgiou D, Cianci G, Purard A. Randomised, controlled trial of long-term moderate exercise training in chronic heart failure. Effects on functional capacity, quality of life, and clinical outcome. Circulation 1999;99:1173-1182.

Ben-Ari E, Rothbaum DA, Linnemeir TJ, Landin RJ, Steinmetz EF, Hillis SJ, Noble JR, Hallam CC, See MR, Shiner R. Benefits of a monitored rehabilitation programme versus physician care after emergency percutaneous transluminal coronary angioplasty: follow-up of risk factors and rate of restenosis. J Cardiopulm Rehabil 1989;7:281-285.

Bengtsson K: Rehabilitation after myocardial infarction. Scand J Rehbil Med 1983;15:1-9.

Benowitz NL. Pharmacologic aspects of cigarette smoking and nicotine addiction. N Engl J Med. 1998;319:1318-1330.

Benz-Scott LA, Ben-Or Keren, Allen JK. Why are women missing from outpatient cardiac rehabilitation programmes? A review of multilevel factors affecting referral, enrollment, and completion. J Women's Health 2002;11(9):773-791.

Blumenthal J, Siegal W, Appelbaum M. Failure to reduce blood pressure in patients with mild hypertension: Results of a randomised controlled trial. JAMA 1991; 266:2098.

Bobbio M, Abecia A, Demichelis B, Magnacca Muscle, Guiltier T. How the exercise electrocardiogram is used in clinical practice in patients with suspected coronary artery disease. Am J Cardiol 1993;72:763-766.

Bock BC, Carmona-Barros RE, Esler JL, Tilkemeier PL. Program participation and physical activity maintenance after cardiac rehabilitation. Behav Modif 2003;27(1):37-53.

Boger RH. Drug interactions of the statins and consequences for drug selection. Int J Clin Pharmacol Ther 2001;39(9):369-382.

Bondestam E, Breikks A, Hartford M. Effects of early rehabilitation on consumption of medical care during the first year after acute myocardial infarction in patients ≥65 years of age. Am J Cardiol 1995;75:767-771.

Bradshaw D, Groenewald P, Launscher R, Nannan N, Nojilana B, Norman, R, Pieterse D, Schneider M, Bourne DE, Timaeus IM, Dorrington R, Johnson L. Initial burden of disease estimates for South Africa. SAMJ 2003; 93:682-288.

Brochu M, Peohlman ET, Ades PA. Obesity, body fat distribution, and coronary artery disease. J Cardiopulm Rehabil 2000;20:96-108.

Brubaker PH, Warner JG Jr, Rejeski WJ, Edwards DG, Matrazzo, BA, Ribisl PM, Miller HS Jr, Herrington DM. Comparison of standard- and extended-length participation in cardiac rehabilitation on body composition, functional capacity and blood lipids. Am J Cardiol 1996;78:769-773.

Brummer P, Linko E, Kasanen A. Myocardial infarction treated by early ambulation. Am Heart J 1956;52:269-272.

Burr ML, Fehily AM, Gilbert JF, Rogers S, Holliday RM, Sweetnam PM, Elwood PC, Deadman NM. Effects of changes in fat, fish and fibre intakes on death and myocardial reinfarction: diet and reinfaction trail (DART). Lancet 1989;334:757-761.

Butland RJA, Pang J, Gross ER, Woodcock AA, Geddes DM. Two-, six- and twelve-minute walking tests in respiratory disease. Br Med J (Clin Res Ed) 1982;284(6329):1607-1608.

Cahalin LP, Mathier MA, Semigran MJ, Dee GW, DiSalvo TG. The six-minute walk test predicts oxygen uptake and survival in patients with advanced heart failure. Chest 1996;110(2):325-332.

Calles-Escandon J, Ballor D, Harvey-Berino J, Ades PA, Tracy R, Sobel B. Amelioration of the inhibition of fibrinolysis in elderly, obese subjects by moderate energy intake restriction. Am J Clin Nutr 1996;64(1):7-11.

Cannistra LB, O'Malley CJ, Balady GJ. Comparison of outcome of cardiac rehabilitation in black and white women. Am J Cardiol 1995;75:890.

Cannistra LB, Balady GJ, O'Malley CJ, Weiner DA, Ryan T. Comparison of the clinical profile and outcome of women and men in cardiac rehabilitation. Am J Cardiol 1992; 69:1274-1279.

Chazerain P, Hayem G, Hamza S, Best C, Ziza JM. Four cases of tendinopathy in patients on statin therapy. Joint Bone Spine 2001;68(5):430-3.

Cheng A, Braunstein JB, Dennison C, Nass C, Blumenthal RS. Reducing global risk for cardiovascular disease: using lifestyle changes and pharmacotherapy. Clin Cardiol 2002;25(5):205-212.

