Immediate and Long-term Effects of Exercise Rehabilitation on Daily Physical Activity of Patients with Cardiopulmonary Disorders

by

Ailar Ramadi

A thesis submitted in partial fulfillment of the requirements for the degree of

Doctor of Philosophy

in

Rehabilitation Science

Faculty of Rehabilitation Medicine
University of Alberta

Abstract

It is well known that there is an inverse relationship between physical activity (PA) and mortality in patients with cardiopulmonary disorders. Consequently, PA is considered the core component of cardiopulmonary rehabilitation programs. Despite the health benefits, the adherence to regular PA following completion of the programs seems challenging. The rehabilitation delivery model has been proposed as a potential factor that might influence participants' long-term PA adherence. Thus, detailed investigation on the PA behavior of cardiopulmonary patients as they progress through different exercise rehabilitation programs from entry to completion and following-up seems warranted. The purpose of this thesis was to study the immediate and long-term impact of different exercise rehabilitation programs on daily PA and exercise capacity in patients with cardiopulmonary disorders. The first study used a multi-sensor device to examine the immediate impact of an exercise rehabilitation program on daily PA of cardiopulmonary patients. At the end of the program participants improved their exercise capacity and demonstrated a PA behavior change at the lower end of the PA continuum. Indeed they spent less time sedentary and increased the time spent in light PA. However, the observed improvements in PA and exercise capacity were not related. The second study used a multi-sensor device to compare the long-term impact of a fast-track versus traditional center-based cardiac rehabilitation (CR) on the PA of coronary artery disease (CAD) patients 6 months following CR entry. The key finding from this study was that participation in CR programs did not result in long-term PA behavior change irrespective of the delivery model. Although participants in both traditional and fast-track CR had higher exercise capacity at 6 months following CR entry, their overall daily PA was not significantly different from what was recorded at baseline. Our third study compared the long-term effectiveness of home versus

center-based CR on sustainability of exercise capacity changes 1 year after completing the CR program. The key finding from this study was that participants were relatively successful in maintaining their achieved gains in exercise capacity for at least 1 year post-CR, independent of CR venue. Although exercise capacity decreased in center-based group from CR completion to 1 year follow-up, the observed decline was clinically insignificant. At the 1 year follow-up, exercise capacity was significantly higher than the baseline values in both groups. The major findings from the three studies in this thesis were that 1) participation in exercise rehabilitation program appears to improve habitual PA at the end of the program; 2) following removal from the program participants resume their baseline PA level despite maintaining the achieved gains in the exercise capacity regardless of the program delivery model. Combined these findings may imply that an increase in exercise capacity alone may not be sufficient to change the habitual sedentary lifestyle. Thus, in order to improve exercise capacity and PA behavior, they need to be targeted independently. CR participants may benefit from structured strategies which promote long-term PA adherence in addition to facilitating exercise capacity improvement. Considering the entire spectrum of PA from sedentary behavior to spontaneous light intensity PA in addition to moderate-vigorous PA (MVPA) is imperative when promoting the PA behavior change. An extensive and accurate assessment of daily PA upon CR entry could provide clinicians with valuable information on the best aspect to target in the PA spectrum and to customize programs to participants' needs and abilities.

Preface

Chapter 4 of this thesis is an original work by Ailar Ramadi. This project received research ethics approval from the University of Alberta Health Research Ethics Board, Project Name "COMPARING THE EFFECTIVENESS OF HOME VERSUS CENTER-BASED CARDIAC REHABILITATION (CR) ON PHYSICAL ACTIVITY, FUNCTIONAL CAPACITY AND SELF-EFFICACY OF CARDIAC PATIENTS", No. Pro00035417, January 10, 2013 and the University of Calgary Conjoint Health Research Ethics Board (CHREB), Project Name "COMPARING THE EFFECTIVENESS OF HOME VERSUS CENTER-BASED CARDIAC REHABILITATION (CR) ON PHYSICAL ACTIVITY, FUNCTIONAL CAPACITY AND SELF-EFFICACY OF CARDIAC PATIENTS", No. E-25199, April 10, 2013.

The introduction in chapter 1 and the literature review in chapter 2, as well as the general discussion and conclusions in chapter 6 are my original work.

Chapter 3 of this thesis received research ethics approval from the University of Alberta Health Research Ethics Board, Project Name "DETERMINING THE IMPACT OF CARDIAC REHABILITATION ON PHYSICAL ACTIVITY AND FUNCTION ABILITY IN ELDERLY CARDIAC PATIENTS", No. B-300508, June 16, 2008. Chapter 3 is a collaborative project and has been published as A. Ramadi, M.K. Stickland, W.M. Rodgers, and R.G. Haennel, "Impact of Supervised Exercise Rehabilitation on Daily Physical Activity of Cardiopulmonary Patients," *Heart & lung: The Journal of Critical Care,* 2015, vol. 44, issue 1, 9-14. I was responsible for concept formation, data analysis, as well as the manuscript composition and revision. R.G. Haennel was the supervisory author and was involved with concept formation and manuscript

edits. M.K. Stickland and W.M. Rodgers were involved with data collection and contributed to manuscript edits.

Chapter 5 of this thesis is a collaborative project and has been published as A. Ramadi, R.G. Haennel, J.A. Stone, R. Arena, T.G. Threlfall, E. Hitt, S.G. Aggarwal, M. Haykowsky, and B.J. Martin, "The Sustainability of Exercise Capacity Changes in Home Versus Center-Based Cardiac Rehabilitation," *Journal of Cardiopulmonary Rehabilitation and Prevention,* 2015, vol. 35, issue 1, 21-28. I was responsible for concept formation, data analysis as well as the manuscript composition and revision. R.G. Haennel and B.J. Martin were the supervisory authors and were involved with concept formation and manuscript edits. J.A. Stone, R. Arena, T.G. Threlfall, E. Hitt, and S.G. Aggarwal were involved with data collection and contributed to manuscript edits. M. Haykowsky contributed to manuscript edits.

Dedication

To my parents whose sacrifices made it possible for me to follow my dreams. Thank you for always standing by my side even though we have been miles apart.

To my sister, Aisan, thank you for being the most caring little sister that anyone could ever ask for. I am very grateful to have you in my life.

And

To my amazing husband, Peyman, thank you for always being there for me. I would not be where I am today without your love, patience, and continuous support.

Acknowledgments

I would like to express my sincere gratitude to my supervisor Dr. Robert (Bob) Haennel for his continuous support, guidance, and encouragement through the course of this program. The immense knowledge, vision, and creative thinking of Dr. Haennel has always been the source of inspiration for me. It was a true honor for me to work under his supervision.

I am also grateful to my committee members Dr. Mark Haykowsky, Dr. Alex Clark, Dr. Wendy Rodgers, and Dr. James Stone for their insightful advice and guidance.

Thanks to the Cardiac Rehabilitation staff at the TotalCardiology Rehabilitation and Risk Reduction Center and the Jim Pattison Center for Heart Health for giving me the opportunity to join their team in order to pursue my research.

Finally, special thanks to the research participants who generously devoted their precious time to these studies.

Table of Contents

List of Tables

List of Figures

Chapter 1

Introduction

1.1. Introduction and Purpose

It is well known that there is an inverse relationship between exercise capacity and mortality (S. N. Blair, Cheng, & Holder, 2001). It has been reported that with 1% improvement in exercise capacity cardiovascular mortality decreases by 2% (Lavie & Milani, 2011). Exercise capacity is determined by different elements (e.g., genetic, diet, age, gender, etc.). However, physical activity (PA) is the key factor that can improve exercise capacity (S. N. Blair et al., 2001). Consequently, PA is considered as one of the main components of cardiopulmonary rehabilitation programs (American Association of Cardiovascular and Pulmonary Rehabilitation, 1999; Nici et al., 2006).

In addition to the beneficial effects of PA that are mediated through exercise capacity, there is a growing evidence on the inverse relationship between the volume of PA and mortality independent of exercise capacity (Myers et al., 2004). In fact, regular PA has been associated with a lower risk of all-cause mortality, respiratory-related hospitalizations and mortality, as well as the incidence of and mortality from cardiovascular disease (Garber et al., 2011; Garcia-Aymerich, Lange, Benet, Schnohr, & Anto, 2006; Haapanen, Miilunpalo, Vuori, Oja, & Pasanen, 1996; Haennel & Lemire, 2002; Leon, Connett, Jacobs, & Rauramaa, 1987). The health statements recommend spending 1000-2000 kcal/week through PA which is associated with up to a 50% decrease in mortality. Even weekly PA energy expenditure as low as 500 kcal/week has been reported to produce health benefits (Haennel & Lemire, 2002; Paterson, Jones, & Rice, 2007).

A systematic review on the relative influence of PA and exercise capacity on health outcomes confirmed the dose-response gradient across both PA and exercise capacity categories for mortality. The highest mortality rate was in unfit-sedentary group and the lowest mortality rate was in fit-highly active group (S. N. Blair et al., 2001). Moreover, being unfit is associated with higher mortality even in active people; and being sedentary is associated with higher mortality even in fit individuals. It has been reported that PA of 1000 kcal/week has the benefit equivalent of 1 metabolic equivalent (MET) improvement in exercise capacity; both leading to approximately 20% decline in risk of mortality (Myers et al., 2004). Based on these findings both PA and exercise capacity seem to play important roles in improving health outcomes.

While participation in exercise rehabilitation programs improves exercise capacity in patients with cardiopulmonary disorders (Froelicher, Jensen, & Sullivan, 1985; Lacasse, Martin, Lasserson, & Goldstein, 2007; Maines et al., 1997), it does not necessarily lead to a more physically active lifestyle. Indeed, despite the health benefits associated with regular PA, many patients fail to maintain optimal levels of regular PA after completing the exercise rehabilitation programs (Bock, Carmona-Barros, Esler, & Tilkemeier, 2003). There is evidence that approximately 50% of patients do not continue regular exercise practice one year following rehabilitation (Bethell, 1999; Brubaker et al., 1996; N. B. Oldridge, 1991). Given that long-term adherence to regular PA following completion of the program is essential to maintain the achieved benefits (Chase, 2011), the sustainability of the gains in the exercise rehabilitation outcomes post-program seems to be challenging (Stone et al., 2011).

It has been proposed that high level of supervision in traditional center-based programs may act as a barrier for independent exercise outside the center (Carlson et al., 2001). In fact participants may develop dependence on training in a supervised setting and consequently lose

their self-efficacy for independent exercise (Carlson, Johnson, Franklin, & VanderLaan, 2000; Carlson et al., 2001). Interestingly, it has been suggested that programs which include more emphasis on the off-site exercise may lead to higher adherence to a physically active lifestyle (Blair, Corrigall, Angus, Thompson, & Leslie, 2011; Carlson et al., 2000; Marchionni et al., 2003; K. M. Smith, Arthur, McKelvie, & Kodis, 2004; K. M. Smith, McKelvie, Thorpe, & Arthur, 2011; Witham et al., 2005; Wolkanin-Bartnik, Pogorzelska, & Bartnik, 2011). This may be due to greater flexibility in scheduling and emphasis on independent exercise early in the program (Carlson et al., 2000; Chase, 2011). Further, self-monitoring which is an essential component of these programs may enhance patients' awareness of their behavior and is considered as one of the most effective strategies to increase participants' PA level (Chase, 2011; Conn, Hafdahl, Brown, & Brown, 2008). Thus, less structured programs which emphasize independent PA might have greater potential for long-term maintenance of the gains.

When examining the PA habits of exercise rehabilitation participants there appear to be mixed results (Carlson et al., 2000; Cowie, Thow, Granat, & Mitchell, 2011; Marchionni et al., 2003; Oerkild et al., 2011; K. M. Smith et al., 2004). The findings could be related to the measurement methods used to assess PA in these studies. Relying solely on surrogate methods (i.e., exercise testing) is insufficient to assess overall PA participation (H. van den Berg-Emons, Bussmann, Balk, Keijzer-Oster, & Stam, 2001). The use of subjective measures is highly influenced by social desirability and recall bias (Ainsworth, 2009; Vanhees et al., 2005) whereas objective measurement tools such as simple accelerometers tend to underestimate the lower end of PA continuum (Mackey et al., 2011).

One unique aspect of this thesis is investigating the entire spectrum of PA from sedentary behavior to vigorous PA using a multi-sensor device. Over the years moderate-vigorous PA

(MVPA) has been the main focus of cardiopulmonary rehabilitation programs. Thus the habitual PA as the lower end of the PA continuum has been overlooked. Indeed the absence of MVPA has often been considered as sedentary behavior (Pate, O'Neill, & Lobelo, 2008). However, there is evidence of a deleterious association between sedentary behavior and mortality risk factors which is independent of MVPA (Healy et al., 2008; Katzmarzyk, Church, Craig, & Bouchard, 2009). It has been suggested that sedentary behavior and the lack of MVPA have different influences on health outcomes; and thus need to be considered as separate risk factors (M. T. Hamilton, Hamilton, & Zderic, 2004; Owen, Sparling, Healy, Dunstan, & Matthews, 2010; Tremblay, Colley, Saunders, Healy, & Owen, 2010). Moreover, the inverse relationship between light PA and metabolic risk factors independent of MVPA further highlights the importance of the lower component of the PA continuum (Healy et al., 2007; Healy et al., 2008). Thus, using a more accurate PA measurement tool that covers the entire spectrum of PA, from sedentary behavior to spontaneous light intensity PA and MVPA over the whole day seems warranted. In this thesis participants are considered sedentary whenever energy expenditure (EE) is ≤ 1.5 METs (Pate et al., 2008). In fact sedentary behavior is considered as a part of the lower end of the PA continuum and refers to activities that do not increase EE markedly above the resting level (e.g., sitting, standing, lying down, watching television, car travel, etc.) (Colley et al., 2011; Pate et al., 2008). Light PA is defined as activities which require an EE of 1.6-2.9 METs (e.g., activities of daily living [ADL]) (Pate et al., 2008). MVPA includes activities with an EE of ≥ 3.0 METs (Pate et al., 1995).

By using a multi-sensor device that integrates accelerometer data with data from multiple physiological sensors (Mackey et al., 2011) we aim to obtain a more accurate measure of PA in exercise rehabilitation participants as they progress from entry to completion and following

completion of different exercise rehabilitation programs. Moreover, this thesis examines the long-term effectiveness of different exercise rehabilitation delivery models on sustainability of the achieved benefits.

1.2. Hypotheses

The purpose of this thesis is to study the immediate and long-term impact of different exercise rehabilitation programs on daily PA and exercise capacity in patients with cardio-pulmonary disorders. The first study of this thesis uses a multi-sensor device to examine the immediate impact of an exercise rehabilitation program on daily PA of cardiopulmonary patients. This study is based on the premise that while exercise rehabilitation improves exercise capacity in patients with cardiopulmonary disorders (Froelicher et al., 1985; Lacasse et al., 2007; Maines et al., 1997), it may not necessarily improve the PA level (R. van den Berg-Emons, Balk, Bussmann, & Stam, 2004). Indeed improving daily PA in cardiopulmonary patients may be challenging due to their habitual sedentary lifestyle. Thus, the hypothesis in the first study was that, although exercise capacity would increase from baseline to the end of the exercise rehabilitation program, there would be no significant change in participants' PA level as a result of participation in an exercise program.

Considering the potential therapeutic effects of PA on coronary atherosclerotic lesions (Hambrecht et al., 1993), the second and third studies focus exclusively on patients with coronary artery disease (CAD). In the second study, we use a multi-sensor device to compare the long-term impact of a fast-track versus traditional center-based cardiac rehabilitation (CR) on the PA of CAD patients 6 months following CR entry. The study is based on the evidence that programs which offer fewer on-site exercise sessions and include more emphasis on the off-site exercise may lead to higher adherence to a physically active lifestyle (Blair et al., 2011; Carlson

et al., 2000; Marchionni et al., 2003; K. M. Smith et al., 2004; K. M. Smith et al., 2011; Witham et al., 2005; Wolkanin-Bartnik et al., 2011). We hypothesized that fast-track CR would result in a significantly higher PA level, exercise capacity, self-efficacy and quality of life at follow-up.

Our third study compares the long-term effectiveness of home versus center-based CR on sustainability of exercise capacity changes 1 year after completing the CR program. Considering the key role of regular PA in maintaining the achieved benefits following CR completion (Chase, 2011), home-based programs may be more likely to maintain the improvements in long-term due to more emphasis on independent off-site PA (Marchionni et al., 2003; K. M. Smith et al., 2004; K. M. Smith et al., 2011). We hypothesized that despite comparable improvements in exercise capacity, body mass index, waist circumference and the blood lipids and fasting glucose at the end of CR in the two programs, participants in home-based CR would be more successful in maintaining the achieved improvements one year following CR completion.

Chapter 2

Literature Review

2.1. Cardiac Rehabilitation

The benefits of ambulation during hospitalization and post-discharge in Coronary Artery Disease (CAD) patients led to the development of Cardiac Rehabilitation (CR) programs. When discharging from hospital, patients were encouraged to exercise in the home environment. However, due to concerns about the safety of unsupervised exercise, formal supervised exercise-based CR programs were developed (Pashkow, 1993). Later it was suggested that in addition to exercise training, CR programs should also include multifaceted strategies aimed at reducing modifiable cardiovascular risk factors (Balady et al., 1994).

The Canadian Association of Cardiac Rehabilitation (2009) defines CR as:

> The enhancement and maintenance of cardiovascular health through individualized programs designed to optimize physical, psychological, social, vocational, and emotional status. This process includes the facilitation and delivery of secondary prevention through risk factor identification and modification in an effort to prevent disease progression and the recurrence of cardiac events. (p. 1)

The elements of CR include patient assessments, nutritional counseling, risk factor management (i.e., lipids, hypertension, smoking, weight, and diabetes), psychosocial management, physical activity counseling and exercise training, as well as the education on the health behavior and medication adherence (Canadian Association of Cardiac Rehabilitation, 2009).

2.2. Cardiac Rehabilitation and Quality Indicators

The effectiveness of CR is highly influenced by its quality. Therefore, CR programs need to use measures to assess the quality of care they provide. Quality indicators for CR programs consist of multiple domains including: 1) Referral, access and wait times; 2) Secondary prevention: assessment, risk stratification and control; 3) Behavioral change, program adherence, psychosocial, education, and return-to-work; and 4) Discharge transition, linkage and communication (Grace & Somanader, 2014).

2.2.1. Referral, Access and Wait Times

Includes assessment of the percentage of eligible patients referred to CR, percentage of patients enrolled in CR within 30 days of hospital discharge, the number of days from referral to enrollment, and the percentage of eligible patients enrolled in CR (Grace & Somanader, 2014).

2.2.2. Secondary Prevention: Assessment, Risk Stratification and Control

Focuses on the percentage of patients who: 1) were assessed for the risk of adverse events; 2) received self-management education; 3) were on Beta-blockers, Statins, Angiotensin-Converting Enzyme (ACE) inhibitors, Angiotensin Receptor Blockers (ARBs), or Acetylsalicylic Acid (ASA) at CR discharge; 4) were taking anti-platelet agents other than ASA at CR discharge; or 5) were assessed for their blood pressure, lipid, adiposity, or blood glucose (Grace & Somanader, 2014).

2.2.3. Behavioral Change, Program Adherence, Psychosocial, Education, and Return-to-Work

Includes assessing percentage of prescribed sessions completed by patients; as well as the percentage of patients who 1) achieved a 0.5 MET gain in exercise capacity from pre to post-CR; 2) met the recommended amount of PA (i.e., 150 minutes/week) at CR completion; 3) received

an intervention encouraging long-term PA post-CR; 4) were assessed for depression; 5) were referred for mental health counseling, smoking cessation, or stress management counseling; or 6) completed the CR program (Grace & Somanader, 2014).

2.2.4. Discharge Transition, Linkage and Communication

Focuses on percentage of discharge summaries that cover the 4 recommended components; as well as the percentage of patients who 1) have communicated with the CR program; or 2) were enrolled in the CR program that had communication with primary care (Grace & Somanader, 2014).

In summary, these indicators provide a guideline that facilitates assessing CR quality. This in turn will improve the quality of care delivered by CR programs and will reduce the risk of morbidity and mortality (Grace & Somanader, 2014).

2.3. Participation in Cardiac Rehabilitation

Although the benefits of CR have been well-established, only 15-30% of eligible patients actually participate in CR programs (Neubeck et al., 2012). There is a multitude of factors which may influence a patient's participation in CR. These factors range from issues related to referral, uptake, and adherence.

2.3.1. Barriers to Referral

Lack of referral has been reported as the most common reason given by patients for not attending CR program (Gravely-Witte et al., 2010). In fact, those who need CR the most are often not referred. These overlooked populations include: women, elderly, ethnic minorities, patients in lower socioeconomic condition, and rural patients (A. M. Clark et al., 2013). In a systematic review, Clark et al. (2013) identified three levels of barriers to CR referral including patient-related barriers, service-related barriers, and professional-related barriers.

2.3.1.1. Patient-related barriers. According to Clark et al. (2013), a lack of consistent information about the program provided by health professionals can be a major impediment to CR participation. The timing, when patients receive information about the CR program could be another factor influencing the referral to CR. When the information is given to the patient just prior to surgery or during initial days of hospitalization post-event, patients may not be able to recall program details. This in turn might impact their ability to request a referral. Thus the combination of providing information about CR at an inappropriate time, with the stress of the event and possible confusion related to memory problems, which is one of the frequent side effects of the medications or surgery, could contribute to a lower referral rate among those who are early in recovery (A. M. Clark et al. 2013).

