University of Alberta

The Predictors of Physical Activity Participation in Elderly Cardiac Patients

by

David Michael Buijs

A thesis submitted to the Faculty of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Master of Science
in
Rehabilitation Science

Faculty of Rehabilitation Medicine

Spring 2013
Edmonton, Alberta

ABSTRACT

THE PREDICTORS OF PHYSICAL ACTIVITY PARTICIPATION IN ELDERLY CARDIAC PATIENTS

Background: Exercise adherence is particularly low among elderly patients with low functional capacity.

Purpose: This study was undertaken to assess the relationship between measures of physical function (PF) with physical activity (PA) in elderly cardiac patients.

Methods: PF was assessed in 93 elderly patients involved in cardiac rehab (78M:15F; age 70 ± 7 years). Measures included the Multidimensional Self-Report Exercise Self-Efficacy, Medical Outcome Study 36-item Short Form Health Survey, Late Life Function and Disability Instrument, grip strength, gait speed, timed up and go test and a six minute walk test. PA was assessed using the SWA which provided data on steps/day (STEPS) and time spent at different MET levels (i.e., sedentary [waking time $\leq$ 1.5 METs, mild [1.5-3.0 METs], moderate [3.0-5.0 METs] and vigorous [>5.0 METs]).

Results: Patients averaged 5,467 ± 3,508 STEPS while spending 67 ± 43 minutes/day in moderate PA. The best predictor of PA was the 6MWT which only provided a moderate indication of STEPS (r^2=0.34; $P<0.05$).

Conclusion: Many elderly cardiac patients may be considered sedentary using STEPS. However, many still accumulated $\geq$ 60 minutes of moderate PA which is associated with many health benefits.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

CR – Cardiac Rehabilitation

CHD – Coronary Heart Disease

PA – Physical Activity

SE – Self-Efficacy

ADL – Activities of Daily Living

6MWT – Six Minute Walk Test

TUG – Timed Up and Go test

SWA – SenseWear™ Mini Armband

STEPS – Steps taken per day

DEE – Daily Energy Expenditure

MSES – Multidimensional Self-Report Exercise Self-Efficacy

ICF – International Classification of Functioning, Disability and Health

SF-36 – Medical Outcome Study 36-item Short-Form Health Survey

LLFDI – Late Life Functioning and Disability Instrument

HRQL – Health Related Quality of Life

CVD – Cardiovascular Disease

II – Inactive at baseline and Inactive at follow up

IA – Inactive at baseline and Active at follow up

AI – Active at baseline and Inactive at follow up

AA – Active at baseline and Active at follow up

CG – Control Group

IG – Intervention Group

SPPB – Short Physical Performance Battery

IADL – Instrumental Activities of Daily Living

PPF – Performance-based Physical Function

PPT – Physical Performance Test

GARS-M – Modified Gait Abnormality Rating Scale

MSST – Modified Sitting Step Test

HFG – High Functioning Group

LFG – Low Functioning Group

CHF – Chronic Heart Failure

AG – Acute Group

RG – Rehabilitation Group

MG – Maintenance Group

Grip – Grip Strength

GS – Gait Speed

TMW – Ten Meter Walk test

AEE – Activity Energy Expenditure

MET – Metabolic Equivalent

CHAPTER I

INTRODUCTION

1.1 Problem Statement

Exercised based cardiac rehabilitation (CR) has been shown to improve functional capacity, cardiovascular risk factors and reduce morbidity and mortality from coronary heart disease (CHD).[1-3] However, the benefits of exercise are only maintained as long as the exercise behaviour is maintained.[4] Secondary prevention and the long term success of CR programs are therefore subject to the patient's ability to maintain healthy behaviours, particularly participation in physical activity (PA).[4-6] Although, findings suggest that many patients maintain healthy behaviours following CR[5, 7-9] other studies have found that many cardiac patients experience a worsening of their cardiovascular risk factors and a decrease in PA and exercise capacity post-CR.[10, 11] Several studies have demonstrated that as many as 50% of cardiac patients return to a sedentary lifestyle within one year of completing CR.[4, 6, 7, 10, 12-14] This finding is of particular concern for the elderly cardiac patient where a decrease in functional reserve may lead to a loss of independence and increased morbidity and mortality rates. Therefore, an investigation into the predictors of participation in PA in elderly cardiac patients may be warranted.

Previous studies on the predictors of long term PA participation in cardiac patients post-CR have largely focused on psychosocial factors and found exercise self-efficacy (SE) (i.e., the belief in being able to successfully execute the behaviour required to produce the desired outcome), PA intentions (i.e., a patient's intention to engage in physical activity), health related barriers (i.e., potential obstacles that may prevent a patient from engaging in PA), education level, and socioeconomic status to be associated with participation in PA.[15] Other studies involving patients not attending a formal exercise program noted that those with low SE reported lower PA participation.[15, 16]

For elderly cardiac patients participation in PA may be more complicated by the presence of co-morbidities.[17-19] In this population, the existence of adverse psychosocial factors and functional limitations may exacerbate physical inactivity. For example 25-50% of community dwelling elderly adults have a fear of falling and 56% of those who fear falling limit their activities.[20] Those with a fear of falling also performed significantly worse on measures of balance, mobility and activities of daily living (ADL).[21] A study by Shimada et al. found that among community dwelling elderly adults, the average gait speed (GS) was approximately 1.25 m/s, which is approaching a threshold ($\leq$ 1m/s) that has been suggested as a predictor of PA cessation.[19]

Traditionally one of the primary outcome measures of CR has been exercise capacity which is typically assessed with a graded exercise test or the six minute walk test (6MWT). It is assumed that by increasing exercise capacity cardiac patients will be more physically active. However, in a study by Ashe et al. 2007, high exercise capacity was not predictive of increased levels of PA in community dwelling seniors with chronic conditions. Indeed the best predictor of exercise capacity and measures of PA participation was mobility as measured by the timed up and go (TUG) test.[22] This finding suggests that leg and core strength may be important determinants of PA participation.

Although there is a body of literature on the predictors of PA participation in cardiac patients, the majority of the literature has focused on psychosocial factors and few have specifically examined elderly patients. Further, those studies that have examined PA participation in elderly cardiac patients have almost exclusively relied on subjective measures to assess PA. These measures tend to overestimate the amount of PA performed.[23] Little is known about the relationship of measures of physical functioning with PA participation in elderly cardiac populations using objective measures. Therefore, the purpose of this study is to determine the predictors of PA participation in elderly cardiac patients.

1.2 Significance

Coronary heart disease is one of the most common causes of death and its incidence and prevalence increase with age.[24] More than 25% of adults over the age of 65 have clinical findings of CHD.[25] Furthermore, CHD can result in a decreased functional capacity which may impact one's independence.[12, 24, 26] Indeed, approximately 20% of disabled community dwelling elderly adults report CHD to be a major contributor to their disability.[25] This is concerning because the disabilities or functional limitations the elderly already experience reduces their functional reserve and places them near a threshold for independence thus exposing them to an increased risk of hospitalization, morbidity and ultimately mortality.[24, 27, 28] This will become an even greater concern for public health with the aging of the population as by 2036 one in four adults is expected to be over the age of 65.[29]

From a rehabilitation standpoint, identifying the predictors of PA participation could help us better understand the factors that influence PA patterns in elderly cardiac patients. Through better understanding these factors we may be able to improve long term PA participation and adherence in this population. In turn this could reduce the societal and economic burden of elderly cardiac patients associated with their increased dependence on others and use of health care services.

1.3 Definition of terms

Physical Activity: Physical activity is typically defined as “any bodily movement produced by skeletal muscles that requires energy expenditure and produces progressive health benefits.”[30]

Exercise: Exercise is commonly described as planned physical activity. The resulting body movements are therefore typically structured and repetitive in nature and are performed with the express purpose of improving or maintaining health and fitness.[30, 31]

Resting Metabolic Rate: An individual’s resting metabolic rate is the energy cost of sitting quietly at rest and is commonly accepted to be 3.5 ml/kg/min.[32, 33]

Metabolic Equivalent: A metabolic equivalent (MET) is a means by which to represent the energy cost of physical activity as multiples of a resting metabolic rate. The advantage of using METs is that they provide a common descriptor of workload and intensity for most modalities and populations. [32, 33]

Sedentary: Sedentary behaviour has been defined as "any waking behaviour characterized by energy expenditure $\leq$ 1.5 METs and in a sitting or reclined posture." [34] Yet operationally it may be defined as all behaviours with an energy cost $\leq$ 1.5 METs.[31, 35] The SWA can provide information on time spent at different MET levels as well as time spent sleeping. Therefore, for the purpose of this study sedentary time will be calculated as the difference between time spent $\leq$ 1.5 METs and time spent sleeping.

Activities of daily living: Activities of daily living refers to everyday tasks that are required for an individual to perform in order to live independently. They may be categorized as being either basic, those required for personal care (i.e., bathing, dressing, etc.), or instrumental, house hold tasks (i.e., cooking, cleaning, shopping, etc.).[36-39]

Disability: The International Classification of Functioning, Disability and Health views disability as malfunctioning or "the negative aspect of functioning." Disability therefore may imply having "difficulty" or "limitations" in performing everyday tasks required for independence.[24, 27, 40-42]

Physical function: According to the American College of Sports Medicine physical function is "the capacity of an individual to carry out physical activities of daily living. Physical function reflects motor function and control, physical fitness, and habitual physical activity and is an independent predictor of functional independence, disability, morbidity and mortality."[31]

Self-Efficacy: is the belief in being able to successfully execute the behaviour required to produce a desired outcome. [15]

Health related quality of life: There is no well-established definition of quality of life. However, some suggest that it consists primarily of two features: functional status and perceived well-being. Health related quality of life according to Shepherd et al., is therefore "a patient's perception or subjective evaluation of the impact of disease on their functional status and well-being."[43]

Mobility: According to Patla et al. mobility may be defined as "the ability to move independently from one point to another."[44]

Exercise capacity: Exercise capacity is the maximum physical exertion that an individual can sustain and is best characterised by maximum oxygen uptake (VO_{2peak}). Accurate assessment relies on a maximal effort from the individual that is prolonged long enough to elicit a steady state response from the cardiovascular system.[45, 46] Maximum oxygen uptake (VO_{2peak}) may also be commonly referred to as maximal aerobic power or aerobic capacity.[47] As a result both terms are often used interchangeably with exercise capacity. For the purpose of this study maximal aerobic power and aerobic capacity will be used interchangeable with exercise capacity.

Elderly: In the literature there is no well-established age range to define elderly; however, a commonly used range is $\geq$ 60 years of age. Furthermore, one of the tools used in this study, the Late Life Function and Disability Instrument, was specifically validated for use with older individuals $\geq$ 60 years old.[48] Therefore, for the purpose of this study elderly will be defined as $\geq$ 60 years of age.

1.4 Objectives

Exercise-based CR has been shown to improve exercise capacity, physical functioning, and psychosocial well-being in elderly cardiac patients.[2, 26] PA is an important element for secondary prevention and maintenance of these benefits.[4-6] However, additional studies are needed to assess the relationship of measures of physical functioning with objective measures of PA participation in elderly cardiac patients. Therefore, the **primary objective** of this study was to examine a number of possible predictors of PA participation in elderly cardiac patients. Physical activity was assessed objectively using the SenseWear™ Mini Armband (SWA) (Body Media, Pittsburgh, PA) which provides information on the number of steps taken per day (STEPS), daily energy expenditure (DEE), activity energy expenditure (AEE) as well as time spent at different PA intensities (i.e., sedentary, mild, moderate and vigorous PA).

Few studies have compared elderly cardiac patients entering a CR exercise program with those who have just completed an exercise-based CR program. Furthermore no one has compared the daily PA patterns of these two populations with elderly patients who have been compliant with an exercise regimen for more than one year. Therefore, a **secondary objective** of this study was to compare the differences between elderly cardiac patients involved in CR and patients who are $\geq$ 1 year post their cardiac event and have maintained a physically active lifestyle on measures of self-reported (exercise SE [MSES], HRQL [SF-36], perceived function [LLFDI]), and objective (Grip, GS, TUG, 6MWT) physical function as well as participation in PA (STEPS, DEE, AEE, PA intensity time).

Chapter II

LITERATURE REVIEW

2.1 Cardiac Rehabilitation and Physical Activity in the Elderly

The benefits of exercise-based CR are well documented and include improvements in blood pressure, lipid profile, exercise capacity and a reduction in obesity.[49, 50] Participation in CR has also been shown to have positive influences on depression, anxiety, somatisation, hostility as well as improvements in HRQL.[11, 50] Furthermore, participation in a CR program has also been shown to decrease morbidity and mortality and more recently to improve physical functioning in elderly cardiac patients.[51] As a result exercise based CR has become an integral part in the treatment and secondary prevention of CHD. For the elderly, CR tends to focus on improving exercise capacity, physical functioning, HRQL and extending disease free survival. [52]

After completion of a CR program patients are encouraged to participate in regular PA. This is because the benefits of PA are well established across both healthy and diseased conditions as well as in the elderly and are similar to those experienced by formal exercise programs.[11, 53-57] For example, PA reduces the incidence of many chronic diseases and the associated risk factors. Being physically fit or active may reduce the risk of premature death due to cardiovascular disease (CVD) by 50% and PA has been shown to improve blood pressure, lipid profile, insulin sensitivity and body composition.[53] Furthermore, PA has also been shown to increases exercise capacity,[15] strength, flexibility and mobility.[55, 58] In those with established CVD PA participation has been shown to improve endothelial dysfunction and potentially halt disease progression and in some cases reverse plaque build-up. [59, 60] Even in those with CHD who have adopted an active lifestyle later in life have been shown to experience a reduced risk of all cause and CVD mortality.[61, 62] This has led to the recommendation that everyone should be accumulating at least 30 minutes a day of moderate intensity PA (i.e., brisk walking) on at least 5 days of the week.[55] Participating in this minimum recommendation is associated with 20-40% reduction in mortality risk.[63]

Probably the most important benefit of regular PA participation for the elderly is the impact it has on their physical functioning and independence.[55, 58, 64] For example Daly et al., 2008 completed a 10 year follow up on the effects of habitual PA on grip strength, balance and gait speed performance in elderly men and women.[64] They compared four groups, those who were inactive at baseline and inactive at follow up (II), inactive at baseline and active at follow up (IA), active at baseline and inactive at follow up (AI), and active at both baseline and follow up (AA). They found that at baseline there was no difference between groups on balance while the active groups performed better on measures of grip strength and gait velocity. At the 10 year follow up the significant decline in grip strength and gait velocity was similar across all groups. However, those active at baseline experienced a smaller decline in balance scores.[64]

In another study by Molino-Lova et al., 2011 the long term effects of a structured PA intervention on physical performance in 99 elderly cardiac patients (who just completed CR) was examined.[65] Nondisabled patients who received elective cardiac surgery and completed an inpatient rehabilitation program were randomized into a control group (CG) and an intervention group (IG). The CG completed a thrice weekly aerobic exercise program whereas the IG attended two additional meetings at program onset where they were taught exercises aimed at improving upper and lower limb muscular strength, body flexibility and muscle length, dynamic balance and coordination. Afterwards, IG patients were instructed to perform these exercises three times a week for approximately 30 minutes. Extensive information on the risk of disability and the consequences on HRQL and family burden were also given to the IG. Participants in both groups were assessed on physical performance using the Short Physical Performance Battery (SPPB) at baseline and 1 year later. For the SPPB participants are timed on three tasks that include balance, five repeated chair stands and a 4-m self-paced walk. Results showed no differences between groups at baseline on their SPPB score. However, the IG significantly improved their SPPB score while the CG did not and the differences were maintained at the 1 year follow up.[65]

Despite the benefits of PA, some studies have found that as many as 50% of cardiac patients stop participating in regular PA within a year of completing CR.[66] In a recent study by Dolansky et al., 2010 the exercise adherence of 248 cardiac patients (age 62 years) was examined during and after a CR program.[11] Participants were interviewed during the 12 week CR program and completed questionnaires on joint pain, co-morbidity, self-efficacy, depressed mood, and social support. They also completed a 6MWT to assess exercise capacity. Over the 48 week duration of the study participants wore a heart rate monitor and completed daily activity logs over a 12 week period. Participants were given a new heart rate monitor and activity log every three months over the 48 week period. Adherence was defined as participating in at least 30 minutes of moderate intensity exercise at least 3 times a week. They found that, at one year as many as 78% of participants were not meeting the recommended three sessions per week of moderate intensity exercise.[11] This finding is supported by others, suggesting that more research is required to better understand the factors that influence PA participation.[67, 68]

2.2 Outcome Measures

Exercise SE has been shown to be an important mediator for the adoption and adherence to health behaviours such as participation in PA.[69-74] Exercise SE has also been shown to be more important in the early stages of behaviour adoption[15, 74] as it may influence the level of commitment, persistence and effort an individual exerts to obtain the desired outcome.[70] In the elderly, exercise SE has been shown to be positively associated with measures of physical function,[75] that PA participation improves SE[76] and those participating in PA with high exercise SE are more likely to be more active[69] and to maintain that behaviour.[77]

In cardiac patients exercise SE has been found to be positively associated with CR outcome measures such as exercise capacity, HRQL[70, 78, 79] and that women have lower exercise SE than men.[79] Studies have shown exercise SE to be predictive of CR program compliance[80] and self-reported PA during the program[81] as well as in the first few weeks following program completion.[82]

In one study by Blanchard et al., 2006 the correlates of change in PA was examined.[15] Five hundred fifty-five patients with CHD who did not attend CR completed surveys at two, six and 12 months after hospital discharge on perceived severity and susceptibility, exercise SE, PA intention, benefits and barriers of PA and a PA questionnaire (Godin Leisure Time Exercise Questionnaire). It was found that PA intentions and health related barriers were positively and negatively associated with changes in PA across all three time intervals respectively. However, using hierarchical linear regressions only the change in exercise SE was predictive of changes in PA between baseline and six months with higher SE predicting higher PA. While between six and 12 months having more time related barriers decreased PA and perceiving more health related benefits increased PA.[15] This finding suggests that exercise SE may play a more important role in determining PA participation in elderly cardiac patients in the early stages of adopting the behaviour such as those involved in CR. However, some of the limitations of Blanchard's et al., study include the use of a subjective measure of PA which tends to overestimate PA and a large portion of the study's participants being younger than 61 years of age which limits its generalizability to elderly cardiac patients.[23] Further investigation into the influence of SE on PA participation in elderly cardiac patients is warranted using objective measures of PA.

Several different questionnaires have been developed to assess exercise SE. One exercise SE questionnaire, the multidimensional self-report exercise self-efficacy (MSES) questionnaire, was designed to assess three domains of SE;

coping, task and scheduling, which are thought to be important for maintaining the behaviour of PA participation.[83] The MSES has been found to be both valid and reliable[83] and has been used with cardiac patients.[84]

2.3 Disability in Cardiac patients

The International Classification of Functioning, Disability and Health (ICF) is a theoretical model used to examine an individual's health and disability as it relates to function.[42] In the general framework of the ICF disability is not merely the result of a health condition but also depends on an individual's body functions, body structures, their activities and their participation in activities.[42] An individual's disability may further be impacted by the contextual factors, such as their environment and personal factors, and is a dynamic process.[42] Disability in the ICF is therefore "the negative aspect of functioning" and implies that an individual is having "difficulty" in performing basic ADLs (i.e., bathing, dressing, toileting) and instrumental activities of daily living (IADL: i.e., cooking, housework, shopping).[37-39, 42] Studies have shown that elderly cardiac patients experience high rates of disability with women experiencing higher rates than men.[1, 27, 85, 86] The probability of developing a disability increases with the number of co-morbidities.[85] Furthermore, many elderly adults' physical abilities may place them near a threshold of independence [24, 27, 28] and the presence of CHD may cause them to fall below this threshold.[12, 24, 26]

As disability may be associated with having "difficulty" in performing IADLs, it is not surprising that studies have shown that PA is inversely related to disability in elderly populations.[87-91] For example a study by Wang et al., 2002 examined the predictors of functional change in 1,875 elderly adults.[91] Participants were interviewed biannually to determine physical function, chronic medical conditions, smoking, alcohol consumption and PA until they were diagnosed with dementia, dropped out or died. In the interview participants were asked to rate their difficulty in performing various basic ADLs and IADLs on a scale of zero, no difficulty, to three, unable to complete the tasks while participating in regular exercise was defined as exercising at least 15 minutes three times a week. Physical function was also assessed using a performance-based physical function (PPF) score consisting of performance on four tasks (GS, repeated chair rise, standing balance, and grip strength). After an average follow-up of 3.4 years difficulty in ADLs and IADLs increased and PPF scores decreased indicating poorer physical function. Those with morbidity had poorer function than those without morbidity and those who exercised at least three times a week experienced less of a functional decline then those who did not. This relationship of exercise with physical function was most noticeable in those with CAD.

2.4 Health Related Quality of Life.

Health related quality of life is a common outcome measure of many rehabilitation programs as it represents the patient’s perception of the impact of their disease on their well-being.[43] In a study by Jeng & Braun 1997, 33 cardiac patients participated in a 12 week tri-weekly exercise program that examined the influence of exercise SE on exercise intensity, compliance rate and CR outcomes.[79] Participants completed self-reported measures of fatigue (Fatigue/Stamina Scale), anxiety (State-Trait Anxiety Inventory), depression (The

Center for Epidemiologic Studies Depression Scale) and HRQL (The Medical Outcome Study 36-item Short-Form health Survey (SF-36)) as well as a graded exercise test at baseline and after program completion. It was found that exercise SE improved throughout the program while compliance rates decreased. Exercise SE was positively associated with exercise capacity (VO_{2max}), stamina and HRQL while it was negatively associated with fatigue. However, only changes in HRQL were positively associated with higher compliance rates at the end of 12 weeks.[79] This finding suggests that HRQL may be an important predictor in PA participation in elderly cardiac patients.

Many disease specific questionnaires have been used to assess HRQL in cardiac patients. However, many of them often refer to symptoms and not the ability to perform IADL. Their use in assessing outcome measures may also be problematic as many have floor and ceiling effects and lack sensitivity to clinical change.[92] The limitation of disease specific HRQL questionnaires may be attributed to the lack of a gold standard for assessing new questionnaires. As a result, a variety of different measures have been used to validate these tools.[92] One frequently used measure in the development of disease specific HRQL questionnaires is the SF-36.[93] The SF-36 is a commonly used general health survey that assesses HRQL across several dimensions of health. The utility of general health surveys over disease specific questionnaires is that they explore a wider range of dimensions and outcomes, and thus, provide a more general picture of health status.[56] Furthermore, the SF-36 is particularly useful in assessing HRQL in elderly community dwelling adults with mobility limitations.[94-96]

2.5 Perceived Function and Disability

In a study by Dolansky et al., 2008 the early disability of older adults that had experienced a cardiac event was examined.[40] Sixty elderly myocardial infarct patients were recruited to undergo measurements of disability and functional limitations (timed balance tests, chair rises and walking four meters, self-reported rating) as well as complete a questionnaire on their self-reported difficulty in performing daily activities (i.e., Katz Activities of Daily Living Scale, Instrumental ADL Scale from the Older Americans Resource Survey). Participants' disability was calculated in two ways as an overall score (from 0 to 30) and categorically for ADLs and IADLs as being disabled (score of 0-5) and not disabled (6-15). During the baseline interview participants were asked to think of their disability and functional limitation prior to their cardiac event when responding to the questionnaires. All measures were repeated at three and six weeks after hospital discharge. Disability was positively associated with self-reported functional limitations, depression, gender and co-morbidity and negatively associated with physical performance on the objective measures of functional limitations. Self-reported functional limitations were negatively related to physical performance. Objective measures of functional limitations improved across all three measurements. However, at week six approximately 70% of participants reported no improvement or a worsening of their disability in IADLs from before their cardiac event.[40] This finding suggests that despite improvements in their physical performance, perceived function and disability did not change. In studies with community dwelling elderly adults it has been shown that those with a fear of falling limit their physical activities.[20, 21] It is possible that in elderly cardiac patients perceived function and disability may be important determinants of their PA participation similar to fear of falling in the elderly. However, this requires further investigation.