Cobb FR, Williams RS, McEwan P, Jones RH, Coleman RE, Wallace AG. Effects of exercise training on ventricular function in patients with recent myocardial infarction. Circulation 1982;66:100-106.

DeBusk RF. Specialised testing after recent acute myocardial infarction. Ann Int Med 1989;110(6):470-81.

DeBusk RF, Blomqvist CG, Kouchoukos NT, Leupker RV, Miller HS, Moss AJ, Pollock ML, Reeves TJ, Selvester RH and Stason WB. Identification and treatment of low-risk patients after acute myocardial infarction and coronary artery bypass graft surgery. New Engl J Med 1986;314, 161-166.

DeBusk RF, Haskell WL, Miller NH, Berra K, Taylor CB, Berger WE, Lew H. Medically-directed at-home rehabilitation soon after uncomplicated acute myocardial infarction: A new model for patient care. Am J Cardiol 1985;55:251-257.

DeBusk RF, Houston N, Haskell W, Fry F. Exercise training soon after myocardial infarction. Am J Cardiol 1979;44:1223-1229.

Demers C, McKelvie RS, Negassa A, Ysuf S. Reliability, validity and responsiveness of the six-minute walk test in patients with heart failure. Am Heart J 2001;142(4):698-703.

De Lorgeril M, Renaud S, Mamelle N, Salen P, Martin JL, Monjaud I, Guidollet J, Touboul P, Delaye J. Mediterranean alpha-linolenic acid-rich-diet in secondary prevention of heart disease. Lancet 1994;343:1454-1459.

Detry JMR, Rousseau M, Vandenbroucke G, Kusumi L, Brasseur L, Bruce RA. Increase arteriovenous oxygen difference after physical training in coronary artery disease. Circulation 1971;44:109-119.

Digenio AG. New developments in cardiac rehabilitation pertinent to South Africa. Cardiovasc J SA 1993;4(5):191-194.

Digenio AG, Sim JGM, Krige K, Stewart A, Morris R, Dowdeswell RJ, Padayachee GN. The Johannesburg cardiac rehabilitation programme. S Afr Med J 1991;79:183-187.

Dreyer M, Derman EW, St Claire Gibson A, Noakes TD. The physiological characterization of cardiac athletes participating in the chronic disease risk reversal and reduction programme. Unpublished Honours Thesis, 2002, University of Cape Town.

Dugmore LD. Tipson RJ. Philips MH, Flint EJ, Stentiford NH, Bone MF, Littler WA. Changes in cardiorespiratory fitness, psychological well-being, quality of life, and vocational status following a 12 month cardiac exercise rehabilitation programme. Heart 1999;81(4):359-66.

Dunbar-Jacob J, Dwyer K, Dunning EJ. Compliance with antihypertensive regimen: a review of the research in the 1980s. Ann Behav Med 1991;13:31-9.

Durnin JVGA, Womersely J. Body fat assessed from the total body density and its estimation from skinfold thickness: measurements on 481 men and women aged from 16 to 72 years. Br J Nutrition 1974;32:77-97.

Edwards WW, Glickman-Weiss, Franks BD, Iyriboz Y, Dodd SL, Quaid TP. Percutaneous transluminal coronary angioplasty rehabilitation. A cost-effective analysis. J Cardiopulmon Rehabil 1993;13:172-81.

Ehsani A, Heath GW, Hagberg JM, Sobel BE, Holloszy JO. Effects of 12 months of intense exercise training on ischaemic ST-segment depression in patients with coronary artery disease. Circulation 1981;64:1116-1124.

Ekelund L, Haskell WL, Johnson JL, Shaley FS, Criqui MH, Sheps DS. Physical fitness as a predictor of cardiovascular mortality in asymptomatic North American men. N Engl J Med 1988;319:1379-1384.

Evanson KR, Rosamond WD, Leupker RV. Predictors of outpatient cardiac rehabilitation utilisation: the Minnesota Heart Surgery Registry. J Cardiopulm Rehabil 1998;18:192-198.

Ewart CK, Taylor CB, Reese LB, DeBusk RF. Effects of early post-myocardial infarction exercise testing on self-perception and subsequent physical activity. Am J Cardiol 1983;51:1076-1080.

Expert panel on detection, evaluation and treatment of high blood cholesterol in adults. Executive summary of the third report of the National Cholesterol Education Program (NCEP) Expert panel on Detection, Evaluation, and Treatment of high blood cholesterol in adults (Adult Treatment Panel III). JAMA 2001;285(19).

Francis GS, Rectot TS. Maximum exercise tolerance as a therapeutic endpoint in heart failure – are we relying on the right measure? Am J Cardiol 1994;73:304-306.

Franklin BA, Bonzheim K, Gordon S, Timmis GC. Rehabilitation of cardiac patients in the twenty-first century: Changing paradigms and perceptions. J Sports Sciences 1998,16:S57-S70.