2.3.1.2. Service-related barriers. The second barrier level identified by Clark et al. (2013) is at the service level. For instance, at this level one barrier may be territoriality, which refers to situations where physicians avoid referring patients to CR because they view CR as a threat to physician-managed treatment. Another service-related barrier may be a lack of sufficient funding. Furthermore, low referral rates could be the result of patient volume in the acute care system which overwhelms the health care professional's ability to provide referrals in a timely manner (A. M. Clark et al. 2013).

2.3.1.3. Professional-related barriers. Relying solely on physicians has been reported as one of the major barriers to CR referral. Physicians typically are the only health professionals who may refer patients to CR. However, sometimes they lack the knowledge about the content, benefits, and safety of CR. On some occasions, physicians have refused to refer patients to CR due to the wrong perception of indications and contraindications for CR. They may view the patients as, being not sick enough for CR, having low motivation, or having trouble accessing the

programs. Thus, the key role of physicians in the referral process and the potential for a lack of awareness about the programs could adversely impact the referral process (A. M. Clark et al. 2013).

2.3.2. Barriers to Uptake and Adherence

Participation in CR also depends on factors influencing uptake and adherence. Uptake is defined as a successful recruitment of patients which results in any participation in CR program. While adherence refers to participation in all or most sessions of a CR program or maintaining healthy behavior related to CR program. Barriers influencing CR uptake and adherence can also be investigated at three levels: patient level, service level, and health professional level (Beswick et al., 2004).

2.3.2.1. Patient-related barriers. Lack of motivation to change lifestyle is one of the key barriers that has a negative influence on CR uptake and adherence. While some patients try to make changes in their lifestyle, others find it difficult to change behavior (Beswick et al., 2004). These patients may not perceive a benefit from participating in the program. In other words, they often do not have a good understanding of CAD. They may not believe that they have control over their own health. Some patients may experience a degree of anxiety associated with starting a new program in new surroundings while others may express a negative attitude towards group classes and are embarrassed about participating in such classes. Moreover, the distress caused by CAD diagnosis often leads to denial, depression and loss of confidence and ultimately affects the patients' willingness to participate in CR (Neubeck et al., 2012). Family life and living condition may also influence participation in CR. A heavy work load or family commitments and lack of family support can adversely impact CR uptake and adherence. Furthermore, travel time to CR

center has been reported as one of the strongest predictors of non-participation (Jackson, Leclerc, Erskine, & Linden, 2005).

2.3.2.2. Service-related barriers. Financial issues may affect patients' attendance in CR programs. In the USA, it has been reported that uptake is higher in patients with insurance coverage for CR (Beswick et al., 2004). Patients' participation in CR also depends on the location of the CR center, availability of car parking, and program scheduling. Uptake and adherence is negatively affected by hard-to-access CR facility, lack of parking lot, and inconvenient timings (Beswick et al., 2004; Neubeck et al., 2012). Furthermore, long wait time from referral to enrollment affects the CR uptake. For every additional day in the wait time, CR uptake decrease by 1% (Russell et al., 2011).

2.3.2.3. Professional-related barriers. Source of referral plays an important role in the patients' attendance, with physician recommendation reported to increase uptake. The lack of CR program knowledge among some health professionals is another major factor that may influence CR uptake. Also, there is a bias among some health professionals to recommend CR to patients who are more likely to be adherent to it (e.g., younger, male, etc.) (Beswick et al., 2004).

In summary, considering the established benefits of CR on mortality and morbidity, attempts to improve patients' attendance in these programs seem crucial. In order to find effective strategies to improve CR participation, understanding the factors influencing referral, uptake, and adherence is essential. Although some of the interventions have been proven to be effective, the effectiveness of others needs further investigation. Home-based CR may be considered as an alternative delivery model which might improve CR participation especially in low to moderate risk patients.

2.4. Cardiac Rehabilitation Delivery Models

Traditionally the outpatient phase of CR occurs in a hospital setting and is often referred to as center-based CR. It is a formal, medically supervised program that is held for a particular period of time in a hospital or health care center (M. Clark, Kelly, & Deighan, 2011). Although beneficial effects of center-based CR has been documented in numerous studies, participation remains sub-optimal specially among women, the elderly and people from minority ethnic groups (Jolly, Taylor, Lip, & Stevens, 2006). The main reasons for poor center-based CR uptake are problems with accessibility of medical centers offering CR, reluctance to participate in group-based activities and work or domestic commitments (Dalal, Zawada, Jolly, Moxham, & Taylor, 2010). Home-based CR was first introduced in the early 1980s in order to increase CR participation (Jolly et al., 2006). In home-based program, patients practice in regular exercise in a flexible setting which is typically their homes. Home-based CR starts with limited hospital visits followed by regular mails or phone calls by a case manager. Alternative delivery models such as internet-based CR, community-based CR, and case management and risk stratification also have been developed which are basically variations of traditional center-based or home-based programs (Canadian Association of Cardiac Rehabilitation, 2009).

2.4.1. Center-based Cardiac Rehabilitation

The efficacy of center-based CR program has been evaluated in numerous studies. Maines et al. (1997) reported significant improvement in exercise capacity, mental health and quality of life (QOL) in CAD patients who participated in a 12 week center-based CR program. Significant increases in exercise capacity, exercise duration and distance walked (6 minute walk test) were noted in female post-coronary artery bypass graft (CABG) patients following 12 weeks of center-based CR whereas, no changes were observed in the inactive control group

(Shabani, Gaeini, Nikoo, Nikbackt, & Sadegifar, 2010). Center-based CR has also been shown to have a positive impact on the exercise capacity of chronic heart failure (CHF) patients (Nishi et al., 2011). Carson et al. (1982) randomly assigned post-myocardial infarction (MI) patients to 12 weeks (2 days/week) of center-based exercise program or an inactive control group. They reported that physical fitness was improved in the training group compared to non-training group. Positive effects of center-based CR on exercise capacity and QOL of post-MI patients have also been reported in other studies (Naughton, 1978; N. Oldridge et al., 1991). A meta-analysis of randomized clinical trials of CR following MI suggested that CR also lowered all-cause mortality and cardiac mortality (Bobbio, 1989; N. B. Oldridge, Guyatt, Fischer, & Rimm, 1988).

Williams et al. (1984) recruited post-MI and post-CABG patients across four age groups (40 to 82 years) in to a 12 week center-based exercise program. Post-training assessment showed significant increases in maximum metabolic equivalents (METs) in all four groups. Although the elderly patients had lower absolute physical work capacity at post-test, the magnitude of change was similar across groups. The similar efficacy of CR on elderly and younger patients was further demonstrated in other studies (Lavie, Milani, & Littman, 1993; Marchionni et al., 1994). Furthermore, it was reported that although some spontaneous increase in total work capacity was observed in the younger inactive patients who did not participate in CR, older inactive patients did not improve at all; which suggests that CR participation is especially important for elderly patients (Marchionni et al., 1994). Stahle, Nordlander, Ryden, and Mattsson (1999) randomized MI patients aged 65-84 years to either a 12 week center-based exercise training program (3 days/week) or an inactive control group. At 12 weeks the intervention group demonstrated a

significant increase in exercise capacity compared to control group. Furthermore, self-reported physical activity (PA) and wellbeing improved significantly at the end of training.

Although center-based CR has been shown to be a highly effective intervention in promoting an early improvement in exercise capacity, the sustainability of this outcome seems to be quite challenging. Investigating the long-term efficacy of center-based CR program demonstrated that at one year post-CR, the improved exercise capacity declined in cardiac patients (Stahle, Mattsson, Ryden, Unden, & Nordlander, 1999). The long-term change in exercise capacity was investigated in CAD patients who participated in an 8 week center-based CR program. At two years post-CR the improved exercise capacity in the participants had declined to the point where it was similar to those who were in the inactive control group (Yu, Li, Ho, & Lau, 2003). Lear et al. (2006) reported a similar trend. Hage, Mattsson, and Stahle (2003) used a self-reported PA scale to assess the long-term effects of exercise training on PA level of cardiac patients 3-6 years after completion of 12 week center-based CR program. At the follow up assessments, although patients in the training group were more active compared to the inactive control group, as well as their own pre-training baseline PA levels, their achieved level of PA (through 12 week CR) was not maintained long-term. Combined these findings might imply that PA level decreases after completion of the formal CR program in cardiac patients.

Most of the studies assessing the impact of CR on PA have assessed exercise capacity to estimate PA level without any direct assessment of daily PA. However, the applicability of exercise tolerance testing to measure daily PA has been challenged by a number of authors suggesting that such testing is not an appropriate means of measuring actual PA (Davies, Jordan, & Lipkin, 1992; Oka, Stotts, Dae, Haskell, & Gortner, 1993; Walsh, Andrews, Evans, & Cowley, 1995). The two main methods of PA assessment are subjective and objective methods. In one

study, PA was assessed using a self-reported scale (subjective measure) (Hage et al., 2003); however such measures lack objectivity. In fact, self-reported instruments measure the patient's subjective perception of PA rather than actual PA (Vanhees et al., 2005). Considering the lack of studies that have actually measured the impact of CR on long-term PA, assessing PA objectively in order to compare the efficacy of CR delivery models on the overall PA levels of cardiac patients seems warranted.

2.4.2. Home-based Cardiac Rehabilitation

The efficacy of home-based CR exercise program has been examined in several studies. In a cross-over study CHF patients who received 8 weeks (5 days/week) of home-based training followed by 8 weeks of no training demonstrated improvements in peak oxygen uptake (VO_{2peak}), exercise duration and self-reported symptoms at the end of the training phase. Further, significant reductions in sub-maximal heart rate (HR) and rate-pressure product were observed (Coats, Adamopoulos, Meyer, Conway, & Sleight, 1990). Similar findings have been observed in numerous studies (Coats et al., 1992; Davey et al., 1992; Salvetti, Oliveira, Servantes, & Vincenzo de Paola, 2008; Webb-Peploe et al., 2000).

It has been reported that patients who completed a 12 week home-based walking program (60 min/day, 5 days/week) experienced significant improvements in the 6 minute walk test (6MWT) distance compared to an inactive control group (Corvera-Tindel, Doering, Woo, Khan, & Dracup, 2004). Similarly Gary et al. (2004) noted that 6MWT distance was significantly greater in female CHF patients who participated in a home-based training program (3 days/week, 12 weeks) compared to an inactive control group. Home-based exercise training has also been shown to be effective in improving CHF patients' symptoms and QOL (Corvera-Tindel et al., 2004; Gary, Sueta, Dougherty, et al., 2004; Oka et al., 2000). At the end of 24 weeks home-

based training Evangelista et al. (2006) reported that obese CHF patients yielded significant weight loss and a trend towards an improvement in 6 MWT distance. It is also noteworthy that, none of the studies evaluating the efficacy of home-based exercise for CHF patients reported any adverse events directly related to exercise training (Hwang & Marwick, 2009). Indeed, meta-analyses on the effects of home-based CR in CHF patients' health outcomes indicated significant improvements in exercise capacity, self-efficacy (SE) and QOL (Chien, Lee, Wu, Chen, & Wu, 2008; Hwang & Marwick, 2009). In summary, home-based CR appears to be a safe intervention which is effective in improving exercise capacity, function and the patient's clinical status.

One study has investigated the long-term efficacy of home-based CR over 6 months. Dracup et al. (2007) evaluated functional status of CHF patients after home-based exercise training. They reported an incremental trend in exercise capacity over the first 3 months and a modulation of that improvement over the second 3 months. Similar to studies on center-based CR, this study has the limitation of not using specific measures to assess patients' PA level. In a study by Furber, Butler, Phongsavan, Mark, and Bauman (2010), patients in a home-based CR program were compared to an inactive control group. The 6 week program included self-monitoring of PA using pedometer and step calendar as well as counseling and goal setting through follow-up phone calls. At 6 weeks and 6 months follow-ups patients in CR program demonstrated a significantly greater improvement in their PA level compared to inactive control group. Moreover at 6 weeks, there was a significant improvement in SE which was maintained at 6 months. Based on these results, the home-based CR with pedometers and telephone support appears to be effective in increasing and maintaining SE and PA levels. The positive impact of home-based self-monitored CR on PA has been confirmed in a recent study by Houle et al. (2011). In this trial, acute coronary syndrome patients were randomly assigned to a home-based

CR group or inactive control group. Participants in home-based CR were given a pedometer, a diary and training instructions. They also received follow-up phone calls from a nurse specialist. At the 3 and 12 months follow-ups, there was a significant improvement in CR patients' step counts compared to inactive control group.

2.4.3. Home-based Versus Center-based Cardiac Rehabilitation

In one of the first studies comparing the efficacy of home versus center-based CR programs post-MI patients were randomly assigned to extended training (23 week home or center-based CR), brief training (8 week home or center-based CR) or no training. Exercise capacity increased significantly at the end of 8 weeks of training in both home and center-based CR groups. The improvement in exercise capacity in the extended training group was not significantly higher than that for brief training group. There was no improvement in the exercise capacity of the non-training group. Thus, home-based CR over 8 weeks was as effective as short and long-term center-based training for improving exercise capacity in post-MI patients. Further, telephone follow-ups from nurses in the home-based program provided as effective intervention as did supervision in the center-based program (Miller, Haskell, Berra, & DeBusk, 1984). For post-CABG patients, home and center-based CR programs appear to yield similar improvements. There is evidence that allocation of patients to home or center-based CR has led to similar increases in peak work load, peak MET and VO_{2peak} (Arthur, Smith, Kodis, & McKelvie, 2002; Kodis et al., 2001).

Marchionni et al. (2003) compared efficacy of home versus center-based CR on total work capacity in post-MI patients who were stratified to one of three age groups (45 to 65 years, 66 to 75 years, and >75 years). At the end of the two months CR similar increases in total work capacity were observed across the age groups. In CHF patients, home and center-based CR

programs have been shown to yield comparable improvements in VO_{2peak} and 6MWT distance (Karapolat et al., 2009). Several studies have reported that both home and center-based CR programs produce comparable improvements in anxiety, depression and QOL (Dalal et al., 2007; Jolly et al., 2007; Karapolat et al., 2009; Marchionni et al., 2003). A meta-analysis compared the effect of home-based and center-based CR on mortality and morbidity, health-related QOL, exercise capacity and modifiable cardiac risk factors (blood pressure, blood lipids, and smoking behavior) in CAD patients. There were no significant differences in health outcomes in patients who participated in home or center-based CR (Dalal et al., 2010). Moreover, three of the trials used in this meta-analysis demonstrated significantly higher adherence to home-based compared to center-based CR (Arthur et al., 2002; Marchionni et al., 2003; K. M. Smith et al., 2004). Better adherence to home-based CR (87%) versus center-based (49%) has also been reported by others (Dalal & Evans, 2003). Recently a systematic review was conducted to evaluate the current evidence on efficacy of home versus center-based CR. They concluded that both CR programs were effective in improving cardiac risk factors (Blair et al., 2011).

Numerous studies have compared long-term efficacy of home versus center-based CR programs on patients' exercise capacity and PA level (Jolly et al., 2007; Marchionni et al., 2003; K. M. Smith et al., 2004; K. M. Smith et al., 2011). Marchionni et al. (2003) demonstrated improvements in total work capacity following both CR models but these improvements were lost by the 6 and 12 month follow-ups in centre-based patients whereas they were preserved in home-based CR patients. Smith et al. (2004) compared sustainability of clinical outcomes 12 months after CR programs (home or center-based). They noted patients in the home-based program reported higher levels of PA compared to the center-based group. Moreover between CR discharge and the 1 year follow-up, patients in the home program maintained their VO_{2peak}

whereas in the center-based group VO_{2peak} declined. Recently the authors reported that VO_{2peak} declined significantly in both groups between 1 and 6 years post-CR. However, the relative rate of decline was higher in the center-based group. Moreover, patients in home-based group reported significantly higher levels of PA compared to center-based group (K. M. Smith et al., 2011).

While the results from these various studies imply that a home program might be more effective in maintaining higher levels of PA in CR participants, others have reported contrasting results (Jolly et al., 2007; Oerkild et al., 2011). Jolly et al. (2007) compared home versus center-based programs in post-MI and revascularization patients and observed comparable results for exercise capacity and self-reported PA at the 6 and 12 month follow-ups. Recently, Oerkild et al. (2011) noted that at the 12 month follow-up, exercise capacity declined significantly regardless of whether the CR program was center or home-based.

Thus, when examining the long-term PA habits of cardiac patients there appear to be mixed results on the efficacy of different CR delivery models. The findings could be related to the measurement methods which have been used to assess PA in these studies. Relying solely on subjective measures or using surrogate methods (i.e., exercise testing) could be insufficient to assess PA (Ainsworth, 2009; H. van den Berg-Emons et al., 2001; Vanhees et al., 2005). Therefore, comparing the efficacy of different CR delivery models using objective measures of PA level seems warranted.

2.4.4. Cardiac Rehabilitation Delivery Model and Physical Activity

There is one study which has used objective measurement of PA to compare the short-term and long-term effects of home versus center-based CR. Cowie, Thow, Granat, and Mitchell (2011) used an accelerometer-based activity monitor to assess PA in CHF patients following 8

weeks of either home or center-based CR versus inactive control group. The *active* PAL ™ recorded step counts and walking cadence (steps/min). The authors reported that immediately after completion of the CR neither programs had any effect on PA. Furthermore, at the 6 month follow-up PA levels were at baseline values regardless of the CR program the patients participated in. One limitation of this study may have been the *active* PAL ™ itself. The *active* PAL ™ is a uniaxial accelerometer. The accuracy of this device to record step counts has been confirmed at walking speeds greater than 1.5 mph in community-dwelling older adults (Grant, Dall, Mitchell, & Granat, 2008). Considering that anything below that threshold may be missed, this device is not an appropriate measuring tool to assess PA in frail elderly population who walk slowly or with a shuffle. Therefore, using a more accurate PA measurement tool that covers the entire spectrum of PA including sedentary behavior and spontaneous light intensity PA seems warranted.

2.5. Exercise Self-efficacy

At present, CR programs are designed primarily based on cardiac patients' physiological status (e.g., exercise capacity, ejection fraction, etc.) (Carlson et al., 2001). One of the limitations of this approach is that physiological status is not a good predictor of independent exercise in these patients (Ewart, 1989; Ewart, Stewart, Gillilan, & Kelemen, 1986; Lemanski, 1990). A number of psychological factors have been identified as important predictors of PA behavior in cardiac patients, including SE (Carlson et al., 2001). In fact, people with high level of SE maintain higher likelihood of engaging in regular PA even in the face of barriers (Bandura, 1986, 1997, 2004; Dishman et al., 2005; Jerome et al., 2002; McAuley et al., 2005; McAuley, Jerome, Elavsky, Marquez, & Ramsey, 2003). SE is defined as confidence in coordinating multiple skills required to develop long-term regular behaviors under variable conditions. However, confidence

to perform exercise (task) per se is not the only factor to consider in developing routine exercise behavior. Other important domains closely related to exercise behavior are time management (scheduling) and overcoming barriers (coping). Therefore, the main domains of SE are: (a) task: one's confidence in performing exercise; (b) coping: confidence in exercising under challenging conditions (e.g., fear of experiencing another coronary event); and (c) scheduling: confidence in time management to do regular exercise (Rodgers, Wilson, Hall, Fraser, & Murray, 2008).

Several studies have investigated the impact of CR on SE. Some of them have focused on the influence of CR on task efficacy and demonstrated that task efficacy significantly increased from pre to post-CR (Foster et al., 1995; Jeng & Braun, 1997; Schuster, Wright, & Tomich, 1995). Barrier efficacy has also been reported to increase after CR (Bock et al., 1997). Blanchard, Rodgers, Courneya, Daub, and Black (2002) conducted a study to determine the impact of CR on task and barrier SE and noted no changes in SE during pre-CR period but significant improvements from pre- to post-CR with subsequent decreases at the post-CR follow-up. Examining SE changes during CR participation showed significant improvement in all SE domains that paralleled increase in energy expenditure calculated during the exercise sessions. Exercise programs improve both physical function and SE to maintain regular exercise in cardiac patients. In fact, changes in SE and PA are self-enhancing: exercise improves SE and high level of SE ultimately leads to higher compliance with exercise (Gardner et al., 2003).

It has been documented that high level of supervision in center-based CR programs can be a barrier for independent exercise in low and moderate risk patients (Carlson et al., 2001). Carlson et al. (2001) examined SE changes in low to moderate risk cardiac patients who participated in either a traditional center-based program or modified program where patients were weaned from the supervised CR program. At 3 months the modified CR group had

significantly greater levels of SE for independent exercise compared to the traditional center-based group. Moreover, 63% of patients in the modified program reported being "very comfortable" while exercising independently; whereas only 33% of traditional group answered "very comfortable". These findings highlight the importance of designing CR programs that promote patients' SE for independent exercise.

Studies on sedentary diabetic patients demonstrated that self-monitoring was a successful approach in improving and maintaining PA behavior (Kirk et al., 2001; Loughlan & Mutrie, 1997). Investigating the effect of self-monitoring on PA behavior in cardiac patients showed that, 6 months post-CR, patients who used a self-monitoring approach had significantly higher SE compared to a traditional CR group. Furthermore patients in the self-monitoring group demonstrated significantly higher PA level at the 6 month follow-up with a significant positive correlation ($r = 0.642$) between SE and PA level (Izawa et al., 2005). In summary, self-monitoring which is often an essential component of home-based CR programs, appears to be an effective approach to improve SE and long-term PA in cardiac patients (Izawa et al., 2005).