One questionnaire that focuses on a person's ability to perform IADL is the Late Life Functioning and Disability Instrument (LLFDI). It was developed to assess the constructs of functioning and disability in older community dwelling adults ($\geq$60 years). The two domains of function and disability reflect an individual's ability to perform discreet physical tasks encountered in daily routines and their ability to take part in major life tasks and social roles, respectively.[97, 98] The LLFDI has been found valid and reliable in older community dwelling populations and has shown strong correlations between its functional domain and the physical function subscale and physical component score of the SF-36. Yet, the main utility of the LLFDI over other self-reported measures is an absence of a floor or ceiling effect in the scores reported.[48, 97] The ability to measure a wide range of functioning and disability may make the LLFDI useful in assessing perceived function and disability in elderly cardiac patients at various stages of disease. Several studies have used the LLFDI to assess perceived function and disability in cardiac patients.[48, 99-101] Despite being valid and reliable questionnaires, such as the SF-36 and the LLFDI, only show mild to moderate correlation with more objective measures of physical functioning (i.e., VO_{2peak}, 6 min walk test distance).[48] Some suggest that the weak correlation between self-reported measures and performance measures may indicate that they are measuring different aspects of health status.[46] Additional research is required to determine which factors are better predictors of PA participation in elderly cardiac patients.

2.6 Physical Function

Some studies have shown that various measures of physical functioning are predictive of disability.[58l, 99] For example, Brach et al., 2002 examined the relationship of physical impairment and disability to physical function in 83 community dwelling elderly men.[99] Participants underwent assessments of physical impairment and disability which included the Physical Performance Test (PPT), Modified Gait Abnormality Rating Scale (GARS-M) from a 15.2 meter walk, walking speed, grip strength, ankle range of motion and the Modified Sitting Step Test (MSST). They found that participants who had a slow GS (0.60 m/s), scored 7.3 on the GARS-M which is close to the cut-off for risk of recurrent falls and were in the 25th percentile of the PPT. Using a stepwise linear regression they found that only grip strength, GS and fall risk were independently related to physical function and accounted for 68% of the variance in physical function.[99] These findings are supported by other studies [102-105] and suggest that measures of strength and mobility are negatively related to disability and positively related to the ability to perform IADLs in the elderly and may impact how physically active they are. In light of these findings strength and mobility may play important roles in how physically active elderly cardiac patients are.

2.6.1 Strength

Strength is positively associated with functional status [106-111] and is predictive of all-cause mortality.[109, 112-116] It has been shown that strength diminishes with advancing age with the most significant decreases occurring after the age of 60.[107, 117-119] Furthermore, a minimum level of muscular strength is required to be able to perform IADLs[120] and the loss of muscular strength in the elderly may result in disability[110, 111, 120] and dependence in IADLs.[110, 121] Hand grip strength (Grip) is a valid and reliable measure of overall upper and lower body strength in older adults[64, 122] and is strongly correlated with measures of hand function[94, 106, 123] which is important in the ability to carry out IADLs.[94, 109, 124, 125]

Studies have shown that Grip is an important predictor of disability in the elderly.[102, 103, 105, 110, 126-128] In a study by Al Snih et al. 2004, 2,493 non-institutionalized Mexican American men and women aged 65 or older were assessed on maximal Grip and their functional disability, the inability to perform ADLs, using a modified version of the Katz Activities of Daily Living scale.[126] Participant's functional disability was reassessed at follow up visits after two, five and 7 years. After controlling for age, marital status, medical conditions, depressive symptoms, cognitive function and body mass index, the hazard ratio of becoming disabled in ADLs was 1.90 and 2.28 for men and women in the lowest quartiles for Grip respectively. Furthermore, each 1kg increase in maximum Grip was shown to reduce limitations in ADLs by 3% and 5% in men and women respectively.[126] These findings are supported by other studies.[102, 103, 105, 110, 127, 128] In the presence of CHD many older adults limit their PA due to a fear of adverse events which leads to further de-conditioning and lose of strength which in turn may result in greater disability.[129]

Others have shown that low Grip is a predictor of increased mobility limitations in the elderly.[122, 125, 130] For example in a study by Sallinen et al. 2010 1,084 men and 1,562 women aged $\geq$ 55 years were assessed on Grip and participated in an interview to determine if they had mobility limitations.[122] It was determined that a maximum Grip score of less than 37 kg and 21 kg in men and women respectively resulted in mobility limitations.[122] Yet few studies have looked at Grip in elderly cardiac patients. Those that have examined Grip in elderly cardiac patients have reported values that are close to these cut-offs.[96, 131, 132] Some studies in healthy elderly populations have shown that higher Grip is positively correlated with PA.[64, 133-136] One study in elderly cardiac patients showed that Grip is responsive to a structured PA program.[65] However, no studies have looked at Grip as a predictor of PA participation in elderly cardiac patients.

2.6.2 Mobility

Mobility is a major concern for the elderly as it decreases with age.[137] Any ensuing limitations or disability may result in a loss of independence,[137, 138] decreased QOL,[137, 139] institutionalization[140] and a higher risk of mortality.[116, 141] Approximately, 47% of elderly adults experience some form of mobility limitation[138] with greater mobility limitations being experienced by women,[142] those with CHD [143, 144] and those who are sedentary.[145, 146]

Regular PA can reduce the risk of mobility limitations.[146] However, one of the challenges in assessing mobility in the elderly is the lack of an accepted gold standard.

2.6.2.1 Gait Speed

One common measure of mobility, GS,[147] has been used as a predictor of future disability,[125, 148] hospitalization,[148] dependence,[105, 148, 149] frailty and mortality in elderly adults[148, 150, 151] and is both valid and reliable.[125, 148, 150] A decrease in GS of 0.1m/s has been found to correspond with a 10% decrease in the ability to perform IADLs.[37] An interesting finding regarding GS in the elderly was reported by Shimada et al., 2007.[19] In this study they examined the relationship between GS and PA cessation in 582 community-dwelling elderly adults. Participants were assessed at baseline and again two years later on their regular PA and physical functioning. Regular PA was defined as carrying out any PA at least five times a week and was assessed by asking participants if they carried out physical activities (yes/no), how often they carried out physical activities (times per week) and what activities they carried out (i.e., golf, ball games, hiking, home-based or group exercise, dancing, swimming, martial arts, jogging, walking, other exercise). Physical functioning was assessed using measures of strength (grip strength, maximal voluntary strength of knee extensors), balance (functional reach test) and gait abnormalities (gait speed). At the two year follow up 67% of participants maintained their PA levels. Using multiple logistic regressions it was found that the female gender, smoking and a GS of < 1 m/s predicted PA cessation.[19] This finding suggests that GS significantly influences PA participation in elderly populations. Studies in cardiac patients have shown agreement with the predictive value of GS for dependence, morbidity and mortality.[152, 153] However, no studies have examined gait speed as a predictor of PA participation in elderly cardiac patients.

2.6.2.2 Timed Up and Go Test

Another common test of mobility that is valid and reliable [154-156] in the elderly is the TUG test. The TUG test has been shown to predict falls [156-158] and difficulties in ADLs.[154, 156, 159] Most notably the TUG test has been shown to be predictive of current PA participation in the elderly.[22]

For example in a study by Ashe et al., 2007 they examined the disparity of exercise capacity and participation in PA in 200 community dwelling elderly adults with chronic conditions.[22] PA was assessed with both self-report (Physical Activity Scale for Individuals with Physical Disabilities) and objective (pedometer) measures. They assessed exercise capacity using the 6MWT as well as balance (National Institutes of Aging and Balance Scale), upper body strength (grip strength), lower extremity strength (handheld myometer) mobility function (TUG), pulmonary function (spirometry), falls SE (Activities-Specific Balance Confidence), disease management SE (Standford Self-efficacy for Managing Chronic Disease scale) and depression (Centre for Epidemiological Studies-Depression Scale). It was found that although 60% of participants had a good exercise capacity ($\geq$ 400m on the 6MWT) only a third of them were considered active as measured by the pedometer ($\geq$ 7500 STEPS). Using multiple linear regressions the best predictor of exercise capacity and both subjective and objective measures of PA was better performance on the TUG.[22] This finding would suggest that mobility is an important determinant of PA participation in the elderly. However, no studies have examined the TUG in elderly cardiac patients.

In another study by Yoshida et al., 2010 they examined the relationship between physical fitness and ambulatory activity in very elderly women with different functional capacities.[160] One hundred and forty seven participants were classified as being either high functioning (HFG) or low functioning (LFG) using the Tokyo Metropolitan Institute of Gerontology Index of Competence. Physical fitness was assessed using handgrip strength, knee extensor strength, postural stability, stepping, one-legged standing time with eyes open, 10m walking time and the TUG test. Ambulatory activity was assessed by STEPS and time spent in ambulatory activity with a triaxial accelerometer (Active style PRO HJA-350IT; OMRON, Kyoto, Japan). Participants wore the accelerometer for twelve days. It was found that the HFG group took more STEPS and spent more time in ambulatory activity then the LFG group. In the LFG both measures of ambulatory activity were negatively correlated with 10m walking time and TUG test while positively correlated with one legged standing time. A similar relationship was found in the HFG with the exception that knee extensor strength was also positively correlated with ambulatory activity. The strongest correlation for the LFG was seen with the 10 meter walking time while the TUG test showed a stronger association in the HFG.[160]

The findings by both Shimada et al., and Ashe et al., suggest that mobility is an important determinant of PA participation in the elderly.[19, 22] However, no studies have examined GS or the TUG test with PA participation in elderly cardiac patients. It is reasonable to assume that a similar relationship may exist in elderly cardiac patients. Yet the findings by Yoshida et al., may indicate that the measure of mobility may be sensitive to the stage of disease[160] as many acute cardiac patients may have more functional limitations,[40] and in turn may be classified as low functioning, then chronic cardiac patients. For example, GS may be a better predictor of PA participation for patients involved in CR while TUG test times may be a better predictor for patients greater than one year after their cardiac event. Further investigation is warranted.

2.6.3 Exercise Capacity

One of the hall mark symptoms of a cardiac event is exercise intolerance. Exercise has been shown to improve cardiovascular risk factors such as cholesterol levels, obesity, and blood pressure.[49] Thus, exercise capacity has become an important outcome measure for CR and it is commonly thought that by improving exercise capacity in cardiac patients they will be more physically active. For example in one study by Guiraud et al., 2012, the short and long term adherence to PA was examined following a phase II CR program in eighty cardiac patients.[14] Participants engaged in exercise sessions three days a week for 21 non consecutive days. Exercise sessions consisted of 45 minutes of aerobic exercise on an ergocycle or treadmill, one hour of outdoor walking at a target heart rate of 60-90% of heart rate reserve and 45 minutes of a fitness, gymnastics, relaxation, QI Gong or aquatic therapy classes. At the completion of the program participants' peak power output, determined by cardiopulmonary stress test, and readiness for change, determined by questionnaire, were assessed. Participants were then either contacted at two months (n=41) or one year (n=39) after program completion and asked to wear a single axis accelerometer for seven days. Time spent at different MET levels (i.e., light 1.8-2.9 METS, moderate 3 – 5.9 METS and vigorous $\geq$ 6 METS) was averaged and used to calculate energy expenditure in kilocalories. The three intensity levels were then summed for a weekly total activity EE. Although, only 53.6% of those at two months and 40% of those one year post CR were active ($\geq$150 minutes per week of moderate intensity PA) peak power output measured at the end of the program had a strongly positive (r=0.39) correlation with total weekly activity energy expenditure.[14] This finding supports that exercise capacity is an important moderator of PA in cardiac patients following CR. However, in Ashe's study exercise capacity was not the best predictor of PA participation in community-dwelling elderly adults with chronic conditions. [22] Further investigation is required to elucidate the role exercise capacity plays in PA participation in elderly cardiac patients.

The gold standard for assessing exercise capacity is peak oxygen uptake (VO_{2peak}).[46] It has been shown to be a good predictor of prognosis in patients with Chronic Heart Failure (CHF) as a peak $VO_2 \leq$ 14ml/kg is associated with a worse prognosis.[161, 162] However, VO_{2peak} has certain limitations; it is time consuming, requires expensive equipment and additional technical expertise which is not available in many rehabilitation programs.[162, 163] Therefore, measuring VO_{2peak} is not the most practical by which to measure exercise capacity.

Surrogate tests for VO_{2peak} have been developed, ranging from treadmill tests, cycle ergometer tests, or simple walking tests. A commonly used test is the 6MWT developed by Guyatt et al., 1985, as it is easy to administer, requires little equipment and has been shown to be valid and reliable.[164] For this test patients are asked to walk as far as they can in six minutes on a 25 meter flat indoor course. The distance the patient covers over the six minutes is recorded. The sub maximal nature of this test is considered to be better representative of IADL than a maximal test of VO_{2peak} particularly in the elderly.[162] The 6MWT has also been shown to have prognostic value as covering a distance less than 300m is associated with increased risk of six month mortality and morbidity.[163] The 6MWT has been used to validate other tools as it is frequently used as an outcome measure in many rehabilitation programs.

2.7 Measures of Physical Activity

Due to the well-established relationship of PA to health it is recommended that elderly adults accumulate at least of 30 minutes of moderate intensity PA most days of the week.[165] However, assessing an individual's PA level may be challenging. The most valid method for assessing PA, the doubly labelled water method,[166, 167] involves an individual ingesting two stable isotopes of water that reflect the metabolism of the body. One to three weeks after ingestion of the isotopes the difference between the rates of loss of the isotopes is analyzed to determine the kilocalories burned over the given period of time.[168] Despite the validity of the doubly labelled water method in assessing PA it is costly, invasive and only provides the average DEE over the two week period.[167, 168] As a result of these limitations many studies on PA in elderly cardiac patients have relied on a more practical method, self-reported questionnaires.[5, 8, 15, 62, 166, 169, 170 , 171, 172 , 173]

Self-reported PA questionnaires also have their own limitations that make their use problematic. For example, they rely on memory recall which lends them to over estimation of the amount of PA performed.[23, 166] Test-retest reliability of these questionnaires may also be very challenging to establish as the test-retest period must be short enough to avoid any change in PA patterns but long enough to avoid any learning effect and as a result few studies have reported the test-retest reliability of many PA questionnaires.[166] Furthermore; many PA questionnaires are less sensitive than more objective measures of PA. In studies assessing changes in PA in response to an intervention a lack of change in PA may be due to the sensitivity of the questionnaire and not the actual intervention.[167] In cardiac patients a lack of sensitivity may also result in an inability to distinguish between patients as many patients only participate in low intensity PA.[166] Finally, many PA questionnaires only show a moderately positive correlation with more objective measures of PA such as the doubly labelled water method.[166]

Some studies on PA in cardiac patients have used other objective measures called pedometers [9, 174, 175] or accelerometers.[14, 176-180] Pedometers measure the number of steps an individual takes in a day. It has been suggested that taking a minimum of 7,000 to 10, 000 steps per day meets the recommended PA level in healthy elderly populations;[181] while in elderly cardiac populations this may be equivalent to 6,500 to 8,500 steps per day.[181-183] Although, pedometers are more cost effective compared to the doubly labelled water method they are unable to measure the different intensity levels of PA.[168] Accelerometers detect acceleration and deceleration in one or more dimensions of movement and use algorithms to estimate energy expenditure.[184-186] Greater acceleration or deceleration implies a greater intensity of PA and concomitantly greater DEE. Even though accelerometers are considered a good objective measure of DEE, there are certain limitations with different types of accelerometers. Uniaxial accelerometers may not be sensitive to motion in all planes while multi-axial accelerometers can be cumbersome and restrict motion if worn properly.[187] Furthermore, accelerometers in general have been shown to under estimate walking activity, overestimate jogging activity and may not detect other forms of PA altogether such as arm movements, resistance type exercises, cycling modalities or the performance of external work.[167]

The SenseWear Mini Armband is another PA monitor that is distinctly unique due to its ability to measure heat production from the body.[187, 188] Moreover, it does not restrict motion due to its location on the arm instead of the hip.[187, 188] When compared with accelerometers, the SWA has been shown to be better at estimating total energy expenditure across most treadmill speeds.[187] Furthermore, it has been validated against the doubly labelled water method and shown strong positive correlations in both healthy[189] and elderly adults.[190] However, few studies have used the SWA with cardiac patients [51, 188] and none have used it to examine the predictors of PA participation.[51, 188]

2.8 Summary

Coronary heart disease will become an ever increasing concern as the population ages. Exercise based CR has been shown to improve physical functioning and many of the symptoms and risk factors of CHD.[1-3, 49] Yet, the benefits accumulated from a CR program are only maintained as long as healthy behaviours are maintained.[4-6] One of the primary symptoms of CHD, reduced exercise capacity, has become an important outcome measure of many CR programs due to its prognostic value.[161, 162] Often it is assumed that by improving a patient's exercise capacity that they will be more physically active and maintain that behaviour. However, studies have shown that many cardiac patients do not maintain their exercise patterns after CR.[4, 6, 7, 10, 12, 13] This can lead to the return of a patient's symptoms, a worsening of their risk factors [10, 11] and an increased risk of morbidity and mortality. Therefore, it is important to determine the factors that influence PA participation in elderly cardiac patients.

Some studies have shown that psychosocial factors such as exercise SE,[15, 74, 80, 81] HQOL[79] and perceived function[40] may be important determinants of PA participation in cardiac populations. Still other studies have indicated that measures of physical function may be important determinants of PA participation in community dwelling elderly adults such as Grip,[64, 102, 103, 105, 110, 122, 126-128, 133-136] GS,[19] and TUG test times.[22] However, no studies have compared elderly cardiac patients involved in CR with those who have managed to maintain the behaviour.

One of the limitations in the current body of literature of PA in elderly cardiac patients is how PA is assessed. Although, the doubly labelled water method is the preferred method to assess PA it is costly, invasive and only assesses average PA over a one to three week period which makes it impractical.[167, 168] As a result many studies have relied on self-reported questionnaires, pedometers or accelerometers to assess PA. However, these methods of assessing PA may not be accurate.[23, 166-168, 187] The SWA is a distinctly different activity monitor[187, 188] that has been found to be both valid and reliable[190] which may prove useful in assessing PA participation in elderly cardiac patients. Thus far, few studies have used the SWA in cardiac populations. Further investigation is required.

Chapter III

METHODS

3.1 Study Design

This study utilized a cross sectional design to determine the predictors of participation in PA across three groups of community dwelling elderly cardiac patients (i.e., acute, rehabilitation and maintenance groups). A convenience sampling technique was used. The **independent variables** were exercise SE (i.e., MSES), HRQOL (i.e., SF-36), perceived function (i.e., LLFDI), strength (i.e., Grip), mobility (i.e., GS, TUG), and exercise capacity (i.e., 6MWT). The **dependent variable** was participation in PA defined as the number of steps taken per day (STEPS), daily energy expenditure (DEE), activity energy expenditure (AEE), and time spent sedentary (waking time spent $\leq$ 1.5 METS) and in mild (1.6-2.9 METS), moderate (3.0-4.9 METS) and vigorous ($\geq$5.0 METS) activity.[31, 35, 191]

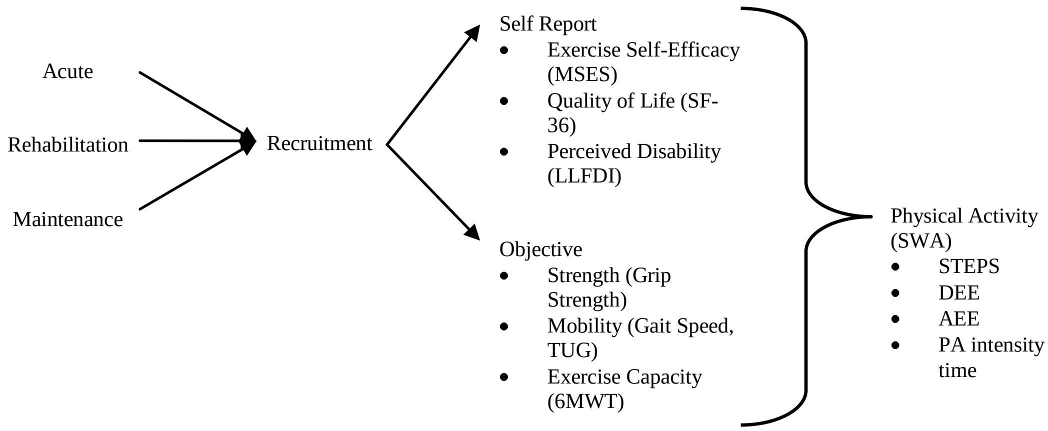


Figure 3.1: Study design. MSES refers to multidimensional self-report exercise self-efficacy, SF-36 refers to Medical Outcomes Study 36-Item Short-Form Survey, LLFDI refers to Late Life Functioning and Disability questionnaire, TUG refers to timed up and go test, 6MWT refers to six minute walk test, SWA refers to SenseWear™ Mini Armband, STEPS refers to steps taken per day, DEE refers to daily energy expenditure (kcal), AEE refers to activity energy expenditure, PA intensity time refers to time spent sedentary (waking time spent ≤ 1.5 METS), and in mild (1.6-2.9 METS), moderate (3.0-4.9 METS) and vigorous (≥5.0 METS).

3.2 Study Participants

3.2.1 Inclusion Criteria

Both male and female cardiac patients ≥ 60 years of age were included. Patients had a primary diagnosis of cardiac disease, were medically stable (i.e., no major change in medication regimen with no major change in condition in the one month prior to study entry), receiving optimal medical therapy and were able to participate in short duration low-intensity exercise. Only outpatients were enrolled into the study.

The acute group (AG) consisted of recent cardiac patients who received surgical intervention (i.e., coronary artery bypass, percutaneous angioplasty, valve repair) and were about to start an exercise-based CR program. The rehabilitation group (RG) consisted of patients who were in their final week of a hospital-based CR exercise program. The maintenance group (MG) was recruited from local fitness and recreational centers and consisted of patients who were ≥ 1 year post their cardiac event and had reported maintaining a physically active lifestyle over at least the last six months. For this study a physically active lifestyle was defined as ≥ 30 minutes of moderate to vigorous intensity exercise at least 3 times a week to a maximum of 300 minutes in a given week.[11, 165] Physical activity for the MG was identified by self-reported questionnaire and verified by objective measures (i.e., SWA).

3.2.2 Exclusion Criteria

Participants were excluded from the study if: they did not meet the inclusion criteria or, (1) they were enrolled in another study that conflicted with the present investigation; (2) they had uncontrolled hypertension (>160/110 mmHg); (3) the condition of their CHD (or other co-morbidities) was not stable; (4) they had physical limitation(s) that precluded low-intensity ambulatory exercise; (5) they were unable to provide written and informed consent or could not complete the questionnaires. Finally participants were excluded if their condition was exacerbated by the study protocol.

3.2.3 Sample Size

Since one of our primary objectives was to determine the best predictor of PA participation in elderly cardiac patients we used multiple linear regression analysis. According to Stevens (2002) in order to develop a reliable regression equation with r^2=0.50, a power of 0.80 and an α= 0.05 approximately 15 subjects are required for each predictor variable.[192] Therefore, because our study used 7 predictor variables a total sample size of n= 105 with each group consisting of n=35 subjects was needed.

3.3 Procedure

For the AG, participants meeting the inclusion criteria were identified by the CR staff during their initial interview prior to starting the exercise program. After receiving consent to release potential participants' names and contact information, CR staff informed the study coordinator who met with potential participants to explain the details of the study. Participants agreeing to be in the study provided written informed consent after which they were given the questionnaires to fill out on their own time and a SWA to wear for at least four consecutive days preceding their first CR exercise class. Participants' first session began with performing the 6MWT followed by participation in the exercise class. A basic demographic information questionnaire (i.e., date of birth, gender, living status, medications, cardiac conditions and co-morbidity) was collected while participants were exercising in the class. The remaining tests of physical function were completed at the end of the exercise class starting with comfortable gait speed, followed by grip strength and finally the TUG test. This order of testing was chosen to ensure minimal interference with participants' CR program as well as minimal fatigue.

Participants meeting the inclusion criteria for the RG were identified by CR staff prior to the final week of their exercise program. After receiving consent to release potential participants' names and contact information CR staff informed the study coordinator who then contacted them to explain the details of the study.