Franklin BA, Hall L, Timmis GC. Contemporary cardiac rehabilitation services. Am J Cardiol 1997;79:1075-1077.

Franklin BA, Swain PD, Shephard RJ. New insights in the prescription of exercise for coronary patients. J Cardiovasc Nurs. 2003;18(2):116-23.

Frasure-Smith N, Lespérance F, Gravel G, Masson A, Juneau Muscle, Talajac M. Social support, depression, and mortality during the first year of myocardial infarction. Circulation 2000;101:1919-24.

Friedman DB, Williams AN, Levine BD. Compliance and efficacy of cardiac rehabilitation and risk factor modification in the medically indigent. Am J Cardiol 1997;79:281-285.

Froelicher V, Jensen D, Genter F, Sullivan M, McKirnan MD, Witztum K, Scharf J, Strong ML, Ashburn W. A randomised trial of exercise training in patients with coronary artery disease. JAMA 1984;252:1291-1297.

Gallagher R, McKinley S, Dracup K. Predictors of women's attendance at cardiac rehabilitation programmes. Progr Cardiovasc Nurs 2003;18(3);121-126.

Gardner JK, McConnell TR, Klinger TA, Herman CP, Hauck CA, Laubach Jr CA. Quality of life and self-efficacy: gender and diagnosis considerations for management during cardiac rehabilitation. J Cardiopulmon Rehabil. 2003;23(4):299-306.

Garratt A, Schmidt L, Macintosh A, Fitzpatrick R. Quality of life measurement: bibliographic study of patient assessed health outcome measures. BMJ 2002;324(7351):1417.

Gianuzzi P, Tavazzi L, Temporelli PL, Corra U, Imparato A, Gattone M, Giordano A, Sala L, Schweiger C, Malinvermi C. Long-term physical training and left ventricular remodelling after anterior myocardial infarction: Results of exercise in anterior myocardial infarction. J Am Coll Cardiol 1993;22:1821-1829.

Gillum RF, Barsky AJ. Diagnosis and management of patient non-compliance. JAMA 1974;228(12):1563-1567.

Ginsberg HN. Is hypertriglyceridemia a risk factor for atherosclerotic cardiovascular disease? A simple question with a complicated answer. Ann Intern Med 1997;126:912-914.

Gordon NF. Clinical effectiveness of three models for comprehensive cardiovascular risk reduction in lower risk patients with CAD. 2000 May AHA Conference.

Gordon NF, Salmon RD, Mitchell BS, Faircloth GC, Levinrad LI, Salmon S, Saxon WE, Reid KS. Innovative Approaches to comprehensive cardiovascular disease risk reduction in clinical and community-based settings. Curr Atheroscler Rep 2001,3(6):498-506.

Gualeni A, Dalai A, Gentilini A, Pagani M, Giordano A, Faggiano P. Effects of maximally tolerated oral therapy on the six-minute walking test in patients with chronic congestive heart failure secondary to either ischaemic or idiopathic dilated cardiomyopathy. Am J Cardiol 1998;81:1370-1372.

Hendrican MC, McKelvie RS, Smith T, McCartney N, Pogue J, Teo KK, Yusuf S. Functional capacity in patients with congestive heart failure. J Card Fail 2000;6(3):214-219.

Heberden W. Commentaries on the history and cure of diseases. In Willlius FA, Keys TW (*eds): Cardiac Classics*. St Louis. CV Nosby Co. 1941, 224.

Hertanu JS, Davis L and Focseneanu M. Cardiac Rehabilitation Exercise Programme: Outcome Assessment. Arch Phys Med Rehabil 1986;67:431-435.

Horton ES. Role and management of exercise in diabetes mellitus. Diabetes Care 1988; 11:210.

Hubert HB, Feinleib M, McNamara PM, Castelli WP. Obesity as an independent risk factor for cardiovascular disease: A 2-year follow-up of participants in the Framingham Heart Study. Circulation 1983;67(5):968-977.

Hung J, Gordon EP, Houston N, Haskell WL, Goris ML, DeBusk RF. Changes in rest and exercise myocardial perfusion and left ventricular function 3 to 26 weeks after clinically uncomplicated acute myocardial infarction: effects of exercise training. Am J Cardiol 1984;54:943-50.

Joliffe JA, Rees K, Taylor RS, Thompson D, Oldridge N, Ebrahim S. Exercise-based rehabilitation for coronary heart disease. From the Cochrane Library, Issue 4, 2001.

Jugdutt BI, Michorowski BL, Kappagoda CT. Exercise training after anterior Q wave myocardial infarction: importance of regional left ventricular function and topography. J Am Coll Cardiol 1988;12:362-72.

Kallio V, Hamalainen H, Hakkila J, Luurila OJ. Reduction in sudden deaths by a multifactorial intervention programme after acute myocardial infarction. Lancet 1979;2(1852):1091-1094.