2.6. Physical Activity Assessment

The impact of regular PA on chronic diseases (e.g., CAD) risk factor modification has urged researchers to develop different techniques for PA assessment (Melanson & Freedson, 1996). More than 30 different methods have been developed to measure PA. The ideal measurement tool should be valid, reliable and practical while not influencing habitual PA behavior. However, possessing all these characteristics by a single instrument does not seem to be feasible. Often, being advantageous in one aspect, an instrument tends to lack an advantage in another (Melanson & Freedson, 1996). PA assessment methods can be classified in to three groups: criterion methods, objective methods and subjective methods (Vanhees et al., 2005).

2.6.1. Criterion Methods

Calorimetry has been identified as the gold standard to quantify energy expenditure (EE). As PA is defined as any bodily movement which results in energy expenditure, EE is often used as a key indicator of PA. The doubly labeled water method (DLW) is a type of calorimetry in which the difference in elimination rate of two ingested stable isotopes (^{2}H and ^{18}O) is used to measure EE. While DLW is a highly accurate method of measuring total EE, it is an expensive technique and is not applicable to large-scale trials. Therefore DLW is mainly used as the gold standard for the validation of other assessment methods (Vanhees et al., 2005).

2.6.2. Objective Methods

Objective methods may be divided into two main categories: HR monitors and activity monitors. HR monitoring is based on the linear relationship between HR and VO_2 during moderate and vigorous PA. HR monitors are usually able to record minute by minute data which are stored for hours and days, thus providing information about duration, frequency and intensity of PA (Vanhees et al., 2005). Although HR monitoring is an unobtrusive and relatively inexpensive method of assessing PA, it has some limitations. At rest and during mild activity relationship between VO_2 and HR may not be linear (Vanhees et al., 2005) and HR is influenced by other factors (e.g., caffeine, stress, smoking, body position) (Livingstone, 1997). Finally, HR monitoring is not an appropriate tool to estimate EE in sedentary people (Livingstone, 1997; Spurr et al., 1988).

Two popular activity monitors are pedometers and accelerometers. Pedometers are small devices worn on person's thigh or waist and record motions in the vertical direction. They count the number of steps taken during walking. By entering an average stride length, the distance walked during particular period of time can be calculated. Pedometers are very accurate tools to

measure step counts. However, they are only useful in walking-related activities and are not sensitive to static activities, isometric exercise, upper body activities, walking on graded surface, cycling, and swimming. Moreover they are not able to measure intensity of walking (Ainsworth, 2009; Melanson & Freedson, 1996; Vanhees et al., 2005).

Accelerometers use piezoelectric transducers and microprocessors to measure magnitude and direction of motion. Therefore they provide information about the intensity and speed of PA. At present, the best types of accelerometers are triaxial accelerometers which are able to measure motion in more than one plane. However, even in these devices, recording some complex movements such as cycling, upper body activities, walking on graded surface, and static activities is partially restricted (Ainsworth, 2009; Vanhees et al., 2005). Investigating the relationship between body acceleration and EE during different activities showed a linear relationship between accelerometer output and EE during walking as well as sedentary activities (Bouten, Westerterp, Verduin, & Janssen, 1994). However, in a subsequent study, accelerometer output had a higher correlation with overall PA level than with EE (Bouten, Verboeket-van de Venne, Westerterp, Verduin, & Janssen, 1996). One of the disadvantages of using accelerometers to estimate EE is that they are not able to distinguish non-wear time from periods of inactivity. This drawback was one of the causes of emerging pattern recognition monitors such as SenseWear Armband (SWA) (Johannsen et al., 2010).

The SWA is a new accelerometer-based activity monitoring device which has been developed to measure EE. Using multiple sensors, SWA can collect information on different parameters (i.e., movement, heat flux, skin temperature, near-body temperature, galvanic skin response). An algorithm uses these data combined with demographic characteristics (gender, age, height and weight) to estimate person's EE, duration of PA and step counts. Movement is

measured using an accelerometer. A sensor that incorporates low thermal resistant materials and thermocouple arrays measures heat flux. Galvanic skin response is measured using two hypoallergenic stainless steel electrodes and shows evaporative heat loss. A thermistor-based sensor is used to measure skin temperature during PA which is an indicator of the body's core temperature (Fruin & Rankin, 2004; Jakicic et al., 2004; Malavolti et al., 2007).

Recently, the accuracy of SWA to measure total EE and physical activity energy expenditure (PAEE) under free-living condition (for 14 consecutive days) was compared to the criterion standard DLW. Although, the SWA underestimated total EE at higher levels of EE which is a common issue among many currently used activity monitors, based on intra-class correlation (ICC) analysis there was a significant agreement between the SWA and DLW estimates of EE (ICC = 0.80, 95% CI = 0.89–0.70). The authors reported significant agreement between the SWA and DLW which was consistent across a range of total EE values. (Johannsen et al., 2010). Similar findings were obtained in a previous study which reported reasonable agreement between the SWA and DLW for the measurement of total EE in healthy adults (St-Onge, Mignault, Allison, & Rabasa-Lhoret, 2007).

Jakicic et al. (2004) conducted a study to examine the validity of SWA to assess EE during four different types of exercise. Participants took part in four exercise modes including treadmill walking, stair stepping, cycle ergometry, and arm ergometry while their EE was measured simultaneously using indirect calorimetry (IC) and SWA. During the protocols, there was no significant difference in EE estimated by SWA and EE measured using IC. The authors concluded that using SWA in combination with exercise-specific algorithms may be a more accurate technique to estimate EE during exercise than other widely used portable EE monitors. Fruin and Rankin (2004) evaluated the validity and reliability of the SWA to estimate EE during

rest and two types of exercise (cycle ergometer and treadmill walking) compared with IC measurement. At rest, there was no significant difference between EE estimated by SWA and EE measured by IC. In fact, the outcomes were highly correlated which implies validity of SWA estimation during rest. Moreover, reliability of SWA estimation was confirmed by comparing two resting sessions. During cycling no significant difference was found between SWA and IC outputs. Considering that triaxial accelerometer has been reported to considerably underestimate the EE of non-weight bearing activities (e.g., cycling) (Campbell, Crocker, & McKenzie, 2002; Jakicic et al., 1999), SWA appears to provide a more accurate estimate of EE during cycling. During treadmill walking, SWA estimation was found to correlate moderately to IC measurement ($r = 0.47 – 0.69$) (Fruin & Rankin, 2004). SWA overestimated the EE of walking with no grade and underestimated EE of the graded walking (Fruin & Rankin, 2004). However, these results were comparable to findings from triaxial accelerometer studies (Campbell et al., 2002; Jakicic et al., 1999; Levine, Baukol, & Westerterp, 2001; Nichols, Morgan, Sarkin, Sallis, & Calfas, 1999; Welk, Blair, Wood, Jones, & Thompson, 2000). The similar magnitude of over- and under estimation in this study and triaxial accelerometer studies implies that both SWA and triaxial accelerometer provides similar estimate of walking energy expenditure (Fruin & Rankin, 2004). Validity and reliability of SWA were further confirmed in another study (Malavolti et al., 2007). In summary, SWA is a valid and reliable tool to estimate resting EE. Also, compared to triaxial accelerometer, SWA provides more accurate estimate of cycling EE and similar estimate of walking EE (Fruin & Rankin, 2004).

These findings indicate that SWA is as accurate as IC in EE assessment. Furthermore, SWA appears to be practically advantageous over IC. For example, using metabolic cart is usually restricted to research laboratories and hospitals and needs presence of a skilled technician

for calibration which makes it a costly technique. In contrast, SWA is portable and self-calibrating and can be easily applied by any health-care professional with lower cost in any health-care setting (Malavolti et al., 2007). It has been documented that most motion detectors are not able to measure elevated EE during recovery period after exercise. For instance, compared with IC, triaxial accelerometer significantly underestimated EE associated with the recovery from treadmill exercise (Sherman et al., 1998). In contrast, the SWA has been reported to be able to accurately estimate the elevated EE immediately after exercise (Fruin & Rankin, 2004). Inclusion of heat flux sensor in SWA has given it the advantage of measuring heat production and heat loss (by-product of metabolism and EE) which may have led to improved ability of SWA to estimate EE compared to other motion sensors (Jakicic et al., 2004). In summary, inclusion of multiple sensors in this device was done mainly in order to overcome the limitations of other objective EE assessment tools (Fruin & Rankin, 2004; Scheers, Philippaerts, & Lefevre, 2012).Also it has minimal interference in activity and it is applicable to free-living EE assessment (Fruin & Rankin, 2004). Considering that elderly patients usually perform their daily activities at lower intensities, SWA appears to be a suitable device to assess their free-living daily PA. Moreover, this device's ability to detect EE associated with wide range of activities (upper body activities, static activities, and non-weight bearing activities) (Scheers et al., 2012; Welk, McClain, Eisenmann, & Wickel, 2007), makes it a preferred choice for present study.

2.6.3. Subjective Methods

Subjective methods of assessing PA include using records, logbooks, and questionnaires. Records and logbooks provide information about the type, purpose, duration, self-reported intensity, and body position during particular period of time. Although detailed information is

obtained by applying records and logbooks, the administration process is difficult for both patients and clinicians (Ainsworth, 2009). It is prone to memory errors, demands a high degree of patient motivation and may alter normal PA patterns (Jacobs, Ainsworth, Hartman, & Leon, 1993; LaPorte, Montoye, & Caspersen, 1985).

Using questionnaires is an inexpensive method of PA assessment which can be easily applied to large populations (Vanhees et al., 2005). Most questionnaires are self-administered, however interview methods are also available for special population (e.g., children, elderly, illiterate). Questionnaires are classified in to three main types: (1) Global questionnaires are short surveys which can be completed in less than a minute and provide information about patient's general PA level. (2) Recall questionnaires are more detailed than global questionnaires (7–20 items). Applying this type of questionnaire, researcher can obtain information about frequency, duration, types, and different domains of PA during the past day, week, or month. Although these questionnaires are very popular, they are prone to recall bias. (3) Quantitative histories are long surveys (e.g., approximately 50 items) about frequency and duration of different activities during the past year or lifetime. Since completing these questionnaires is time-consuming they are not usually used in clinical settings. In general, self-report techniques are limited in their objectivity and may lead to underestimation or overestimation of different activities (Ainsworth, 2009). Results from a systematic review on 148 studies reported low-to-moderate correlations (mean of 0.37) between self-report and direct measurements of PA (Prince et al., 2008). Social desirability, age, complexity of the questionnaire, seasonal variation, and length of period surveyed are the main factors that influence underestimation or overestimation of self-reported PA (Vanhees et al., 2005). Self-report methods have the advantage of being inexpensive,

unobtrusive, and non-reactive. Moreover they are relatively easy to apply and have the capability of assessing different dimensions of PA in a single instrument (Baranowski, 1988).

2.7. Exercise Capacity and Quality of Life

Assessing exercise capacity by measuring VO_{2peak} during a graded exercise testing is considered as the reference method for determining physiological function in cardiac patients. This method is usually used for exercise intensity prescription and outcome assessment during CR programs. However, this technique is time-consuming and requires expensive equipment and technical expertise (Cheetham, Taylor, Burke, O'Driscoll, & Green, 2005; Gary, Sueta, Rosenberg, & Cheek, 2004; Gayda, Temfemo, Choquet, & Ahmaidi, 2004). As multiple assessments are required for exercise training studies, using exercise test appears to lack practicality especially in elderly patients (Cheetham et al., 2005). Further, VO_{2peak} may not reflect the elderly CAD patient's ability to perform activities of daily living (Sharma & Anker, 2001). It has been reported that 22% of elderly cardiac patients were not able to carry out treadmill testing mainly because of fear of falling (Harada, Chiu, & Stewart, 1999). These limitations have led to an increasing use of simple walking tests to assess functional exercise capacity (Butland, Pang, Gross, Woodcock, & Geddes, 1982; Guyatt et al., 1985; Lipkin, Scriven, Crake, & Poole-Wilson, 1986).

One of the most popular walking tests is the 6MWT. The 6MWT is a sub-maximal exercise test. Considering that most activities of daily living are done at sub-maximal level, this test is a good indicator of patients' functional exercise capacity to perform daily activities ("ATS statement: guidelines for the six-minute walk test," 2002; Bautmans, Lambert, & Mets, 2004). Being a self-paced test it is also a safe procedure that has been adopted for use in the elderly and cardiac disease populations ("ATS statement: guidelines for the six-minute walk test," 2002;

Ingle et al., 2006). Moderate to strong correlation between 6MWT distance and VO_{2peak} has been reported in numerous studies (Cahalin, Mathier, Semigran, Dec, & DiSalvo, 1996; Faggiano, D'Aloia, Gualeni, Lavatelli, & Giordano, 1997; D. M. Hamilton & Haennel, 2000; Opasich et al., 2001; Riley, McParland, Stanford, & Nicholls, 1992; Solway, Brooks, Lacasse, & Thomas, 2001; Zugck et al., 2000).

It has been reported that in older adults 6MWT performance depends on different physiological and psychological factors. Physiological measures, especially the ones which are associated with mobility have been shown to have a significant effect on 6MWT distance (Lord & Menz, 2002). The 6MWT was reported as a reliable and valid indicator of physical performance and self-reported physical functioning (Harada et al., 1999). This test also correlates well with measures of QOL (Guyatt, Townsend, Keller, Singer, & Nogradi, 1991). Lord and Menz (2002) have reported that the distance covered in the 6MWT was significantly associated with subjects' self-reported PA limitations. However, objective assessment of PA level showed that there is a difference between individual's ability to perform PA and actual participation in PA. In this study although 60% of participants were at the optimal level of functional capacity (measured by the 6MWT) only one third of them met the recommended level of PA (Ashe, Eng, Miller, & Soon, 2007).

Hamilton and Haennel (2000) examined the validity and reliability of 6MWT in an outpatient CR setting. According to findings from that study there was a linear relationship between 6MWT and maximum METs from a symptom-limited graded exercise test ($r = 0.687$, $p < 0.001$) indicating the validity of the test. Furthermore test-retest reliability of the 6MWT was confirmed by intra-class correlation of 0.97. Therefore, the 6MWT may be regarded as a valid and reliable measure of functional exercise ability in stable CR participants.

In summary, the 6MWT appears to be a general measure of physical performance and mobility (Lord & Menz, 2002); and may better reflect patients' functional exercise capacity to perform daily activities ("ATS statement: guidelines for the six-minute walk test," 2002; Bautmans et al., 2004). Considering that our study mainly focuses on patients' daily function rather than cardiovascular exercise capacity, the 6MWT is used as one of the outcome measures in present study. Moreover, despite the association between the 6MWT distance and self-reported PA, there appears to be a discrepancy between functional exercise capacity and actual PA assessed by objective measures. Therefore, although different CR delivery models have shown comparable results in terms of improving exercise capacity, comparing their impact on PA level is needed.

Furthermore, it is important to evaluate the patients' QOL for a thorough assessment of any intervention (Jette & Downing, 1994); especially the ones which aim to improve different aspects of health such as mobility, functioning, mental health, and overall well-being (Brazier et al., 1992). The MacNew Heart Disease Health-related QOL Instrument is a self-administered questionnaire that has been designed to evaluate cardiac patients' perception of the way their illness has influenced their daily life in the two weeks period. It consists of 27 items and three major domains: physical limitations domain, emotional function domain, and social function domain (Hofer, Lim, Guyatt, & Oldridge, 2004). The questionnaire is a modified version of the QOL after MI instrument which was an interview-administered questionnaire and was designed for post-MI patients who were referred to CR (N. Oldridge et al., 1991). The MacNew has a global score and also individual scores for each domain. The individual domain scores are calculated by averaging the responses in each domain. The score in each domain ranges between 1 (poor QOL) and 7 (high QOL). For a domain to be scored, at least half of the items in it should

be answered. If less than half of the items for a domain are answered, the score will be considered missing for that domain. The global score is the average of all the scored items (except for the missing domains) (Lim et al., 1993; Valenti, Lim, Heller, & Knapp, 1996).

The successful administration of the questionnaire to more than 5200 cardiac patients has been documented in several studies (Dixon, Lim, Powell, & Fisher, 2000; Foster et al., 1995; Heller, Knapp, Valenti, & Dobson, 1993; Heller, Lim, Valenti, & Knapp, 1997; N. Oldridge et al., 1991; H. J. Smith, Taylor, & Mitchell, 2000). Numerous studies have examined the validity and reliability of the MacNew questionnaire (Dixon, Lim, & Oldridge, 2002; Hillers et al., 1994; Lim, Johnson, O'Connell, & Heller, 1998; Lim et al., 1993; Valenti et al., 1996). The MacNew items cover the major aspects of a comprehensive QOL framework; which is an indicator of its acceptable content validity (Hillers et al., 1994). Construct validity of the MacNew was established by identifying three main domains (i.e., physical, emotional, and social) which explain 63.0 – 66.5% of the variance. It was further confirmed by the MacNew score distinguishing among groups with known differences in factors such as age, gender, previous MI, CABG, and re-hospitalization (Lim et al., 1993; Valenti et al., 1996). Furthermore, the MacNew score has been shown to predict the rates of adverse events following discharge in ischemic heart disease patients (Lim et al., 1998).

The reliability of the MacNew was examined by assessing internal consistency and reproducibility. The internal consistency of the questionnaire has been reported to range between 0.93 and 0.95 (Valenti et al., 1996). Also, with an acceptable reproducibility of at least 0.70, it is considered as a highly reliable measurement tool (Aaronson et al., 2002). The Questionnaire has been shown to be responsive and sensitive to changes in QOL (Aaronson et al., 2002); with a change of 0.5 in the scores (i.e., global and individual scales scores) considered as the smallest

difference which is clinically important (Dixon et al., 2002). Moreover, MacNew can detect the changes in QOL during CR in patients with different cardiac diagnoses (Maes, De Gucht, Goud, Hellemans, & Peek, 2008). In summary, the MacNew is a valuable instrument to evaluate QOL in cardiac patients. It can be administered to different cardiac patient groups, such as heart surgery (i.e., valve surgery and CABG), patients with implantable cardioverter defibrillator, MI patients with and without percutaneous coronary intervention, patients with stable angina with and without percutaneous coronary intervention, and heart failure patients (Maes et al., 2008). It takes maximum of 10 minutes to complete the questionnaire which makes it highly acceptable for the respondents (Hofer et al., 2004).

Chapter 3

Impact of Supervised Exercise Rehabilitation on Daily Physical Activity of Cardiopulmonary Patients[1]

3.1. Introduction

It is well known that there is an inverse linear relationship between amount of aerobic physical activity (PA) and mortality in patients with cardiopulmonary disorders. In fact, regular aerobic PA of moderate to vigorous intensity has been associated with a lower risk of all-cause mortality, respiratory-related hospitalisations and mortality, as well as the incidence of and mortality from cardiovascular disease (Garber et al., 2011; Garcia-Aymerich et al., 2006; Haapanen et al., 1996; Haennel & Lemire, 2002; Leon et al., 1987). Consequently, aerobic PA is considered a core component of cardiopulmonary rehabilitation programs (American Association of Cardiovascular and Pulmonary Rehabilitation, 1999; Nici et al., 2006). While an improved exercise capacity is considered one of the benchmark outcomes associated with completion of an exercise rehabilitation (ER) program (Lacasse et al., 2007; Maines et al., 1997), research suggests that this increased exercise capacity may not be indicative of a more active lifestyle following completion of the ER program (R. van den Berg-Emons et al., 2004). Indeed the impact of ER programs on the objectively measured quantity and quality of daily PA in cardiopulmonary patients is not completely understood.

[1] A version of this chapter has been published:
Ramadi, A., Stickland, M. K., Rodgers, W. M., & Haennel, R. G. (2015). Impact of supervised exercise rehabilitation on daily physical activity of cardiopulmonary patients. *Heart Lung, 44*(1), 9-14. doi: 10.1016/j.hrtlng.2014.11.001.

Earlier studies which have attempted to objectively measure daily PA of ER participants have reported mixed findings, which may be attributed to the types of devices used to assess PA (Coronado et al., 2003; Cowie et al., 2011; Mador, Patel, & Nadler, 2011; Pitta et al., 2008; Sewell, Singh, Williams, Collier, & Morgan, 2005; Steele et al., 2008; Steele et al., 2003; R. van den Berg-Emons et al., 2004; Walker, Burnett, Flavahan, & Calverley, 2008). PA outcomes reported in these studies have been obtained using devices such as simple accelerometers which provide only a general view of PA status (e.g., vector magnitude, signal counts, mean activity score, etc.). By integrating accelerometer data with data from multiple physiological sensors a more accurate measure of the entire spectrum of PA from low-intensity PA, which is often underestimated by simple accelerometers, to vigorous PA may be obtained (Mackey et al., 2011). Therefore the purpose of this study was to use a multi-sensor device to objectively assess the impact of a supervised ER program on the quantity and quality of daily PA of patients with cardiopulmonary disorders.

3.2. Methods

3.2.1. Study Design and Participants

This was a prospective one group pretest-posttest study. Participants were cardiac or pulmonary patients who participated in supervised ER programs. Both males and females $\geq$ 60 years of age were included. All participants were medically stable (i.e., no changes in medication during the study), receiving optimal medical therapy and were able to participate in exercise. Patients were excluded if they had 1) exercise-limiting non-cardiopulmonary co-morbidity (i.e., orthopedic, neuromuscular, etc.); 2) uncontrolled hypertension (resting, seated blood pressure $\geq$ 160 systolic or $\geq$ 90 diastolic); 3) unstable cardiac disease or previous coronary artery bypass graft (CABG) surgery, or New York Heart Association (NYHA) functional classification class

III or IV; 4) recent respiratory exacerbation; 5) required supplemental oxygen; 6) cognitive dysfunction; or 7) there was a profound language barrier. This study was approved by the university's health research ethics board (Appendix A) and written informed consent was obtained from each participant prior to their entry into the study.