Participants agreeing to be in the study were tested during their second last exercise class following the same format as the AG. Once the tests of physical function were completed participants were given the questionnaires to complete and a SWA to wear for the first four days following their last exercise class. The study coordinator arranged to pick up the SWA after the four monitoring days.

The MG was recruited from the general public at local recreational facilities using flyers, advertisements in local senior's newsletters and word of mouth. Potential participants in the MG contacted the study coordinator at which time he explained the study details to them and arranged a date and time for testing. For the MG written informed consent was obtained prior to any testing. The testing began with the completion of all questionnaires followed by the tests of physical function which followed the same format as the previous two groups with the exception of the 6MWT being done last. At the end of the session participants were given a SWA to wear for four consecutive days, following which the study coordinator arranged to pick them up. To ensure that participants in the MG were physically active they were asked on the demographic questionnaire about the type physical activity they participated in, duration per day (i.e., minutes), frequency per week and how long they had maintained this behaviour for. The amount of PA the MG performed was later verified using the results from the SWA.

3.4 Outcome Measures

3.4.1 Measuring Exercise Self-Efficacy

Exercise SE was measured using the multidimensional self-report exercise self-efficacy (MSES) questionnaire. The MSES consists of 9 items that cover three domains of exercise SE, task (i.e., ability to perform basic aspects of the behaviour), coping (i.e., ability to perform basic aspects of the behaviour in the face of challenges) and scheduling, which relate to significant barriers for participation in exercise behaviour.[83] Each item on the MSES begins with the phrase "how confident are you that you can…." and are followed by a statement pertaining to one of the three domains (i.e., "……complete your exercises correctly", "…..do your exercises when you lack energy", "…..arrange your schedule to include regular exercise sessions"). When responding to each item participants were asked to think of exercise as "walking at a moderate intensity three times a week for about 30 minutes" and to score their response on a scale of 0% (no confidence) to 100% (complete confidence). The MSES has been found to be both valid and reliable across a variety of different populations.[83] For this study only task exercise SE was reported.

3.4.2 Measuring Health Related Quality of Life

Health related quality of life was assessed using the Medical Outcomes Study 36-Item Short-Form Survey (SF36). The SF36 is a self-administered questionnaire consisting of 36 questions across eight scales that include the following general concepts of health status: physical functioning, role limitations due to physical health problems, bodily pain, general health perceptions, vitality, social functioning, role limitations due to emotional problems and general mental health. The item responses are aggregated to calculate a score for each dimension ranging from 0 to100, with higher scores representing better health status. The eight scales can be combined into a Physical Component Summary and a Mental Component Summary. Since the aim of this study is to determine the predictors of PA participation only the Physical Component Summary will be reported. A score below 65 on the Physical Component Summary is the cut-off for being considered dependent.[193]

3.4.3 Measuring Perceived Function

Perceived function was measured by self-report using the Late Life Functioning and Disability Instrument (LLFDI). The LLFDI consists of two components: disability and function. The disability component relates to disability or limitations in expected roles. It consists of 16-items of an individual's performance of activities on two domains: frequency and limitation. Frequency of performing an activity is rated on a 5-point scale ranging from 'very often' to 'never'. Limitation of performing an activity is also rated on a 5- point scale but ranges from 'completely limited' to 'not at all limited'. The functional component is related to functional limitations and consists of 32-items. The 32-items measure the difficulty in performing physical functional tasks. The functional component can be divided into three subscales: upper extremity function, basic lower extremity function and advanced lower extremity function. Each of the subscales is rated on a 5-point scale ranging from 'none' to 'cannot do'. The subscales for both disability and function are then summed and converted into standard scores ranging from 0-100. The LLFDI has been found to be reliable and valid for adults over the age of 60.[48] For this study only the functional component score will be reported.

3.4.4 Measuring Strength

Strength was assessed by Grip using a hand held dynamometer. Grip strength is an easy and simple test of upper body strength[112] and hand function[107] that has shown to be valid and to have both intra-rater reliability (ICC=0.95)[122] and test-retest reliability (ICC $\geq$ 0.85).[194] A grip strength score less than 37 kg and 21 kg for men and women respectively are associated with increased mobility limitations[122] and a minimum score of 9 kg is commonly considered to be needed to be functional.[115] Following the American Society of Hand Therapists protocol participants were instructed to breathe out while they are encouraged by the researcher to exert the strongest possible force.[195] Two trials were recorded alternating between hands and starting with the dominant hand. The maximum score out of the four trials was used.

3.4.5 Measuring Mobility

Mobility was assessed using comfortable GS. Comfortable GS has been used as a predictor of future ADL or mobility disability,[148] physical activity cessation [19] as well as important adverse events (i.e., hospitalization, dependence, frailty and mortality) in elderly adults.[150] Gait speed was assessed using the 10 meter walk test (TMW).[196] A distance of 10 meters was measured and marked with pylons with an additional five meters marked on either side to allow for acceleration and deceleration.[197, 198] Participants started at the first of the four lines at one end and were instructed on the word “go” to walk in a straight line at a speed that was safe and comfortable for them until they reached the very last marker at the opposite end. The time from when their first foot crossed the second line until their first foot crossed the third line was recorded.[196] The TMW has shown good test-retest reliability (ICC = 0.87) in older adults with Parkinson’s disease.[198, 199] A slow gait speed of ≤ 1.0 m/s is predictive of one year mortality[200] and physical activity cessation after a two year follow up.[19]

Mobility was also assessed by the timed up and go (TUG) test. The TUG test was developed to assess basic mobility in frail community dwelling elderly adults (≥ 60 years).[154] Participants start by sitting with their back against the backrest of a standardized armchair (40-50 cm high) and a three meter distance from the chair is marked with a piece of tape on the floor. On the word go participants are asked to stand up, walk three meters, turnaround, walk back to the chair and sit back down. The time from the word go until their back rests against the backrest of the chair is recorded. Better mobility and balance is indicated by performing the task in a shorter amount of time.[201] A TUG test time > 10 seconds is indicative of increased dependence in ADLs.[154, 156] The TUG has shown construct validity with other measures of balance and mobility such as the Berg Balance Scale(r = -0.81), gait speed (r = -0.61), Barthel Index of Activities of Daily Living (r = -0.78)[154], postural sway (r = -0.48) Functional Stair Test (r = 0.59) and step frequency (r = -0.59).[155] The TUG test has also shown high intra-tester and inter-tester reliability (ICC = 0.99, ICC [3,1] = 0.92-0.96, ICC

[3,3] = 0.98).[154-156]As a tool the TUG test shows great utility as it mimics IADLs by combining several important tasks that relate to balance, gait speed, and functional ability.[154]

3.4.6 Measuring Exercise Capacity

Exercise capacity was assessed with a six minute walk test (6MWT) following the American Thoracic Society guidelines.[202] The 6MWT has been shown to have moderate to good construct validity with the gold standard for exercise capacity, VO_{2peak}, when walking a distance less than 490 meters.[203] In a study comparing oxygen consumption to the 6MWT Gremeaux et al. found elderly healthy subjects walked an average distance of 444 ± 58 m.[204] The 6MWT has also shown test-retest reliability (ICC= 0.82-0.96).[203] For safety of the participant they were asked to wear a safety belt and the researcher walked behind them. During the test participants were allowed to stop and rest whenever they wanted. The test was stopped if participants experienced chest pain, intolerable dyspnea, leg cramps, staggering, diaphoresis, and became pale or ashen in appearance. The utility of the 6MWT is that it is a sub-maximal test and therefore, more closely mimics ADLs.[155]

3.4.7 Measuring Physical Activity

Physical activity participation was assessed using a SWA. The SWA was developed to measure PA across a wide range of populations. It was worn on the upper left triceps and uses four sensors, a heat flux sensor, galvanic skin response sensor, skin temperature sensor, and a three axis-accelerometer. Information from the four sensors is recorded second by second and entered into an algorithm to calculate DEE, measured in kilocalories and metabolic equivalents. A SWA can determine when and how long a person wears them, how much time they spend sedentary or in mild, moderate and vigorous physical activity, when the person lies down or sleeps and how many steps the person takes in a day. Participants were asked to wear a SWA for at least 4 days, with a minimum of 1 weekend day; in the hope that 3 full days (midnight to midnight) of data was collected. The average of three days was used (two weekdays and at least one weekend day) and only days where the SWA was worn for a minimum of 95% of the day (22 hours and 48 minutes)[205] were included for analysis to ensure an accurate representation of their daily PA over an entire week. Physical activity participation was reported as the STEPS (number of steps taken per day), DEE (kcal), AEE (kcal) and PA intensity time (time spent sedentary [waking time $\leq$ 1.5 METS], in mild (1.6-2.9 METS), moderate (3-4.9 METS) and vigorous ($\geq$5 METS) activity).[31, 35, 191]

Activity energy expenditure was calculated using the following equations:[206]

$$DEE = RMR + TEM + AEE \qquad \textbf{(Eq1)}$$

where DEE was measured using the SWA; RMR is the daily energy cost of the resting metabolic rate (RMR) and was estimated using equations two and three for men and women respectively;

$$RMR_{men} = 66.0 + [13.7 \cdot body\ mass\ (kg)] + [5.0 \cdot height\ (cm)] - [6.8 \cdot age\ (years)] \qquad \textbf{(Eq2)}$$

$$RMR_{women} = 655 + [9.6 \cdot body\ mass\ (kg)] + [1.85 \cdot height\ (cm)] - [4.7 \cdot age\ (years)] \qquad \textbf{(Eq3)}$$

From previous studies the thermic response to meals (TEM) is commonly estimated to be 10% of DEE.[207, 208] Substituting for TEM:

$$DEE = RMR + (0.1 \cdot DEE) + AEE \qquad \textbf{(Eq4)}$$

and solving for AEE:

$$AEE = (DEE \cdot 0.90) - RMR \qquad \textbf{(Eq5)}$$

The SWA have been shown to be valid and reliable in many populations including cardiac patients.[51, 188] However, some limitations do exist; for example the SWA cannot accurately quantify energy expenditure of cycling modalities. This limitation is due to the fact that the 3-axis accelerometer sensor measures displacement and when someone is using a cycling modality their body where the SWA is mounted is stationary. Therefore, there is no displacement for the accelerometer sensor to measure. Another limitation of SWA is that they are not waterproof and therefore cannot be worn while swimming. Therefore, participants were asked to refrain from swimming or cycling as their primary mode of exercise while wearing the SWA. Participants were given the SWA to wear at the end of the testing session.

3.5 Statistical Analysis

It is important to note that although the PA measure of STEPS is an ordinal scale that in a meta-analysis by Tudor-Locke et al., 2011[209] it has been shown that studies of PA intervention in healthy elderly populations with small effect sizes may give rise to an increase in STEPS of 775 while studies of CHD patients with large effect sizes may lead to an increase of 2,215 STEPS.[209] Due to the considerably large increases in STEPS that may be expected from PA interventions compared to the smallest unit of measurement on this scale (i.e., one step/day) it may be reasonable to treat this variable as interval data. Data will be expressed as mean ± SD. Therefore, for the **primary objective**, to determine the best predictor of participation in PA (i.e., STEPS, DEE, AEE and PA intensity time) using the predictor variables of self-reported (exercise SE, HRQOL, perceived function) and objectively (Grip, GS, TUG, 6MWT) measured physical function a regression analysis was done. Pearson correlations were calculated to determine the significance of the relationships between the predictor variables and the measures of PA participation. Only predictors with a significant P value $\leq$ 0.05 were included in the final regression analysis. Multicollinearity in each regression model was assessed by examining the tolerance and the variance inflation factor of the predictor variables in the final regression models. Predictor variables with a tolerance < 0.10 and a variance inflation factor > 10 were considered to significantly co vary.[210] If two predictor variables were determined to significantly co vary the regression analysis was done again without the predictor variable that had the highest variance inflation factor. To determine the differences between the three groups a 1-way ANOVA analysis was done for all variables (exercise SE, HRQOL, perceived function, Grip, GS, TUG, 6MWT, STEPS, DEE, AEE, and PA intensity time) using a Bonferroni correction. A level of significance will be set at $\alpha = 0.05$ with a power of 0.80.

Chapter IV

Results

4.1 Participants

Over a period of 9 months 129 participants were recruited into the study. Six withdrew from the study for personal reasons, 9 were excluded for wearing the SWA for less than 95% of the day on one or more of the days that it was worn, six were excluded from the RG for completing < 80% of their CR program, two were excluded from the MG for averaging < 30 minutes a day at a moderate to vigorous intensity, and one was excluded because of a change in medication while wearing the SWA that resulted in a PA pattern that the participant reported as not being typical for them. A further 9 participants were excluded for being outliers, which was defined as being > three standard deviations outside of the mean on at least one of the primary outcome measures.[211] Descriptive information on the remaining 93 participants (AG, N = 32; RG, N = 32; MG, N = 29) that completed the study is presented in Table 4.1. There was no difference between the groups in age or ratio of males to females. Participants in the AG waited 40 ± 24 days after hospital discharge before starting their CR program while the RG waited 29 ± 11 ($P<0.05$). The RG attended 92 ± 6% of their exercise classes and while the MG was 46 ± 57 months post their cardiac event.

Table 4.1. Participant Characteristics.

Participants	93
Descriptive Variables	
Gender	78M:15F
Age (years)	69.9 ± 6.6
Height (cm)	170.8 ± 9.5
Weight (kg)	83.3 ± 15.0
Body Mass Index ($kg \cdot m^{-2}$)	28.4 ± 3.8
Primary Diagnosis	
MI	49 (53%)
PCI	57 (61%)
CABG	26 (28%)
Valve	12 (13%)
Heart Failure	4 (4%)
Medications	
ASA	89 (96%)
Anti-platelet	59 (63%)
Beta-Blocker	82 (88%)
ACE-Inhibitor	74 (78%)
Ca^{2+} Channel Blocker	15 (16%)
Statin	86 (93%)
Diuretic	27 (29%)
Nitrate	1 (1%)
Digoxin	3 (3%)
Insulin	7 (8%)
Bronchodilator	8 (9%)

Data are presented as mean + SD or as the absolute number (percentage) MI= Myocardial Infract; PCI= Percutaneous Coronary Intervention; CABG; Coronary Artery Bypass Graft; Valve= Valvular Repair; ASA= Acetylsalicylic Acid.

4.2 Primary Objective

To determine the best predictor of PA participation in elderly cardiac patients, a multiple linear regression was done. The associations between the measures of PA and measures of physical function are presented in Tables 4.2 and 4.3. Overall, the six minute walk distance was the strongest measure of physical function to predict STEPS and DEE. The strongest predictor for AEE and vigorous activity was perceived function (LLFDI) while exercise SE (MSES) predicted time spent in moderate activity. No measures of physical function predicted sedentary time or mild PA. The final regression models are presented in Table 4.4.

Table 4.2. Significant bivariate correlations between measures of physical activity and predictor variables using Pearson product correlation coefficient.

Measures of Physical Activity							
STEPS	**r**	**DEE**	**r**	**AEE**	**r**	**Sedentary**	**r**
Age	-0.27*	Age	-0.24*	SF-36	0.28*	BMI	0.27*
MSES	0.34*	BMI	0.42*	LLFDI	0.36*	MSES	-0.22*
SF-36	0.30*	SF-36	0.28*	Grip	0.36*	SF-36	-0.21*
LLFDI	0.46*	LLFDI	0.35*	TUG	-0.21*	LLFDI	-0.27*
GS	0.48*	GS	0.26*	6MWT	0.32*	GS	-0.28*
Grip	0.21*	Grip	0.61*			6MWT	-0.25*
TUG	-0.35*	TUG	-0.28*				
6MWT	0.57*	6MWT	0.37*				

STEPS, steps per day; DEE, daily energy expenditure; AEE, activity energy expenditure; Sedentary, waking time ≤ 1.5 METs; MSES, multi-dimensional self-report exercise self-efficacy; SF-36, Medical Outcomes Study 36-Item Short-Form Survey; LLFDI, Late Life Function and Disability Instrument; GS, gait speed; Grip, grip strength; TUG, timed up and go test; 6MWT, six minute walk test; * significant at $P < 0.05$.

Table 4.3. Significant bivariate correlations between time spent at different physical activity intensities and predictor variables using Pearson product correlation coefficient.

Intensity of Physical Activity					
Mild	**r**	**Moderate**	**r**	**Vigorous**	**r**
BMI	-0.26*	BMI	-0.22*	LLFDI	0.31*
6MWT	0.21*	MSES	0.24*	GS	0.22*
		SF-36	0.24*	6MWT	0.25*
		LLFDI	0.33*		
		GS	0.25*		
		6MWT	0.35*		

Mild, time spent between 1.6 - 2.9 METS; Moderate, time spent between 3.0 - 4.9 METS; Vigorous, time spent ≥ 5.0 METS; MSES, multi-dimensional self-report exercise self-efficacy; SF-36, Medical Outcomes Study 36-Item Short-Form Survey; LLFDI, Late Life Function and Disability Instrument; GS, gait speed; 6MWT, six minute walk test; * significant at $P < 0.05$.

Table 4.4. Detailed forward multiple-regression for measures of physical activity in elderly cardiac patients.

Measures of PA (Dependent Variables)	**Independent Variables in Final Model**	**Adjusted r^2**	**Standardized Beta**	**P**
STEPS	6MWT	0.34	0.51	0.000
	RG		0.23	
DEE	Grip	0.59	0.36	0.000
	BMI		0.30	
	Male		0.31	
	AG		-0.25	
AEE	AG	0.30	-0.31	0.000
	Male		0.31	
	LLFDI		0.22	
Sedentary	AG	0.21	0.23	0.000
	BMI		0.29	
	RG		-0.21	
Mild	RG	0.11	0.26	0.002
	BMI		-0.22	
Moderate	AG	0.32	-0.38	0.000
	Male		0.28	
	BMI		-0.27	
	MSES		0.21	
Vigorous	LLFDI	0.12	0.31	0.001
	BMI		-0.21	

PA, physical activity; STEPS, steps per day; DEE, daily energy expenditure; AEE, activity energy expenditure; Sedentary, waking time $\leq$ 1.5 METs; Mild, time spent between 1.6-2.9 METS; Moderate, time spent between 3.0-4.9 METS; Vigorous, time spent $\geq$ 5.0 METS; 6MWT, six minute walk test; RG, rehabilitation group; Grip, grip strength; BMI, body mass index; AG, acute group; LLFDI, Late Life Function and Disability Instrument; MSES, multi-dimensional self-report exercise self-efficacy.

4.3 Secondary Objective

4.3.1 Physical Function

No differences were observed for self-reported measures of physical function or on the objective measures of Grip, TUG and 6MWT (Table 4.5). However, the AG was found to have a slower GS (1.3 ± 0.2 m/s) than both the RG (1.5 ± 0.2 m/s) and MG (1.5 ± 0.2 m/s; $P \leq 0.05$ for both); while no difference was seen between the RG and MG on GS (Figure 4.1).

Table 4.5. Summary of measure of physical function in elderly cardiac patients.

Measures of Physical Function	Grouped (N=93)	AG (N= 32)	RG (N = 32)	MG (N= 29)
Self-Report Measures				
MSES	87 ± 14	88 ± 12	89 ± 13	84 ± 18
SF-36	74 ± 19	68 ± 22	75 ± 17	79 ± 16
LLFDI	66 ± 9	64 ± 9	69 ± 10	66 ± 9
Objective Measures				
GS (m/s)	1.4 ± 0.2	1.3 ± 0.2	1.5 ± 0.2*	1.5 ± 0.2*
Grip (kg)	33 ± 9	32 ± 10	33 ± 9	33 ± 9
TUG (s)	8.9 ± 2.3	9.6 ± 3.1	8.6 ± 1.7	8.3 ± 1.6
6MWT (m)	476 ± 89	446 ± 90	494 ± 98	489 ± 68

AG, acute group; RG, rehabilitation group; MG, maintenance group; MSES, multi-dimensional self-report exercise self-efficacy; SF-36, Medical Outcomes Study 36-Item Short-Form Survey; LLFDI, late life function and disability instrument; GS, gait speed; Grip, grip strength; TUG, timed up and go; 6MWT, six minute walk test; * significant at $P < 0.05$ from the AG.

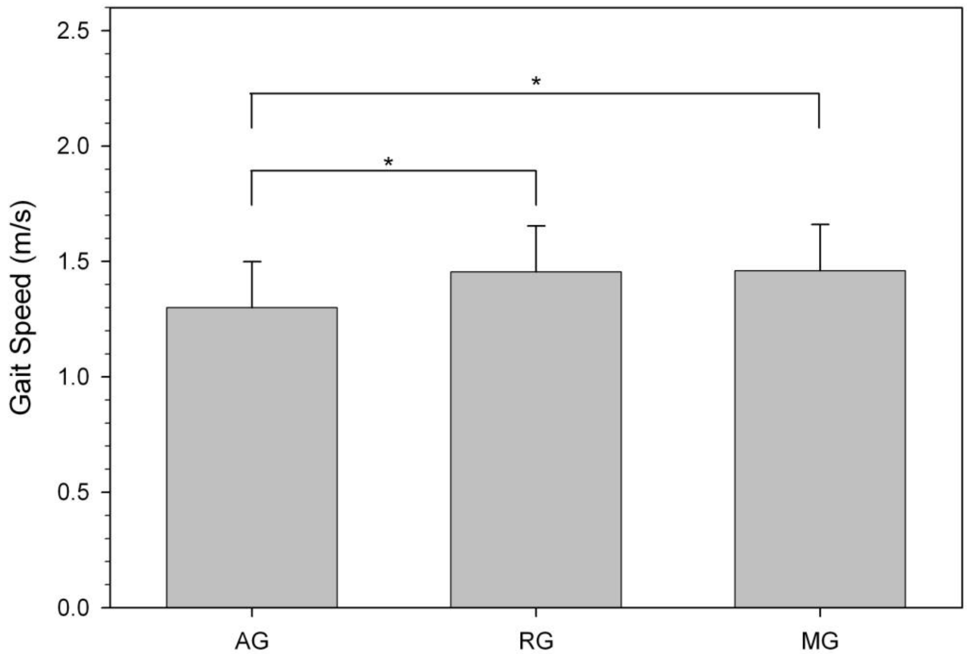


Figure 4.1. Differences in gait speed between elderly cardiac patients in the acute group (AG), rehabilitation group (RG) and the maintenance group (MG). Values are expressed as mean ± standard error of the mean. * Significant at $P \leq 0.05$.

4.3.2 Physical Activity

With respect to daily PA, participants took 5,467 ± 3,508 STEPS and expended 2,464 ± 496 kilocalories. However, only 645 ± 305 kilocalories of their DEE can be attributed to PA. Participants spent a total of 746 ± 114 minutes sedentary, 187 ± 63 minutes in mild activity, 67 ± 43 minutes in moderate activity and 6 ± 9 minutes in vigorous activity (Table 4.6).

Table 4.6. Summary of daily physical activity.

Measures of PA		**Grouped (N=93)**	**AG (N=32)**	**RG (N=32)**	**MG (N=29)**
STEPS		5467 ± 3508	4050 ± 1993^{a}	6899 ± 4734^{a}	5452 ± 2569
DEE	(kilocalories)	2464 ± 496	2260 ± 448^{b}	2536 ± 549	2609 ± 419^{b}
AEE	(kilocalories per day)	645 ± 305	487 ± 206^{ab}	755 ± 367^{a}	697 ± 256^{b}
Sedentary	(min)	746 ± 114	797 ± 120^{a}	697 ± 112^{a}	743 ± 85
Mild	(min)	187 ± 63	163 ± 51^{a}	209 ± 72^{a}	188 ± 57
Moderate	(min)	67 ± 43	45 ± 29^{ab}	85 ± 52^{a}	71 ± 33^{b}
Vigorous	(min)	6 ± 9	4 ± 6	9 ± 12	6 ± 7

PA, physical activity; AG, acute group; RG, rehabilitation group; MG, maintenance group; STEPS, steps per day; DEE, daily energy expenditure; AEE, activity energy expenditure; Sedentary, waking time $\leq$ 1.5 METs; Mild, time spent between 1.6-2.9 METs; Moderate, time spent between 3.0-4.9 METs; Vigorous, time spent $\geq$ 5.0 METs. Suffix ^{a} represents P value < 0.05 between AG and RG; Suffix ^{b} represents P value < 0.05 between AG and MG.