Karlik BA, Yarcheski A. Learning needs of cardiac patients: A partial replication study. Heart Lung 1987;16(5): 544-551.

Karlsdottir AE, Foster C, Porcari JP, Palmer-McLean K, White-Kibe R, Backes RC. Hemodynamic responses during aerobic and resistance exercise. J Cardiopulm Rehabil 2002;22(3):140-177.

Kavanagh T. Does exercise improve coronary collateralisation? A new look at an old belief. Phys and SportsMed 1989;17(1):96-113.

Krone RJ. The role of risk stratification in the early management of a myocardial infarction. Ann Inten Med 1992;116:223-237.

Krone RJ, Gilespie JA, Weld FM, Miller JP, Moss AJ. Low-level exercise testing after myocardial infarction: usefulness in enhancing clinical risk stratification. Circulation 1985;71:80-89.

Kruse WH-H. Compliance with treatment of hyperlipoproteinemia in medical practice and clinical trails. New York: Raven Press, 1991;175-86.

Laughlin MH. Effects of exercise training on coronary transport capacity. J Appl Physiol 1985;58:468-476.

Laughlin MH, Overholser KA, Bhatte M. Exercise training increases coronary transport reserve in miniature swine. J Appl Physiol 1989;67:1140-1149.

Langenfeld H, Schneider B, Grimm W, Beer M, Knoche M, Riegger G, Kochsiek K. The six-minute walk – an adequate exercise test for pacemaker patients? Pacing Clin Electrophysiol 1990;13(12 Pt 2):1761-1765.

Langer A, Freeman MR, Josse RG, Steiner G, Armstrong PW. Detection of silent myocardial ischaemia in Diabetes Mellitus. Am J Cardiol 1991;67:1073-1078.

Lavie CJ, Milani RV. Patients with baseline exercise capacity benefit from cardiac rehabilitation and exercise training programmes. Am Heart J 1994;128:1105-1109.

Lavie CJ, Milani RV. Effects of cardiac rehabilitation and exercise training on exercise capacity, coronary risk factors, behavioural characteristics, and quality of life in women. Am J Cardiol 1995;75(5):340-343.

Lavie CJ, Milani RV. Effects of cardiac rehabilitation programs on exercise capacity, coronary risk factors, behavioural characteristics, and quality of life in a large elderly cohort. Am J Cardiol 1995;76(3):177-179.

Lavie CJ, Milanie RV. Effects of cardiac rehabilitation and exercise training in obese patients with coronary artery disease. Chest 1996;109:52-56.

Lavie CJ, Milani RV, Littman AM. Benefits of cardiac rehabilitation and exercise training in secondary coronary prevention in the elderly. J Am Coll Cardiol 1993;22(3):678-83.

Lavorato L, Grypma S, Spenceley S, Hagen B, Nowatzki N. Positive outcomes in cardiac rehabilitation: the little programme that could. Can J Cardiovasc Nurs 2003;13(3):13-9.

Law M. Lipids and cardiovascular disease. In:Yusuf S, Cairns JA, Camm AJ, Fallen EL, Gersh BJ, eds. Evidence based cardiology. London: BMJ 1998;191-205.

Lee AP, Ice R, Blessey R, Sanmarco ME. Long-term effects of physical training on coronary patients with impaired left ventricular function. Circulation 1988;78:506-15.

Leren P. The Oslo diet-heart study. Eleven year report. Circulation 1970;42:935-42.

Lespérance F, Frasure-Smith N, Talajic M, Bourassa MG. Five-year risk of cardiac mortality in relation to initial severity and one-year changes in depression symptoms after myocardial infarction. Circulation 2002;105:1049-1053.

Letac B, Cribier A, Desplanches JF. A study of left ventricular function in coronary patients before and after physical training. Circulation 1977;56:375-382.

Levin LA, Perk J, Hedback B. Cardiac rehabilitation – a cost-analysis. J Intern Med. 1991;230:427-434.

Levine S, Lown B. "Armchair" treatment of acute coronary thrombosis. JAMA 1952:148:1365-1369.

Levy D, Larson MR, Vasan RS, Kannal WB, Ho KK. The progression from hypertension to congestive heart failure. JAMA 1996;275(20):1557-1562.

Linden W, Stossel C, Maurice J. Psychological interventions for patients with coronary artery disease: a meta-analysis. Arch Intern Med 1996;156:745-52.

Lipkin DP, Scriven AJ, Crake T, Poole-Wilson PA. Six minute walking test for assessing exercise capacity in chronic heart failure. Br Med J (Clin Res Ed) 1986;292(6521):653-655.

Maines TY, Lavie CJ, Milani RV, Cassidy MM, Gilliland YE, Murgo JP. Effects of cardiac rehabilitation and exercise programmes on exercise capacity, coronary risk factors, behaviour, and quality of life in patients with coronary artery disease. South Med J 1997;90(1):43-49.