Patients referred for ER who met the inclusion criteria were approached by an ER staff member and informed about the ongoing study. Those who expressed an interest in participating were contacted by one of the investigators and the study was explained in detail. Upon obtaining written informed consent, demographic information was documented followed by baseline assessments. Participants completed a twice weekly ER program (i.e., 8-10 weeks, 16-20 sessions in total) in either a cardiac or pulmonary ER facility. Exercise sessions consisted of stretching, aerobic, and strengthening exercises. Aerobic training was performed on a treadmill or cycle ergometer for 40 minutes at the intensity based on patients' exercise tolerance. All participants were encouraged to supplement their ER program with unsupervised PA on non-training days. Moreover, topics such as staying active were discussed in education classes. At the end of the ER program all assessments were repeated.

3.2.2. Outcome Measures

3.2.2.1. Exercise capacity. To assess exercise capacity, a 6 minute walk test (6MWT) was completed following the American Thoracic Society guidelines ("ATS statement: guidelines for the six-minute walk test," 2002). 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, or became pale or ashen in appearance.

3.2.2.2. Physical activity. Daily PA was assessed objectively using the SenseWear Pro™ Armband (SWA; BodyMedia, Pittsburgh, PA). The SWA is a dual axis accelerometer that uses

multiple additional sensors (i.e., heat flux, galvanic skin response, near body temperature, and skin temperature) to estimate energy expenditure (EE). It also provides information about step counts (steps/day) and time spent in different intensities of PA (i.e., sedentary, light, moderate or vigorous). The SWA has been validated against the doubly labeled water technique and has shown strong correlation with it when estimating daily EE ($r = 0.89$) (Mackey et al., 2011). The SWA has been shown to be a valid device to assess PA in many populations (e.g., both cardiac and pulmonary patients) (Cole, LeMura, Klinger, Strohecker, & McConnell, 2004; Hill, Dolmage, Woon, Goldstein, & Brooks, 2010). It should be noted that this device does not provide information on the type of PA; however our focus was on the intensity and duration of PA.

Participants were instructed to wear the SWA on the back of the upper right arm for at least 3 full days. They wore the device throughout the day and removed it when bathing or showering. To ensure an accurate representation of their daily PA, the average of three days was used. Using the SWA data, steps/day was calculated by averaging the total number of steps taken each minute for all three days. As it has been recommended that a minimum of 5,500 steps/day is associated with optimal health benefits in sedentary older adults and/or individuals with disability and chronic conditions, we also recorded the number of participants meeting this target at each assessment point (Tudor-Locke et al., 2011).

Using EE data we obtained information on the time spent in different PA intensities. Participants were considered sedentary whenever energy expenditure was $\leq$ 1.5 metabolic equivalents (METs) (Pate et al., 2008). Sedentary waking time was also calculated after excluding the sleep data from overall sedentary time. Light PA was defined as activities which required an energy expenditure of 1.6-2.9 METs (e.g., activities of daily living [ADL]) (Pate et

al., 2008). Moderate to vigorous PA (MVPA) included activities with an energy expenditure of ≥ 3.0 METs (Pate et al., 1995).

For time spent in MVPA guidelines recommend accumulating bouts of at least 10 minutes (Garber et al., 2011; Haskell et al., 2007). Therefore we inspected the data to determine both the total minutes of MVPA and continuous MVPA occurring in ≥10 minutes bouts (i.e., $MVPA_{10+}$). To count as an $MVPA_{10+}$ the bout had to exceed the moderate intensity cut-point of 3 METs for a minimum of 10 consecutive minutes with allowance for a maximum of two observations falling below the cut-point during the period (i.e., 8 out of 10 minutes) (Colley et al., 2011). For both total MVPA and $MVPA_{10+}$ we also recorded PA energy expenditure (PAEE) (i.e., $PAEE_{(\geq 3\ METs)}$ and $PAEE_{10+\ (\geq 3\ METs)}$). The $PAEE_{(\geq 3\ METs)}$ is often used as the threshold intensity required for the health benefits (Garber et al., 2011; Haskell et al., 2007). In this study of older adults with cardiopulmonary disorders, we also used the second marker which was defined as PA requiring an energy expenditure >1.5 METs (i.e., $PAEE_{(>1.5\ METs)}$); and is an appropriate measure of the sedentary/activity threshold for older adults (Dogra & Stathokostas, 2012).

3.2.3. Statistical Analysis

Normality of the data was analyzed using the Kolmogorov-Smirnov test. Changes in variables with normal distribution were analyzed using paired t-tests. Wilcoxon Signed Ranks tests were used to analyze the changes in variables with violated normality assumption. Further, some secondary analyses were undertaken to address the concern that the dependent variables might have been influenced by the patient group (i.e., cardiac vs. pulmonary). Participants' demographics at baseline were compared between the two patient groups using un-paired t-test (normally distributed variable), Mann-Whitney U test (non-normal variable) or chi-squared

statistics (categorical variable). Mixed Between-Within Subjects Analysis of Variances were used to determine if the patterns of changes in variables over time were parallel across the two patient groups.

The McNemar test was used to analyze the change in proportion of participants who met the minimum recommended daily steps criteria from baseline to end of ER. The relationships between change in 6MWT distance and changes in measures of PA were also analyzed using Pearson correlations. All tests with a $p < 0.05$ were considered significant. All analyses were conducted using SPSS version 21.

3.3. Results

A total of 37 patients (16 cardiac: 21 pulmonary) with the mean age of 75 years participated in this study. Baseline demographics and clinical data are presented in Table 3.1. Participants wore the SWA for 21 ± 3 hours/day at baseline and 20 ± 3 hours/day at the end of ER ($p = 0.149$). All but one participant completed the 6MWT. With $\alpha = 0.05$ and sample size of $n = 37$ this study had the power of ~ 0.70 to detect the change in PA energy expenditure (i.e., $PAEE_{(>1.5\ METs)}$) with the effect size of $d = 0.57$.

3.3.1. Exercise Capacity

As would be anticipated the 6MWT distance was greater at the end of the ER program (444 ± 101 m vs. baseline: 396 ± 91 m; $p = 0.000$).

3.3.2. Step Counts

The average daily step count increased significantly at the end of the ER program (Table 3.2). At baseline 24% of participants met the threshold of 5,500 steps/day whereas at the end of ER 40% achieved this threshold. However, the increase in the proportion of participants meeting the daily step count goal was not significant ($p = 0.070$). Also, we examined the number of daily

steps taken at the intensities of > 1.5 METs and ≥ 3 METs (i.e., steps/day $_{(>1.5METs)}$ and steps/day $_{(\geq 3METs)}$). The steps/day $_{(>1.5METs)}$ increased significantly; whereas steps taken above 3 METs (i.e., steps/day $_{(\geq 3METs)}$) remained unchanged (Table 3.2).

3.3.3. Time in Different PA Intensities

Sedentary time showed a significant decline from baseline to the end of ER. Participants spent approximately 77% of their waking hours sedentary (≤ 1.5 METs) at baseline which dropped to 73% at the end of the ER. While sedentary time decreased, participants increased time spent in light PA (Table 3.2). However, time spent in MVPA did not change from baseline to the end of ER. At baseline participants spent 48 ± 48 min/day in MVPA (Median= 28); of this 27 ± 37 min/day (Median=12) was spent in continuous bouts of PA which were a minimum of 10 min in duration (i.e., $MVPA_{10+}$). At the end of the ER program they averaged 59 ± 65 min/day (Median= 43) and 36 ± 52 min/day (Median= 19) in MVPA and $MVPA_{10+}$ respectively. It is noteworthy that time spent in $MVPA_{10+}$ remained unchanged over the course of the study (Table 3.2).

3.3.4. Energy Expenditure

Data from the SWA indicated that the total daily EE was unaffected by the ER program (baseline: 1,878 ± 434 kcal/day vs. ER completion: 1,960 ± 567 kcal/day; p = 0.185). There was a significant increase in the PAEE $_{(>1.5\ METs)}$ from baseline to the end of ER. However, when PAEE was defined as EE ≥ 3 METs there was no significant change from baseline to end of ER in either total PAEE $_{(\geq 3\ METs)}$ or $PAEE_{10+\ (\geq 3\ METs)}$. At baseline, PAEE $_{(\geq 3\ METs)}$ accounted for 227 ± 213 kcal/day (Median= 119) with 125 ± 173 kcal/day (Median=55) spent in continuous bouts of PA ≥10 min (i.e., $PAEE_{10+\ (\geq 3\ METs)}$). At the end of the ER program participants averaged 306

± 371 kcal/day (Median= 198) of PAEE $_{(\geq 3\ METs)}$; however only 180 ± 291 kcal/day (Median= 104) was spent in ≥10 min bouts (i.e., $PAEE_{10+\ (\geq 3\ METs)}$) (Table 3.2).

Results from the secondary analyses indicated that at baseline, there were no significant differences in mean age (cardiac: 75 ± 7 years vs. pulmonary: 74 ± 6 years; p = 0.538), body mass index (BMI) (cardiac: 27 ± 5 kg/m^2 vs. pulmonary: 29 ± 6 kg/m^2; p = 0.252), or gender distribution (cardiac male: 56% vs. pulmonary male: 62%; p = 0.993) between the two patient groups (i.e., cardiac vs. pulmonary). Mixed Between-Within Subjects Analysis of Variance revealed no significant Group × Time interactions for the assessed variables (Table 3.3). This indicates that changes in variables over time were not influenced by the patient group. In fact the patterns of changes in variables over time were parallel across the two groups. However, cardiac patients had higher steps/day, steps/day $_{(>1.5METs)}$, steps/day $_{(\geq 3METs)}$, PAEE $_{(\geq 3\ METs)}$, and time spent in MVPA and $MVPA_{10+}$ compared to pulmonary patients over the course of the study (Table 3.3).

3.3.5. Relationship Between Exercise Capacity and PA Measures

There was no correlation between the change in 6MWT distance and the changes in the various PA measures (Table 3.4).

3.4. Discussion

The purpose of this study was to assess the impact of a supervised ER program on the daily PA of patients with cardiopulmonary disorders. A key finding from this study was the significant decrease in sedentary time with a corresponding increase in light PA at the completion of ER. However, there was no significant change in the time spent in MVPA. This finding is consistent with the results from a similar study on pulmonary patients (Coronado et al., 2003). Coronado et al. (2003) used a uniaxial accelerometer to measure the time spent in

different walking speeds and noted no change in the time spent walking at a moderate-vigorous intensity (i.e., > 5km/hr.) post-ER.

The decline in sedentary time along with the increase in the time spent in light PA implies that our participants were more mobile after completing the program which is in agreement with the results from previous studies (Pitta et al., 2008; Walker et al., 2008). Pitta et al. (2008) used triaxial accelerometer to measure PA and noted a significant increase in mean walking time at the completion of the ER program. Interestingly, most of their participants whose walking time increased showed a decline in time spent lying down. This parallels our findings on less sedentary time after ER. Using a uniaxial accelerometer Walker et al. (2008) reported that their subjects spent higher percentage of recording time moving at the post-ER assessment. Our results suggest that ER did not impact MVPA; however it did result in a PA behavior change at the lower end of the PA continuum.

Recently it has been suggested that sedentary behavior and the lack of MVPA have different influences on health outcomes; and thus need to be considered as separate risk factors (M. T. Hamilton et al., 2004; Owen et al., 2010; Tremblay et al., 2010). Various studies have shown deleterious association between sedentary time and risk factors (e.g., waist circumference and triglycerides) and mortality independent of MVPA (Healy et al., 2008; Katzmarzyk et al., 2009). Furthermore, light PA which is hard to capture in the assessments by self-report measures is often considered part of sedentary behavior (Pate et al., 2008). However, light PA (i.e., PA in the 1.6-2.9 MET range) is a major contributing factor in the total daily EE and should be assessed as a separate component of the activity continuum (Pate et al., 2008). It has been documented that there is an inverse relationship between light PA and waist circumference and metabolic risk factors independent of MVPA (Healy et al., 2007; Healy et al., 2008). There is

also evidence indicating that sedentary time is often replaced with light PA rather than MVPA. In fact when sedentary time is decreased, time spent in light PA typically increases (Healy et al., 2008). This is consistent with our findings and underscores the view that ER can lead to increased PA even if it is not in the MVPA range. Improvement in light PA which often aligns with ADL might be of more importance to older patients with chronic conditions (Cress & Meyer, 2003).

A commonly used method to assess PA in both healthy and patient populations is step count assessed by either pedometers or accelerometers. Our participants took significantly more steps at the completion of ER; which is a promising finding compared to the results from similar studies in cardiac and pulmonary patients (Cowie et al., 2011; Dallas, McCusker, Haggerty, Rochester, & Zuwallack, 2009). However, our participants' average daily step count still fell below the recommended threshold (i.e., 5,500 steps/day). The fact that the participants failed to achieve the threshold may mitigate the importance of the observed increased step count at the end of ER. However, focusing exclusively on step counts does not provide a true indication of overall changes in PA as it does not provide any indication of activity intensity and excludes non-ambulatory activities.

It is noteworthy that compared with other accelerometer-based monitors SWA provides a more accurate estimate of energy expenditure in non-ambulatory activities (e.g., during cycling) (Fruin & Rankin, 2004). Results from our assessment of PAEE suggest that changes in daily PA occurred in the light PA range rather than in MVPA. At the end of ER our participants averaged 836 kcal/day in PAEE $_{(>1.5\ METs)}$. There is evidence that free living PAEE >770 kcal/day is associated with significantly lower mortality risk (Manini et al., 2006). Further, our analysis of the relationship between step count and PA intensity (i.e., >1.5 METs vs. ≥ 3 METs) confirmed

that the observed increment in steps was during light intensity PA. Combined these findings imply clinical significance of the observed results despite the failure in achieving the recommended threshold for step counts. Our findings may also suggest that activities requiring EE >1.5 METs might be more appropriate measure of the activity threshold for older adults. This observation parallels findings from previous research that emphasized the importance of a sedentary/activity threshold at 1.5 METs in older adults population (Dogra & Stathokostas, 2012).

In general, our findings highlight the fact that participation in ER appears to increase daily PA but more so in the light intensity level which aligns with ADL. This observation adds credence to the "whole-of-day" approach which underlines the importance of considering the entire spectrum of PA from sedentary behavior to spontaneous light intensity PA and MVPA over the whole day rather than focusing exclusively on regimented bouts of MVPA (Manns, Dunstan, Owen, & Healy, 2012). This approach encourages lowering sedentary time and increasing time spent in light PA in addition to promoting MVPA (Healy et al., 2007; Manns et al., 2012; Owen et al., 2010; Tremblay et al., 2010; Tremblay, Esliger, Tremblay, & Colley, 2007). In a review on individuals with mobility disabilities, Manns et al. (2012) stated that focusing on sedentary time and light PA may be more feasible when starting the PA behavior change and may lead to more successful and sustainable results. These observations may be equally applicable to other chronic disease populations. Being habitually inactive, individuals with cardiopulmonary disorders could be a good target for this approach. The results from the present study confirm that, in this population, changes in the high end of the PA continuum (i.e., MVPA) may not be easily achieved through the current approaches to ER. However, such programs may have a positive impact on both sedentary time and overall daily activity.

While we observed increases in exercise capacity and daily PA, the two measures are not necessarily related. Present findings indicate that increased exercise capacity does not necessarily result in a more active lifestyle. In fact an increase in exercise capacity alone may not be sufficient to change the habitual sedentary lifestyle (Larson, 2007). Our results parallel the findings by Zwerink, van der Palen, van der Valk, Brusse-Keizer, and Effing (2013) who reported only a moderate to weak relationship between change in daily PA and change in exercise capacity in a group of pulmonary patients post-ER. These authors suggested that in order to improve exercise capacity and PA behavior, ER programs need to design interventions to target both factors. This could be accomplished by adding behavioral change techniques such as cognitive behavioral therapy or motivational interviewing to the exercise training programs.

3.4.1. Limitations

Findings should be interpreted cautiously due to the small sample size, lack of a control group and variations in patient groups and ER settings. As exercise is considered a core component of cardiopulmonary rehabilitation we were unable to include a non-exercise group (American Association of Cardiovascular and Pulmonary Rehabilitation, 1999; Nici et al., 2006). Our secondary analysis revealed that the observed changes were not influenced by any variations in patient groups or ER setting.

The timing of our PA assessments varied across the two patient groups but was consistent for each participant (e.g. Cardiac = Pre-ER to Post ER; Pulmonary = 1st week ER to last week ER). Moreover, results from the secondary analysis revealed that the patterns of changes over time were parallel across the two groups.

Some might suggest that findings from present study may also have been influenced by the number of days that PA was monitored. In the current study we monitored PA for 3 days at

each assessment point. According to the study by Rowe, Kemble, Robinson, and Mahar (2007) two monitoring days are sufficient in an older population (i.e., > 60 years) due to the lower intra-individual variability between monitoring days.

Furthermore, large variations were observed in some of our variables. This could not be addressed by excluding participants; as the sample would lose its representativeness. Also, it is unlikely increasing the sample size would result in a lower degree of variation. However, a larger sample could give us the advantage of more power as well as the opportunity to investigate the sample by splitting it into different activity groups.

3.4.2. Clinical Implications

Our findings underline the value of a thorough PA assessment in patients who are referred to ER programs. For patients entering ER it is imperative that the supervising clinicians have an understanding of their patient's current PA. As was observed, the majority of these patients appear to be habitually inactive. Therefore changes in the high end of the PA continuum (i.e., MVPA) may not be easily achieved or maintained (Bock et al., 2003). A more achievable goal may be to encourage these patients to reduce sedentary time and increase light PA. Once this is accomplished patients might be better equipped to transition to MVPA.

3.4.3. Future Research

By assessing a patient's current PA level we can customize ER programs to that participant's needs and abilities. Research can then assess the impact of such programming on long-term PA compliance. Further the use of accelerometers could be valuable in examining fatigue by assessing variations in the spectrum of PA on an exercise day versus a non-exercise day. Finally, future studies may benefit from the inclusion of a non-exercise control group to ascertain the impact of ER on daily PA of the participants.

3.5. Conclusions

Findings from the present study imply that changes in daily PA in patients participating in ER occur in activities where the EE is in light intensity rather than in MVPA. These results would suggest that for older individuals with cardiopulmonary disorders, ER programs appear to be consistent with the "whole-of-day" approach to increase PA. Our findings also indicate that increased exercise capacity does not necessarily result in a more active lifestyle, as the improvement in exercise capacity was unrelated to increases in PA.

Table 3.1. Baseline sample demographics and clinical characteristics

Demographics	
Age (years)	74.6 (6.2)
Male	22 (59.5%)
BMI (kg/m^2)	28.3 (5.6)
Primary diagnosis	
Anterior MI	2 (5.4%)
NSTEMI	8 (21.6%)
STEMI	6 (16.2%)
Asthma	3 (8.1%)
Bronchiectasis	1 (2.7%)
Lung cancer	1 (2.7%)
COPD	12 (32.4%)
Pulmonary fibrosis	4 (10.8%)

BMI: body mass index; MI: myocardial infarction; NSTEMI: non ST segment elevation myocardial infarction; STEMI: ST segment elevation myocardial infarction; COPD: chronic obstructive pulmonary disease.
Data are presented as mean (standard deviation) or as the absolute number (percentage).

Table 3.2. Changes in daily physical activity from baseline to exercise rehabilitation completion

	Baseline	**ER completion**	**p value[a]**
Steps/day	4006 (2317)	4505 (2536)	0.024
Steps/day $_{(>1.5\ METs)}$	3544 (2200)	4032 (2481)	0.027
Steps/day $_{(\geq 3\ METs)}$	1573 (1557)	1822 (1676)	0.331
Sedentary time (hours/day)	17.33 (3.44)	15.98 (3.64)	0.005
Waking sedentary time (% waking hours)	77.04 (8.64)	72.55 (11.30)	0.002
Light PA (hours/day)	2.76 (1.16)	3.12 (1.33)	0.045
MVPA (min/day)	47.91 (47.68)	59.21 (64.58)	0.298
$MVPA_{10+}$ (min/day)	27.31 (36.95)	35.72 (51.61)	0.393
PAEE $_{(>1.5\ METs)}$ (kcal/day)	676.18 (265.91)	836.45 (483.91)	0.015
PAEE $_{(\geq 3\ METs)}$ (kcal/day)	226.54 (213.35)	306.50 (371.27)	0.236
$PAEE_{10+}$ $_{(\geq 3\ METs)}$ (kcal/day)	125.26 (172.84)	180.07 (290.69)	0.309

ER: exercise rehabilitation; MET: metabolic equivalent; PA: physical activity; Sedentary: ≤ 1.5 METs; Light: 1.6-2.9 METs; MVPA: moderate-vigorous (≥ 3 METs) physical activity; $MVPA_{10+}$: moderate-vigorous physical activity in bouts ≥10 min; PAEE: physical activity energy expenditure; $PAEE_{10+}$: physical activity energy expenditure in bouts ≥10 min.
Data are presented as mean (standard deviation).
[a] Paired t-tests and Wilcoxon signed rank tests were used for analyses; The level of significance was set at $p < 0.05$.