When assessing the difference in STEPS between the groups the RG took more STEPS (6,899 ± 4,734 STEPS) than the AG (4,050 ± 1,993 STEPS; $P \leq 0.05$). However, no difference was found in the STEPS between the MG and either of the AG or RG (Figure 4.2). In terms of DEE the MG (2,609 ± 419 kilocalories) had higher DEE than the AG (2,260 ± 448 kilocalories; $P \leq 0.05$) but not the RG. No difference was seen between the AG and RG (Figure 4.3). Nevertheless, both the RG (755 ± 367 kilocalories) and MG (697 ± 256 kilocalories) expended more energy during activity than the AG (487 ± 206 kilocalories; $P \leq 0.05$ for both; see Figure 4.4). Furthermore the AG spent more time sedentary (797 ± 120 minutes) than the RG (697 ± 112 minutes; $P \leq 0.05$) while there was no difference in sedentary between the MG with either the AG or RG groups (Figure 4.5). With respect to mild PA, the RG spent more time in mild activities (209 ± 72 min) compared to the AG (163 ± 51 min; $P \leq 0.05$). While there was no difference in the amount of time spent in mild activity for the MG compared to either the AG or RG (Figure 4.6). With respect to moderate PA the RG was as active (85 ± 52 min) as the MG (71 ± 33 min). However, both groups spent more time in moderate PA than the AG (45 ± 29 min; $P \leq 0.05$ for both; Figure 4.7). All three groups spent less than 10 minutes in vigorous PA.

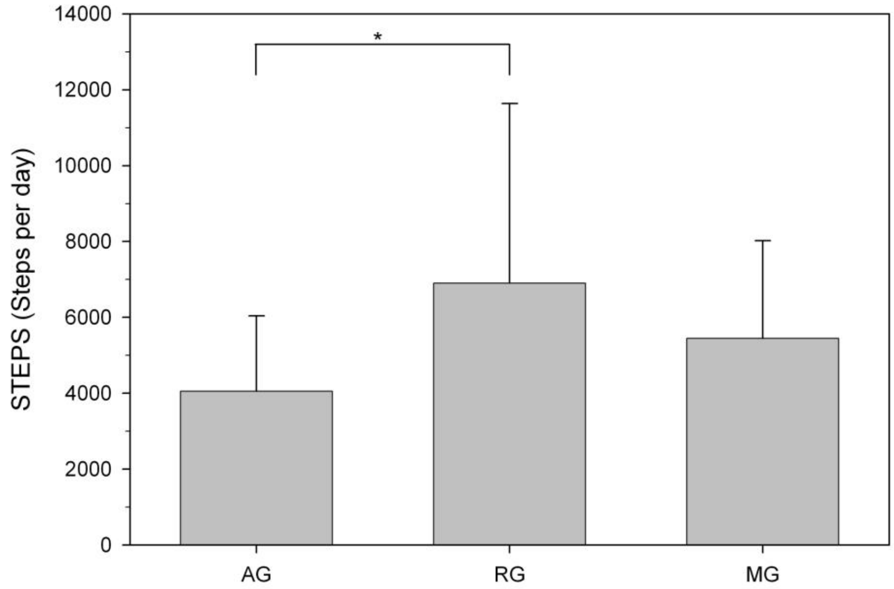


Figure 4.2. Differences in average steps taken each day for cardiac patients in the acute group (AG), the rehabilitation group (RG) and the maintenance group (MG). Values are expressed as mean ± standard error of the mean; * significant at P$\leq$ 0.05.

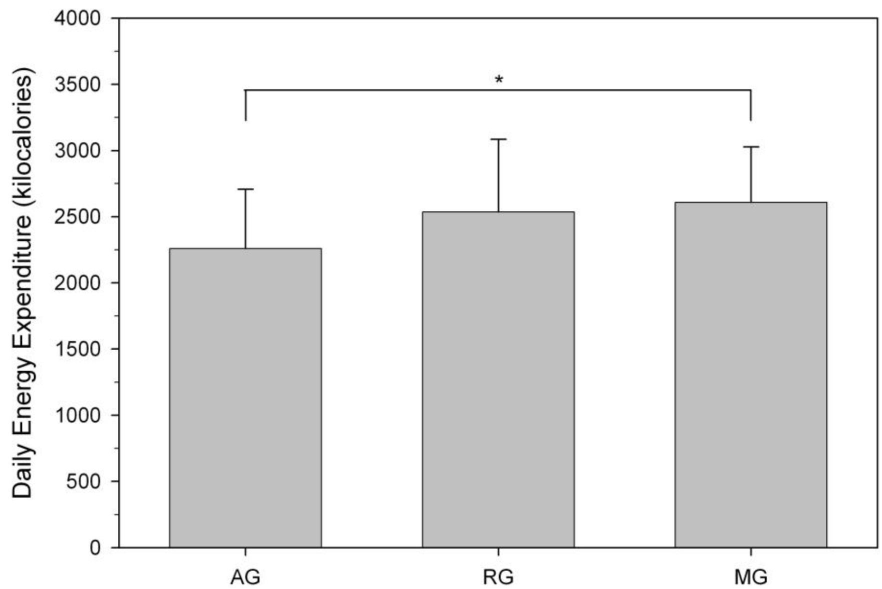


Figure 4.3. Differences in daily energy expenditure between elderly cardiac patients in the acute group (AG), rehabilitation group (RG), and the maintenance group (MG). Values are expressed as mean ± standard error of the mean; * significant at P$\leq$ 0.05.

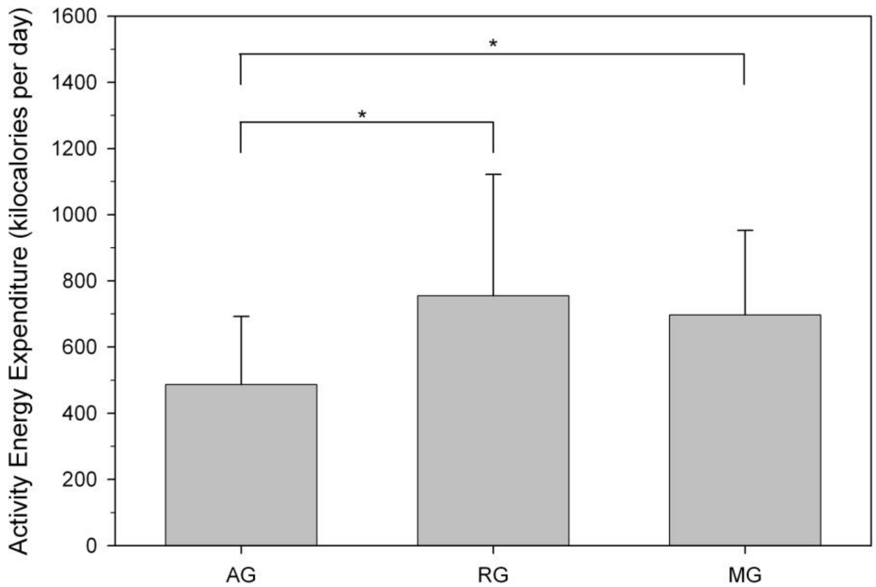


Figure 4.4. Differences in activity energy expenditure in elderly cardiac patients in the acute group (AG), rehabilitation group (RG) and the maintenance group (MG); AEE stands for activity energy expenditure (AEE = [daily energy expenditure·0.9]- resting metabolic rate). Values are expressed as mean ± standard error of the mean; * significant at P≤ 0.05.

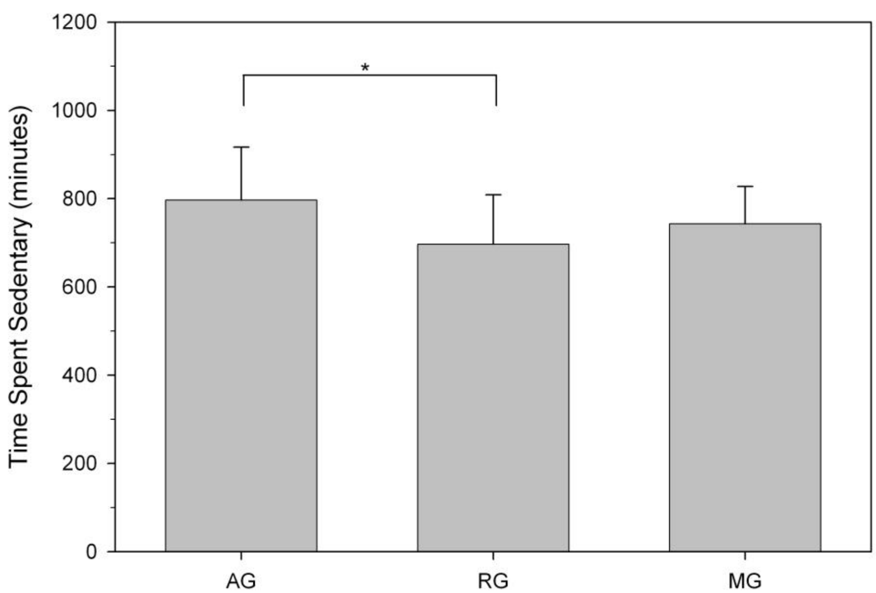


Figure 4.5. Differences in sedentary time of elderly cardiac patients in the acute group (AG), rehabilitation group (RG) and the maintenance group (MG); sedentary is equal to waking time spent ≤ 1.5 METS. Values are expressed as mean ± standard error of the mean; * significant at P≤ 0.05.

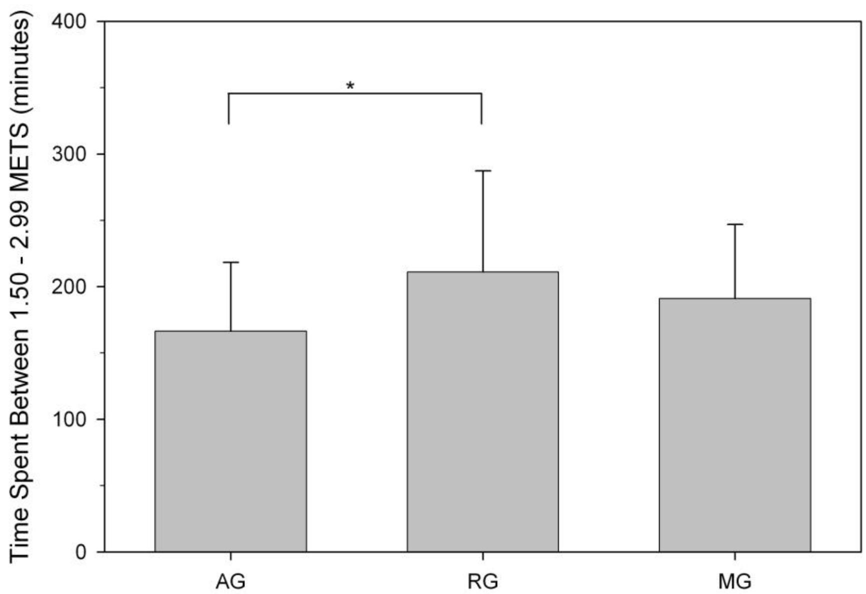


Figure 4.6. Differences in time spent in mild activity in elderly cardiac patients in the acute group (AG), rehabilitation group (RG) and the maintenance group (MG). Values are expressed as mean ± standard error of the mean; * significant at P≤ 0.05.

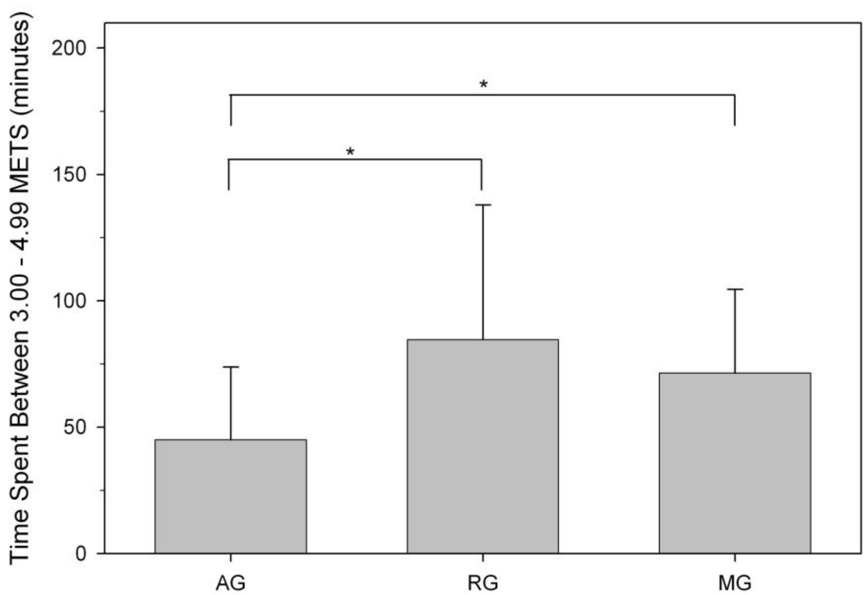


Figure 4.7. Differences in time spent in moderate activity in elderly cardiac patients in the acute group (AG), rehabilitation group (RG) and the maintenance group (MG). Values are expressed as mean ± standard error of the mean; * significant at P≤ 0.05.

Chapter V
Discussion

5.1 Study Overview

The aim of this study was to examine the relationship between physical function and daily PA in elderly cardiac patients. Physical function was measured both by self-report (i.e., MSES, SF-36, LLFDI) and objectively (i.e., Grip, GS, TUG, 6MWT) in three distinct groups of cardiac patients (AG, RG, MG). In order to objectively quantify PA, patients wore a SWA for a minimum of four days. The primary objective was to determine the best predictor of daily PA in elderly patients with the expectation that measures of mobility (i.e., GS, TUG) would be the best predictors. The secondary objective of this study was to determine the differences between elderly patients participating in CR (i.e., AG, RG) with those that have reportedly maintained the behavior of being physically active (i.e., MG). It was anticipated that patients who had just completed CR would be as physically active as those that were ≥ one year post-CR and were still physically active and that they would perform just as well on measures of physical function. It was also anticipated that patients just starting CR would be the least physically active and would perform worse on measures of physical function.

5.2 Measures of Physical Activity

The benefits of exercise for older adults both with and without CHD have been well established and range from improving cardiovascular risk factors to physical functioning.[1-3, 11, 49-51, 53-62, 64] To achieve the health benefits, associated with regular PA such as CHD risk reduction, a minimum of 30 minutes of moderate PA five days of the week or 20 minutes of vigorous PA three days of the week (or a combination of the two) is recommended.[165] However, despite strong evidence supporting the benefits of exercise, relatively few patients maintain their activity after completing a formal exercise based CR program.[4, 6, 7, 10, 12-14] As a result, some studies have begun to examine the predictors of regular PA. Notably, Ashe et al. found that in community dwelling seniors mobility was a stronger predictor of STEPS than exercise capacity, the traditional focus of many CR programs.[22] Our findings run contrary to Ashe's in that we found exercise capacity (i.e., 6MWT distance) was the strongest predictor of STEPS. This discrepancy may be due to the fact that participants in our study had fewer co-morbidities and performed better on at least one mobility test (i.e., TUG test 8.9 ± 2.3 vs 10.1 ± 2.6 seconds) than the participants in Ashe's study. This implies that our participants were relatively healthier and more mobile.

Some suggest that in order to achieve the minimum recommended 30 minutes of moderate to vigorous PA that individuals should cover 3,000 STEPS in addition to their base line activity.[212] In the general population this typically results in individuals covering approximately 10,000 STEPS.[209] However, due to their limitations in physical functioning older adults and individuals with chronic disease may not be able to achieve 10,000 STEPS, thus 7,000 – 7,500 STEPS has been suggested as a more appropriate goal for these populations.[209] In Ashe's study only 30% of participants walked ≥ 7,500 STEPS whereas in the present study even though participants were relatively healthier, fewer participants covered ≥ 7,500 STEPS (i.e., 18%; AG=1; RG =12; MG=4). However, an important consideration, when comparing these two studies, is the high degree of variability in STEPS observed in those participating in the two studies. For instance, the normal range of STEPS observed for these two populations is 2,000-7,000.[209] This disparity in the literature raises the question of the methods used to determine STEPS in these studies.

Many studies use activity monitors called pedometers to quantify STEPS due to their ease of use, low cost and comprehensible output (i.e., STEPS).[213] However, the reliability of pedometers depends on the mechanism used to determine STEPS.[214] In Ashe’s study a spring levered pedometer (DigiWalker SW-200, Lee’s Summit, MO) was used which consists of a lever suspended horizontally by a spring.[213] As the hip moves up and down with ambulatory activity the lever also moves in response to the vertical motion of the hip. The up and down movement of the lever arm in turn opens and closes an electrical circuit which is registered as a step.[213] However, this type of pedometer is susceptible to measurement error based on its position on the waist (i.e., hip versus posterior) and tilt angle of the pedometer.[213-215] Furthermore, spring levered pedometers are only accurate at certain walking speeds.[213, 214] As a result spring levered pedometers may be susceptible to large errors in measurement.

Accelerometers are activity monitors that are more accurate than pedometers because they utilize the piezoelectric crystal mechanism and are able to measure activity in multiple dimensions.[213, 216] The most accurate accelerometers measure activity in three dimensions.[216] In the present study we used an activity monitor (SWA) that utilizes a triaxial accelerometer to determine

STEPs. This device may therefore be superior to the pedometers used in Ashe's study and may explain the discrepancy in STEPS across the two studies.

When we examined the difference between the groups in our study it was expected that the RG and MG groups would be more active than the AG. However, our findings did not support this hypothesis. In fact while we observed that the RG covered significantly more STEPS than the AG, no other differences were seen for STEPS between groups (Figure 4.2). These findings support previous studies which have suggested that although exercise-based CR gives rise to increased PA immediately following program completion at long term follow up PA tends to decline back towards pre-program levels.[4-6] However, there are more robust measures than STEPS to assess PA.

The most robust means for assessing PA is DEE, measured by doubly labeled water.[166, 167] However, even though the doubly labeled water method is the "gold standard", it is often impractical to use in epidemiological and intervention based studies.[166] Compared to the doubly labeled water technique the SWA shows strong agreement for assessing DEE.[188] By using the SWA we were able to measure DEE of elderly cardiac patients participating in exercise based programs and our findings are in line with previous studies.[206] However, an important consideration is that there may be a large inter-individual variability in DEE that may not be due to PA alone.[32, 206] As a result, studies examining PA using the doubly labeled water method will also report AEE by either measuring or estimating the RMR and the TEM. In our study we were able to calculate AEE by estimating for both the RMR and the TEM.[47, 208]

A common goal of many CR programs is to achieve an AEE of at least 1,500 kilocalories per week as it is associated with preventing disease progression and a reduction in all-cause mortality.[60, 217, 218] Others have suggested a more aggressive goal of $\geq$ 2,200 kilocalories per week as it has been positively associated with partial disease regression.[60, 171] When we examined AEE in our study we found that over half of our participants expended $\geq$ 1,500 kilocalories (i.e., 63%) while a third expended > 2,200 kilocalories (i.e., 35%). We also expected the RG and MG to be more active than the AG and our results for AEE supported this hypothesis (Figure 4.4). Although this finding contradicts what we observed for STEPS, the discrepancy may be attributed to the inability of STEPS to capture the intensity of activity. Moreover, the intensity of activity is an important determinant of the extent of health benefits from exercise.[219]

Another commonly used method to quantify PA is the use of METs because they allow the comparison of the energy cost and intensity across a wide range of activities.[32] The MET range commonly accepted to represent a moderate intensity for most individuals in CR is 3.0 – 5.9 METs.[14] However, the concept of the MET is based on a widely accepted constant for RMR (3.5 ml/kg/min) to determine one MET that was derived from a single 70 kg man.[32] Some chronic conditions (i.e., COPD, arthritis) experienced by the elderly may elevate the RMR[208] while CHD and some medications may lower it.[32] Moreover, an individual’s fitness level impacts the relative load when you use METs as an indicator of intensity.[191] Therefore, using absolute MET values may not be appropriate for elderly individuals with chronic diseases.[191]

As a consequence, for this study we used more conservative definitions for moderate and vigorous activity, 3.0 – 4.9 METs and ≥ 5.0 METs respectively.[31] All three groups achieved a minimum of 45 minutes/day of moderate activity with the RG and MG groups accumulating significantly more moderate activity than the AG (Figure 4.7). No differences were observed in time spent in vigorous activity across the three groups. Although the AG spent the least amount of time in moderate activity, as a group a large proportion of the participants in this group (69%) achieved the minimum recommendation (i.e., ≥ 30 minutes). These findings suggest that elderly cardiac patients are in fact fairly active even prior to starting CR and highlight the importance of considering the intensity of activities when assessing PA.

An emerging field of interest is the study of sedentary behavior. While often conceptualized as the absence of moderate and vigorous PA, increasing evidence suggests that sedentary behavior may be an independent predictor of adverse health outcomes such as cardiovascular risk factors, morbidity and mortality.[34, 220, 221] This may be due to the fact that it is possible for individuals meeting the PA guidelines to still spend the majority of their time sedentary.[221] The misconception that sedentary behavior is the absence of moderate and vigorous PA has led many studies to group mild activity (1.6 – 2.9 METs) with sedentary behavior.[35] However, mild activities may include tasks such as slow walking, cooking and washing dishes which are some typical ADLs. Mild activity may represent participation in ADLs and therefore is a distinctly different entity from sedentary behavior.[222] In this study we observed the AG spent less time in mild activity than the RG (Figure 4.6).

While many studies have used objective measures to examined PA, relatively few have examined sedentary behavior.[221] Furthermore, many studies in CR define sedentary behavior as the absence of a formal exercise intervention or moderate and vigorous PA.[7, 14, 223, 224] Consequently, few studies have reliably reported the amount of time spent in sedentary behavior for many populations. Matthews et al., used accelerometers to report the amount of time spent in sedentary behavior in those living in the United States and observed that seniors ($\geq$ 60 years old) spent as much as 60% of their time sedentary.[225] Our findings indicated that participants spent 73% of their time sedentary with the AG group spending more time in sedentary behavior than the RG (Figure 4.5). The discrepancy between Matthew's study and our own may be due to the amount of time participants in each study were monitored. Participants in Matthew's study only wore the accelerometers for 14 hours/day while our participants wore the SWA for $\geq$ 23 hours/day. To our knowledge no other studies have reliably reported sedentary behavior in elderly cardiac patients.

5.3 Predicting Physical Activity

The primary objective of this study was to determine the best predictor of PA in elderly cardiac patients. Previous studies have attempted to predict PA in both cardiac patients and the elderly with varying results. Some found psychosocial factors to be important determinants of PA while others showed measures of physical function were better predictors. [15, 17-19, 22] Ashe's study was unique because it highlighted the disparity between the ability to be active and actual participation in PA for community dwelling seniors.[22] Furthermore, it challenged the notion that exercise capacity is the primary factor that impacts PA in this population.[22] However, Ashe was only able to predict 27% of the variance in STEPS. The novelty of our study was the ability to objectively express PA in multiple ways (i.e., STEPS, DEE, AEE, PA intensity time) using the SWA. Yet despite our methodology we were still only able to predict 34% of the variance in PA with the best prediction model being STEPS. Moreover, the best determinant of PA was not consistent for all our measures of activity. Exercise capacity best predicted STEPS and DEE, while exercise SE predicted moderate activity and perceived function predicted AEE and vigorous activity. This may be due to the fact that some of our measures better represent different measures of PA. For example when answering the MSES participants were specifically asked to think of exercise as moderate activity. Our findings may provide further support to the disparity between the ability to be active and actual participation in activity observed in Ashe's study.