Malfatoo G, Faccini M, Sala L, Branzi G, Bragato R, Leonelti G. Effects of cardiac rehabilitation and beta-blocker therapy on heart rate variability after first myocardial infarction. Am J Cardiol 1998;81:834-40.

Mallory G, White P, Salcedo-Salgar J. The speed of healing of myocardial infarction: a study of the pathological anatomy in seventy-two cases. Am Heart J 1939;18:647-71.

Maron BJ, Shirani J, Poliac LC, Mathange R, Roberts WC, Mueller FO. Sudden death in young competitive athletes: clinical, demographic, and pathological profiles. JAMA 1996;276:199-204.

McAlister FA, Lawson FME, Teo KK, Armstrong PW. Randomised trials of secondary prevention programmes in coronary heart disease: systematic review. BMJ 2001;323:957-62.

McBride P, Schrott HG, Plance MB, Underbakke G, Brown RL. Primary care practice adherence to National Cholesterol Education Programme Guidelines for patients with coronary artery disease. Arch Intern Med 1998;158:1238-44.

McKelvie RS, Jones NL. Cardiopulmonary exercise testing. Clin Chest Med 1989;10(2):277-291.

Meade TW, Imeson J, Stirling Y. Effects of changes in smoking and other characteristics of clotting factors and the risk of ischaemic heart disease. Lancet 1987;2:986-988.

Mertons DJ, Kavanagh T, Campbell RB, Shepherd RJ. Exercise without dietary restriction as a means to long-term fat loss in the obese cardiac patient. J Sports Med Phys Fitness 1998;38:310-316.

Miyamoto S, Nagaya N, Satoh T, Kyotoni S, Sakamaki F, Fujita M, Nakanishi N, Miyatake K. Clinical correlates and prognostic significance of six-minute walk test in patients with primary pulmonary hypertension. Comparison with cardiopulmonary exercise testing. Am J Respir Crit Care Med 2000;161(Pt 1):487-492.

Michaelides AP, Dilaveris PE, Psomadaki ZD, Aggelakas S, Stafanadis C, Cokkinos D, Gialafos J, Toutouzas PK. Reliability of the exercise-induced ST-segment changes to detect restenosis three months after coronary angioplasty: Significance of the appearance in other leads. Am Heart J 1998;135:449-456.

Milani RV, Lavie CJ, Cassidy MM. Effects of cardiac rehabilitation and exercise training programmes on depression in patients after major coronary events. Am Heart J 1996;132:726-732.

Milani RV, Lavie CJ. Behavioural differences and effects of cardiac rehabilitation in diabetic patients following cardiac events. Am J Med 1996;100(5):517-523.

Montgomery PS, Gardner AW. The clinical utility of a six-minute walk test in peripheral arterial occlusive disease patients. J Am Geriatr Soc 1998;46(6):706-711.

Morales FJ, Montemayor T, Martinz. Shuttle versus six-minute walk test in prediction of outcome in chronic heart failure. Int J Cardiol 2000;76(2-3):101-105.

Morrin L, Black S, Reid R. Impact of duration in a cardiac rehabilitation programme on coronary risk profile and health-related quality of life outcomes. J Cardiopulm Rehabil 2000;20(2):115-121.

Muller DW, Topol EJ. Selection of patients with acute myocardial infarction for thrombolytic therapy. Ann Intern Med 1990;113:949-960.

Myers J, Prakash M, Froelicher V, Do D, Partington S, Atwood JE. Exercise capacity and mortality among men referred for exercise testing. N Engl J Med 2002;346:793-801.

Needs and priorities in cardiac rehabilitation and secondary prevention in patients with coronary artery disease. WHO Technical Report Series 831. Geneva: World Health Organisation, 1993.

Newby LK, Eisenstein EL, Califf RM, Thompson TD, Nelson CL, Peterson ED, Armstrong PW, Van de Werf F, White HD, Topol EJ, Mark DB. Cost effectiveness of early discharge after uncomplicated myocardial infarction. N Engl J Med 2000;342(11):749-755.

O'Connor GT, Buring YE, Yusuf S, Goldhaber SZ, Olmstead EM, Paffenbarger RS Jr, Hennekens CH. An overview of randomised trials of rehabilitation with exercise after myocardial infarction. Circulation 1989;80:234-244.

O'Keeffe ST, Lye M, Donnellan C, Carmichael DN. Reproducibility and responsiveness of quality of life assessment and six minute walk test in elderly heart failure patients. Heart 1998;80(4):377-382.

Oldridge NB. Cardiac rehabilitation exercise programme. Compliance and compliance-enhancing strategies. Sports Med 1988_a;6:42-55.

Oldridge NB, Streiner DL. The health belief model: predicting compliance and dropout in cardiac rehabilitation. Med Sci Sports Exerc 1990;22(5):678-683.