Table 3.3. Exercise capacity and daily physical activity over time by patient group

	Cardiac		Pulmonary		
	Baseline	**ER completion**	**Baseline**	**ER completion**	**p value[a]**
6MWT[b] (m)	421 (98)	484 (85)	376 (82)	412 (104)	0.140
Armband on body time (hours/day)	21 (2)	20 (3)	21 (4)	20 (4)	0.652
Steps/day[b,c]	4984 (1881)	5416 (2088)	3260 (2378)	3811 (2672)	0.784
Steps/day $_{(>1.5\ METs)}$[b,c]	4484 (1747)	4943 (2004)	2828 (2276)	3338 (2627)	0.906
Steps/day $_{(\geq 3\ METs)}$[c]	2314 (1378)	2365 (1353)	1007 (1471)	1409 (1807)	0.293
Sedentary time[b] (hours/day)	17.4 (2.3)	15.8 (2.7)	17.3 (4.2)	16.1 (4.3)	0.657
Waking sedentary time[b] (% waking hours)	75 (7)	70 (11)	79 (10)	75 (11)	0.701
Light PA[b] (hours/day)	2.6 (1.0)	3.1 (1.4)	2.9 (1.3)	3.1 (1.3)	0.589
MVPA[c] (min/day)	71.1 (53.7)	76.1 (75.6)	30.3 (34.2)	46.3 (53.1)	0.598
$MVPA_{10+}$[c] (min/day)	43.0 (43.6)	48.3 (63.7)	15.3 (26.2)	26.1 (39.1)	0.747
Daily EE (kcal/day)	1898 (411)	2021 (747)	1863 (461)	1914 (394)	0.568
PAEE $_{(>1.5\ METs)}$[b] (kcal/day)	744 (184)	945 (594)	625 (309)	754 (374)	0.594
PAEE $_{(\geq 3\ METs)}$[c] (kcal/day)	316 (188)	413 (479)	158 (210)	225 (244)	0.781
$PAEE_{10+\ (\geq 3\ METs)}$ (kcal/day)	181 (154)	257 (384)	83 (178)	122 (182)	0.672

ER: exercise rehabilitation; 6MWT: 6 minute walk test; MET: metabolic equivalent; PA: physical activity; Sedentary: ≤ 1.5 METs; Light: 1.6-2.9 METs; MVPA: moderate-vigorous (≥ 3 METs) physical activity; $MVPA_{10+}$: moderate-vigorous physical activity in bouts ≥10 min; EE: energy expenditure; PAEE: physical activity energy expenditure; $PAEE_{10+}$: physical activity energy expenditure in bouts ≥10 min.

Data are presented as mean (standard deviation). [a] p values of Group × Time interactions; [b] Indicates significant change from baseline to ER completion; [c] Indicates significant difference between the two groups; The level of significance was set at $p < 0.05$.

Table 3.4. Correlations between change in six minute walk distance and changes in physical activity measures

PA measure change	Exercise capacity change	R	p value
	Δ 6MWT		
Δ Steps/day		-0.051	0.766
Δ Steps/day (>1.5 METs)		-0.057	0.741
Δ Sedentary time (hours/day)		0.128	0.455
Δ Waking sedentary time (% waking hours)		0.188	0.273
Δ Light PA (hours/day)		0.067	0.698
Δ PAEE (>1.5 METs) (kcal/day)		-0.157	0.362

PA: physical activity; 6MWT: 6 minute walk test; MET: metabolic equivalent; Sedentary: ≤ 1.5 METs; Light: 1.6-2.9 METs; PAEE: physical activity energy expenditure.
The level of significance was set at $p < 0.05$; No significant correlation was found between change in 6MWT distance and changes in PA measures.

3.6. References

American Association of Cardiovascular and Pulmonary Rehabilitation (1999). *Guidelines for Cardiac Rehabilitation and Secondary Prevention Programs*. Champaign, IL: Human Kinetics.

ATS statement: guidelines for the six-minute walk test. (2002). *Am J Respir Crit Care Med, 166*(1), 111-117. doi: 10.1164/ajrccm.166.1.at1102

Bock, B. C., Carmona-Barros, R. E., Esler, J. L., & Tilkemeier, P. L. (2003). Program participation and physical activity maintenance after cardiac rehabilitation. *Behav Modif, 27*(1), 37-53.

Cole, P. J., LeMura, L. M., Klinger, T. A., Strohecker, K., & McConnell, T. R. (2004). Measuring energy expenditure in cardiac patients using the Body Media Armband versus indirect calorimetry. A validation study. *J Sports Med Phys Fitness, 44*(3), 262-271.

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011). Physical activity of Canadian adults: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Rep, 22*(1), 7-14.

Coronado, M., Janssens, J. P., de Muralt, B., Terrier, P., Schutz, Y., & Fitting, J. W. (2003). Walking activity measured by accelerometry during respiratory rehabilitation. *Journal of Cardiopulmonary Rehabilitation, 23*(5), 357-364.

Cowie, A., Thow, M. K., Granat, M. H., & Mitchell, S. L. (2011). A comparison of home and hospital-based exercise training in heart failure: immediate and long-term effects upon physical activity level. *Eur J Cardiovasc Prev Rehabil, 18*(2), 158-166. doi: 1741826710389389 [pii]

10.1177/1741826710389389

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

Dallas, M. I., McCusker, C., Haggerty, M. C., Rochester, C. L., & Zuwallack, R. (2009). Using pedometers to monitor walking activity in outcome assessment for pulmonary rehabilitation. *Chron Respir Dis, 6*(4), 217-224. doi: 6/4/217 [pii]

10.1177/1479972309346760

Dogra, S., & Stathokostas, L. (2012). Sedentary behavior and physical activity are independent predictors of successful aging in middle-aged and older adults. *J Aging Res, 2012*, 190654. doi: 10.1155/2012/190654

Fruin, M. L., & Rankin, J. W. (2004). Validity of a multi-sensor armband in estimating rest and exercise energy expenditure. *Med Sci Sports Exerc, 36*(6), 1063-1069.

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I. M., . . . Swain, D. P. (2011). 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, 43*(7), 1334-1359. doi: 10.1249/MSS.0b013e318213fefb

Garcia-Aymerich, J., Lange, P., Benet, M., Schnohr, P., & Anto, J. M. (2006). Regular physical activity reduces hospital admission and mortality in chronic obstructive pulmonary disease: a population based cohort study. *Thorax, 61*(9), 772-778. doi: 10.1136/thx.2006.060145

Haapanen, N., Miilunpalo, S., Vuori, I., Oja, P., & Pasanen, M. (1996). Characteristics of leisure time physical activity associated with decreased risk of premature all-cause and cardiovascular disease mortality in middle-aged men. *Am J Epidemiol, 143*(9), 870-880.

Haennel, R. G., & Lemire, F. (2002). Physical activity to prevent cardiovascular disease. How much is enough? *Can Fam Physician, 48*, 65-71.

Hamilton, M. T., Hamilton, D. G., & Zderic, T. W. (2004). Exercise physiology versus inactivity physiology: an essential concept for understanding lipoprotein lipase regulation. *Exerc Sport Sci Rev, 32*(4), 161-166.

Haskell, W. L., Lee, I. M., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A., . . . Bauman, A. (2007). Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc, 39*(8), 1423-1434. doi: 10.1249/mss.0b013e3180616b27

Healy, G. N., Dunstan, D. W., Salmon, J., Cerin, E., Shaw, J. E., Zimmet, P. Z., & Owen, N. (2007). Objectively measured light-intensity physical activity is independently associated with 2-h plasma glucose. *Diabetes Care, 30*(6), 1384-1389. doi: 10.2337/dc07-0114

Healy, G. N., Wijndaele, K., Dunstan, D. W., Shaw, J. E., Salmon, J., Zimmet, P. Z., & Owen, N. (2008). Objectively measured sedentary time, physical activity, and metabolic risk: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Diabetes Care, 31*(2), 369-371. doi: dc07-1795 [pii]

10.2337/dc07-1795

Hill, K., Dolmage, T. E., Woon, L., Goldstein, R., & Brooks, D. (2010). Measurement properties of the SenseWear armband in adults with chronic obstructive pulmonary disease. *Thorax, 65*(6), 486-491. doi: 10.1136/thx.2009.128702

Katzmarzyk, P. T., Church, T. S., Craig, C. L., & Bouchard, C. (2009). Sitting time and mortality from all causes, cardiovascular disease, and cancer. *Med Sci Sports Exerc, 41*(5), 998-1005. doi: 10.1249/MSS.0b013e3181930355

Lacasse, Y., Martin, S., Lasserson, T. J., & Goldstein, R. S. (2007). Meta-analysis of respiratory rehabilitation in chronic obstructive pulmonary disease. A Cochrane systematic review. *Eura Medicophys, 43*(4), 475-485.

Larson, J. L. (2007). Functional performance and physical activity in chronic obstructive pulmonary disease: theoretical perspectives. *COPD, 4*(3), 237-242. doi: 10.1080/15412550701480372

Leon, A. S., Connett, J., Jacobs, D. R., Jr., & Rauramaa, R. (1987). Leisure-time physical activity levels and risk of coronary heart disease and death. The Multiple Risk Factor Intervention Trial. *JAMA, 258*(17), 2388-2395.

Mackey, D. C., Manini, T. M., Schoeller, D. A., Koster, A., Glynn, N. W., Goodpaster, B. H., . . . Cummings, S. R. (2011). Validation of an armband to measure daily energy expenditure in older adults. *J Gerontol A Biol Sci Med Sci, 66*(10), 1108-1113. doi: 10.1093/gerona/glr101

Mador, M. J., Patel, A. N., & Nadler, J. (2011). Effects of pulmonary rehabilitation on activity levels in patients with chronic obstructive pulmonary disease. *J Cardiopulm Rehabil Prev, 31*(1), 52-59. doi: 10.1097/HCR.0b013e3181ebf2ef

Maines, T. Y., Lavie, C. J., Milani, R. V., Cassidy, M. M., Gilliland, Y. E., & Murgo, J. P. (1997). Effects of cardiac rehabilitation and exercise programs on exercise capacity, coronary risk factors, behavior, and quality of life in patients with coronary artery disease. *South Med J, 90*(1), 43-49.

Manini, T. M., Everhart, J. E., Patel, K. V., Schoeller, D. A., Colbert, L. H., Visser, M., . . . Harris, T. B. (2006). Daily activity energy expenditure and mortality among older adults. *JAMA, 296*(2), 171-179. doi: 10.1001/jama.296.2.171

Manns, P. J., Dunstan, D. W., Owen, N., & Healy, G. N. (2012). Addressing the nonexercise part of the activity continuum: a more realistic and achievable approach to activity programming for adults with mobility disability? *Phys Ther, 92*(4), 614-625. doi: 10.2522/ptj.20110284

Nici, L., Donner, C., Wouters, E., Zuwallack, R., Ambrosino, N., Bourbeau, J., . . . ATS/ERS Pulmonary Rehabilitation Writing Committee. (2006). American Thoracic Society/European Respiratory Society statement on pulmonary rehabilitation. *Am J Respir Crit Care Med, 173*(12), 1390-1413. doi: 10.1164/rccm.200508-1211ST

Owen, N., Sparling, P. B., Healy, G. N., Dunstan, D. W., & Matthews, C. E. (2010). Sedentary behavior: emerging evidence for a new health risk. *Mayo Clin Proc, 85*(12), 1138-1141. doi: 10.4065/mcp.2010.0444

Pate, R. R., O'Neill, J. R., & Lobelo, F. (2008). The evolving definition of "sedentary". *Exerc Sport Sci Rev, 36*(4), 173-178. doi: 10.1097/JES.0b013e3181877d1a

Pate, R. R., Pratt, M., Blair, S. N., Haskell, W. L., Macera, C. A., Bouchard, C., . . . et al. (1995). Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA, 273*(5), 402-407.

Pitta, F., Troosters, T., Probst, V. S., Langer, D., Decramer, M., & Gosselink, R. (2008). Are patients with COPD more active after pulmonary rehabilitation? *Chest, 134*(2), 273-280. doi: 10.1378/chest.07-2655

Rowe, D. A., Kemble, C. D., Robinson, T. S., & Mahar, M. T. (2007). Daily walking in older adults: day-to-day variability and criterion-referenced validity of total daily step counts. *J Phys Act Health, 4*(4), 434-446.

Sewell, L., Singh, S. J., Williams, J. E., Collier, R., & Morgan, M. D. (2005). Can individualized rehabilitation improve functional independence in elderly patients with COPD? *Chest, 128*(3), 1194-1200. doi: 10.1378/chest.128.3.1194

Steele, B. G., Belza, B., Cain, K. C., Coppersmith, J., Lakshminarayan, S., Howard, J., & Haselkorn, J. K. (2008). A randomized clinical trial of an activity and exercise adherence intervention in chronic pulmonary disease. *Archives of Physical Medicine and Rehabilitation, 89*(3), 404-412. doi: 10.1016/j.apmr.2007.11.003; 10.1016/j.apmr.2007.11.003

Steele, B. G., Belza, B., Hunziker, J., Holt, L., Legro, M., Coppersmith, J., . . . Lakshminaryan, S. (2003). Monitoring daily activity during pulmonary rehabilitation using a triaxial accelerometer. *Journal of Cardiopulmonary Rehabilitation, 23*(2), 139-142.

Tremblay, M. S., Colley, R. C., Saunders, T. J., Healy, G. N., & Owen, N. (2010). Physiological and health implications of a sedentary lifestyle. *Appl Physiol Nutr Metab, 35*(6), 725-740. doi: 10.1139/H10-079

Tremblay, M. S., Esliger, D. W., Tremblay, A., & Colley, R. (2007). Incidental movement, lifestyle-embedded activity and sleep: new frontiers in physical activity assessment. *Can J Public Health, 98 Suppl 2*, S208-217.

Tudor-Locke, C., Craig, C. L., Aoyagi, Y., Bell, R. C., Croteau, K. A., De Bourdeaudhuij, I., . . . Blair, S. N. (2011). How many steps/day are enough? For older adults and special populations. *Int J Behav Nutr Phys Act, 8*, 80. doi: 10.1186/1479-5868-8-80

van den Berg-Emons, R., Balk, A., Bussmann, H., & Stam, H. (2004). Does aerobic training lead to a more active lifestyle and improved quality of life in patients with chronic heart failure? *Eur J Heart Fail, 6*(1), 95-100. doi: 10.1016/j.ejheart.2003.10.005

Walker, P. P., Burnett, A., Flavahan, P. W., & Calverley, P. M. (2008). Lower limb activity and its determinants in COPD. *Thorax, 63*(8), 683-689. doi: 10.1136/thx.2007.087130; 10.1136/thx.2007.087130

Zwerink, M., van der Palen, J., van der Valk, P., Brusse-Keizer, M., & Effing, T. (2013). Relationship between daily physical activity and exercise capacity in patients with COPD. *Respir Med, 107*(2), 242-248. doi: 10.1016/j.rmed.2012.09.018

Chapter 4

Long-term Physical Activity Behavior Following Completion of Fast-track Versus Traditional Center-based Cardiac Rehabilitation

4.1. Introduction

It is well known that there is an inverse relationship between physical activity (PA), all-cause mortality and mortality from cardiovascular disease (Garber et al., 2011; Haapanen et al., 1996; Haennel & Lemire, 2002; Leon et al., 1987). Previous studies have demonstrated that PA level increases in cardiac rehabilitation (CR) participants at the end of program (Blanchard et al., 2010; Karjalainen et al., 2012; Oliveira, Ribeiro, & Gomes, 2008; Ramadi, Stickland, Rodgers, & Haennel, 2015; Yohannes, Doherty, Bundy, & Yalfani, 2010). However, many patients fail to maintain optimal levels of regular PA after completing CR programs (Bethell, 1999; Bock et al., 2003; Brubaker et al., 1996; N. B. Oldridge, 1991). Interestingly, it has been suggested that CR programs which offer fewer on-site exercise sessions and include more emphasis on the off-site exercise may lead to higher adherence to a physically active lifestyle (Blair et al., 2011; Carlson et al., 2000; Marchionni et al., 2003; K. M. Smith et al., 2004; K. M. Smith et al., 2011; Witham et al., 2005; Wolkanin-Bartnik et al., 2011). This finding may be attributed to greater scheduling flexibility and an emphasis on independent exercise early in the program (Carlson et al., 2000; Chase, 2011).

When examining the impact of different CR delivery models on the PA habits of cardiac patients there appear to be mixed results (Carlson et al., 2000; Cowie et al., 2011; Marchionni et al., 2003; Oerkild et al., 2011; K. M. Smith et al., 2004). The findings may, in part, be due to the measurement methods used to assess PA. Relying solely on surrogate methods (i.e., exercise testing) is insufficient to assess overall PA participation (H. van den Berg-Emons et al., 2001).

The use of subjective measures is highly influenced by social desirability and recall bias (Ainsworth, 2009; Vanhees et al., 2005) whereas objective measurement tools such as simple accelerometers often underestimate the lower end of PA continuum (Mackey et al., 2011). Thus, to assess the long-term impact of different CR delivery models on overall daily PA the utilization of a more accurate PA measurement tool seems warranted. The purpose of this study was to use a multi-sensor accelerometer to compare the long-term impact of a fast-track versus traditional center-based CR on the PA of coronary artery disease (CAD) patients six months following CR entry. In addition to assessing long-term PA, we also examined the changes in participants exercise capacity, exercise self-efficacy (SE) and quality of life (QOL) in the two programs.

4.2. Methods

4.2.1. Study Design and Participants

This was a prospective repeated measures study in which the long-term impact of two CR program models (fast-track and traditional CR) on PA, exercise capacity, SE and QOL was compared. As the focus of this study was on long-term impact of different CR delivery models we chose to recruit patients as they underwent the standard CR exercise programs offered at two different CR sites. Thus, assigning participants was not randomized. Both programs were center-based with the fast-track program offering fewer on-site sessions to encourage more independent exercise.

4.2.1.1. Fast-track program. This 8 week program required patients to exercise on-site once a week. They were given activity logs and were encouraged to supplement this exercise program with 2 to 4 additional sessions/week independently.

4.2.1.2. Traditional program. The 12 week traditional program involved on-site exercise twice weekly. Participants were given activity logs and were encouraged to supplement this exercise program with 1 to 3 additional sessions/week independently.

The on-site training regimen for both programs included aerobic training (e.g., treadmill, cycle ergometer, or elliptical trainer) which incorporated a warm-up (5 minutes), steady-state exercise (20-60 minutes), and a cool-down (5 minutes). During steady-state exercise, participants exercised at a rating of perceived exertion of 12-14 (on the Borg 6-20 scale). Both programs followed the national guidelines for CR and participants in both groups had access to variety of education classes including a session on exercise and physically active lifestyle (Canadian Association of Cardiac Rehabilitation, 2009).

For both sites, patients referred to CR with a diagnosis of CAD were recruited (Figure 4.1). Participants were low to moderate risk, medically stable males and females who were able to participate in moderate intensity exercise. High risk patients were excluded including those with: 1) severe heart failure (New York Heart Association functional class III or IV); 2) unstable angina; 3) uncontrolled dysrhythmia; 4) large anterior infarcts with apical involvement; 5) co-morbidities which might get aggravated by exercise; 6) severe cognitive impairment; 7) any condition which might preclude the patient's ability to perform moderate intensity exercise; or 8) a history of prior participation in an outpatient CR program during the last one year.

Patients who met the inclusion criteria were approached by CR staff and were informed about the study. Those who expressed an interest in participating in the study were contacted by one of the investigators and the study was explained to them in details. The information sheet was provided to them. Upon obtaining written informed consent, demographic information was documented followed by baseline assessments. Participants were assessed at baseline, 12 weeks,

and again 6 months following CR entry. This study was approved by two institutional health research ethics review boards (Appendix B and C).

4.2.2. Outcome Measures

4.2.2.1. Exercise capacity. To assess exercise capacity, a 6 minute walk test (6MWT) was completed following the American Thoracic Society guidelines ("ATS statement: guidelines for the six-minute walk test," 2002).

4.2.2.2. Physical activity. Daily PA was assessed objectively using the SenseWear™ Mini Armband (SWA; BodyMedia, Pittsburgh, PA). The SWA uses multiples sensors (3-axis accelerometer, heat flux, galvanic skin response, and skin temperature) to estimate energy expenditure (EE). Minute by minute data from this device were used to provide information on the number of steps/day, EE, and time spent in different intensities of activity (i.e., sedentary, light, moderate or vigorous PA). Participants were instructed to wear the SWA on the back of the upper left arm for a minimum of 4 complete days except during bathing or swimming. To ensure an accurate representation of their daily PA, only days where the SWA was worn for ≥80% of the day were included for analysis (Dontje et al., 2014). For the purpose of this study, sleep data were excluded.

Steps/day were calculated by averaging the total number of steps taken each minute for all valid days. We also recorded EE for PA > 1.5 METs (i.e., PAEE $_{(>1.5\ METs)}$). Using EE data we obtained information on the time spent in different PA intensities. Sedentary time was defined as waking time with an EE ≤ 1.5 METs (Dogra & Stathokostas, 2012; Pate et al., 2008). Light PA was defined as activities which required an EE of 1.6-2.9 METs (e.g., activities of daily living [ADL]) (Pate et al., 2008). Moderate to vigorous PA (MVPA) included activities with an EE of ≥ 3.0 METs (Pate et al., 1995).