5.4 Self-Reported Measures of Physical Function

Physical function is an important outcome for elderly patients as it may impact independence.[226, 227] A secondary objective of this study was therefore to determine the differences between our groups on measures of physical function. Self-reported questionnaires are appealing tools to assess physical function as they are relatively inexpensive as well as quick and easy to administer.[226, 228] Some studies have shown that self-reported physical function improves with participation in CR while others have shown no change despite improvement in objective measures of physical function.[216, 227, 229-231] In this study we included self-reported questionnaires of physical function (i.e., exercise SE, perceived function and HRQL) that were shown to be important mediators of exercise and PA.[15, 20, 21, 40, 69-74, 79] The expectation was that both the RG and MG would perform better than the AG. However, no differences were observed across our three groups. These findings may be attributed to some of the limitations commonly reported for self-reported questionnaires including depth of the scales, ability to detect subtle differences, and the ability of respondents to accurately recall their activities.[22, 228, 232, 233] Despite these limitations many maintain that measures of self-reported physical function assess different constructs than objective measures and therefore are still important outcomes for CR.[228] Consequently, it is recommended that self-reported physical function is measured in combination with more objective means.[228]

5.5 Objective Measures of Physical Function

Objective measures of physical function have the advantage of scales with more depth and greater sensitivity to change.[228] Yet the real utility of the objective measures are the pre-established criteria and normative data in the literature that can be used to evaluate individuals and guide exercise prescriptions. In this study we included objective measures of physical function (i.e., strength, mobility, and exercise capacity) that have been shown to impact disability and PA in the elderly. Again it was expected that while outperforming the AG both the RG and MG would perform comparably on these measures. However, only our results for GS supported this hypothesis (Figure 4.1). In fact no other discernible differences were observed across groups for our objective measures of physical function. This may be attributed to the fact that the AG group waited significantly longer before starting CR than the RG and therefore had more time to recover after their cardiac event.

Regarding grip strength Sallinen et al., established that Grips ≤ 37 kg in men and ≤ 21 kg in women over the age of 55 are associated with increased mobility limitations.[122] Our participants demonstrated Grips at or below these mobility thresholds for their respective gender (i.e., 35 ± 8 kg for men; 21 ± 5 kg for women). While findings similar to ours have been reported elsewhere [96] others have shown higher values.[131, 132] The higher values may be due to the inclusion of younger participants.[131, 132] Indeed Baum et al., showed that there was no difference in upper body strength when he compared cardiac patients across a wide age range (i.e., 30-90 years) with age-matched healthy controls.[234] If we compare our participants to individuals of the same age and gender we see similar Grip results (i.e., 35 kg for men 70-79 years old, 20 kg for women 70-79 years old).[118] Combined these findings may indicate that many of our participants may experience some mobility limitations, which may result in difficulties in performing IADL. Yet muscular strength as it relates to physical function may not be any more noteworthy for elderly cardiac patients than it would for individuals without CHD.

Mobility was assessed using both the TUG test and GS. Some have suggested that elderly individuals that performed the TUG test in ≥ 20 seconds required help in basic ADLs such as transfers and self-care[154, 159] while others have shown that a TUG test time > 13 or 14 seconds is predictive of an increased risk of falling.[156, 235] Still other studies have proposed that performing the TUG test in > 10 seconds is indicative of having increased difficulty and therefore dependence in IADLs.[22, 160] Our participants completed the TUG in < 10 seconds. Comparing our results to a meta-analysis by Bohannon et al., 2006 we see that our findings are in line with TUG test times for persons 70-79 year olds of (9.2 seconds).[236] This may indicate that our elderly cardiac patients in the present study have relatively good mobility and are likely independent in both basic and instrumental ADLs.

Gait speed was included in this study because it has been used to determine vulnerability and adverse health outcomes in clinical populations.[148] Specifically gait speeds of 0.8 m/s and 1.0 m/s have been commonly used to predict hospitalization due to mobility and ADL disability respectively.[148] Individuals that are able to walk faster than 1.0 m/s are therefore at a lower risk of adverse events. In a recent study by Shimada et al. it was shown that a GS of 1.0 m/s may also predict PA cessation in community-dwelling seniors.[19] Our findings showed that although the AG walked slower than both the RG and MG groups, they still demonstrated a GS well above 1.0 m/s. In fact only three participants had a GS below 1.0 m/s and none were below 0.8 m/s. Finally, all three of our groups had an average GS $\geq$ 1.3 m/s which is indicative of relatively fit individuals above 65years of age.[105, 148]

Other studies have suggested that an increase in GS of 0.1 m/s is clinically significant as it has been shown to reduce all-cause mortality.[237, 238] Moreover, an increment of 0.1 m/s in GS has been shown to reduce an individual's disability by 10%.[37] In one study by Robinett et al. it was demonstrated that the GS required to cross a streetlight ranged from 0.50 m/s to 1.38 m/s with urban centres tending to require a faster GS than rural centres.[239] Indeed when we compared our three groups with Robinett's study the AG had a GS below 1.38 m/s whereas both the RG and MG groups had a GS well above 1.38m/s. These findings may suggest that regardless of being relatively fit prior to participating in CR that patients may still experience significant improvements in their ability to perform IADL and therefore their independence following CR. Furthermore, this improvement in GS may be maintained in those who continue to exercise.

Exercise intolerance is a cardinal symptom of CHD that is most commonly characterised by a reduction in a patient's VO_{2peak} due to its robust prognostic value for all-cause mortality.[161, 162] A commonly used cut point on the 6MWT is 300m as some have suggested that it provides similar prognostic value as VO_{2peak} in clinical populations.[163, 240, 241] Only five of our participants walked < 300m (AG = 3; RG=2) which gives further support to the relative health of the participants in our study despite the presence of CHD. It was surprising that we did not observe a difference in exercise capacity (i.e., 6MWT distance) across our three groups. However, when we examined a sub group of patients that completed the 6MWT pre and post CR we did observe a statistically significant improvement in 6MWT distances.

Some have also suggested that a meaningful change in 6MWT distance may be 20-50 m.[242] While we found no difference in 6MWT distances across groups, our results did show that both the RG and MG groups walked > 40 m more than the AG. The reason we did not observe a significant difference between groups may have been a result of the longer wait time before starting CR experienced by the AG. The longer wait time may have resulted in greater healing and recovery of the AG after their cardiac event and before performing our measures of physical function.

Yet another consideration of exercise intolerance in CHD is the impact their low exercise capacity may have on a patient's ability to perform ADLs and in turn their independence. Studies have shown that the minimum VO_{2peak} required for independent living is 15-18 ml/kg/min.[243] A more relevant cut point on the 6MWT for our current study may be 450 meters as Morales and colleagues have shown that walking < 450 m is predictive of having a VO_{2peak} < 14 ml/kg/min.[244] In this present study 34 participants walked < 450 m, the largest number of them being in the AG (AG = 16; RG = 9; MG = 9), and therefore may have had greater difficulty in performing ADLs. In fact 450 m is a reasonable cut point for elderly populations as a normal distance to cover on the 6MWT for healthy older adults is 444m.[204]

5.6 Summary

Many studies endeavoring to predict PA in cardiac patients and the elderly have relied on pedometers as an objective measure of PA. The novelty of this study was the ability to objectively assess PA using both STEPS and other common measures of PA (i.e., DEE, AEE, PA intensity time) in elderly cardiac patients participating in exercise-based programs. While we observed the RG covered more STEPS than the AG, no other differences were seen for STEPS. This would suggest that CR gives rise to an increase in PA which declines back to pre-program levels over time. Furthermore, we demonstrated that relatively few participants were meeting the recommend 7,500 STEPS. However, our results for time spent in moderate activity indicated that even though participants in the AG were less active than the other two groups many were still accumulating more than the minimum recommended 30 minutes of moderate PA. This may suggest that elderly cardiac patients are more active than previously expected prior to starting CR. These findings highlight the importance of considering intensity of activity when measuring PA.

With respect to predicting PA, while we were able to account for the intensity of activity, using MET levels, our best prediction model of PA was still STEPS. This would suggest that despite there being more representative measures of PA, STEPS may still be a useful measure of activity in CR. Furthermore, while physical function was a major focus of this study due to its potential impact on the independence of elderly patients, none of our measures provided more than a moderate indication of PA. Ultimately, our findings further reinforce those of

Ashe in that PA is more complex than merely having the functional capacity to be physically active and requires further investigation.

5.7 Limitations

One limitation of this study was its cross sectional design which simply allows us to infer possible relationships. While studies using cross sectional designs are quick and inexpensive, they rely on groups that are representative of each other which often makes it difficult to control for confounding variables. In this present study a confounding variable that may have impacted our results was the longer wait time experienced by the AG prior to starting CR (AG, 40 ± 24 days vs RG, 29 ± 11 days; $p<0.05$). Even though our findings indicated that there were no significant differences on the majority of our physical function measures an analysis of a sub group (n=32) that performed the 6MWT pre and post CR showed a significant difference in the distance walked ($p<0.05$). This would suggest that our findings may in fact be due to the longer wait time experienced by the AG. However, despite this potential limitation cross sectional designs are a logical first step as they allow for a preliminary investigation prior to investing significant time and money.

Another potential limitation was the number of monitoring days used to assess PA. Scheers et al., suggested a minimum of three complete (i.e., worn for 95% of the day) monitoring days for most measures of PA (DEE, PA intensity time) and five days for STEPS are required using the SWA in order to achieve a reliable measure of PA.[205] Furthermore, Scheers also noted that there is a difference in PA between weekdays and weekend days with individuals tending to be more active on Saturdays and less active on Sundays. As a result Scheers suggests that both Saturday and Sunday should be included in addition to the minimum three to five monitoring days to achieve a reliable estimate of PA. In the present study we included three monitoring days (i.e., two week days and one weekend day). However, wearing the SWA for longer periods presents a potential risk of developing a skin irritation. Since the intended population in this study was the elderly (i.e. >60 years) it was thought that there would be less intra-individual variation in PA and therefore three monitoring days would be sufficient.

The requirement that the MG be currently participating in a minimum of 30 minutes of moderate intensity PA at least three days of the week over the last six months could also be viewed as a limitation. Determining if participants met this criterion prior to the study was only possible using a self-reported questionnaire. Self-reported questionnaires have been shown to overestimate PA. While it was possible to confirm participants' current level of PA using the SWA, the duration of this behaviour could not be verified by a more objective measure.

5.8 Future Considerations

While many of our findings confirm previous studies, the real novelty was the multiple measures we used to assess PA. Our findings highlight the importance of considering the intensity of activity particularly in those with low functional capacities. Future studies of PA should include MET levels for mild, moderate and vigorous PA that are appropriate for the population under investigation. Furthermore, sedentary behaviour is distinctly different from the absence of moderate to vigorous PA and should be treated as such when examining PA. Additionally the number of monitoring days should be considered in future investigations. In this study it was thought that three monitoring days (two week days and one weekend day) would be sufficient for a reliable estimate of PA. However, a great deal of intra-individual variability was still observed. Future studies using activity monitors should incorporate both weekend days in addition to three weekdays when assessing PA to increase the reliability of the measure. Future investigations should incorporate a longitudinal design examining pre and post-CR as well as at 6 and 12 months after program completion.

REFERENCES CITED

1. Ades PA, Savage PD, Tischler MD, Poehlman ET, Dee J, Niggel J: **Determinants of disability in older coronary patients**. *Am Heart J* 2002, **143**(1):151-156.

2. Ades PA, Maloney A, Savage P, Carhart RL, Jr.: **Determinants of physical functioning in coronary patients: response to cardiac rehabilitation**. *Arch Intern Med* 1999, **159**(19):2357-2360.

3. Marchionni N, Fattirolli F, Fumagalli S, Oldridge N, Del Lungo F, Morosi L, Burgisser C, Masotti G: **Improved exercise tolerance and quality of life with cardiac rehabilitation of older patients after myocardial infarction: results of a randomized, controlled trial**. *Circulation* 2003, **107**(17):2201-2206.

4. 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.

5. Sin MK, Sanderson B, Weaver M, Giger J, Pemberton J, Klapow J: **Personal characteristics, health status, physical activity, and quality of life in cardiac rehabilitation participants**. *Int J Nurs Stud* 2004, **41**(2):173-181.

6. Chase JA: **Systematic Review of Physical Activity Intervention Studies After Cardiac Rehabilitation**. *The Journal of cardiovascular nursing* 2011.

7. Macchi C, Polcaro P, Cecchi F, Zipoli R, Sofi F, Romanelli A, Pepi L, Sibilio M, Lipoma M, Petrilli M *et al*: **One-year adherence to exercise in elderly patients receiving postacute inpatient rehabilitation after cardiac surgery**. *Am J Phys Med Rehabil* 2009, **88**(9):727-734.

8. Boesch C, Myers J, Habersaat A, Ilarraza H, Kottman W, Dubach P: **Maintenance of exercise capacity and physical activity patterns 2 years after cardiac rehabilitation**. *J Cardiopulm Rehabil* 2005, **25**(1):14-21; quiz 22-13.

9. Izawa KP, Yamada S, Oka K, Watanabe S, Omiya K, Iijima S, Hirano Y, Kobayashi T, Kasahara Y, Samejima H *et al*: **Long-term exercise maintenance, physical activity, and health-related quality of life after cardiac rehabilitation**. *Am J Phys Med Rehabil* 2004, **83**(12):884-892.

10. Hansen D, Dendale P, Raskin A, Schoonis A, Berger J, Vlassak I, Meeusen R: **Long-term effect of rehabilitation in coronary artery**

disease patients: randomized clinical trial of the impact of exercise volume. *Clin Rehabil* 2010, **24**(4):319-327.

11. Dolansky MA, Stepanczuk B, Charvat JM, Moore SM: **Women's and men's exercise adherence after a cardiac event**. *Research in gerontological nursing* 2010, **3**(1):30-38.

12. Gupta R, Sanderson BK, Bittner V: **Outcomes at one-year follow-up of women and men with coronary artery disease discharged from cardiac rehabilitation: what benefits are maintained?** *J Cardiopulm Rehabil Prev* 2007, **27**(1):11-18; quiz 19-20.

13. Sharp J, Freeman C: **Patterns and predictors of uptake and adherence to cardiac rehabilitation**. *J Cardiopulm Rehabil Prev* 2009, **29**(4):241-247.

14. Guiraud T, Granger R, Gremeaux V, Bousquet M, Richard L, Soukarie L, Babin T, Labrunee M, Bosquet L, Pathak A: **Accelerometer as a tool to assess sedentarity and adherence to physical activity recommendations after cardiac rehabilitation program**. *Ann Phys Rehabil Med* 2012, **55**(5):312-321.

15. Blanchard CM, Reid RD, Morrin LI, Beaton LJ, Pipe A, Courneya KS, Plotnikoff RC: **Correlates of physical activity change in patients not attending cardiac rehabilitation**. *J Cardiopulm Rehabil* 2006, **26**(6):377-383.

16. Moore SM, Dolansky MA, Ruland CM, Pashkow FJ, Blackburn GG: **Predictors of women's exercise maintenance after cardiac rehabilitation**. *J Cardiopulm Rehabil* 2003, **23**(1):40-49.

17. Giuli C, Papa R, Mocchegiani E, Marcellini F: **Predictors of participation in physical activity for community-dwelling elderly Italians**. *Arch Gerontol Geriatr* 2011.

18. Walsh JM, Pressman AR, Cauley JA, Browner WS: **Predictors of physical activity in community-dwelling elderly white women**. *J Gen Intern Med* 2001, **16**(11):721-727.

19. Shimada H, Lord SR, Yoshida H, Kim H, Suzuki T: **Predictors of cessation of regular leisure-time physical activity in community-dwelling elderly people**. *Gerontology* 2007, **53**(5):293-297.

20. Howland J, Lachman ME, Peterson EW, Cote J, Kasten L, Jette A: **Covariates of fear of falling and associated activity curtailment**. *Gerontologist* 1998, **38**(5):549-555.

21. Li F, Fisher KJ, Harmer P, McAuley E, Wilson NL: **Fear of falling in elderly persons: association with falls, functional ability, and quality of life**. *J Gerontol B Psychol Sci Soc Sci* 2003, **58**(5):P283-290.

22. Ashe MC, Eng JJ, Miller WC, Soon JA: **Disparity between physical capacity and participation in seniors with chronic disease**. *Med Sci Sports Exerc* 2007, **39**(7):1139-1146.

23. Lichtman SW, Pisarska K, Berman ER, Pestone M, Dowling H, Offenbacher E, Weisel H, Heshka S, Matthews DE, Heymsfield SB: **Discrepancy between self-reported and actual caloric intake and exercise in obese subjects**. *N Engl J Med* 1992, **327**(27):1893-1898.

24. Yazdanyar A, Newman AB: **The burden of cardiovascular disease in the elderly: morbidity, mortality, and costs**. *Clin Geriatr Med* 2009, **25**(4):563-577, vii.

25. Kennedy R, Andrews G, Caird F: **Ischemic Heart Disease**. *Br Heart J* 1977, **39**:1121-1127.

26. Ades PA, Waldmann ML, Poehlman ET, Gray P, Horton ED, Horton ES, LeWinter MM: **Exercise conditioning in older coronary patients. Submaximal lactate response and endurance capacity**. *Circulation* 1993, **88**(2):572-577.

27. Pinsky JL, Jette AM, Branch LG, Kannel WB, Feinleib M: **The Framingham Disability Study: relationship of various coronary heart disease manifestations to disability in older persons living in the community**. *Am J Public Health* 1990, **80**(11):1363-1367.

28. Scrutinio D, Bellotto F, Lagioia R, Passantino A: **Physical activity for coronary heart disease: cardioprotective mechanisms and effects on prognosis**. *Monaldi Arch Chest Dis* 2005, **64**(2):77-87.

29. Canada S: **Population projections for Canada, provinces and territories**; 2010.

30. **Physical activity and cardiovascular health. NIH Consensus Development Panel on Physical Activity and Cardiovascular Health**. *Jama* 1996, **276**(3):241-246.

31. Garber CE, Blissmer B, Deschenes MR, Franklin BA, Lamonte MJ, Lee IM, Nieman DC, Swain DP: **American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise**. *Med Sci Sports Exerc* 2011, **43**(7):1334-1359.

32. Savage PD, Toth MJ, Ades PA: **A re-examination of the metabolic equivalent concept in individuals with coronary heart disease**. *J Cardiopulm Rehabil Prev* 2007, **27**(3):143-148.

33. Byrne NM, Hills AP, Hunter GR, Weinsier RL, Schutz Y: **Metabolic equivalent: one size does not fit all**. *J Appl Physiol* 2005, **99**(3):1112-1119.

34. Dogra S, Stathokostas L: **Sedentary behavior and physical activity are independent predictors of successful aging in middle-aged and older adults**. *J Aging Res* 2012, **2012**:190654.

35. Pate RR, O'Neill JR, Lobelo F: **The evolving definition of "sedentary"**. *Exerc Sport Sci Rev* 2008, **36**(4):173-178.

36. Covinsky K: **Aging, arthritis, and disability**. *Arthritis Rheum* 2006, **55**(2):175-176.

37. Judge JO, Schechtman K, Cress E: **The relationship between physical performance measures and independence in instrumental activities of daily living. The FICSIT Group. Frailty and Injury: Cooperative Studies of Intervention Trials**. *J Am Geriatr Soc* 1996, **44**(11):1332-1341.

38. Gilliss CL, Gortner SR, Hauck WW, Shinn JA, Sparacino PA, Tompkins C: **A randomized clinical trial of nursing care for recovery from cardiac surgery**. *Heart Lung* 1993, **22**(2):125-133.

39. Carroll DL: **The importance of self-efficacy expectations in elderly patients recovering from coronary artery bypass surgery**. *Heart Lung* 1995, **24**(1):50-59.

40. Dolansky MA, Moore SM: **Older adults' early disability following a cardiac event**. *West J Nurs Res* 2008, **30**(2):163-180.

41. Simonsick EM, Kasper JD, Guralnik JM, Bandeen-Roche K, Ferrucci L, Hirsch R, Leveille S, Rantanen T, Fried LP: **Severity of upper and lower extremity functional limitation: scale development and validation with self-report and performance-based measures of physical function. WHAS Research Group. Women's Health and Aging Study**. *J Gerontol B Psychol Sci Soc Sci* 2001, **56**(1):S10-19.

42. Dahl TH: **International classification of functioning, disability and health: an introduction and discussion of its potential impact on rehabilitation services and research**. *J Rehabil Med* 2002, **34**(5):201-204.

43. Shepherd CW, While AE: **Cardiac rehabilitation and quality of life: a systematic review**. *Int J Nurs Stud* 2012, **49**(6):755-771.

44. Patla AE, Shumway-Cook A: **Dimensions of mobility: defining the complexity and difficulty associated with community mobility**. *Journal of Aging and Physical Activity* 1999, **7**(1):7-19.

45. Goldstein RE: **Exercise Capacity**, 3rd ed. edn. Boston: Butterworths; 1990.

46. Myers J, Zaheer N, Quaglietti S, Madhavan R, Froelicher V, Heidenreich P: **Association of functional and health status measures in heart failure**. *J Card Fail* 2006, **12**(6):439-445.

47. McArdle WD, Katch FI, Katch VL: **Exercise Physiology: Nutrition, Energy and Human Performance**, 7th edn: Lippincott Williams & Wilkins; 2010.

48. Hand C, Richardson J, Letts L, Stratford P: **Construct validity of the late life function and disability instrument for adults with chronic conditions**. *Disabil Rehabil* 2010, **32**(1):50-56.

49. Lavie CJ, Milani RV: **Benefits of cardiac rehabilitation and exercise training programs in elderly coronary patients**. *The American journal of geriatric cardiology* 2001, **10**(6):323-327.

50. Menezes AR, Lavie CJ, Milani RV, Arena RA, Church TS: **Cardiac rehabilitation and exercise therapy in the elderly: Should we invest in the aged?** *J Geriatr Cardiol* 2012, **9**(1):68-75.

51. Johnston M, Macdonald K, Manns P, Senaratne M, Rodgers W, Haennel RG: **Impact of Cardiac Rehabilitation on the Ability of Elderly Cardiac Patients to Perform Common Household Tasks**. *J Cardiopulm Rehabil Prev* 2010.

52. Aggarwal A, Ades PA: **Exercise rehabilitation of older patients with cardiovascular disease**. *Cardiol Clin* 2001, **19**(3):525-536.

53. Saccomann IC, Cintra FA, Gallani MC: **Psychometric properties of the Minnesota Living with Heart Failure--Brazilian version--in the elderly**. *Qual Life Res* 2007, **16**(6):997-1005.

54. Warburton DE, Nicol CW, Bredin SS: **Health benefits of physical activity: the evidence**. *Cmaj* 2006, **174**(6):801-809.

55. Blair SN, Morris JN: **Healthy hearts--and the universal benefits of being physically active: physical activity and health**. *Ann Epidemiol* 2009, **19**(4):253-256.

56. Soriano N, Ribera A, Marsal JR, Brotons C, Cascant P, Permanyer-Miralda G: **Improvements in health-related quality of life of patients admitted for heart failure. The HF-QoL study**. *Rev Esp Cardiol* 2010, **63**(6):668-676.

57. Rodriguez-Artalejo F, Guallar-Castillon P, Pascual CR, Otero CM, Montes AO, Garcia AN, Conthe P, Chiva MO, Banegas JR, Herrera MC: **Health-related quality of life as a predictor of hospital readmission and death among patients with heart failure**. *Arch Intern Med* 2005, **165**(11):1274-1279.

58. Vermeulen J, Neyens JC, van Rossum E, Spreeuwenberg MD, de Witte LP: **Predicting ADL disability in community-dwelling elderly people using physical frailty indicators: a systematic review**. *BMC geriatrics* 2011, **11**:33.

59. Hambrecht R, Fiehn E, Weigl C, Gielen S, Hamann C, Kaiser R, Yu J, Adams V, Niebauer J, Schuler G: **Regular physical exercise corrects endothelial dysfunction and improves exercise capacity in patients with chronic heart failure**. *Circulation* 1998, **98**(24):2709-2715.

60. Hambrecht R, Niebauer J, Marburger C, Grunze M, Kalberer B, Hauer K, Schlierf G, Kubler W, Schuler G: **Various intensities of leisure time physical activity in patients with coronary artery disease: effects on cardiorespiratory fitness and progression of coronary atherosclerotic lesions**. *J Am Coll Cardiol* 1993, **22**(2):468-477.

61. Wannamethee SG, Shaper AG, Walker M: **Physical activity and mortality in older men with diagnosed coronary heart disease**. *Circulation* 2000, **102**(12):1358-1363.