Oldridge NB. Compliance with cardiac rehabilitation services. J Cardiopulm Rehab 1991_a;11:115-127.

Oldridge NB. Comprehensive cardiac rehabilitation: is it cost-effective? Eur Heart J 1998;19(suppl):O42-O49.

Oldridge NB, Donner AP, buck CW, Jones NL, Andrew GM, Parker JO, Cunningham DA, Kavanagh T, Rechnitzer PA, Sutton JR. Predictors of dropout from cardiac exercise rehabilitation. Ontario Exercise-Heart Collaborative study. Am J Cardiol 1983;51:70-74.

Oldridge NB, Guyatt GH, Fischer ME, Rimm AA. Cardiac rehabilitation after myocardial infarction. Combined experience of randomised clinical trials. JAMA 1988_b;260:945-950.

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

Oldridge NB, Guyatt G, Jones N, Crowe J, Singer J, Feeny D, McKelvie R, Runins J, Streiner D, Torrance G. Effects on quality of life with comprehensive rehabilitation after myocardial infarction. Am J Cardiol 1991_b;67(13):1084-1089.

Oldridge NB, Stump TE, Nothwhr FK, Clark DO. Prevalence and outcomes of comorbid metabolic and cardiovascular conditions in middle- and older-age adults. J Clin Epidemiol 2001;54(9):928-934.

Omenn GS, Anderson KW, Kronmal RA, Vlietstra RE. The temporal pattern of reduction of mortality risk after smoking cessation. Am J Prev Med 1990;6:251-257.

Ornish D, Brown SE, Scherwitz LW, Billings JH, Armstrong WT, Ports TA, McLanahan SM, Kirkeeide RL, Brand RJ, Gould KL. Can lifestyle changes reverse coronary heart disease? The Lifestyle Heart Trial. Lancet 1990;336:129-133.

Ornish D, Scherwitz LW, Billings JH, Guld KL, Merrit TA, Sparler S, Armstrong WT, Ports TA, Kirkeeide RL, Hogeboom C, Brand RJ. Intensive lifestyle changes for the reversal of coronary heart disease. JAMA 1998;280(23):2001-2007.

Paffenbarger RS Jr, Hyde RT, Wing AL, Hsieh CC. Physical activity, all-cause mortality and longevity of college alumni. N Engl J Med 1986;314:605-613.

Pashkow FJ. Issues in contemporary cardiac rehabilitation: Historical Perspective. J Am Coll Cardiol 1993;21:822-834.

Perk J, Hedback B, Engvall J. Effects of cardiac rehabilitation after coronary artery bypass grafting on readmissions, return to work, and physical fitness: a case-control study. Scand J Soc Med 1990;18(1):45-51.

Pierson LM, Herbert WG, Norton HJ, Kiebzak GM, Griffith P, Fedor JM, Ramp WK, Cook JW. Effects of combined aerobic and resistance training versus aerobic training alone in cardiac rehabilitation. J Cardiopulm Rehabil 2001;21(2):101-110.

Poston WS, Haddock CK, Conard MW, Jones P, Spertus J. Assessing depression in the cardiac patient. When is the appropriate time to assess depression in the patient undergoing coronary revascularisation? Behav Modif 2003;27(1):26-36.

Prochaska JO. Working in harmony with how people change naturally. The Weight Control Digest 1993;251-255.

Quell, KJ, Porcari JP, Franklin BA, Foster C, Andreuzzi RA, Anthony RM. Is brisk walking an adequate aerobic training stimulus for cardiac patients? Chest 2002;122(5):1582-1586.

Redelmeier DA, Tan SH, Booth GL. The treatment of unrelated disorders in patients with chronic medical disease. N Engl J Med 1998;338(21):1516-1520.

Redwood DR, Rosing DR, Epstein SE. Circulatory and symptomatic effects of physical training in patients with coronary artery disease and angina pectoris. N Engl J Med 1972;286(18):959-65

Rejeski WJ, Foy CG, Brawley LR, Brubaker PH, Focht BC, James BC, Norris JL, Smith ML. Older adults in cardiac rehabilitation: a new strategy for enhancing physical function. Med Sci Sport Exerc 2002;34(11):1705-1713.

Rodgers GP, Ayanian JZ, Balady G, Beasley JW, Brown KA, Gervino EV, Paridon S, Quinones M, Schlant RC together with Task Force members. American College of Cardiology / American Heart Association Clinical Competence Statement on Stress Testing. A report of the American College of Cardiology / American Heart Association / American College of Physicians – American Society of Internal Medicine Task Force on Clinical Competence. Circulation 2000;102:1726.

Roul G, Germain R, Bareiss P. Does the 6-minute walk test predict the prognosis in patients with NYHA class II or III chronic heart failure. Am Heart J 1998;136(3):449-457.

Savage PD, Brochu M, Scott P, Ades PA. Low caloric energy expenditure in cardiac rehabilitation. Am Heart J 2000;140:527-533.