For time spent in MVPA guidelines recommend PA in bouts of 10 minutes or more (Garber et al., 2011; Haskell et al., 2007). Therefore we inspected the data to determine both the total minutes of MVPA and continuous MVPA occurring in ≥10 minutes bouts (i.e., $MVPA_{10+}$). To count as an $MVPA_{10+}$ the bout had to exceed the moderate intensity cut-point of 3 METs for a minimum of 10 consecutive minutes with allowance for a maximum of two observations falling below the cut-point during the period (i.e., 8 out of 10 minutes) (Colley et al., 2011).

4.2.2.3. Exercise self-efficacy. Self-reported SE was measured using the Multidimensional Exercise Self-efficacy Scale (Appendix D). The scale is designed to assess three domains of SE: task, coping and scheduling. It has 9 items which begin with the phrase "how confident are you that you can…" followed by statements corresponding to task, coping and scheduling aspects of exercise behavior. Task SE assessed confidence in completing exercise using proper technique, following directions to complete the exercise, and performing all of the movements required for the exercise. Coping SE focused on how confident the patients were to exercise when feeling discomfort from exercise, lacking energy, and not feeling well. Scheduling SE evaluated confidence in including exercise in daily routine, exercising consistently every day of the week, and arranging one's schedule to include regular exercise. Each response was provided on a 100% scale, ranging from 0% (no confidence) to 100% (complete confidence). Patients were instructed to think of exercise as "walking for 30-60 minutes a day, 5 days of the week". The multidimensional SE scale was studied across different populations and was found to be both reliable and valid (Rodgers et al., 2008).

4.2.2.4. Quality of life. QOL was assessed using MacNew Heart Disease Health-related Quality of Life Instrument (Appendix E). The MacNew Heart Disease QOL instrument is a self-administered questionnaire that has been designed to evaluate cardiac patients' perception of the

way their illness has influenced their daily life in the two weeks period. It consists of 27 items and three major domains: physical domain, emotional domain, and social domain. The MacNew has a global score and also individual scores for each domain. The individual domain scores are calculated by averaging the responses in each domain. The score in each domain ranges between 1 (poor QOL) and 7 (high QOL). The global score is the average of all the scored items (Hofer et al., 2004; Lim et al., 1993; Valenti et al., 1996). MacNew has been shown to be reliable, valid, and responsive in patients with angina and myocardial infarction (Hofer et al., 2012; Lim et al., 1993; Valenti et al., 1996) and can detect the changes in QOL during CR in patients with different cardiac diagnoses (Maes et al., 2008).

4.2.3. Statistical Analysis

Baseline characteristics were compared between the two groups using un-paired t-test, Chi-square test, or Fisher's Exact test. Mixed between-within subjects analysis of variance was used to compare the changes over time across the two groups. All statistical tests with a $p < 0.05$ were considered significant. Significance levels were adjusted using Bonferroni for pairwise comparisons. All analyses were conducted using IBM SPSS Statistics version 21.

4.3. Results

Forty four low to moderate risk CAD patients participated either in traditional (n = 24) or fast-track (n = 20) CR programs. Participants attended in 87 ± 11 % and 92 ± 13 % of the on-site sessions offered at traditional and fast-track programs respectively. The attendance was not significantly different between the two groups ($p = 0.237$). Baseline demographic and clinical data for the two groups are presented in Table 4.1. No significant differences in age, gender distribution, primary diagnosis, or risk factors were observed between the groups (Table 4.1). SWA on-body time during waking hours was calculated after excluding the sleep time. Results

from mixed between-within subjects analysis of variance showed that the on-body time was not different at each assessment point ($p = 0.563$) or between groups ($p = 0.891$) (Table 4.2). With $\alpha = 0.05$ and sample size of $n = 44$ this study had the power of 0.69 to detect the change in PA energy expenditure (i.e., PAEE $_{(>1.5\ METs)}$) with the effect size of $\eta^2_p = 0.099$.

4.3.1. Exercise Capacity

The 6MWT data was available in 43 participants (traditional: 24; fast-track: 19). At 12 weeks 6MWT distance increased significantly in both groups ($p < 0.05$, 95% CI -59.88 to -28.65). The observed change was not different across the two groups (time × group interaction $p = 0.107$). From 12 weeks to 6 months exercise capacity remained unchanged in both groups (12 weeks vs. 6 months $p = 1.000$, 95% CI -20.46 to 9.95; baseline vs. 6 months $p < 0.05$, 95% CI -65.88 to -33.16) (Table 4.2). The 6MWT distance was higher in traditional CR participants over the course of the study ($p < 0.05$).

4.3.2. Step Counts

There was no significant change in the daily step count over time in either of the groups ($p = 0.194$; time × group interaction $p = 0.674$). The step count was comparable across the groups on all assessment points ($p = 0.097$) (Table 4.2).

4.3.3. Energy Expenditure

At 12 weeks PA energy expenditure (i.e., PAEE $_{(>1.5\ METs)}$) increased significantly in both groups ($p < 0.05$, 95% CI -418.22 to -5.10). The observed change was not different across the two groups (time × group interaction $p = 0.096$). However at 6 months PAEE $_{(>1.5\ METs)}$ was comparable to the baseline level (12 weeks vs. 6 months $p < 0.05$, 95% CI 48.42 to 305.68 ; baseline vs. 6 months $p = 1.000$, 95% CI -245.67 to 176.45).

4.3.4. Time in Different PA Intensities

There was a significant change in sedentary time over the course of the study ($p < 0.05$) and the observed change was not different across the two groups (time × group interaction $p = 0.757$). From baseline to 12 weeks there was a trend towards a less sedentary time in both groups ($p = 0.055$, 95% CI -0.01 to 1.66). When calculated as percentage of the waking hours, the observed decline in sedentary time was statistically significant ($p < 0.05$, 95% CI 0.09 to 9.55). However at 6 months sedentary time was comparable to the baseline level (12 weeks vs. 6 months $p < 0.05$, 95% CI -6.78 to -0.65; baseline vs. 6 months $p = 1.000$, 95% CI -3.66 to 5.89) (Table 4.2).

Although a significant effect of time was detected for light PA ($p < 0.05$; time × group interaction $p = 0.405$) pairwise comparisons adjusted with Bonferroni correction demonstrated no significant change in any of the assessment intervals (baseline vs. 12 weeks $p = 0.100$, 95% CI -1.11 to 0.07; 12 weeks vs. 6 months $p = 0.065$, 95% CI -0.02 to 0.87; baseline vs. 6 months $p = 1.000$, 95% CI -0.62 to 0.43). Moreover, there was no significant change in percentage of waking hours spent in light PA in either of the groups over the course of the study ($p = 0.051$; time × group interaction $p = 0.561$) (Table 4.2).

As a group, participants spent 65 ± 60 min/day (Median = 51) in MVPA at baseline, of this, 44 ± 48 min/day (Median = 31) was spent in continuous bouts of PA (i.e., $MVPA_{10+}$). At 12 weeks they averaged 88 ± 68 min/day (Median = 68) and 60 ± 58 min/day (Median = 42) in MVPA and $MVPA_{10+}$ respectively. MVPA accounted for 71 ± 63 min/day (Median = 52) with 48 ± 50 min/day (Median = 28) spent in continuous bouts of PA ≥10 min (i.e., $MVPA_{10+}$) at 6 months. Neither group showed any significant change in total MVPA or $MVPA_{10+}$ between the three assessment points (MVPA: $p = 0.069$; time × group interaction $p = 0.194$; $MVPA_{10+}$: $p =$

0.130; time × group interaction p = 0.136) (Table 4.2). It is noteworthy that there were no significant differences between the two groups in any of the PA time markers over the course of the study (sedentary: p = 0.266; light PA: p = 0.380; MVPA: p = 0.317; $MVPA_{10+}$: p = 0.339) (Table 4.2).

4.3.5. Exercise Self-efficacy

At 12 weeks coping SE score increased significantly in both groups ($p < 0.05$, 95% CI -17.42 to -1.82). The observed change was not different across the two groups (time × group interaction p = 0.707). However, at 6 months coping SE score was not significantly different than the baseline value (p = 0.393, 95% CI -13.66 to 3.23). Task and scheduling SE scores remained unchanged over the course of the study in both groups (task SE: p = 0.066; time × group interaction p = 0.243; scheduling SE: p = 0.356; time × group interaction p = 0.296). SE was not significantly different between the two groups at any assessment point (task SE: p = 0.945; coping SE: p = 0.917; scheduling SE: p = 0.748) (Table 4.3).

4.3.6. Quality of Life

At 12 weeks, MacNew Heart Disease QOL global and individual domain scores increased significantly in both traditional and fast-track groups (global: $p < 0.05$, 95% CI -0.91 to -0.46; physical: $p < 0.05$, 95% CI -1.09 to -0.58; emotional: $p < 0.05$, 95% CI -0.76 to -0.24; social: $p < 0.05$, 95% CI -1.20 to -0.63; Figure 4.2). The observed changes were not different across the two groups (global: time × group interaction p = 0.455; physical: time × group interaction p = 0.719; emotional: time × group interaction p = 0.053; social: time × group interaction p = 0.868). From 12 weeks to 6 months they all remained unchanged in both groups (12 weeks vs. 6 months: global: p = 1.000, 95% CI -0.17 to 0.18; physical: p = 1.000, 95% CI -0.14 to 0.22; emotional: p = 1.000, 95% CI -0.20 to 0.22; social: p = 1.000, 95% CI -0.24 to

0.12; baseline vs. 6 months : global: $p < 0.05$, 95% CI -0.91 to -0.44; physical: $p < 0.05$, 95% CI -1.07 to -0.52; emotional: $p < 0.05$, 95% CI -0.74 to -0.24; social: $p < 0.05$, 95% CI -1.28 to -0.66). No significant differences were observed between the two groups at any assessment point (global: $p = 0.309$; physical: $p = 0.906$; emotional: $p = 0.138$; social: $p = 0.878$).

4.4. Discussion

The purpose of this study was to compare the impact of traditional versus fast-track CR on the long-term daily PA of cardiac patients following completion of their CR. Our findings indicate that, although participants in both traditional and fast-track CR had higher exercise capacity at 6 months post-CR entry, their overall daily PA was not significantly different from what was recorded at baseline. Indeed participation in CR programs did not result in long-term PA behavior change irrespective of the delivery model.

Maintaining an increased exercise capacity at the 6 month follow-up is consistent with our previous findings on center-based and home-based CR participants. We found that at 1 year follow-up exercise capacity was significantly higher than the baseline in both center-based and home-based CR groups (Ramadi, Haennel, et al., 2015). Other studies on CR programs have reported similar results (Martin, Aggarwal, et al., 2012; K. M. Smith et al., 2004; Stahle, Mattsson, et al., 1999). Findings from previous studies indicated that despite a decline in exercise capacity following completion of CR programs, it remained higher than baseline for a period of up to 1 year post-CR (K. M. Smith et al., 2004; Stahle, Mattsson, et al., 1999).

There is evidence that many patients fail to maintain optimal levels of regular PA following completion of CR programs (Bethell, 1999; Bock et al., 2003; Brubaker et al., 1996; N. B. Oldridge, 1991). Interestingly, it has been suggested that CR programs that offer fewer on-site exercise sessions and include more emphasis on off-site PA may result in higher adherence

to PA in long-term (Blair et al., 2011; Carlson et al., 2000; Marchionni et al., 2003; K. M. Smith et al., 2004; K. M. Smith et al., 2011; Witham et al., 2005; Wolkanin-Bartnik et al., 2011). However, in the present study, we did not find any difference in PA between CR entry and 6 month follow-up in either CR group. The divergent results from our study versus previous investigations might partially be attributed to different methodologies. PA outcomes in previous studies have been self-reported. Given the high level of subjectivity in self-reported instruments the results might be subject to bias (Ainsworth, 2009; Vanhees et al., 2005). Present findings are consistent with a study by Cowie et al. (2011) who used the accelerometer-based activity monitor to assess PA in patients following either center or home-based CR. The authors reported that at the 6 month follow-up daily steps were comparable to baseline regardless of the CR delivery model.

In the present study, neither MVPA nor $MVPA_{10+}$ changed significantly between baseline and 6 months in either group. However, the present data showed that 68% of our participants met the recommended MVPA time necessary for health improvement (i.e., 30 minutes/day) (Fletcher et al., 2001) at baseline with at least half of participants (52%) accumulating it through continuous MVPA (i.e., $MVPA_{10+}$). There is evidence that patients who meet the MVPA guideline at the CR onset show less improvement in MVPA compared to the ones who do not meet the recommended levels (Blanchard et al., 2010). Therefore, lack of further improvement in these variables is not surprising.

In the past the absence of MVPA has been defined as sedentary behavior (Pate et al., 2008). However, there is evidence of a deleterious association between sedentary behavior and mortality risk factors which is independent of MVPA (Healy et al., 2008; Katzmarzyk et al., 2009). It has been suggested that sedentary behavior and the lack of MVPA have different

influences on health outcomes; and thus need to be considered as separate risk factors (M. T. Hamilton et al., 2004; Owen et al., 2010; Tremblay et al., 2010). In the present study, although sedentary time decreased from baseline to 12 weeks, 6 months following CR entry, participants were as sedentary as they were at the baseline assessment. These findings were consistent with our previous study on cardiac patients at different stages of recovery following a cardiac event. Patients within 1 year of CR completion were found to be as sedentary as the new CR referrals (Buijs et al., 2015). Interestingly in our two previous studies CR participants demonstrated lower sedentary time at the end of the CR program (Buijs et al., 2015; Ramadi, Stickland, et al., 2015). These findings imply that patients tend to resume their baseline sedentary behavior following removal from CR programs.

One interesting observation in the present study was that our participants demonstrated elevated sedentary time and substantially low level of light PA despite the fact that at least half of them met the recommended level of MVPA on all three assessment points. According to the Canadian Health Measures Survey (CHMS), Canadian adults >40 years old are sedentary for about 71% of their daily waking hours while light PA accounts for approximately 28% of their waking hours (Colley et al., 2011). In the present study, upon CR entry, participants, as a group, spent 75% of their waking time sedentary and only 18% of waking time performing light PA. Six months following CR entry, sedentary time remained elevated (74%) while the time spent in light PA remained low (19%). Similar values have been reported by other studies in CAD patients (Buijs et al., 2015; Karjalainen et al., 2012; Ramadi, Stickland, et al., 2015). Given that the slight differences in our cut-points with the thresholds used in CHMS may have caused underestimation of sedentary time and overestimation of time spent in light PA in the present study; substantially lower level of light PA in our participants is striking.

Combined these findings might imply that there is possibility of lowering time spent in spontaneous PA (i.e., light PA) in favour of keeping the MVPA at the recommended level. Although our evidence may not be sufficient for a firm conclusion on the occurrence of such a phenomenon, this has been documented in previous training studies. They have reported that after excluding the training session, the mean PA on training days was significantly lower compared to non-training days (Goran & Poehlman, 1992; Meijer, Westerterp, & Verstappen, 1999). This might be a potential risk worth considering while working with CR participants as there is evidence that high level of MVPA is not sufficient to fully compensate for the deleterious effects of elevated sedentary time (Matthews et al., 2012). Moreover, substituting light PA for sedentary behavior can lead to substantial metabolic and mortality benefits due to the inverse relationship between light PA and metabolic risk factors (Healy et al., 2007; Healy et al., 2008; Manini et al., 2006; Matthews et al., 2012; Matthews et al., 2007). This might further highlight the importance of considering the entire spectrum of PA from sedentary behavior to spontaneous light PA and MVPA over the whole day rather than focusing exclusively on regimented bouts of MVPA (Manns et al., 2012). In fact the recommended MVPA needs to be performed beyond the spontaneous daily activities (i.e., light PA) rather than replacing it (Tudor-Locke et al., 2011).

Furthermore, in this study we examined the participants' QOL and exercise SE. QOL improved over the course of the study in both groups. This was consistent with the findings from previous studies (Dalal et al., 2007; Yohannes et al., 2010). Our results indicated that SE was comparable across the two CR groups. Task and scheduling SE remained unchanged over the course of the study regardless of the CR group. However, one should note that in the present study participants showed a high level of both domains at the outset; and the scores remained

elevated over the course of the study. Despite a significant increase in coping SE at 12 week assessment in both groups, at 6 months it was comparable to the baseline level. It is noteworthy that coping SE demonstrated the lowest scores among the domains. In the present study coping SE evaluates the patient's confidence in exercising when feeling discomfort from exercise, lacking energy, and not feeling well. These are related to the physiological states which is one of the main sources of SE. In physical tasks, people usually judge their capabilities of doing the tasks based on their physiological response and they might interpret any kind of fatigue or pain as a sign of physical incapability (Wood & Bandura, 1989). Given that CAD patients are usually very cautious about getting symptomatic, even normal physiological responses to exercise might be misinterpreted as being risky. This misinterpretation may mitigate the SE for PA. Ultimately PA may be restricted in this population due to fear associated with cardiovascular symptoms (Ades, 2001; Neill et al., 1985). Combined these findings might imply that our CR participants perceived themselves as competent in carrying out regular PA. However, they may need strategies that address physiological states (e.g., education about normal physiological responses to exercise) in order to maintain their confidence to exercise when facing physiological barriers (Houle et al., 2011).

4.4.1. Limitations

Findings might be affected by the small sample size. Further, in order to assess the impact of different CR delivery models on the PA of CAD patients, we chose to follow patients as they completed the standardized programs at two different CR centers. Thus, our study used a nonrandomized design. Nevertheless, when we compared the baseline demographics and risk factors the two groups were found to be equivalent. The difference in 6MWT distance between the two groups may be attributed to the rater bias due to the multi-center nature of the study.

However, the present study was focused on the changes in the outcomes that occurred over time. Our findings indicated that the observed change in 6MWT distance was not different across the two groups.

Findings from present study should be interpreted with caution. Although participants were instructed to supplement their exercise program with additional exercise sessions independently, we do not have complete records of the number of exercise sessions completed off-site. In fact despite providing activity logs we did not obtain sufficient data due to the low response rate.

Furthermore, we observed large variations in some of our measures. Excluding participants from the analysis was not possible due to the risk of losing the sample representativeness. Also, it is unlikely the larger sample would result in a lower degree of variation. However, with a larger sample we could investigate the participants by stratifying them into different activity groups.

4.5. Conclusions

In general our findings support the long-term effectiveness of CR on exercise capacity of low to moderate risk CAD patients irrespective of the delivery model. However, participation in CR program, whether it be a fast-track or traditional CR exercise program may not lead to long-term PA behavior change. Thus, CR participants may benefit from structured strategies which promote long-term PA adherence in addition to facilitating exercise capacity improvement. An extensive and accurate assessment of daily PA upon CR entry could provide clinicians with valuable information on the best aspect to target in the PA spectrum. With most programs being mainly focused on MVPA, habitual PA has often been overlooked in CR participants. Considering the entire spectrum of PA from sedentary behavior to spontaneous light intensity PA

in addition to MVPA is imperative when promoting the PA behavior change. Furthermore, by assessing patients' SE when entering CR clinicians may identify the areas of weakness which might be affecting the long-term PA adherence. This may provide valuable guidance in designing customized strategies according to the individual's needs.

Table 4.1. Baseline sample characteristics by CR delivery model

	Traditional (n= 24)	**Fast-track (n=20)**	**p value**
Age (years)	61 ± 10	64 ± 7	0.186
Male	17 (70.8%)	17 (85.0%)	0.306
BMI (kg/m^2)	28.6 ± 5.1	27.9 ± 4.1	0.623
Caucasian	22 (91.7%)	16 (80.0%)	0.387
Married	19 (79.2%)	19 (95.0%)	0.198
Living alone	4 (16.7%)	1 (5.0%)	0.356
Employed	17 (70.8%)	11 (55.0%)	0.440
Post-secondary education (≥ Bachelor's degree)	8 (33.3%)	8 (40.0%)	0.886
Primary diagnosis			1.000
MI	15 (62.5%)	13 (65.0%)	
Angina	9 (37.5%)	7 (35.0%)	
Risk factors			
HTN	18 (75.0%)	15 (75.0%)	1.000
Dyslipidemia	18 (75.0%)	19 (95.0%)	0.106
DM	5 (20.8%)	4 (20.0%)	1.000
Current smoker	4 (16.7%)	2 (10.0%)	0.673
Previous smoker	16 (66.7%)	12 (60.0%)	0.886
Obesity	10 (41.7%)	5 (25.0%)	0.400

CR: cardiac rehabilitation; BMI: body mass index; MI: myocardial infarction; HTN: hypertension; DM: diabetes mellitus.
Data are presented as mean ± standard deviation or as the absolute number (percentage).