62. Aijo M, Parkatti T: **Independent and combined association of physical activity and cardiac disease on mortality risk in the very old**. *J Aging Health* 2011, **23**(1):70-85.

63. Myers J: **The health benefits and economics of physical activity**. *Curr Sports Med Rep* 2008, **7**(6):314-316.

64. Daly RM, Ahlborg HG, Ringsberg K, Gardsell P, Sernbo I, Karlsson MK: **Association between changes in habitual physical activity and changes in bone density, muscle strength, and functional performance in elderly men and women**. *J Am Geriatr Soc* 2008, **56**(12):2252-2260.

65. Molino-Lova R, Pasquini G, Vannetti F, Paperini A, Forconi T, Polcaro P, Zipoli R, Cecchi F, Macchi C: **Effects of a structured physical activity intervention on measures of physical performance in frail elderly patients after cardiac rehabilitation: a pilot study with 1-year follow-up**. *Intern Emerg Med* 2011.

66. Bethell HJ: **Exercise in cardiac rehabilitation**. *Br J Sports Med* 1999, **33**(2):79-86.

67. Bock BC, Albrecht AE, Traficante RM, Clark MM, Pinto BM, Tilkemeier P, Marcus BH: **Predictors of exercise adherence following participation in a cardiac rehabilitation program**. *Int J Behav Med* 1997, **4**(1):60-75.

68. McAuley E: **Self-efficacy and the maintenance of exercise participation in older adults**. *J Behav Med* 1993, **16**(1):103-113.

69. Woodgate J, Brawley LR: **Self-efficacy for exercise in cardiac rehabilitation: review and recommendations**. *J Health Psychol* 2008, **13**(3):366-387.

70. Everett B, Salamonson Y, Davidson PM: **Bandura's exercise self-efficacy scale: validation in an Australian cardiac rehabilitation setting**. *Int J Nurs Stud* 2009, **46**(6):824-829.

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

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

73. McAuley E, Jerome GJ, Elavsky S, Marquez DX, Ramsey SN: **Predicting long-term maintenance of physical activity in older adults**. *Prev Med* 2003, **37**(2):110-118.

74. McAuley E, Jerome GJ, Marquez DX, Elavsky S, Blissmer B: **Exercise self-efficacy in older adults: social, affective, and behavioral influences**. *Ann Behav Med* 2003, **25**(1):1-7.

75. McAuley E, Konopack JF, Morris KS, Motl RW, Hu L, Doerksen SE, Rosengren K: **Physical activity and functional limitations in older women: influence of self-efficacy**. *J Gerontol B Psychol Sci Soc Sci* 2006, **61**(5):P270-277.

76. Shin KR, Kang Y, Park HJ, Heitkemper M: **Effects of exercise program on physical fitness, depression, and self-efficacy of low-income elderly women in South Korea**. *Public Health Nurs* 2009, **26**(6):523-531.

77. McAuley E, Morris KS, Motl RW, Hu L, Konopack JF, Elavsky S: **Long-term follow-up of physical activity behavior in older adults**. *Health Psychol* 2007, **26**(3):375-380.

78. Cheng TY, Boey KW: **The effectiveness of a cardiac rehabilitation program on self-efficacy and exercise tolerance**. *Clin Nurs Res* 2002, **11**(1):10-21.

79. Jeng C, Braun LT: **The influence of self-efficacy on exercise intensity, compliance rate and cardiac rehabilitation outcomes among coronary artery disease patients**. *Prog Cardiovasc Nurs* 1997, **12**(1):13-24.

80. Vidmar PM, Rubinson L: **The relationship between self-efficacy and exercise compliance in a cardiac population**. *Journal of Cardiopulmonary Rehabilitation* 1994, **14**(4):246-254.

81. Gortner SR, Jenkins LS: **Self-efficacy and activity level following cardiac surgery**. *J Adv Nurs* 1990, **15**(10):1132-1138.

82. Blanchard CM, Rodgers WM, Courneya KS, Daub B, Black B: **Self-efficacy and mood in cardiac rehabilitation: should gender be considered?** *Behav Med* 2002, **27**(4):149-160.

83. Rodgers WM, Wilson PM, Hall CR, Fraser SN, Murray TC: **Evidence for a multidimensional self-efficacy for exercise scale**. *Res Q Exerc Sport* 2008, **79**(2):222-234.

84. Fraser SN, Rodgers WM, Murray TC, Daub B: **The enduring impact of social factors on exercise tolerance in men attending cardiac rehabilitation**. *J Cardiopulm Rehabil Prev* 2007, **27**(2):92-96; quiz 97-98.

85. Fried LP, Bandeen-Roche K, Kasper JD, Guralnik JM: **Association of comorbidity with disability in older women: the Women's Health and Aging Study**. *J Clin Epidemiol* 1999, **52**(1):27-37.

86. Ades PA, Savage PD, Brochu M, Tischler MD, Lee NM, Poehlman ET: **Resistance training increases total daily energy expenditure in disabled older women with coronary heart disease**. *J Appl Physiol* 2005, **98**(4):1280-1285.

87. Basler HD, Luckmann J, Wolf U, Quint S: **Fear-avoidance beliefs, physical activity, and disability in elderly individuals with chronic low back pain and healthy controls**. *The Clinical journal of pain* 2008, **24**(7):604-610.

88. Van Den Brink CL, Picavet H, Van Den Bos GA, Giampaoli S, Nissinen A, Kromhout D: **Duration and intensity of physical activity and**

disability among European elderly men. *Disabil Rehabil* 2005, **27**(6):341-347.

89. Di Francesco V, Zamboni M, Zoico E, Bortolani A, Maggi S, Bissoli L, Zivelonghi A, Guariento S, Bosello O: **Relationships between leisure-time physical activity, obesity and disability in elderly men**. *Aging Clin Exp Res* 2005, **17**(3):201-206.

90. Wu SC, Leu SY, Li CY: **Incidence of and predictors for chronic disability in activities of daily living among older people in Taiwan**. *J Am Geriatr Soc* 1999, **47**(9):1082-1086.

91. Wang L, van Belle G, Kukull WB, Larson EB: **Predictors of functional change: a longitudinal study of nondemented people aged 65 and older**. *J Am Geriatr Soc* 2002, **50**(9):1525-1534.

92. Green CP, Porter CB, Bresnahan DR, Spertus JA: **Development and evaluation of the Kansas City Cardiomyopathy Questionnaire: a new health status measure for heart failure**. *J Am Coll Cardiol* 2000, **35**(5):1245-1255.

93. Garin O, Ferrer M, Pont A, Rue M, Kotzeva A, Wiklund I, Van Ganse E, Alonso J: **Disease-specific health-related quality of life questionnaires for heart failure: a systematic review with meta-analyses**. *Qual Life Res* 2009, **18**(1):71-85.

94. Incel NA, Sezgin M, As I, Cimen OB, Sahin G: **The geriatric hand: correlation of hand-muscle function and activity restriction in elderly**. *Int J Rehabil Res* 2009, **32**(3):213-218.

95. Lawton MP, Brody EM: **Assessment of older people: self-maintaining and instrumental activities of daily living**. *Gerontologist* 1969, **9**(3):179-186.

96. Izawa K, Hirano Y, Yamada S, Oka K, Omiya K, Iijima S: **Improvement in physiological outcomes and health-related quality of life following cardiac rehabilitation in patients with acute myocardial infarction**. *Circ J* 2004, **68**(4):315-320.

97. Sayers SP, Jette AM, Haley SM, Heeren TC, Guralnik JM, Fielding RA: **Validation of the Late-Life Function and Disability Instrument**. *J Am Geriatr Soc* 2004, **52**(9):1554-1559.

98. Denkinger MD, Igl W, Coll-Planas L, Bleicher J, Nikolaus T, Jamour M: **Evaluation of the short form of the late-life function and disability instrument in geriatric inpatients-validity, responsiveness, and sensitivity to change**. *J Am Geriatr Soc* 2009, **57**(2):309-314.

99. Brach JS, VanSwearingen JM: **Physical impairment and disability: relationship to performance of activities of daily living in community-dwelling older men**. *Phys Ther* 2002, **82**(8):752-761.

100. Cress ME, Meyer M: **Maximal voluntary and functional performance levels needed for independence in adults aged 65 to 97 years**. *Phys Ther* 2003, **83**(1):37-48.

101. Audelin MC, Savage PD, Ades PA: **Exercise-based cardiac rehabilitation for very old patients (> or =75 years): focus on physical function**. *J Cardiopulm Rehabil Prev* 2008, **28**(3):163-173.

102. Gill TM, Murphy TE, Barry LC, Allore HG: **Risk factors for disability subtypes in older persons**. *J Am Geriatr Soc* 2009, **57**(10):1850-1855.

103. Ishizaki T, Watanabe S, Suzuki T, Shibata H, Haga H: **Predictors for functional decline among nondisabled older Japanese living in a community during a 3-year follow-up**. *J Am Geriatr Soc* 2000, **48**(11):1424-1429.

104. Gill TM, Williams CS, Tinetti ME: **Assessing risk for the onset of functional dependence among older adults: the role of physical performance**. *J Am Geriatr Soc* 1995, **43**(6):603-609.

105. Shinkai S, Watanabe S, Kumagai S, Fujiwara Y, Amano H, Yoshida H, Ishizaki T, Yukawa H, Suzuki T, Shibata H: **Walking speed as a good predictor for the onset of functional dependence in a Japanese rural community population**. *Age Ageing* 2000, **29**(5):441-446.

106. Hyatt RH, Whitelaw MN, Bhat A, Scott S, Maxwell JD: **Association of muscle strength with functional status of elderly people**. *Age Ageing* 1990, **19**(5):330-336.

107. Desrosiers J, Bravo G, Hebert R, Dutil E: **Normative data for grip strength of elderly men and women**. *Am J Occup Ther* 1995, **49**(7):637-644.

108. Meyer RD, Goggin NL, Jackson AW: **A comparison of grip strength and selected psychomotor performance measures in healthy and frail elderly females**. *Res Q Exerc Sport* 1995, **66**(1):1-8.

109. van Lier AM, Payette H: **Determinants of handgrip strength in free-living elderly at risk of malnutrition**. *Disabil Rehabil* 2003, **25**(20):1181-1186.

110. Norman K, Stobaus N, Gonzalez MC, Schulzke JD, Pirlich M: **Hand grip strength: outcome predictor and marker of nutritional status**. *Clin Nutr* 2011, **30**(2):135-142.

111. Rantanen T, Guralnik JM, Foley D, Masaki K, Leveille S, Curb JD, White L: **Midlife hand grip strength as a predictor of old age disability**. *Jama* 1999, **281**(6):558-560.

112. Sasaki H, Kasagi F, Yamada M, Fujita S: **Grip strength predicts cause-specific mortality in middle-aged and elderly persons**. *Am J Med* 2007, **120**(4):337-342.

113. Rantanen T, Volpato S, Ferrucci L, Heikkinen E, Fried LP, Guralnik JM: **Handgrip strength and cause-specific and total mortality in older disabled women: exploring the mechanism**. *J Am Geriatr Soc* 2003, **51**(5):636-641.

114. Gale CR, Martyn CN, Cooper C, Sayer AA: **Grip strength, body composition, and mortality**. *Int J Epidemiol* 2007, **36**(1):228-235.

115. Phillips P: **Grip strength, mental performance and nutritional status as indicators of mortality risk among female geriatric patients**. *Age Ageing* 1986, **15**(1):53-56.

116. Lyyra TM, Leskinen E, Heikkinen E: **A cohort study found good respiratory, sensory and motor functions decreased mortality risk in older people**. *J Clin Epidemiol* 2005, **58**(5):509-516.

117. Rantanen T, Masaki K, Foley D, Izmirlian G, White L, Guralnik JM: **Grip strength changes over 27 yr in Japanese-American men**. *J Appl Physiol* 1998, **85**(6):2047-2053.

118. Peters MJ, van Nes SI, Vanhoutte EK, Bakkers M, van Doorn PA, Merkies IS, Faber CG: **Revised normative values for grip strength with the Jamar dynamometer**. *J Peripher Nerv Syst* 2011, **16**(1):47-50.

119. Hirsch CH, Fried LP, Harris T, Fitzpatrick A, Enright P, Schulz R: **Correlates of performance-based measures of muscle function in the elderly: the Cardiovascular Health Study**. *J Gerontol A Biol Sci Med Sci* 1997, **52**(4):M192-200.

120. Rantanen T: **Muscle strength, disability and mortality**. *Scand J Med Sci Sports* 2003, **13**(1):3-8.

121. Rantanen T, Avlund K, Suominen H, Schroll M, Frandin K, Pertti E: **Muscle strength as a predictor of onset of ADL dependence in people aged 75 years**. *Aging Clin Exp Res* 2002, **14**(3 Suppl):10-15.

122. Sallinen J, Stenholm S, Rantanen T, Heliovaara M, Sainio P, Koskinen S: **Hand-grip strength cut points to screen older persons at risk for mobility limitation**. *J Am Geriatr Soc* 2010, **58**(9):1721-1726.

123. Werle S, Goldhahn J, Drerup S, Simmen BR, Sprott H, Herren DB: **Age- and Gender-Specific Normative Data of Grip and Pinch Strength in a Healthy adult Swiss Population**. *J Hand Surg Eur Vol* 2009.

124. Desrosiers J, Hebert R, Bravo G, Dutil E: **Upper extremity performance test for the elderly (TEMPA): normative data and correlates with sensorimotor parameters. Test d'Evaluation des Membres Superieurs de Personnes Agees**. *Arch Phys Med Rehabil* 1995, **76**(12):1125-1129.

125. Verghese J, Wang C, Xue X, Holtzer R: **Self-reported difficulty in climbing up or down stairs in nondisabled elderly**. *Arch Phys Med Rehabil* 2008, **89**(1):100-104.

126. Al Snih S, Markides KS, Ottenbacher KJ, Raji MA: **Hand grip strength and incident ADL disability in elderly Mexican Americans over a seven-year period**. *Aging Clin Exp Res* 2004, **16**(6):481-486.

127. Giampaoli S, Ferrucci L, Cecchi F, Lo Noce C, Poce A, Dima F, Santaquilani A, Vescio MF, Menotti A: **Hand-grip strength predicts incident disability in non-disabled older men**. *Age Ageing* 1999, **28**(3):283-288.

128. Shechtman O, Mann WC, Justiss MD, Tomita M: **Grip strength in the frail elderly**. *Am J Phys Med Rehabil* 2004, **83**(11):819-826.

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

130. Ostchega Y, Dillon CF, Lindle R, Carroll M, Hurley BF: **Isokinetic leg muscle strength in older americans and its relationship to a standardized walk test: data from the national health and nutrition examination survey 1999-2000**. *J Am Geriatr Soc* 2004, **52**(6):977-982.

131. Mroszczyk-McDonald A, Savage PD, Ades PA: **Handgrip strength in cardiac rehabilitation: normative values, interaction with physical function, and response to training**. *J Cardiopulm Rehabil Prev* 2007, **27**(5):298-302.

132. Izawa KP, Oka K, Watanabe S, Yokoyama H, Hiraki K, Morio Y, Kasahara Y, Omiya K: **Gender-related differences in clinical characteristics and physiological and psychosocial outcomes of Japanese patients at entry into phase II cardiac rehabilitation**. *J Rehabil Med* 2008, **40**(3):225-230.

133. Crosby CA, Wehbe MA, Mawr B: **Hand strength: normative values**. *J Hand Surg Am* 1994, **19**(4):665-670.

134. Liu KP, Chu MM: **Grip strength and physical demand of previous occupation in a well-functioning cohort of Chinese older adults**. *Percept Mot Skills* 2006, **103**(1):14-20.

135. Sin M-K, Choe M-A, Kim J, Chae Y-R, Jeon M-Y, Vezeau T: **Comparison of body composition, handgrip strength, functional capacity, and physical activity in elderly Koreans and Korean immigrants**. *Research in gerontological nursing* 2009, **2**(1):20-29.

136. Rolland Y, Lauwers-Cances V, Pahor M, Fillaux J, Grandjean H, Vellas B: **Muscle strength in obese elderly women: effect of recreational physical activity in a cross-sectional study**. *Am J Clin Nutr* 2004, **79**(4):552-557.

137. Rubenstein LZ, Powers CM, MacLean CH: **Quality indicators for the management and prevention of falls and mobility problems in vulnerable elders**. *Ann Intern Med* 2001, **135**(8 Pt 2):686-693.

138. Shumway-Cook A, Ciol MA, Yorkston KM, Hoffman JM, Chan L: **Mobility limitations in the Medicare population: prevalence and sociodemographic and clinical correlates**. *J Am Geriatr Soc* 2005, **53**(7):1217-1221.

139. Netuveli G, Wiggins RD, Hildon Z, Montgomery SM, Blane D: **Quality of life at older ages: evidence from the English longitudinal study of aging (wave 1)**. *J Epidemiol Community Health* 2006, **60**(4):357-363.

140. von Bonsdorff M, Rantanen T, Laukkanen P, Suutama T, Heikkinen E: **Mobility limitations and cognitive deficits as predictors of institutionalization among community-dwelling older people**. *Gerontology* 2006, **52**(6):359-365.

141. Hirvensalo M, Rantanen T, Heikkinen E: **Mobility difficulties and physical activity as predictors of mortality and loss of independence in the community-living older population**. *Journal of the American Geriatrics Society* 2000, **48**(5):493-498.

142. Leveille SG, Penninx BW, Melzer D, Izmirlian G, Guralnik JM: **Sex differences in the prevalence of mobility disability in old age: the dynamics of incidence, recovery, and mortality**. *J Gerontol B Psychol Sci Soc Sci* 2000, **55**(1):S41-50.

143. Yeom HA, Fleury J, Keller C: **Risk factors for mobility limitation in community-dwelling older adults: a social ecological perspective**. *Geriatr Nurs* 2008, **29**(2):133-140.

144. Ahto M, Isoaho R, Puolijoki H, Laippala P, Romo M, Kivela SL: **Functional abilities of elderly coronary heart disease patients**. *Aging (Milano)* 1998, **10**(2):127-136.

145. Avlund K, Damsgaard MT, Sakari-Rantala R, Laukkanen P, Schroll M: **Tiredness in daily activities among nondisabled old people as determinant of onset of disability**. *J Clin Epidemiol* 2002, **55**(10):965-973.

146. Visser M, Simonsick EM, Colbert LH, Brach J, Rubin SM, Kritchevsky SB, Newman AB, Harris TB: **Type and intensity of activity and risk of mobility limitation: the mediating role of muscle parameters**. *J Am Geriatr Soc* 2005, **53**(5):762-770.

147. Malatesta D, Simar D, Dauvilliers Y, Candau R, Ben Saad H, Prefaut C, Caillaud C: **Aerobic determinants of the decline in preferred walking speed in healthy, active 65- and 80-year-olds**. *Pflugers Arch* 2004, **447**(6):915-921.

148. Abellan van Kan G, Rolland Y, Andrieu S, Bauer J, Beauchet O, Bonnefoy M, Cesari M, Donini LM, Gillette Guyonnet S, Inzitari M *et al*: **Gait speed at usual pace as a predictor of adverse outcomes in community-dwelling older people an International Academy on Nutrition and Aging (IANA) Task Force**. *J Nutr Health Aging* 2009, **13**(10):881-889.

149. Potter JM, Evans AL, Duncan G: **Gait speed and activities of daily living function in geriatric patients**. *Arch Phys Med Rehabil* 1995, **76**(11):997-999.

150. Munoz-Mendoza CL, Cabanero-Martinez MJ, Millan-Calenti JC, Cabrero-Garcia J, Lopez-Sanchez R, Maseda-Rodriguez A: **Reliability of 4-m and 6-m walking speed tests in elderly people with cognitive impairment**. *Arch Gerontol Geriatr* 2011, **52**(2):e67-70.

151. Dumurgier J, Elbaz A, Ducimetiere P, Tavernier B, Alperovitch A, Tzourio C: **Slow walking speed and cardiovascular death in well functioning older adults: prospective cohort study**. *Bmj* 2009, **339**:b4460.

152. Purser JL, Kuchibhatla MN, Fillenbaum GG, Harding T, Peterson ED, Alexander KP: **Identifying frailty in hospitalized older adults with significant coronary artery disease**. *J Am Geriatr Soc* 2006, **54**(11):1674-1681.

153. Afilalo J, Eisenberg MJ, Morin JF, Bergman H, Monette J, Noiseux N, Perrault LP, Alexander KP, Langlois Y, Dendukuri N *et al*: **Gait speed as an incremental predictor of mortality and major morbidity in elderly**

patients undergoing cardiac surgery. *J Am Coll Cardiol* 2010, **56**(20):1668-1676.

154. Podsiadlo D, Richardson S: **The timed "Up & Go": a test of basic functional mobility for frail elderly persons**. *J Am Geriatr Soc* 1991, **39**(2):142-148.

155. Steffen TM, Hacker TA, Mollinger L: **Age- and gender-related test performance in community-dwelling elderly people: Six-Minute Walk Test, Berg Balance Scale, Timed Up & Go Test, and gait speeds**. *Phys Ther* 2002, **82**(2):128-137.

156. Shumway-Cook A, Brauer S, Woollacott M: **Predicting the probability for falls in community-dwelling older adults using the Timed Up & Go Test**. *Phys Ther* 2000, **80**(9):896-903.

157. Kristensen MT, Foss NB, Kehlet H: **Timed "up & go" test as a predictor of falls within 6 months after hip fracture surgery**. *Phys Ther* 2007, **87**(1):24-30.

158. Morris R, Harwood RH, Baker R, Sahota O, Armstrong S, Masud T: **A comparison of different balance tests in the prediction of falls in older women with vertebral fractures: a cohort study**. *Age Ageing* 2007, **36**(1):78-83.

159. Wennie Huang WN, Perera S, VanSwearingen J, Studenski S: **Performance measures predict onset of activity of daily living difficulty in community-dwelling older adults**. *J Am Geriatr Soc* 2010, **58**(5):844-852.

160. Yoshida D, Nakagaichi M, Saito K, Wakui S, Yoshitake Y: **The relationship between physical fitness and ambulatory activity in very elderly women with normal functioning and functional limitations**. *Journal of physiological anthropology* 2010, **29**(6):211-218.

161. Belardinelli R, Georgiou D, Cianci G, Purcaro A: **Randomized, 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**(9):1173-1182.

162. Rostagno C, Gensini GF: **Six minute walk test: a simple and useful test to evaluate functional capacity in patients with heart failure**. *Intern Emerg Med* 2008, **3**(3):205-212.

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

164. Guyatt GH, Sullivan MJ, Thompson PJ, Fallen EL, Pugsley SO, Taylor DW, Berman LB: **The 6-minute walk: a new measure of exercise capacity in patients with chronic heart failure**. *Can Med Assoc J* 1985, **132**(8):919-923.

165. ACSM: **ACMS's Guidelines for Exercise Testing and Prescription**, 8th ed. edn. New York, NY: Lippincott Williams and Wilkins; 2010.

166. Le Grande MR, Elliott PC, Worcester MU, Murphy BM, Goble AJ: **An evaluation of self-report physical activity instruments used in studies involving cardiac patients**. *J Cardiopulm Rehabil Prev* 2008, **28**(6):358-369.

167. Shephard RJ: **Limits to the measurement of habitual physical activity by questionnaires**. *Br J Sports Med* 2003, **37**(3):197-206; discussion 206.

168. Welk GJ: **Physical activity asessements for health-related research**. Champaign, IL: Human Kinetics Publishers, Inc.; 2002.

169. Blanchard CM, Reid RD, Morrin LI, McDonnell L, McGannon K, Rhodes RE, Spence JC, Edwards N: **Understanding physical activity during home-based cardiac rehabilitation from multiple theoretical perspectives**. *J Cardiopulm Rehabil Prev* 2011, **31**(3):173-180.

170. Jenson M, Suls J, Lemos K: **A comparison of physical activity in men and women with cardiac disease: do gender roles complicate recovery?** *Women Health* 2003, **37**(1):31-48.

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

172. Allison MJ, Keller C: **Physical activity maintenance in elders with cardiac problems**. *Geriatr Nurs* 2000, **21**(4):200-203.