Savage PD, Brochu M, Poehlman ET, Ades PA. Reduction in obesity and coronary risk factors after high caloric exercise training in overweight coronary patients. Am Heart J. 2003;146(2):317-323.

Savage PD, Lee M, Harvey-Berino J, Brochu M, Ades PA. Weight reduction in the cardiac rehabilitation setting. J Cardiopulm Rehabil 2002;22(3):154-160.

Schachinger V, Britten MB, Zeiher AM. Prognostic impact of coronary vasodilator dysfunction on adverse long-term outcome of coronary heart disease. Circulation 2000;101:1899-1906.

Schairer JR, Keteyian SJ, Ehrman JK, Brawner CA, Berkebile ND. Leisure time physical activity of patients in maintenance cardiac rehabilitation. J Cardiopulmon Rehabil 2003;23(4):260-265.

Schairer JR, Kostelnik T, Proffitt SM, Faitel KI, Windeler S, Rickman LB, Brawner CA, Keteyian SJ. Caloric expenditure during cardiac rehabilitation. J Cardiopulm Rehabilitation 1998;18(4):290-294.

Schiller E, Baker J. Return to work after myocardial infarction: evaluation of planned rehabilitation and of predictive rating scale. Med J Aust 1976;1:859-862.

Schlant RC, Blomqvist CG, Brandenburg RO, DeBusk R, Ellestad MH, Fletcher GF, Froelicher VF Jr, Hall RJ, McCallister BD, McHenry PL. Guidelines for exercise testing. A report for the American College of Cardiology/American Heart Association Subcommittee on exercise testing. J Am Coll Cardiol 1986;8:725-38.

Schuler G, Hambrecht R, Schlierf G, Niebauer J, Hauer K, Neumann J, Hoberg E, Drinkmann A, Bacher F, Grunze M, Kubler W. Regular physical exercise and low-fat diets: Effects on progression of coronary artery disease. Circulation 1992;86:1-11.

Shah MR, Hasselblad V, Gheorghiade M, Adams KF Jr, Swedberg K, Califf RM, O'Connor CM. Prognostic usefulness of the six-minute walk test in patients with advanced congestive heart failures secondary to ischaemic or non-ischaemic cardiomyopathy. Am J Cardiol 2001;88(9):987-993.

Singh RB, Rastogi SS, Verma R, Laxmi B, Singh R, Ghosh S, Niaz MA. Randomised controlled trial of cardioprotective diet in patients with recent acute myocardial infarction: results of one year follow up. BMJ 1992; 314(6833):1015-1019.

Sinzinger H. Two different types of exercise-induced muscle pain without myopathy and CK elevation during HMG-Co-enzyme-A-reductase inhibitor treatment. Atherosclerosis 1999;143:459-460.

Siscovick DS, Weiss NS, Fletcher RH, Lasky T. The incidence of primary cardiac arrest during vigorous exercise. N Eng J Med 1984, 311:874-877.

Smith SC, Amsterdam E, Balady GJ, Bonow RO, Fletcher GF, Froelicher V, Heath G, Limacher MC, Maddahi J, Pryor D, Redberg RF, Roccella E, Ryan T, Smaha L, Wenger NK. Beyond secondary prevention: Identifying the high-risk patient for primary prevention: tests for silent and inducible ischaemia: writing group II. Circulation 2000;101:e12.

Southard BH, Southard DR, Nuckolls J. Clinical trial of an Internet-based Case management system for secondary prevention of heart disease. J Cardiopulm Rehabil. 2003;23(5):341-348.

Sox HC, Littenberg B, Garber AM. The role of exercise testing in screening for coronary artery disease. Ann Int Med 1989;110:456-469.

Staniforth AD, Andrew R, Harrison M, Perry A, Cowley AJ. "Value" of improved treadmill exercise capacity: lessons from a study of rate responsive pacing. Heart 1998;80:383-386.

Starling MR, Crawford MH, Kennedy GT, O'Rourke RA. Treadmill exercise tests predischarge and six weeks post-myocardial infarction to detect abnormalities of known prognostic values. Ann Intern Med 1981;94:721-727.

Stein RA, Michielli D, Diamond J, Horwitz B, Krasnow N. The cardiac response to exercise training: echocardiographic analysis at rest and during exercise. Am J Cardiol 1980;46:219-225.

Stratton JR, Chandler WL, Schwartz RS, Cerqueira MD, Levy WC, Kahn SE, Larson VG, Cain KC, Beard JC, Abrass IB. Effects of physical conditioning on fibrinolytic variables and fibrinogen in young and old healthy adults. Circulation 1991;83:1692-1697.

Stuart RL Jr, Ellestad MH. National survey of exercise stress testing facilities. Chest 1980;77:94-97.