Table 4.2. Changes in exercise capacity and physical activity from baseline to 12 weeks to 6 month follow-up in traditional versus fast-track CR

	Traditional			Fast-track		
	Baseline	**12 weeks**	**6 months**	**Baseline**	**12 weeks**	**6 months**
6MWT[a] (m)	567 ± 83	609 ± 74[b]	604 ± 91[d]	494 ± 91	541 ± 78[b]	556 ± 83[d]
SWA on-body time (waking hours/day)	16.39 ± 1.31	16.82 ±1.24	16.40 ± 1.26	16.79 ± 1.71	16.44 ± 1.01	16.52 ± 1.15
Steps/day	6995 ± 2452	8264 ± 4151	7445 ± 4241	5794 ± 3446	6334 ± 2694	6209 ± 2746
$PAEE_{(>1.5\ METs)}$ (kcal/day)	863 ± 502	1244 ± 609[b]	990 ± 550[c]	866 ± 621	909 ± 471[b]	808 ± 421[c]
Sedentary time						
(hours/day)	12.24 ± 2.17	11.25 ± 2.05	11.79 ± 1.88[c]	12.69 ± 2.93	12.03 ± 2.02	12.55 ± 2.45[c]
(% of waking hours)	75 ± 11	67 ± 12[b]	72 ± 12[c]	75 ± 14	73 ± 12[b]	76 ± 12[c]
Light PA						
(hours/day)	3.06 ± 1.38	3.86 ± 1.38	3.31 ± 1.34	3.01 ± 1.55	3.24 ± 1.73	2.94 ± 1.72
(% of waking hours)	19 ± 8	23 ± 8	20 ± 7	18 ± 9	20 ± 10	18 ± 10
MVPA (min/day)	65 ± 53	103 ± 73	78 ± 69	65 ± 68	70 ± 58	62 ± 54
$MVPA_{10+}$ (min/day)	42 ± 43	73 ± 64	53 ± 53	45 ± 55	45 ± 49	41 ± 48

CR: cardiac rehabilitation; 6MWT: 6 minute walk test; SWA: SenseWear Armband; PA: physical activity; PAEE: physical activity energy expenditure; Sedentary: waking time ≤ 1.5 METs; Light: 1.6-2.9 METs; MVPA: moderate-vigorous (≥ 3 METs) physical activity; $MVPA_{10+}$: moderate-vigorous physical activity in bouts ≥ 10 min.
Data are presented as mean ± standard deviation.
[a] Significant difference between groups at all 3 assessment points.
[b] Significant change from baseline to 12 weeks in a given group.
[c] Significant change from 12 weeks to 6 months in a given group.
[d] Significant change from baseline to 6 months in a given group.
Significance levels were adjusted using Bonferroni for pairwise comparisons.

Table 4.3. Changes in self-efficacy scores from baseline to 12 weeks to 6 month follow-up in traditional versus fast-track CR

	Traditional			Fast-track		
	Baseline	**12 weeks**	**6 months**	**Baseline**	**12 weeks**	**6 months**
Task SE	88 ± 16	93 ± 7	94 ± 6	90 ± 13	95 ± 8	90 ± 14
Coping SE	68 ± 22	76 ± 19[a]	74 ± 21	68 ± 28	80 ± 21[a]	73 ± 23
Scheduling SE	78 ± 23	78 ± 22	79 ± 18	75 ± 25	85 ± 22	79 ± 22

CR: cardiac rehabilitation; SE: self-efficacy.
Data are presented as mean ± standard deviation.
[a] Significant change from baseline to 12 weeks in a given group.
No significant change from 12 weeks to 6 months.
No significant change from baseline to 6 months.
No significant difference between the two groups in any domain.
Significance levels were adjusted using Bonferroni for pairwise comparisons.

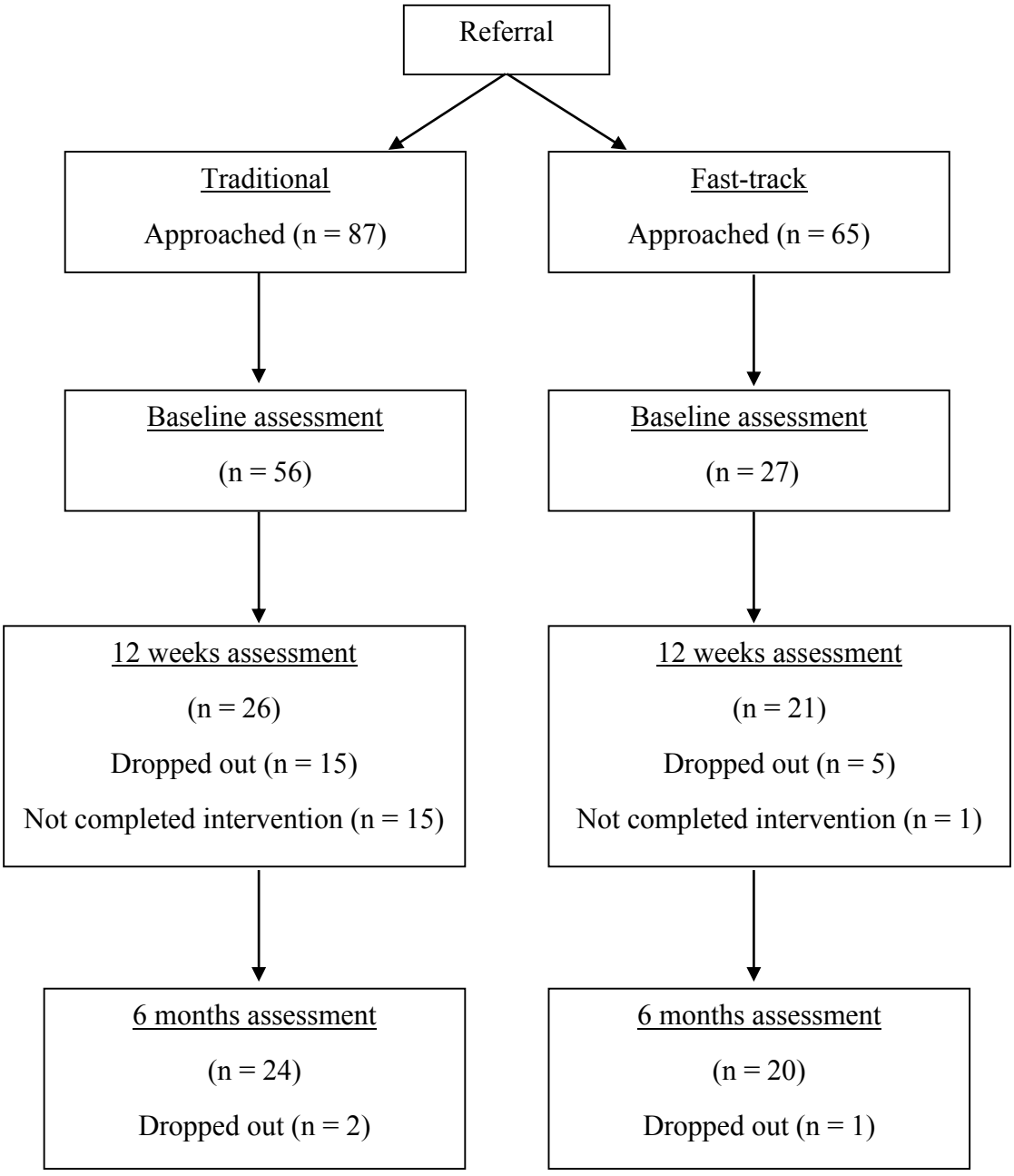

Figure 4.1. Flow diagram: participant recruitment.

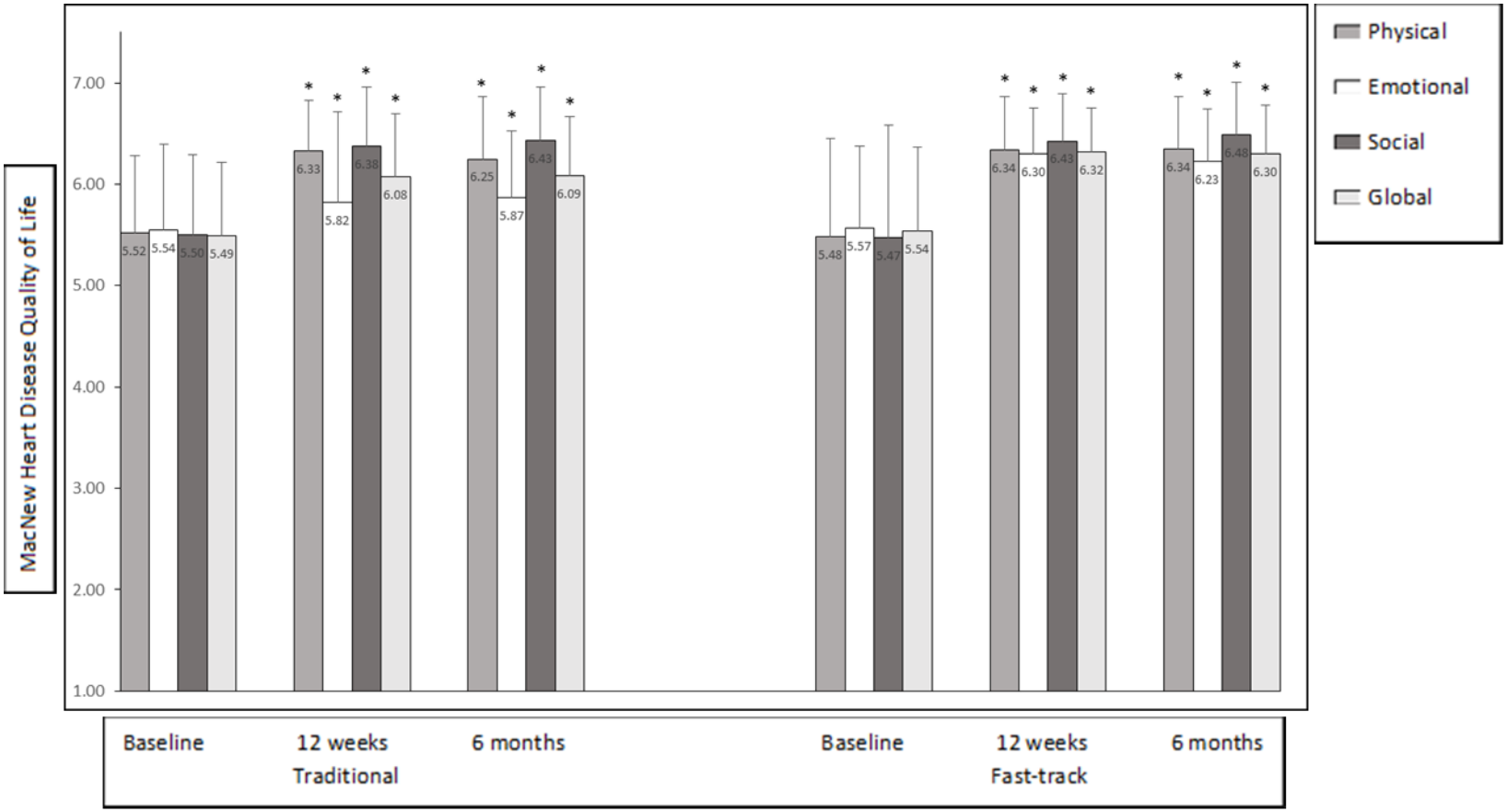

Figure 4.2. Changes in MacNew heart disease health-related quality of life scores from baseline to 12 weeks to 6 month follow-up in traditional versus fast-track CR. * Significant difference versus baseline in a given group. No significant difference between the two groups in any domain. Significance levels were adjusted using Bonferroni for pairwise comparisons.

4.6. References

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

Ainsworth, B. E. (2009). How do I measure physical activity in my patients? Questionnaires and objective methods. *Br J Sports Med, 43*(1), 6-9. doi: bjsm.2008.052449 [pii] 10.1136/bjsm.2008.052449

ATS statement: guidelines for the six-minute walk test. (2002). *Am J Respir Crit Care Med, 166*(1), 111-117. doi: 10.1164/ajrccm.166.1.at1102

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

Blair, J., Corrigall, H., Angus, N. J., Thompson, D. R., & Leslie, S. (2011). Home versus hospital-based cardiac rehabilitation: a systematic review. *Rural Remote Health, 11*(2), 1532. doi: 1532 [pii]

Blanchard, C. M., Reid, R. D., Morrin, L. I., McDonnell, L., McGannon, K., Rhodes, R. E., . . . Edwards, N. (2010). 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, 30*(4), 240-245. doi: 10.1097/HCR.0b013e3181d0c4ae

Bock, B. C., Carmona-Barros, R. E., Esler, J. L., & Tilkemeier, P. L. (2003). Program participation and physical activity maintenance after cardiac rehabilitation. *Behav Modif, 27*(1), 37-53.

Brubaker, P. H., Warner, J. G., Jr., Rejeski, W. J., Edwards, D. G., Matrazzo, B. A., Ribisl, P. M., . . . Herrington, D. M. (1996). Comparison of standard- and extended-length

participation in cardiac rehabilitation on body composition, functional capacity, and blood lipids. *Am J Cardiol, 78*(7), 769-773.

Buijs, D. M., Ramadi, A., MacDonald, K., Lightfoot, R., Senaratne, M., & Haennel, R. G. (2015). Quantity and quality of daily physical activity in older cardiac patients at different stages of recovery following a cardiac event. *Canadian Journal of Cardiovascular Nursing, 25*(3), 10-16.

Canadian Association of Cardiac Rehabilitation. (2009). *Canadian Guidelines for Cardiac Rehabilitation and Cardiovascular Disease Prevention: Translating Knowledge into Action* (3rd ed.). Winnipeg, MB: Canadian Association of Cardiac Rehabilitation.

Carlson, J. J., Johnson, J. A., Franklin, B. A., & VanderLaan, R. L. (2000). Program participation, exercise adherence, cardiovascular outcomes, and program cost of traditional versus modified cardiac rehabilitation. *Am J Cardiol, 86*(1), 17-23.

Chase, J. A. (2011). Systematic review of physical activity intervention studies after cardiac rehabilitation. *J Cardiovasc Nurs, 26*(5), 351-358. doi: 10.1097/JCN.0b013e3182049f00

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011). Physical activity of Canadian adults: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Rep, 22*(1), 7-14.

Cowie, A., Thow, M. K., Granat, M. H., & Mitchell, S. L. (2011). A comparison of home and hospital-based exercise training in heart failure: immediate and long-term effects upon physical activity level. *Eur J Cardiovasc Prev Rehabil, 18*(2), 158-166. doi: 1741826710389389 [pii]

10.1177/1741826710389389

Dalal, H. M., Evans, P. H., Campbell, J. L., Taylor, R. S., Watt, A., Read, K. L., . . . Pereira Gray, D. J. (2007). Home-based versus hospital-based rehabilitation after myocardial infarction: A randomized trial with preference arms--Cornwall Heart Attack Rehabilitation Management Study (CHARMS). *Int J Cardiol, 119*(2), 202-211. doi: S0167-5273(06)01423-9 [pii]

10.1016/j.ijcard.2006.11.018

Dogra, S., & Stathokostas, L. (2012). Sedentary behavior and physical activity are independent predictors of successful aging in middle-aged and older adults. *J Aging Res, 2012*, 190654. doi: 10.1155/2012/190654

Dontje, M. L., van der Wal, M. H., Stolk, R. P., Brugemann, J., Jaarsma, T., Wijtvliet, P. E., . . . de Greef, M. H. (2014). Daily physical activity in stable heart failure patients. *J Cardiovasc Nurs, 29*(3), 218-226. doi: 10.1097/JCN.0b013e318283ba14

Fletcher, G. F., Balady, G. J., Amsterdam, E. A., Chaitman, B., Eckel, R., Fleg, J., . . . Bazzarre, T. (2001). Exercise standards for testing and training: a statement for healthcare professionals from the American Heart Association. *Circulation, 104*(14), 1694-1740.

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I. M., . . . Swain, D. P. (2011). 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, 43*(7), 1334-1359. doi: 10.1249/MSS.0b013e318213fefb

Goran, M. I., & Poehlman, E. T. (1992). Endurance training does not enhance total energy expenditure in healthy elderly persons. *Am J Physiol, 263*(5 Pt 1), E950-957.

Haapanen, N., Miilunpalo, S., Vuori, I., Oja, P., & Pasanen, M. (1996). Characteristics of leisure time physical activity associated with decreased risk of premature all-cause and cardiovascular disease mortality in middle-aged men. *Am J Epidemiol, 143*(9), 870-880.

Haennel, R. G., & Lemire, F. (2002). Physical activity to prevent cardiovascular disease. How much is enough? *Can Fam Physician, 48*, 65-71.

Hamilton, M. T., Hamilton, D. G., & Zderic, T. W. (2004). Exercise physiology versus inactivity physiology: an essential concept for understanding lipoprotein lipase regulation. *Exerc Sport Sci Rev, 32*(4), 161-166.

Haskell, W. L., Lee, I. M., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A., . . . Bauman, A. (2007). Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc, 39*(8), 1423-1434. doi: 10.1249/mss.0b013e3180616b27

Healy, G. N., Dunstan, D. W., Salmon, J., Cerin, E., Shaw, J. E., Zimmet, P. Z., & Owen, N. (2007). Objectively measured light-intensity physical activity is independently associated with 2-h plasma glucose. *Diabetes Care, 30*(6), 1384-1389. doi: 10.2337/dc07-0114

Healy, G. N., Wijndaele, K., Dunstan, D. W., Shaw, J. E., Salmon, J., Zimmet, P. Z., & Owen, N. (2008). Objectively measured sedentary time, physical activity, and metabolic risk: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Diabetes Care, 31*(2), 369-371. doi: dc07-1795 [pii]

10.2337/dc07-1795

Hofer, S., Lim, L., Guyatt, G., & Oldridge, N. (2004). The MacNew Heart Disease health-related quality of life instrument: a summary. *Health and quality of life outcomes, 2*, 3. doi: 10.1186/1477-7525-2-3

Hofer, S., Saleem, A., Stone, J., Thomas, R., Tulloch, H., & Oldridge, N. (2012). The MacNew Heart Disease Health-Related Quality of Life Questionnaire in patients with angina and patients with ischemic heart failure. *Value in health : the journal of the International Society for Pharmacoeconomics and Outcomes Research, 15*(1), 143-150. doi: 10.1016/j.jval.2011.07.003

Houle, J., Doyon, O., Vadeboncoeur, N., Turbide, G., Diaz, A., & Poirier, P. (2011). Innovative program to increase physical activity following an acute coronary syndrome: randomized controlled trial. *Patient Educ Couns, 85*(3), e237-244. doi: 10.1016/j.pec.2011.03.018

Karjalainen, J. J., Kiviniemi, A. M., Hautala, A. J., Niva, J., Lepojarvi, S., Makikallio, T. H., . . . Tulppo, M. P. (2012). Effects of exercise prescription on daily physical activity and maximal exercise capacity in coronary artery disease patients with and without type 2 diabetes. *Clin Physiol Funct Imaging, 32*(6), 445-454. doi: 10.1111/j.1475-097X.2012.01148.x

Katzmarzyk, P. T., Church, T. S., Craig, C. L., & Bouchard, C. (2009). Sitting time and mortality from all causes, cardiovascular disease, and cancer. *Med Sci Sports Exerc, 41*(5), 998-1005. doi: 10.1249/MSS.0b013e3181930355

Leon, A. S., Connett, J., Jacobs, D. R., Jr., & Rauramaa, R. (1987). Leisure-time physical activity levels and risk of coronary heart disease and death. The Multiple Risk Factor Intervention Trial. *JAMA, 258*(17), 2388-2395.

Lim, L. L., Valenti, L. A., Knapp, J. C., Dobson, A. J., Plotnikoff, R., Higginbotham, N., & Heller, R. F. (1993). A self-administered quality-of-life questionnaire after acute myocardial infarction. *Journal of clinical epidemiology, 46*(11), 1249-1256.

Mackey, D. C., Manini, T. M., Schoeller, D. A., Koster, A., Glynn, N. W., Goodpaster, B. H., . . . Cummings, S. R. (2011). Validation of an armband to measure daily energy expenditure in older adults. *J Gerontol A Biol Sci Med Sci, 66*(10), 1108-1113. doi: 10.1093/gerona/glr101

Maes, S., De Gucht, V., Goud, R., Hellemans, I., & Peek, N. (2008). Is the MacNew quality of life questionnaire a useful diagnostic and evaluation instrument for cardiac rehabilitation? *Eur J Cardiovasc Prev Rehabil, 15*(5), 516-520. doi: 10.1097/HJR.0b013e328303402b

Manini, T. M., Everhart, J. E., Patel, K. V., Schoeller, D. A., Colbert, L. H., Visser, M., . . . Harris, T. B. (2006). Daily activity energy expenditure and mortality among older adults. *JAMA, 296*(2), 171-179. doi: 10.1001/jama.296.2.171

Manns, P. J., Dunstan, D. W., Owen, N., & Healy, G. N. (2012). Addressing the nonexercise part of the activity continuum: a more realistic and achievable approach to activity programming for adults with mobility disability? *Phys Ther, 92*(4), 614-625. doi: 10.2522/ptj.20110284

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

Martin, B. J., Aggarwal, S. G., Stone, J. A., Hauer, T., Austford, L. D., Knudtson, M., & Arena, R. (2012). Obesity negatively impacts aerobic capacity improvements both acutely and 1-year following cardiac rehabilitation. *Obesity (Silver Spring), 20*(12), 2377-2383. doi: 10.1038/oby.2012.119

Matthews, C. E., George, S. M., Moore, S. C., Bowles, H. R., Blair, A., Park, Y., . . . Schatzkin, A. (2012). Amount of time spent in sedentary behaviors and cause-specific mortality in US adults. *Am J Clin Nutr, 95*(2), 437-445. doi: 10.3945/ajcn.111.019620

Matthews, C. E., Jurj, A. L., Shu, X. O., Li, H. L., Yang, G., Li, Q., . . . Zheng, W. (2007). Influence of exercise, walking, cycling, and overall nonexercise physical activity on mortality in Chinese women. *Am J Epidemiol, 165*(12), 1343-1350. doi: 10.1093/aje/kwm088

Meijer, E. P., Westerterp, K. R., & Verstappen, F. T. (1999). Effect of exercise training on total daily physical activity in elderly humans. *European journal of applied physiology and occupational physiology, 80*(1), 16-21.