173. Blanchard CM, Reid RD, Morrin LI, McDonnell L, McGannon K, Rhodes RE, Spence JC, Edwards N: **Demographic and clinical determinants of moderate to vigorous physical activity during home-based cardiac rehabilitation: the home-based determinants of exercise (HOME) study**. *J Cardiopulm Rehabil Prev* 2010, **30**(4):240-245.

174. Clark AM, Munday C, McLaughlin D, Catto S, McLaren A, Macintyre PD: **Peer support to promote physical activity after completion of centre-based cardiac rehabilitation: Evaluation of access and effects**. *Eur J Cardiovasc Nurs* 2011.

175. Furber S, Butler L, Phongsavan P, Mark A, Bauman A: **Randomised controlled trial of a pedometer-based telephone intervention to**

increase physical activity among cardiac patients not attending cardiac rehabilitation. *Patient Educ Couns* 2010, **80**(2):212-218.

176. Ayabe M, Brubaker PH, Dobrosielski D, Miller HS, Ishi K, Yahiro T, Kiyonaga A, Shindo M, Tanaka H: **The physical activity patterns of cardiac rehabilitation program participants**. *J Cardiopulm Rehabil* 2004, **24**(2):80-86.

177. Reid RD, Morrin LI, Pipe AL, Dafoe WA, Higginson LA, Wielgosz AT, LeHaye SA, McDonald PW, Plotnikoff RC, Courneya KS *et al*: **Determinants of physical activity after hospitalization for coronary artery disease: the Tracking Exercise After Cardiac Hospitalization (TEACH) Study**. *Eur J Cardiovasc Prev Rehabil* 2006, **13**(4):529-537.

178. Stevenson TG, Riggin K, Nagelkirk PR, Hargens TA, Strath SJ, Kaminsky LA: **Physical activity habits of cardiac patients participating in an early outpatient rehabilitation program**. *J Cardiopulm Rehabil Prev* 2009, **29**(5):299-303.

179. Jones NL, Schneider PL, Kaminsky LA, Riggin K, Taylor AM: **An assessment of the total amount of physical activity of patients participating in a phase III cardiac rehabilitation program**. *J Cardiopulm Rehabil Prev* 2007, **27**(2):81-85.

180. Oliveira J, Ribeiro F, Gomes H: **Effects of a home-based cardiac rehabilitation program on the physical activity levels of patients with coronary artery disease**. *J Cardiopulm Rehabil Prev* 2008, **28**(6):392-396.

181. Tudor-Locke C, Bassett DR, Jr.: **How many steps/day are enough? Preliminary pedometer indices for public health**. *Sports Med* 2004, **34**(1):1-8.

182. VanWormer JJ, Boucher JL, Pronk NP, Thoennes JJ: **Lifestyle behavior change and coronary artery disease: effectiveness of a telephone-based counseling program**. *J Nutr Educ Behav* 2004, **36**(6):333-334.

183. Ayabe M, Brubaker PH, Dobrosielski D, Miller HS, Kiyonaga A, Shindo M, Tanaka H: **Target step count for the secondary prevention of cardiovascular disease**. *Circ J* 2008, **72**(2):299-303.

184. Witham MD, Argo IS, Johnston DW, Struthers AD, McMurdo ME: **Predictors of exercise capacity and everyday activity in older heart failure patients**. *Eur J Heart Fail* 2006, **8**(2):203-207.

185. Asakuma S, Ohyanagi M, Iwasaki T: **Simple methods of assessing physical activity in patients with chronic heart failure**. *Congest Heart Fail* 2000, **6**(5):250-255.

186. van den Berg-Emons HJ, Bussmann JB, Balk AH, Stam HJ: **Validity of ambulatory accelerometry to quantify physical activity in heart failure**. *Scand J Rehabil Med* 2000, **32**(4):187-192.

187. King GA, Torres N, Potter C, Brooks TJ, Coleman KJ: **Comparison of activity monitors to estimate energy cost of treadmill exercise**. *Med Sci Sports Exerc* 2004, **36**(7):1244-1251.

188. Cole PJ, LeMura LM, Klinger TA, Strohecker K, McConnell TR: **Measuring energy expenditure in cardiac patients using the Body Media Armband versus indirect calorimetry. A validation study**. *J Sports Med Phys Fitness* 2004, **44**(3):262-271.

189. Johannsen DL, Calabro MA, Stewart J, Franke W, Rood JC, Welk GJ: **Accuracy of armband monitors for measuring daily energy expenditure in healthy adults**. *Med Sci Sports Exerc* 2010, **42**(11):2134-2140.

190. Mackey DC, Manini TM, Schoeller DA, Koster A, Glynn NW, Goodpaster BH, Satterfield S, Newman AB, Harris TB, Cummings SR: **Validation of an Armband to Measure Daily Energy Expenditure in Older Adults**. *J Gerontol A Biol Sci Med Sci* 2011, **66A**(10):1108-1113.

191. Nelson ME, Rejeski WJ, Blair SN, Duncan PW, Judge JO, King AC, Macera CA, Castaneda-Sceppa C: **Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association**. *Circulation* 2007, **116**(9):1094-1105.

192. Stevens J (ed.): **Applied multivariate statistics for the social sciences**, 4th edn: Lawrence Erlbaum Associates; 2002.

193. McHorney CA, Ware JE, Jr., Lu JF, Sherbourne CD: **The MOS 36-item Short-Form Health Survey (SF-36): III. Tests of data quality, scaling assumptions, and reliability across diverse patient groups**. *Med Care* 1994, **32**(1):40-66.

194. Coldham F, Lewis J, Lee H: **The reliability of one vs. three grip trials in symptomatic and asymptomatic subjects**. *J Hand Ther* 2006, **19**(3):318-326; quiz 327.

195. Shyam Kumar AJ, Parmar V, Ahmed S, Kar S, Harper WM: **A study of grip endurance and strengh in different elbow positions**. *J Orthop Traumatol* 2008, **9**(4):209-211.

196. Salbach NM, Mayo NE, Higgins J, Ahmed S, Finch LE, Richards CL: **Responsiveness and predictability of gait speed and other disability**

measures in acute stroke. *Arch Phys Med Rehabil* 2001, **82**(9):1204-1212.

197. Lindemann U, Najafi B, Zijlstra W, Hauer K, Muche R, Becker C, Aminian K: **Distance to achieve steady state walking speed in frail elderly persons**. *Gait Posture* 2008, **27**(1):91-96.

198. Schenkman M, Cutson TM, Kuchibhatla M, Chandler J, Pieper C: **Reliability of impairment and physical performance measures for persons with Parkinson's disease**. *Phys Ther* 1997, **77**(1):19-27.

199. Arnadottir SA, Mercer VS: **Effects of footwear on measurements of balance and gait in women between the ages of 65 and 93 years**. *Phys Ther* 2000, **80**(1):17-27.

200. Cesari M, Kritchevsky SB, Penninx BW, Nicklas BJ, Simonsick EM, Newman AB, Tylavsky FA, Brach JS, Satterfield S, Bauer DC *et al*: **Prognostic value of usual gait speed in well-functioning older people--results from the Health, Aging and Body Composition Study**. *J Am Geriatr Soc* 2005, **53**(10):1675-1680.

201. Lin MR, Hwang HF, Hu MH, Wu HD, Wang YW, Huang FC: **Psychometric comparisons of the timed up and go, one-leg stand, functional reach, and Tinetti balance measures in community-dwelling older people**. *J Am Geriatr Soc* 2004, **52**(8):1343-1348.

202. **ATS statement: guidelines for the six-minute walk test**. *Am J Respir Crit Care Med* 2002, **166**(1):111-117.

203. Pollentier B, Irons SL, Benedetto CM, Dibenedetto AM, Loton D, Seyler RD, Tych M, Newton RA: **Examination of the six minute walk test to determine functional capacity in people with chronic heart failure: a systematic review**. *Cardiopulm Phys Ther J* 2010, **21**(1):13-21.

204. Gremeaux V, Iskandar M, Kervio G, Deley G, Perennou D, Casillas JM: **Comparative analysis of oxygen uptake in elderly subjects performing two walk tests: the six-minute walk test and the 200-m fast walk test**. *Clin Rehabil* 2008, **22**(2):162-168.

205. Scheers T, Philippaerts R, Lefevre J: **Variability in physical activity patterns as measured by the SenseWear Armband: how many days are needed?** *Eur J Appl Physiol* 2012, **112**(5):1653-1662.

206. Goran MI, Poehlman ET: **Total energy expenditure and energy requirements in healthy elderly persons**. *Metabolism* 1992, **41**(7):744-753.

207. Poehlman ET, Melby CL, Goran MI: **The impact of exercise and diet restriction on daily energy expenditure**. *Sports Med* 1991, **11**(2):78-101.

208. Elia M, Ritz P, Stubbs RJ: **Total energy expenditure in the elderly**. *Eur J Clin Nutr* 2000, **54 Suppl 3**:S92-103.

209. Tudor-Locke C, Craig CL, Aoyagi Y, Bell RC, Croteau KA, De Bourdeaudhuij I, Ewald B, Gardner AW, Hatano Y, Lutes LD *et al*: **How many steps/day are enough? For older adults and special populations**. *Int J Behav Nutr Phys Act* 2011, **8**:80.

210. Boslaugh S: **Statistics in a Nutshell**. In., 2nd edn: O'Reilly Media, Inc.; 2012.

211. Team EID: **Outlier detection methods**. In: *Oracle Crystal Ball.* 2012.

212. Marshall SJ, Levy SS, Tudor-Locke CE, Kolkhorst FW, Wooten KM, Ji M, Macera CA, Ainsworth BE: **Translating physical activity recommendations into a pedometer-based step goal: 3000 steps in 30 minutes**. *Am J Prev Med* 2009, **36**(5):410-415.

213. Schneider PL, Crouter S, Bassett DR: **Pedometer measures of free-living physical activity: comparison of 13 models**. *Med Sci Sports Exerc* 2004, **36**(2):331-335.

214. Abel MG, Peritore N, Shapiro R, Mullineaux DR, Rodriguez K, Hannon JC: **A comprehensive evaluation of motion sensor step-counting error**. *Appl Physiol Nutr Metab* 2011, **36**(1):166-170.

215. Crouter SE, Schneider PL, Bassett DR, Jr.: **Spring-levered versus piezo-electric pedometer accuracy in overweight and obese adults**. *Med Sci Sports Exerc* 2005, **37**(10):1673-1679.

216. Vanhees L, Lefevre J, Philippaerts R, Martens M, Huygens W, Troosters T, Beunen G: **How to assess physical activity? How to assess physical fitness?** *Eur J Cardiovasc Prev Rehabil* 2005, **12**(2):102-114.

217. Mezzani A, Hamm LF, Jones AM, McBride PE, Moholdt T, Stone JA, Urhausen A, Williams MA: **Aerobic exercise intensity assessment and prescription in cardiac rehabilitation: a joint position statement of the European Association for Cardiovascular Prevention and Rehabilitation, the American Association of Cardiovascular and Pulmonary Rehabilitation and the Canadian Association of Cardiac Rehabilitation**. *Eur J Prev Cardiol* 2012.

218. Paffenbarger RS, Jr., Kampert JB, Lee IM, Hyde RT, Leung RW, Wing AL: **Changes in physical activity and other lifeway patterns influencing longevity**. *Med Sci Sports Exerc* 1994, **26**(7):857-865.

219. ACSM: **ACSM's Resoucre Manual for Guidelines for Exercise Testing and Prescription**, 6th ed edn: Lippincott Williams and Wilkins; 2010.

220. Santos DA, Silva AM, Baptista F, Santos R, Vale S, Mota J, Sardinha LB: **Sedentary behavior and physical activity are independently related to functional fitness in older adults**. *Exp Gerontol* 2012, **47**(12):908-912.

221. Tremblay MS, Colley RC, Saunders TJ, Healy GN, Owen N: **Physiological and health implications of a sedentary lifestyle**. *Appl Physiol Nutr Metab* 2010, **35**(6):725-740.

222. Owen N, Sparling PB, Healy GN, Dunstan DW, Matthews CE: **Sedentary behavior: emerging evidence for a new health risk**. *Mayo Clin Proc* 2010, **85**(12):1138-1141.

223. Freyssin C, Jr., Blanc P, Verkindt C, Maunier S, Prieur F: **Effect of long-term physical activity practice after cardiac rehabilitation on some risk factors**. *Int J Rehabil Res* 2011, **34**(4):357-359.

224. Pimenta N, Santa-Clara H, Fragoso IJ: **Comparison of body composition and body fat distribution of patients following a cardiac rehabilitation program and sedentary patients**. *Rev Port Cardiol* 2010, **29**(7-8):1163-1180.

225. Matthews CE, Chen KY, Freedson PS, Buchowski MS, Beech BM, Pate RR, Troiano RP: **Amount of time spent in sedentary behaviors in the United States, 2003-2004**. *Am J Epidemiol* 2008, **167**(7):875-881.

226. Cress ME, Schechtman KB, Mulrow CD, Fiatarone MA, Gerety MB, Buchner DM: **Relationship between physical performance and self-perceived physical function**. *J Am Geriatr Soc* 1995, **43**(2):93-101.

227. Rehabilitation CAoC: **Canadian Guidelines for Cardiac Rehabilitation and Cardiovascular Disease Prevention**, 3rd edn; 2009.

228. Pepin V, Alexander JL, Phillips WT: **Physical function assessment in cardiac rehabilitation: self-report, proxy-report and performance-based measures**. *J Cardiopulm Rehabil* 2004, **24**(5):287-295.

229. Ades PA, Savage PD, Cress ME, Brochu M, Lee NM, Poehlman ET: **Resistance training on physical performance in disabled older female cardiac patients**. *Med Sci Sports Exerc* 2003, **35**(8):1265-1270.

230. Hawkes AL, Nowak M, Speare R: **Short Form-36 Health Survey as an evaluation tool for cardiac rehabilitation programs: is it appropriate?** *J Cardiopulm Rehabil* 2003, **23**(1):22-25.

231. Brochu M, Savage P, Lee M, Dee J, Cress ME, Poehlman ET, Tischler M, Ades PA: **Effects of resistance training on physical function in older disabled women with coronary heart disease**. *J Appl Physiol* 2002, **92**(2):672-678.

232. Ades PA, Green NM, Coello CE: **Effects of exercise and cardiac rehabilitation on cardiovascular outcomes**. *Cardiol Clin* 2003, **21**(3):435-448, viii.

233. McHorney CA, Tarlov AR: **Individual-patient monitoring in clinical practice: are available health status surveys adequate?** *Qual Life Res* 1995, **4**(4):293-307.

234. Baum K, Hildebrandt U, Edel K, Bertram R, Hahmann H, Bremer FJ, Bohmen S, Kammerlander C, Serafin M, Ruther T *et al*: **Comparison of skeletal muscle strength between cardiac patients and age-matched healthy controls**. *Int J Med Sci* 2009, **6**(4):184-191.

235. Dite W, Temple VA: **A clinical test of stepping and change of direction to identify multiple falling older adults**. *Arch Phys Med Rehabil* 2002, **83**(11):1566-1571.

236. Bohannon RW: **Reference values for the timed up and go test: a descriptive meta-analysis**. *J Geriatr Phys Ther* 2006, **29**(2):64-68.

237. Hardy SE, Perera S, Roumani YF, Chandler JM, Studenski SA: **Improvement in usual gait speed predicts better survival in older adults**. *J Am Geriatr Soc* 2007, **55**(11):1727-1734.

238. Perera S, Studenski S, Chandler JM, Guralnik JM: **Magnitude and patterns of decline in health and function in 1 year affect subsequent 5-year survival**. *J Gerontol A Biol Sci Med Sci* 2005, **60**(7):894-900.

239. Robinett CS, Vondran MA: **Functional ambulation velocity and distance requirements in rural and urban communities. A clinical report**. *Phys Ther* 1988, **68**(9):1371-1373.

240. Rasekaba T, Lee AL, Naughton MT, Williams TJ, Holland AE: **The six-minute walk test: a useful metric for the cardiopulmonary patient**. *Intern Med J* 2009, **39**(8):495-501.

241. Faggiano P, D'Aloia A, Gualeni A, Giordano A: **Assessment of oxygen uptake during the six-minute walk test in patients with heart failure**. *Chest* 1997, **111**(4):1146.

242. Perera S, Mody SH, Woodman RC, Studenski SA: **Meaningful change and responsiveness in common physical performance measures in older adults**. *J Am Geriatr Soc* 2006, **54**(5):743-749.

243. Shephard RJ: **Maximal oxygen intake and independence in old age**. *Br J Sports Med* 2009, **43**(5):342-346.

244. Morales FJ, Martinez A, Mendez M, Agarrado A, Ortega F, Fernandez-Guerra J, Montemayor T, Burgos J: **A shuttle walk test for assessment of functional capacity in chronic heart failure**. *Am Heart J* 1999, **138**(2 Pt 1):291-298.

245. Mathiowetz V, Weber K, Volland G, Kashman N: **Reliability and validity of grip and pinch strength evaluations**. *J Hand Surg Am* 1984, **9**(2):222-226.

246. Mathiowetz V, Kashman N, Volland G, Weber K, Dowe M, Rogers S: **Grip and pinch strength: normative data for adults**. *Arch Phys Med Rehabil* 1985, **66**(2):69-74.

247. Bohannon RW, Peolsson A, Massy-Westropp N, Desrosiers J, Bear-Lehman J: **Reference values for adult grip strength measured with a Jamar dynamometer: descriptive meta-analysis**. *Physiotherapy* 2006, **92**:11-15.

248. Nakamura R, Hosokawa T, Tsuji I: **Relationship of muscle strength for knee extension to walking capacity in patients with spastic hemiparesis**. *Tohoku J Exp Med* 1985, **145**(3):335-340.

APPENDIX A

Date:	December 22, 2011
Study ID:	Pro00026196
Principal Investigator:	Robert Haennel
Study Title:	The predictors of physical activity participation in elderly cardiac patients
Approval Expiry Date:	December 20, 2012

Thank you for submitting the above study to the Health Research Ethics Board - Health Panel. Your application, including revisions received December 21, 2011, has been reviewed and approved on behalf of the committee.

The Health Research Ethics Board assessed all matters required by section 50(1)(a) of the Health Information Act. Subject consent for access to identifiable health information is required for the research described in the ethics application, and appropriate procedures for such consent have been approved by the Health Research Ethics Board - Health Panel. In order to comply with the Health Information Act, a copy of the approval form is being sent to the Office of the Information and Privacy Commissioner.

A renewal report must be submitted next year prior to the expiry of this approval if your study still requires ethics approval. If you do not renew on or before the renewal expiry date (December 20, 2012), you will have to re-submit an ethics application.

The membership of the Health Research Ethics Board - Biomedical Panel complies with the membership requirements for research ethics boards as defined in Division 5 of the Food and Drug Regulations and the Tri-Council Policy Statement. The HREB - Biomedical Panel carries out its functions in a manner consistent with Good Clinical Practices.

Approval by the Health Research Ethics Board does not encompass authorization to access the patients, staff or resources of Alberta Health Services or other local health care institutions for the purposes of the research. Enquiries regarding Alberta Health approval should be directed to (780) 407-6041. Enquiries regarding Covenant Health approvals should be directed to (780) 735-2274.

Sincerely,

Doug Gross, Ph.D.
Associate Chair, Health Research Ethics Board - Health Panel

Note: This correspondence includes an electronic signature (validation and approval via an online system).

APPENDIX B

CONSENT FORM

THE PREDICTORS OF PHYSICAL ACTIVITY PARTICIPATION IN ELDERLY CARDIAC PATIENTS

PRINCIPAL INVESTIGATOR:

R. Haennel Ph.D FACSM — U of A, Faculty of Rehabilitation Medicine 492-2889

CO-INVESTIGATORS:

D. Buijs M.Sc Candidate — U of A, Faculty of Rehabilitation Medicine 492-2609

M. Haykowsky Ph.D — U of A, Faculty of Rehabilitation Medicine 492-5970

T. Manns Ph.D — U of A, Faculty of Rehabilitation Medicine 492-7274

Do you understand that you have been asked to be in a research study?

Yes No

Have you received and read a copy of the attached Information Sheet?

Yes No

Do you understand the benefits and risks involved in taking part in this research study?

Yes No

Have you had an opportunity to ask questions and discuss this study?

Yes No

Do you understand that you are free to refuse to participate, or to withdraw from the study at any time, without consequence, and that your information will be withdrawn at your request?

Yes No

Has the issue of confidentiality been explained to you? Do you understand who will have access to your information?

Yes No

Do you want the investigator(s) to inform your family doctor or specialist that you are participating in this research study. If so, please provide your doctor's name

: ______________________________ Yes No

I understand withdraw from this study will not affect my current or future Medical care.

Yes No

This study was explained to me by:

____

I agree to take part in this study.

___________________________ ___________________________

Signature of Research Participant Date

____

Printed Name

I believe that the person signing this form understands what is involved in the study and voluntarily agrees to participate.

_______________________________________ ____________________
Signature of Investigator or Designee Date

Department of Physical Therapy
2-50 Corbett Hall • University of Alberta • Edmonton • Canada • T6G 2G4

APPENDIX C

INFORMATION SHEET

THE PREDICTORS OF PHYSICAL ACTIVITY PARTICIPATION IN ELDERLY CARDIAC PATIENTS

PRINICPAL INVESTIGATOR:

R. Haennel Ph.D FACSM U of A, Faculty of Rehabilitation Medicine 492-2889

CO-INVESTIGATORS:

D. Buijs M.Sc Candidate U of A, Faculty of Rehabilitation Medicine 492-2609

M. Haykowsky Ph.D U of A, Faculty of Rehabilitation Medicine 492-5970

T. Manns Ph.D U of A, Faculty of Rehabilitation Medicine 492-7274

BACKGROUND: Patients recovering from a heart attack are encouraged to participate in physical activity, such as walking and cycling. The impact of this more active lifestyle on the ability to perform everyday tasks remains an area under investigation.

PURPOSE: You are being asked to participate in a study that will assess the relationship between the ability to perform everyday tasks and physical activity participation.

DESCRIPTION OF THE STUDY

If you decide to participate in this study, the total time commitment will be approximately 1 hour on one occasion and you will also be asked to wear an activity monitor for four days. Participation in this study will not affect or influence your medical treatment.

RESEARCH PROCEDURES

Questionnaires. You will be asked to fill out a series of three questionnaires that will ask you about your ability to perform everyday tasks, to exercise and your perceived well being. Each questionnaire will take approximately five minutes to complete for a total of 15 minutes.

Assessment of the Ability to Perform Everyday Tasks. You will also be asked to perform a number of simple tests that measure your ability to perform everyday tasks. The most demanding of the tests will involve walking for 6 minutes. You will also be asked to get up from a chair, walk a short distance and sit back down. We will also measure your grip strength and how fast you can walk 10 meters. All of these tests are performed at your own pace and will take approximately 15 minutes in total to complete.

Daily Physical Activity. You will be given an armband to wear for four consecutive days. The armband is worn on the back of your upper right arm, where it can be easily placed underneath clothing. The arm band is worn at all times of the day and night (i.e., at work, during exercise, while sleeping) except when showering or swimming. After four days a member of the research team will pick up the armband from you.

POSSIBLE BENEFITS

Once all testing is complete a research assistant will be pleased to sit with you and explain your results to you. You will gain a better understanding of their ability to perform everyday tasks as well as how physically active you are on a typical day.

POSSIBLE RISKS

The exercises that you will perform are generally safe. Data from people with and without heart disease suggests that the possibility of having a heart attack or dying during a maximal effort treadmill test is 1 in 10,000 tests. In this study the risk will be lower as the exercises you will be performing will be done at a very low effort level. All testing will be done under the supervision of qualified personnel, a certified Exercise Specialist, and you may stop the test at any time.

COSTS

You will be reimbursed for all parking expenses associated with all appointments at the University of Alberta.

CONFIDENTIALITY

Only researchers in this study will have access to your results. It is possible that your records of these results may be inspected or copied for quality assurance by the University of Alberta Health Research Ethics Board.

All records will be kept in a locked drawer at the University of Alberta. Records must be kept for seven years, and after that will be destroyed.