Sullivan MJ, Higginbotham MB, Cobb FR. Exercise training in patients with chronic heart failure delays the ventilatory anaerobic threshold and improves submaximal exercise performance. Circulation 1989;79:324-329.

Thomas RJ, Miller NH, Lamendola C, Berra K, Hedback B, Durstine JL, Haskell W. National survey on gender differences in cardiac rehabilitation programmes: patient characteristics and enrolment patterns. J Cardiopulmon Rehabil 1996;16(6);402-412.

Thompson PD, Lim V. Physical activity in the prevention of atherosclerotic coronary heart disease. Curr Treat Option Cardiovasc Med 2003;5(4):279-285.

Tiukinhoy S, Boehar N, Hsie M. Improvement in heart rate recovery after cardiac rehabilitation. J Cardiopulmon Rehabil 2003;23(2):84-87.

Todd IC and Ballentyne D. Antianginal efficacy of exercise training: a comparison with beta-blockade. Br Heart J 1990;64:14-19.

Topol EJ, Juni JE, O'Neill WW, Nicklas JM, Shea MJ, Burek K, Pitt B. Exercise testing three days after onset of acute myocardial infarction. Am J Cardiol 1987;60:958-962.

Turner RC, Millns H, Neil HAW, Stratton IM, Manley SE, Mathews DR, Holman RR. Risk factor for coronary artery disease in non-insulin dependant diabetes mellitus: United Kingdom prospective diabetes study (UKPDS: 23). BMJ 1998;316:823-828.

Van Camp SP, Peterson RA. Cardiovascular complications of outpatient cardiac rehabilitation programmes. JAMA 1986;256:1160-1163.

Vanhees L, Fagard R, Thijs L, Staessen J, Amery A. Prognostic significance of peak exercise capacity in patients with coronary artery disease. J Am Coll Cardiol 1994;23:258-63.

Verani MS, Hartung GH, Hoepfel-Harris J, Welton DE, Pratt CM, Miller PR. Effects of exercise training on left ventricular performance and myocardial perfusion in patients with coronary artery disease. Am J Cardiol 1981;47:797-803.

Wannamethee SG, Shaper AG. Physical activity in the prevention of cardiovascular disease: an epidemiological perspective. Sports Med 2001;31(2):101-104.

Walsh JT, Andrews R, Evans A, Cowley AJ. Failure of "effective" treatment for heart failure to improve normal customary activity. Br Heart J 1995;74(4):373-376.

Weisman IM, Zellabos RJ. Clinical exercise testing. Clin Chest Med 2001;22(4):679-701.

Wenger NK, Froelicher ES, Smith LK et al. Cardiac rehabilitation: Clinical practice guidelines. Rockville, MD.: Agency for Health Care Policy and Research and the National Heart, Lung and Blood Institute, 1995. (AHCPR publication no. 96-0672).

White RD, Evans CH. Performing the exercise test. Prim Care 2001;28(1):29-53.

Wilhelmsson C, Vedin JA, Elmfeldt D, Tibblin G, Wilhelmsen L. Smoking and myocardial infarction. Lancet 1975;1:415-40.

Williams MA. Exercise testing in cardiac rehabilitation. Exercise prescription and beyond. Cardiol Clin 2001;19(3):415-431.

Williams MA, Maresh CM, Esterbrooks DJ, Harbrecht JJ, Sketch MH. Early exercise training in patients older than age 65 years compared with that in younger patients after acute myocardial infarction or coronary artery bypass grafting. Am J Cardiol 1985;55:263-266.

Wood D, De Backer G, Faergeman O, Graham I, Mancia G, Pyorala K together with members of the Task Force. Prevention of coronary heart disease in clinical practice. Recommendations of the Second Joint Task Force of European and other Societies on coronary prevention. Eur Heart J 1998;19:1434-1503.

Wright DJ, Khan KM, Gossage EM, Saltissi S. Assessment of a low-intensity cardiac rehabilitation programme using the six-minute walk test. Clin Rehabil 2001;15(2):119-124.

WHO Internet Publication. http://www.who.int/medicalcentre/releases/pr83/en. Cardiovascular death and disability can be reduced more than 50 percent.

Wymen R, Vitcenda M, McBride P. The surveillance of cholesterol management in the cardiac rehabilitation setting. J Cardiopulm Rehabil 2002;22(4):245-250.

Yates BC, Braklow-Whitton JL, Agrawal S. Outcomes of cardiac rehabilitation participants and nonparticipants in a rural area. Rehabil Nurs 2003;28(2):57-63.

Zabel M, Malik M, Hnatkova K, Papademetriou V, Pittaras A, Fletcher RD, Franz MR. Analysis of T-wave morphology from the 12-lead electrocardiogram for prediction of long-term prognosis in male US veterans. Circulation 2002;105:1066-1070.

"Not by might, nor by power, but by My Spirit, says the Lord"

Zechariah 4:6.