WITHDRAW

You are free to withdraw from the research study at any time. If you withdraw from the study or it is discontinued at any time, the quality of your medical care will not be affected.

CONTACT NAMES AND TELEPHONE NUMBERS

If you have questions about your rights as a patient in this study, you may contact the Covenant Health- Patient Relations Office (780) 735-7494.

If you have concerns about any aspect of this study, you may contact Dr. Lynn Penrod at the Research Ethics Office of the University of Alberta (780) 492-2615.

These offices have no affiliation with this study or its investigators.

If you have any questions about your participation in this study please contact any of the individuals identified below:

Robert Haennel, PhD	Office: 780-492-2889
David Buijs, M.Sc Candidate	Office: 780-492-2609

APPENDIX D

THE PREDICTORS OF PHYSICAL ACTIVITY PARTICIPATION IN ELDERLY CARDIAC PATIENTS

Name: ______________________ Date: ____________________

Date of Birth: __________________ Gender: Male / Female

Marital Status: _______________ Living Status: ________________

Employment Status: __________________

What is your heart condition? Please check all that apply:

☐ Myocardial Infarct (Heart Attack)

☐ STEMI ☐ Non-STEMI

☐ Valvular Disease

☐ Coronary Artery Bypass (CABG)

☐ Coronary Angioplasty (PCI) ☐ Stent

☐ Idiopathic Cardio-myopathy

☐ Heart Failure

When were you diagnosed with and/or treated for your heart condition?

____
____
____
____
____

How often do you currently exercise: (i.e., minutes per day, days per week, etc.)

____
____
____
____
____
____

What is your main form of exercise (i.e., walking, cycling, aqua size, etc.)

____
____
____
____
____
____

How long have you been exercising like this: _____________________

Does your partner encourage you to exercise? YES NO

Does your partner exercise with you? YES NO

If you attended cardiac rehabilitation when did you complete your program and how many exercise classes did you attend?

____
____
____
____
____

If you have not attended cardiac rehabilitation and are planning to, when is your intended start date:________________

Do you have any <u>other</u> conditions that affect you ability to exercise: (i.e., Osteoarthritis, Diabetes, etc.)

____
____
____
____
____

Please list the medications you are presently taking and their dose:

____
____
____
____
____
____
____

Have these medications changed within the last month?

YES NO

Department of Physical Therapy

2-50 Corbett Hall • University of Alberta • Edmonton • Canada • T6G 2

APPENDIX E

Self-Efficacy for Exercise

Please indicate HOW CONFIDENT YOU ARE THAT YOU CAN PERFORM each of the exercise related tasks below. When you think of exercise, think of walking at a moderate intensity three times per week for about 30 minutes

0%	10 %	20 %	30 %	40 %	50 %	60 %	70 %	80 %	90 %	100 %
No confidence										Complete Confidence

HOW CONFIDENT ARE YOUTHAT YOU CAN…….

Complete your exercise using proper technique	%
Follow directions to complete the exercise	%
Perform all of the movements required for your	%
Exercise when you feel discomfort from the	%
Do your exercise when you lack energy	%
Include exercise in your daily routine	%
Exercise consistently every day of the week	%
Do your exercise when you don’t feel well	%
Arrange your schedule to include regular exercise	%

APPENDIX F

NAME: ____________________ DATE: ___________________________

SF-36 Health Survey

INSTRUCTIONS: This survey asks your views about your health in an effort to get to know you better. This information will help keep track of how you feel and how well you are able to do your usual activities. All information provided will be kept confidential.

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

1. In general, would you say your health is:

circle one

Excellent 1

Very Good 2

Good 3

Fair 4

Poor 5

2. <u>Compared to one year</u> ago, how would you rate your health in general <u>now</u>:

circle one

Much better now than one year ago 1

Somewhat better now than one year ago 2

About the same as one year ago 3

Somewhat worse now than one year ago 4

Much worse now than one year ago 5

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

ACTIVITIES	YES, LIMITED A LOT	YES, LIMITED A LITTLE	NO, NOT LIMITED AT ALL
Vigorous activities, such as running, lifting heavy objects, participating in strenuous sports	1	2	3
Moderate activities, such as moving a table, pushing a vacuum cleaner bowling or playing golf	1	2	3
Lifting or carrying groceries	1	2	3
Climbing **several** flights of stairs	1	2	3
Climbing **one** flight of stairs	1	2	3
Bending, kneeling or stooping	1	2	3
Walking **more than a mile**	1	2	3
Walking **several blocks**	1	2	3
Walking **one block**	1	2	3
j. Bathing or dressing yourself	1	2	3

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

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

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

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

6. **During <u>the past 4 weeks</u> to what extent has your physical health or emotional problems interfered with your normal social activities with family, friends, neighbors, or groups?**

circle one

Not at all..1

Slightly..2

Moderately...3

Quite a bit..4

Extremely...5

7. **How much <u>bodily</u> pain have you had during <u>the past 4 weeks</u>**?

circle one

None 1

Very Mild..2

Mild ....…3

Moderate..4

Severe 5

Very Severe..6

8. **During <u>the past 4 weeks</u> how much did pain interfere with your normal work (including both work and outside the home and housework)?**

circle one

Not at all..1

Slightly...2

Moderately...3

Quite a bit..4

Extremely..5

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

	ALL OF THE TIME	MOST OF THE TIME	A GOOD BIT OF THE TIME	SOME OF THE TIME	A LITTLE OF THE TIME	NONE OF THE TIME
a. Did you feel full of pep?	1	2	3	4	5	6
b. Have you been a very nervous person	1	2	3	4	5	6
c. Have you felt so down in the dumps that nothing could cheer you up?	1	2	3	4	5	6
d. Have you felt calm and peaceful?	1	2	3	4	5	6
e. Did you have a lot of energy?	1	2	3	4	5	6
f. Have you felt downhearted and blue?	1	2	3	4	5	6
g. Did you feel worn out?	1	2	3	4	5	6
h. Have you been a happy person?	1	2	3	4	5	6
i. Did you feel tired?	1	2	3	4	5	6

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

All of the time	1
Most of the time	2
Some of the time	3
A little of the time	4
None of the time	5

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

	DEFINITELY TRUE	MOSTLY TRUE	DON'T KNOW	MOSTLY FALSE	DEFINITELY FALSE
a. I seem to get sick a little easier than other people	1	2	3	4	5
b. I am as healthy as anybody I know	1	2	3	4	5
c. I expect my health to get worse	1	2	3	4	5
d. My health is excellent	1	2	3	4	5

APPENDIX G

In this questionnaire you will be asked about your ability to do specific activities as part of your daily routine. It is not important that you actually do the activities on a daily basis or at all, you can still answer these questions by determining how difficult you **think** the activity would be for you.**PART 1**

How much difficulty do you have…? (This is **without** the help of anyone else or the use of any assistive walking device)	**None**	**A little**	**Some**	**Quite a lot**	**Can't do**
1. Unscrewing the lid off a previously unopened jar without using any devices.	**5**	**4**	**3**	**2**	**1**
2. Going up and down a flight of stairs inside using a handrail.	**5**	**4**	**3**	**2**	**1**
3. Putting on and taking off long pants (including managing fasteners).	**5**	**4**	**3**	**2**	**1**
4. Running 1/2 mile or more.	**5**	**4**	**3**	**2**	**1**
5. Using common utensils for preparing meals (e.g. can opener, vegetable peeler, or sharp knife).	**5**	**4**	**3**	**2**	**1**
6. Holding a full glass of water in one hand.	**5**	**4**	**3**	**2**	**1**
7. Walking a mile, taking rests as necessary.	**5**	**4**	**3**	**2**	**1**
8. Going up and down a flight of stairs outside, without using a handrail.	**5**	**4**	**3**	**2**	**1**
9. Running a short distance, such as to catch a bus.	**5**	**4**	**3**	**2**	**1**
10. Reaching overhead while standing, as if to pull a light cord.	**5**	**4**	**3**	**2**	**1**

Questionnaire (Part 1) continued…

How much difficulty do you have…? (This is **without** the help of anyone else or the use of any assistive walking device)	**None**	**A little**	**Some**	**Quite a lot**	**Can't do**
11. Sitting down in and standing up from a low, soft couch.	**5**	**4**	**3**	**2**	**1**
12. Putting on and taking off a coat or jacket.	**5**	**4**	**3**	**2**	**1**
13. Reaching behind your back as if to put a belt through a belt loop.	**5**	**4**	**3**	**2**	**1**
14. Stepping up and down from a curb.	**5**	**4**	**3**	**2**	**1**
15. Opening a heavy, outside door.	**5**	**4**	**3**	**2**	**1**
16. Rip open a package of snack food using only your hands (e.g. cellophane wrapping on crackers).	**5**	**4**	**3**	**2**	**1**
17. Pouring from a large pitcher.	**5**	**4**	**3**	**2**	**1**
18. Getting into and out of a car/taxi (sedan).	**5**	**4**	**3**	**2**	**1**
19. Hiking a couple of miles on uneven surfaces, including hills.	**5**	**4**	**3**	**2**	**1**
20. Going up and down 3 flights of stairs inside, using a handrail.	**5**	**4**	**3**	**2**	**1**
21. Picking up a kitchen chair and moving it in order to clean.	**5**	**4**	**3**	**2**	**1**
22. Using a step stool to reach into a high cabinet.	**5**	**4**	**3**	**2**	**1**
23. Making a bed, including spreading and tucking in the bed sheets.	**5**	**4**	**3**	**2**	**1**
24. Carrying something in both arms while climbing a flight of stairs (e.g. laundry basket).	**5**	**4**	**3**	**2**	**1**
25. Bending over from a standing position to pick up a piece of clothing from the floor.	**5**	**4**	**3**	**2**	**1**

Questionnaire (Part 1) continued…

How much difficulty do you have…? (This is **without** the help of anyone else or the use of any assistive walking device)	**None**	**A little**	**Some**	**Quite a lot**	**Can't do**
26. Walking around one floor of your home, taking into consideration thresholds, doors, furniture, and a variety of floor coverings.	**5**	**4**	**3**	**2**	**1**
27. Getting up from the floor (as if you were laying on the ground).	**5**	**4**	**3**	**2**	**1**
28. Washing dishes, pots, and utensils by hand while standing at a sink.	**5**	**4**	**3**	**2**	**1**
29. Walking several blocks.	**5**	**4**	**3**	**2**	**1**
30. Taking a 1 mile, brisk walk without stopping to rest.	**5**	**4**	**3**	**2**	**1**
31. Stepping on and off a bus.	**5**	**4**	**3**	**2**	**1**
32. Walking on a slippery surface outdoors.	**5**	**4**	**3**	**2**	**1**

PART 2	How often do you…?					To what Extent do you feel limited in…..?				
	Very Often	**Often**	**Once in a While**	**Almost Never**	**Never**	**Not at All**	**A Little**	**Some-times**	**A Lot**	**Completely**
Keep (Keeping) in touch with others through letters, phone or email.	5	4	3	2	1	5	4	3	2	1
Visit (Visiting) friends and family in their homes.	5	4	3	2	1	5	4	3	2	1
Provide care or assistance to others. *This may include providing personal care, transportation and running errands for family members or friends.*	5	4	3	2	1	5	4	3	2	1
Take care of the inside of your home. *This includes managing and taking responsibility for homemaking, laundry, housecleaning and minor household repairs.*	5	4	3	2	1	5	4	3	2	1

PART 2	How often do you…?					To what Extent do you feel limited in…..?				
	Very Often	**Often**	**Once in a While**	**Almost Never**	**Never**	**Not at All**	**A Little**	**Some-times**	**A Lot**	**Completely**
Work at a volunteer job outside your home.	5	4	3	2	1	5	4	3	2	1
Take part in active recreation. *This may include bowling, golf, tennis, hiking, walking, jogging or swimming.*	5	4	3	2	1	5	4	3	2	1
Take care of household business and finances. *This may include managing and taking responsibility for your money., paying bills dealing with a landlord or tenant, dealing with utility companies or government agencies.*	5	4	3	2	1	5	4	3	2	1
Take care of your own health. *This may include managing daily medications, following a special diet, scheduling doctor's appointments.*	5	4	3	2	1	5	4	3	2	1

PART 2	How often do you…?					To what Extent do you feel limited in…..?				
	Very Often	**Often**	**Once in a While**	**Almost Never**	**Never**	**Not at All**	**A Little**	**Some-times**	**A Lot**	**Completely**
Travel out of town for at least on overnight stay.	5	4	3	2	1	5	4	3	2	1
Take part in a regular fitness program. *This may include walking for exercise, stationary biking, weight lifting or exercise classes.*	5	4	3	2	1	5	4	3	2	1
Invite people into your home for a meal or entertainment.	5	4	3	2	1	5	4	3	2	1
Go out with others to public places such as restaurants or movies.	5	4	3	2	1	5	4	3	2	1
Take care of your own personal care needs. *This includes bathing, dressing and toileting.*	5	4	3	2	1	5	4	3	2	1

PART 2	**How often do you…?**					**To what Extent do you feel limited in…..?**				
	Very Often	**Often**	**Once in a While**	**Almost Never**	**Never**	**Not at All**	**A Little**	**Some-times**	**A Lot**	**Completely**
Take part in organized social activities. *This may include clubs, cards playing, senior centre events, community or religious groups.*	5	4	3	2	1	5	4	3	2	1
Take care of local errands. *This may include managing or taking responsibility for shopping for food and personal items and going to the bank library or dry cleaners.*	5	4	3	2	1	5	4	3	2	1
Preparing meals for yourself. *This may include planning, cooking and cleaning up*	5	4	3	2	1	5	4	3	2	1

THANK YOU

APPENDIX H:

GRIP STRENGTH PROTOCOL[245, 246]

1. Have the individual sit with their shoulder adducted and neutrally rotated, elbow flexed at 90º, forearm in neutral position, and wrist between 0º and 30º dorseflexion and between 0º and 15º ulnar deviation.

2. Set the JAMAR Hand Dynamometer to the second handle position from the inside.

3. After the individual is positioned properly, say, “Squeeze as hard as you can…harder!... harder!... relax.”

4. Record the scores of two trials for alternating between each hand. The maximum score of the four trials can be compared to normative data.

Table 1. Consolidated grip strength reference values[247]

	Males		Females	
Age Range (years)	Left (kg) mean (95% CI)	Right (kg) mean (95% CI)	Left (kg) mean (95% CI)	Right (kg) mean (95% CI)
55-59	41.0 (33.7-48.4)	44.1 (36.7-51.4)	27.2 (24.6-29.5)	29.9 (26.4-33.6)
60-64	38.7 (33.4-44.0)	41.7 (36.8-46.7)	23.0 (18.6-27.3)	25.9 (22.2-29.6)
65-69	38.2 (32.0-44.4)	41.7 (35.4-47.9)	22.9 (19.6-26.2)	25.6 (22.5-28.8)
70-74	36.2 (30.3-42.1)	38.2 (32.0-44.5)	22.5 (19.1-25.8)	24.2 (20.7-27.8)
75+	29.8 (24.8-34.7)	28.0 (12.7-31.0)	16.4 (14.7-18.1)	18.0 (16.0-19.9)

References

245. Mathiowetz V, Weber K, Volland G, Kashman N: **Reliability and validity of grip and pinch strength evaluations**. *J Hand Surg Am* 1984, **9**(2):222-226.

246. Mathiowetz V, Kashman N, Volland G, Weber K, Dowe M, Rogers S: **Grip and pinch strength: normative data for adults**. *Arch Phys Med Rehabil* 1985, **66**(2):69-74.

247. Bohannon RW, Peolsson A, Massy-Westropp N, Desrosiers J, Bear-Lehman J: **Reference values for adult grip strength measured with a Jamar dynamometer: descriptive meta-analysis**. *Physiotherapy* 2006, **92**:11-15.

Appendix I

10 meter walk test (TMW) Protocol [196, 199, 248]

1. Measure a 10 meter distance on the ground and mark with pylons to indicate the start and stop lines.

2. Measure and mark an additional five meters at each end to allow for acceleration and deceleration.

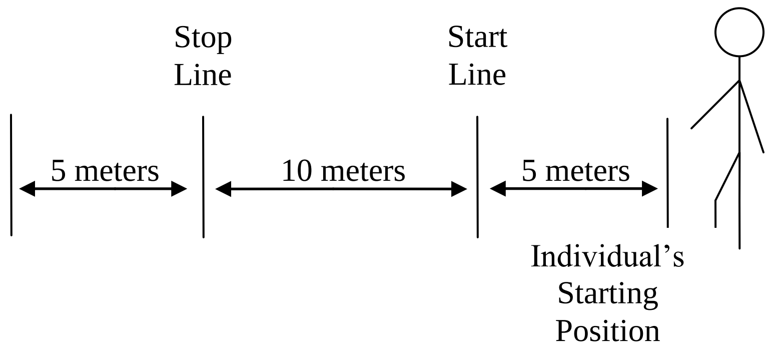
3. Have the individual line up at the first of the two lines at one end.

4. Instruct the individual on the word "go," they are to walk in a straight line at a pace that is safe and comfortable for them, until they reach the second of the two pylons at the opposite end.

5. The time from when the individual's first foot crosses the start line until their first foot crosses the stop line is measured, though they continue walking the final two meters.

6. Participants are allowed to perform one practice trial before completing two test trials. Ensure that there is an adequate rest period in between each trial.

7. The average of the two test trials is calculated and used as the average comfortable gait speed.



References

196. Salbach NM, Mayo NE, Higgins J, Ahmed S, Finch LE, Richards CL: **Responsiveness and predictability of gait speed and other disability measures in acute stroke**. *Arch Phys Med Rehabil* 2001, **82**(9):1204-1212.

199. Arnadottir SA, Mercer VS: **Effects of footwear on measurements of balance and gait in women between the ages of 65 and 93 years**. *Phys Ther* 2000, **80**(1):17-27.

248. Nakamura R, Hosokawa T, Tsuji I: **Relationship of muscle strength for knee extension to walking capacity in patients with spastic hemiparesis**. *Tohoku J Exp Med* 1985, **145**(3):335-340.

Appendix J

TIMED UP AND GO (TUG) TEST PROTOCOL[154]

1. Measure a 3 meter distance from a standardised arm chair (seat height approximately 46 cm) and mark with a cone on the floor.

2. Have the individual start by sitting with their back against the chair and arms resting on the chair's arms.

3. Individuals are instructed that on the word "go", they are to get up and walk at a comfortable and safe pace to the cone 3 meters away, walk around the cone, return to the chair and sit down again.

4. Have the individual walk through the test once before being timed in order to become familiar with the test.

5. The time from the word "go" until their back rests against the chair again is recorded.

Table 1.Reference values for Timed Up and Go (TUG) test times[236]

Age (years)	Studies/Groups (n)	Total Sample	Seconds for TUG Mean (95% CI)	Homogeneity Q (p)
60-99	21/49	4395	9.4 (8.9-9.9)	45.5 (0.576)
60-69	5/7	176	8.1 (7.1-9.0)	1.6 (0.953)
70-79	7/12	798	9.2 (8.2-10.2)	2.6 (0.995)
80-99	7/12	1102	11.3 (10.0-12.7)	12.6 (0.318)

References

154. Podsiadlo D, Richardson S: **The timed "Up & Go": a test of basic functional mobility for frail elderly persons**. *J Am Geriatr Soc* 1991, **39**(2):142-148.

236. Bohannon RW: **Reference values for the timed up and go test: a descriptive meta-analysis**. *J Geriatr Phys Ther* 2006, **29**(2):64-68.

Appendix K

6 MINUTE WALK PROTOCOL[202]

Pre test

1. *Repeat testing should be performed about the same time of day to minimize intraday variability.*

2. A "warm-up" period before the test should not be performed.

3. The patient should sit at rest in a chair, located near the starting position, for at least 10 minutes before the test starts. During this time, check for contraindications, measure pulse and blood pressure, and make sure that clothing and shoes are appropriate.

4. Pulse oximetry is optional. If it is performed, measure and record baseline heart rate and oxygen saturation (SpO_2) and follow manufacturer's instructions to maximize the signal and to minimize motion artifact. Make sure the readings are stable before recording. Note pulse regularity and whether the oximeter signal quality is acceptable. The rationale for measuring oxygen saturation is that although the distance is the primary outcome measure, improvement during serial evaluations may be manifest either by an increased distance or by reduced symptoms with the same distance walked. The SpO2 should not be used for constant monitoring during the exercise. The technician must not walk with the patient to observe the SpO_2. If worn during the walk, the pulse oximeter must be lightweight (less than 2 pounds), battery powered, and held in place (perhaps by a "fanny pack") so that the patient does not have to hold or stabilize it and so that stride is not affected. Many pulse oximeters have considerable motion artifact that prevents accurate readings during the walk.

5. Have the patient stand and rate their baseline dyspnea and overall fatigue using the Borg scale.

6. Set the lap counter to zero and the timer to 6 minutes. Assemble all necessary equipment (lap counter, timer, clipboard, Borg Scale, worksheet) and move to the starting point.

7. Instruct the patient as follows:
   "The object of this test is to walk as far as possible for 6 minutes. You will walk back and forth in this hallway. Six minutes is a long time to walk, so you will be exerting yourself. You will probably get out of breath or become exhausted. You are permitted to slow down, to stop, and to rest as necessary. You may lean against the wall while resting, but resume walking as soon as you are able. You will be walking back and forth around the cones. You should pivot briskly around the cones and continue back the other way

without hesitation. Now I'm going to show you. Please watch the way I turn without hesitation."

Demonstrate by walking one lap yourself. Walk and pivot around a cone briskly.

"Are you ready to do that? I am going to use this counter to keep track of the number of laps you complete. I will click it each time you turn around at this starting line. Remember that the object is to walk AS FAR AS POSSIBLE for 6 minutes, but don't run or jog. Start now, or whenever you are ready."

8. Position the patient at the starting line. You should also stand near the starting line during the test. Do not walk with the patient – you may walk several steps behind. As soon as the patient starts to walk, start the timer.

9. Do not talk to anyone during the walk. Use an even tone of voice when using the standard phrases of encouragement. Watch the patient. Do not get distracted and lose count of the laps. Each time the participant returns to the starting line, click the lap counter once (or mark the lap on the worksheet). Let the participant see you do it. Exaggerate the click using body language, like using a stopwatch at a race.

   After the first minute, tell the patient the following (in even tones): "You are doing well. You have 5 minutes to go." When the timer shows 4 minutes remaining, tell the patient the following: "Keep up the good work. You have 4 minutes to go." When the timer shows 3 minutes remaining, tell the patient the following: "You are doing well. You are halfway done." When the timer shows 2 minutes remaining, tell the patient the following: "Keep up the good work. You have only 2 minutes left." When the timer shows only 1 minute remaining, tell the patient: "You are doing well. You have only 1 minute to go."

   Do not use other words of encouragement (or body language to speed up). If the patient stops walking during the test and needs a rest, say this: "You can lean against the wall if you would like; then continue walking whenever you feel able." Do not stop the timer. If the patient stops before the 6 minutes are up and refuses to continue (or you decide that they should not continue), wheel the chair over for the patient to sit on, discontinue the walk, and note on the worksheet the distance, the time stopped, and the reason for stopping prematurely.

   When the timer is 15 seconds from completion, say this: "In a moment I'm going to tell you to stop. When I do, just stop right where you are and I will come to you." When the timer rings (or buzzes), say this: "Stop!" Walk over to the patient. Consider taking the chair if they look exhausted. Mark the spot where they stopped by placing a bean bag or a piece of tape on the floor.

10. Post-test: Record the post-walk Borg dyspnea and fatigue levels and ask this: "What, if anything, kept you from walking farther?"

11. If using a pulse oximeter, measure SpO_2 and pulse rate from the oximeter and then remove the sensor.

12. Record the number of laps from the counter (or tick marks on the worksheet).

13. Record the additional distance covered (the number of meters in the final partial lap) using the markers on the wall as distance guides. Calculate the total distance walked, rounding to the nearest meter, and record it on the worksheet.

14. Congratulate the patient on good effort and offer a drink of water

Reference

202. **ATS statement: guidelines for the six-minute walk test**. *Am J Respir Crit Care Med* 2002, **166**(1):111-117.