Neill, W. A., Branch, L. G., De Jong, G., Smith, N. E., Hogan, C. A., Corcoran, P. J., . . . Osberg, S. (1985). Cardiac disability. The impact of coronary heart disease on patients' daily activities. *Arch Intern Med, 145*(9), 1642-1647.

Oerkild, B., Frederiksen, M., Hansen, J. F., Simonsen, L., Skovgaard, L. T., & Prescott, E. (2011). Home-based cardiac rehabilitation is as effective as centre-based cardiac rehabilitation among elderly with coronary heart disease: results from a randomised clinical trial. *Age Ageing, 40*(1), 78-85. doi: afq122 [pii]

10.1093/ageing/afq122

Oldridge, N. B. (1991). Compliance with cardiac rehabilitation services. *Journal of Cardiopulmonary Rehabilitation, 11*, 115-127.

Oliveira, J., Ribeiro, F., & Gomes, H. (2008). Effects of a home-based cardiac rehabilitation program on the physical activity levels of patients with coronary artery disease. *J Cardiopulm Rehabil Prev, 28*(6), 392-396. doi: 10.1097/HCR.0b013e31818c3b83

01273116-200811000-00007 [pii]

Owen, N., Sparling, P. B., Healy, G. N., Dunstan, D. W., & Matthews, C. E. (2010). Sedentary behavior: emerging evidence for a new health risk. *Mayo Clin Proc, 85*(12), 1138-1141. doi: 10.4065/mcp.2010.0444

Pate, R. R., O'Neill, J. R., & Lobelo, F. (2008). The evolving definition of "sedentary". *Exerc Sport Sci Rev, 36*(4), 173-178. doi: 10.1097/JES.0b013e3181877d1a

Pate, R. R., Pratt, M., Blair, S. N., Haskell, W. L., Macera, C. A., Bouchard, C., . . . et al. (1995). Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA, 273*(5), 402-407.

Ramadi, A., Haennel, R. G., Stone, J. A., Arena, R., Threlfall, T. G., Hitt, E., . . . Martin, B. J. (2015). The sustainability of exercise capacity changes in home versus center-based cardiac rehabilitation. *J Cardiopulm Rehabil Prev, 35*(1), 21-28. doi: 10.1097/hcr.0000000000000084

Ramadi, A., Stickland, M. K., Rodgers, W. M., & Haennel, R. G. (2015). Impact of supervised exercise rehabilitation on daily physical activity of cardiopulmonary patients. *Heart Lung, 44*(1), 9-14. doi: 10.1016/j.hrtlng.2014.11.001

Rodgers, W. M., Wilson, P. M., Hall, C. R., Fraser, S. N., & Murray, T. C. (2008). Evidence for a multidimensional self-efficacy for exercise scale. *Res Q Exerc Sport, 79*(2), 222-234.

Smith, K. M., Arthur, H. M., McKelvie, R. S., & Kodis, J. (2004). Differences in sustainability of exercise and health-related quality of life outcomes following home or hospital-based cardiac rehabilitation. *Eur J Cardiovasc Prev Rehabil, 11*(4), 313-319. doi: 00149831-200408000-00008 [pii]

Smith, K. M., McKelvie, R. S., Thorpe, K. E., & Arthur, H. M. (2011). Six-year follow-up of a randomised controlled trial examining hospital versus home-based exercise training after coronary artery bypass graft surgery. *Heart, 97*(14), 1169-1174. doi: 10.1136/hrt.2010.202036

Stahle, A., Mattsson, E., Ryden, L., Unden, A., & Nordlander, R. (1999). Improved physical fitness and quality of life following training of elderly patients after acute coronary events. A 1 year follow-up randomized controlled study. *Eur Heart J, 20*(20), 1475-1484.

Tremblay, M. S., Colley, R. C., Saunders, T. J., Healy, G. N., & Owen, N. (2010). Physiological and health implications of a sedentary lifestyle. *Appl Physiol Nutr Metab, 35*(6), 725-740. doi: 10.1139/H10-079

Tudor-Locke, C., Craig, C. L., Aoyagi, Y., Bell, R. C., Croteau, K. A., De Bourdeaudhuij, I., . . . Blair, S. N. (2011). How many steps/day are enough? For older adults and special populations. *Int J Behav Nutr Phys Act, 8*, 80. doi: 10.1186/1479-5868-8-80

Valenti, L., Lim, L., Heller, R. F., & Knapp, J. (1996). An improved questionnaire for assessing quality of life after acute myocardial infarction. *Qual Life Res, 5*(1), 151-161.

van den Berg-Emons, H., Bussmann, J., Balk, A., Keijzer-Oster, D., & Stam, H. (2001). Level of activities associated with mobility during everyday life in patients with chronic congestive heart failure as measured with an "activity monitor". *Phys Ther, 81*(9), 1502-1511.

Vanhees, L., Lefevre, J., Philippaerts, R., Martens, M., Huygens, W., Troosters, T., & Beunen, G. (2005). How to assess physical activity? How to assess physical fitness? *Eur J Cardiovasc Prev Rehabil, 12*(2), 102-114. doi: 00149831-200504000-00004 [pii]

Witham, M. D., Gray, J. M., Argo, I. S., Johnston, D. W., Struthers, A. D., & McMurdo, M. E. (2005). Effect of a seated exercise program to improve physical function and health status in frail patients > or = 70 years of age with heart failure. *Am J Cardiol, 95*(9), 1120-1124. doi: 10.1016/j.amjcard.2005.01.031

Wolkanin-Bartnik, J., Pogorzelska, H., & Bartnik, A. (2011). Patient education and quality of home-based rehabilitation in patients older than 60 years after acute myocardial infarction. *J Cardiopulm Rehabil Prev, 31*(4), 249-253. doi: 10.1097/HCR.0b013e31821c1391

Wood, R., & Bandura, A. (1989). Social cognitive theory of organizational management. *Academy of Management Review, 14*(3), 361-384.

Yohannes, A. M., Doherty, P., Bundy, C., & Yalfani, A. (2010). The long-term benefits of cardiac rehabilitation on depression, anxiety, physical activity and quality of life. *J Clin Nurs, 19*(19-20), 2806-2813. doi: 10.1111/j.1365-2702.2010.03313.x

JCN3313 [pii]

Chapter 5

The Sustainability of Exercise Capacity Changes in Home Versus Center-based Cardiac Rehabilitation[2]

5.1. Introduction

It is well known that participation in center-based cardiac rehabilitation (CR) exercise programs can improve exercise capacity (Froelicher et al., 1985; Lavie et al., 1993; Maines et al., 1997; N. Oldridge et al., 1991; Perk, Hedback, & Engvall, 1990). Although supervised programs can yield improvements in exercise capacity, the sustainability of these improvements post-CR seems to be challenging (Stone et al., 2011). Yu, Li, Ho, and Lau (2003) evaluated the long-term changes in exercise capacity in cardiac patients who participated in an 8 week center-based CR program. At the two year follow-up, the improved exercise capacity had declined to the point where it was similar to those who were in the inactive control group.

As an alternative delivery model, home-based CR was first introduced in the early 1980s and involves patients exercising in unsupervised flexible settings (Ashworth, Chad, Harrison, Reeder, & Marshall, 2005; Jolly et al., 2006). Several systematic reviews comparing the efficacy of home versus center-based CR on health outcomes have demonstrated that both program

[2] A version of this chapter has been published:
Ramadi, A., Haennel, R. G., Stone, J. A., Arena, R., Threlfall, T. G., Hitt, E., . . . Martin, B. J. (2015). The sustainability of exercise capacity changes in home versus center-based cardiac rehabilitation. *J Cardiopulm Rehabil Prev, 35*(1), 21-28. doi: 10.1097/hcr.0000000000000084.

delivery models are effective in the short-term (Blair et al., 2011; Dalal et al., 2010). However, examining the long-term efficacy of home versus center-based CR programs on patients' exercise capacity has resulted in mixed findings. Oerkild et al. (2011) noted that the decline in exercise capacity was similar in both center and home-based CR participants at the 1 year follow-up. By contrast, Marchionni et al. (2003) noted that improvement in exercise capacity at the completion of CR was lost 6 months post-CR in patients who had attended a center-based program, whereas it was preserved in those who had participated in a home-based CR program. Similarly, in 2 randomized controlled trials conducted by Smith et al. (2004; 2011) home-based programs were reported to be superior in maintaining exercise capacity.

Studies that examined the impact of self-selected home versus center-based exercise training in cardiac patients have focused exclusively on the short-term effectiveness of the programs (Kodis et al., 2001; Wakefield et al., 2014). The long-term effectiveness of self-selected home versus center-based CR exercise training has not been investigated. Thus, the objective of this study was to compare the immediate and 1 year effectiveness of home versus center-based CR on exercise capacity (i.e., peak metabolic equivalents [METs]), heart rate (HR) recovery at 1 minute, self-reported weekly exercise time spent in prescribed target HR, body mass index (BMI), waist circumference, and the blood lipids and fasting glucose levels in cardiac patients who were given the choice of participating in a center-based or home-based CR program.

5.2. Methods

This was a retrospective study using a database from a 12 week multidisciplinary CR program that offers both center and home-based CR. The database includes records on all participants who have been referred to the CR program since 1996. Additional patient

information was obtained from the Alberta Provincial Project for Outcomes Assessment in Coronary Heart disease (APPROACH) database (Ghali & Knudtson, 2000). The information obtained from the databases included participant demographic data, medical history (including cardiovascular risk factors), estimated exercise capacity in peak METs, 1 minute HR recovery, self-reported weekly exercise time spent in prescribed target HR, BMI, waist circumference, and the blood lipids and fasting glucose levels. Data were recorded at baseline (prior to CR), after 12 weeks of CR and again 1 year after completion of the CR program. This project was approved by the local institutional ethics review board.

5.2.1. Participants

All patients referred to CR between 1996 and 2009 with a diagnosis of coronary artery disease over the age of 18 years who had complete data for exercise capacity and self-reported exercise at the three assessment points were included in the study. At the time of program entry written informed consent was obtained. Only patients consenting to research were used in the data analysis.

5.2.2. Intervention

Baseline assessment was completed after referral and before commencement of the CR exercise program. Following the baseline assessment, participants were given the opportunity to choose between center-based or home-based exercise programs. Both programs were 12 weeks in duration and all participants had access to appointments with a registered dietician, registered social worker, counseling sessions, and education classes for the duration of the program.

5.2.2.1. Center-based CR program. The supervised training regimen included 2 to 3 days/week of aerobic training (e.g., walking on the track, treadmill, cycle ergometer, or elliptical trainer) which incorporated a warm-up (5 minutes), steady-state exercise (20-60 minutes), and a

cool-down (5 minutes). During steady-state exercise, participants exercised at an intensity of 45-85% of the HR reserve based on their medical history and the results from a graded exercise test. During the exercise sessions participants were also instructed to achieve a rating of perceived exertion of 12-14 (on the Borg 6-20 scale). Participants were also encouraged to supplement this exercise rehabilitation program with 1 to 3 additional sessions/week independently.

5.2.2.2. Home-based CR program. Participants selecting the home-based training program attended supervised exercise for a minimum of 1 session where they were given instructions and advised to exercise on their own for 20-60 minutes, 3 to 5 days/week. Each participant was advised to warm-up (5 minutes), then exercise at target HR (20-60 minutes), and finish with cool-down (5 minutes). Participants were asked to train at their prescribed target HR (45-85% of the HR reserve). The rating of perceived exertion scale was also described to patients and they were asked to exercise at a rating of perceived exertion of 12-14 (on the Borg 6-20 scale) and were cautioned not to exercise at or above a rating of 15 (on the Borg scale = hard). The CR staff phoned patients every 3 weeks in order to monitor and update their program.

5.2.3. Outcome Measures

5.2.3.1. Exercise capacity. Exercise capacity was estimated from treadmill exercise tests completed at three points (i.e., baseline, post-CR, and 1 year follow-up). The treadmill test involved either a Bruce or a modified Bruce protocol. All exercise tests continued until volitional fatigue or signs/symptoms of exertional intolerance (American College of Sports Medicine, 2010). Peak exercise capacity was estimated from the final stage speed and grade and was reported as peak METs (American College of Sports Medicine, 2010; McConnell & Clark, 1987).

5.2.3.2. HR recovery. During each exercise test, peak HR and 1 minute post-exercise HR in supine position were recorded. HR recovery was calculated as the drop in HR from peak to 1 minute post-exercise.

5.2.3.3. Self-reported exercise. At each exercise testing assessment, participants were asked to report the number of exercise sessions per week and time spent in their prescribed target HR during each session. The reported exercise frequency and duration were used to calculate the total volume of exercise per week (i.e., min/week).

5.2.3.4. BMI and waist circumference. BMI and waist circumference were also recorded at the 3 assessment points.

5.2.3.5. Blood lipids and fasting blood glucose. Fasting blood glucose and blood lipids (high-density lipoprotein [HDL], low-density lipoprotein [LDL], total cholesterol, and triglycerides) were assessed before and after CR and at the 1 year follow-up.

5.2.4. Statistical Analysis

Baseline characteristics were compared between the two groups using un-paired t-test and χ^2 statistics (Gravetter & Wallnau, 2009a, 2009b). Mixed between-within subjects analysis of covariance was used to compare the changes over time across the two groups while controlling for the confounding variables (i.e., age and gender) (Gamst, Meyers, & Guarino, 2008a, 2008b). All statistical tests with a p value < 0.05 were considered significant. All analyses were conducted using IBM SPSS Statistics version 21.

5.3. Results

A total of 7,142 patients were identified from the CR database. Only 3,488 had complete data for exercise capacity and self-reported exercise at the 3 assessment points and were included in the analysis. They participated either in center-based (n = 2,803) or home-based (n = 685) CR.

Data on supervised training attendance was available in 2,036 (73%) of center-based participants. They averaged 19 out of 24-36 exercise sessions which were offered to them in the center (i.e., 69% of offered sessions). The number of exercise sessions completed was not recorded in home-based group. Baseline demographic and clinical data for the 2 groups are presented in Table 5.1. The home-based group was younger with a higher exercise capacity, lower ratio of male to female participants, and a lower incidence of hypertension ($p < 0.05$) (Tables 5.1 and 5.2). With $\alpha = 0.05$ and sample size of $n = 3,488$ this study had the power of 1.000 to detect the change in exercise capacity (i.e., peak METs) with the effect size of $\eta^2_\rho = 0.028$.

5.3.1. Exercise Capacity

Post-CR exercise capacity increased significantly in both groups ($p < 0.05$) with the center-based CR group demonstrating the largest increase (time × group interaction $p < 0.05$). From post-CR to the 1 year follow-up, exercise capacity remained unchanged in home-based CR participants ($p = 0.183$) while it declined in the center-based CR group ($p < 0.05$). The home-based group had higher exercise capacity at all the assessment points ($p < 0.05$) (Table 5.2).

5.3.2. HR Recovery

One minute HR recovery data was available in 963 participants (center-based: 696; home-based: 267) at the 3 assessment points. From baseline to post-CR to 1 year follow-up, the mean HR recovery was 23 ± 10, 25 ± 12, and 25 ± 11 beats in center-based group and 24 ± 12, 25 ± 11, and 25 ± 12 beats in home-based group. There was no significant change in 1 minute HR recovery over time in either of the groups ($p = 0.294$).

5.3.3. Self-reported Exercise

There was a significant change in self-reported exercise volume over time in both groups ($p < 0.05$); and the change was not different across the 2 groups (time × group interaction $p = 0.999$). Immediately following CR, self-reported weekly exercise time increased in both groups ($p < 0.05$). However, both groups showed a drop in exercise time between CR completion and the 1 year follow-up ($p < 0.05$) (Table 5.2).

5.3.4. BMI and Waist Circumference

BMI and waist circumference data were available in a subsample of n = 3,190 participants (center-based: 2,561; home-based: 629) at the 3 assessment points. Both groups showed a decline in BMI and waist circumference at the end of the 12 week CR ($p < 0.05$). However, from post-CR to 1 year follow-up both BMI and waist circumference increased in both groups ($p < 0.05$) (Table 5.3). The changes observed over time were not different across the 2 groups (BMI: time × group interaction $p = 0.071$; waist circumference: time × group interaction $p = 0.268$).

5.3.5. Blood Lipids and Fasting Blood Glucose

Blood lipids and fasting blood glucose data were available in a subsample of n = 1,537 participants (center-based: 1,240; home-based: 297) at the 3 assessment points. From baseline to post-CR to 1 year follow-up, HDL, and total cholesterol increased significantly in both groups ($p < 0.05$) (Table 5.3). There was no difference in the observed changes over time across the 2 groups (HDL: time × group interaction $p = 0.508$; total cholesterol: time × group interaction $p = 0.108$). No significant change was found in LDL, triglycerides, and fasting blood glucose levels in either of the groups over the course of the study (LDL: $p = 0.056$; triglycerides: $p = 0.255$; fasting blood glucose: $p = 0.291$) (Table 5.3).

5.4. Discussion

In this study, participating in a 12 week exercise training program either at the CR center with supervision or unsupervised in the community resulted in a significant improvement in exercise capacity. This finding is consistent with previous studies (Arthur et al., 2002; Dalal et al., 2010; Jolly et al., 2006; Karapolat et al., 2009; Kodis et al., 2001; Marchionni et al., 2003; Miller et al., 1984; Oerkild et al., 2011). Also the observed improvements are within the range of exercise capacity changes often seen in CR studies that include exercise training (Arthur et al., 2002; Kodis et al., 2001; K. M. Smith et al., 2004). There is evidence that every 1 $mL \cdot kg^{-1} \cdot min^{-1}$ (i.e., 0.28 METs) increase in exercise capacity is associated with a 10% reduction in cardiovascular mortality (Kavanagh et al., 2002, 2003). Increases of 0.95 METs and 0.73 METs in exercise capacity (for the center-based and home-based groups respectively) indicate the potential clinical significance of our findings.

Interestingly, at the 1 year follow-up, exercise capacity remained unchanged in participants who chose home-based CR, whereas those who chose the center-based CR demonstrated a decline in exercise capacity. This finding is consistent with some previous studies (Marchionni et al., 2003; K. M. Smith et al., 2004) and might imply the relative superiority of home-based CR in retaining the achieved gain in exercise capacity at least 1 year post-CR. In home-based programs there is more emphasis on self-monitoring and independent exercise. Self-monitoring might in turn enhance patient awareness of their behavior which could ultimately lead to better adherence to long-term behavior change (Conn et al., 2008). Furthermore, developing early adaptation of exercise behavior changes to the patient home environment may play a key role in exercise sustainability (Chase, 2011). In contrast, center-based CR participants may develop dependence on facility-based training due to higher level of

supervision (Carlson et al., 2000). It has been suggested that high level of supervision in center-based CR programs can be a barrier for independent off-site exercise in cardiac patients (Carlson et al., 2001).

However, one must remember that, in this study, the home-based group had a higher exercise capacity from the outset. Furthermore, the observed decline in center-based group exercise capacity was small ($\eta^2_p = 0.019$). For the center-based CR participants, exercise capacity was estimated to decrease only 0.12 METs and this is far short of the previously mentioned change in exercise capacity (0.28 METs) required to impact patient mortality (Kavanagh et al., 2002, 2003). This suggests that, even though there was a decline in center-based group exercise capacity 1 year post-CR, the decrease may be clinically insignificant.

The findings from this study suggest that allowing participants to choose where they attend CR may offset the relatively large decline in exercise capacity typically seen in participants who participated in a center-based CR program (Hughes, Mutrie, & Macintyre, 2007; Oerkild et al., 2011; K. M. Smith et al., 2004; Stahle, Mattsson, et al., 1999). For instance, Hughes et al. (2007) reported a decline of 2.3 $mL \cdot kg^{-1} \cdot min^{-1}$ in exercise capacity in CR participants which was much greater than what we observed. Although our center-based participants were relatively young compared with previous studies (Oerkild et al., 2011; Stahle, Mattsson, et al., 1999), they demonstrated a smaller decline in exercise capacity at the follow-up even when compared with patients of similar age (Hughes et al., 2007; K. M. Smith et al., 2004). Furthermore, at the 1 year follow-up, exercise capacity was still significantly higher than the baseline values observed in both groups ($p < 0.05$). These findings imply that, by allowing participants to self-select the location of their CR exercise, both programs were relatively effective in maintaining the exercise capacity 1 year post-CR.

Once a CR program ends, sustaining physical activity is essential to maintain the achieved benefits (Brubaker et al., 2000; Chase, 2011). The self-reported exercise time results suggest that although by the 1 year follow-up both groups were trending down towards their pre-CR levels, participants in both programs continued to exceed the exercise volume necessary for health improvements over the course of the study (i.e., 30 minutes of moderate to vigorous exercise 3 days/week) (Fletcher et al., 2001). These findings suggest that both center-based and home-based CR participants were successful in maintaining an acceptable exercise volume which might be one of the reasons for their relative success in exercise capacity maintenance.

Our participants had higher exercise capacity at baseline than the patients in the previous studies (Oerkild et al., 2011; K. M. Smith et al., 2004). They had an average exercise capacity of 8 METs at baseline, which was nearly double the values reported by Oerkild et al. (2011) and Smith et al. (2004). Having relatively high exercise capacity might reflect that these patients were more active at the outset. Indeed at baseline, the self-reported exercise of groups exceeded the recommended exercise volume for cardiac patients (Fletcher et al., 2001). Our participants' success in maintaining the achieved gain in exercise capacity at 1 year post-CR might also be attributed to an established exercise habit pre dating their enrollment in CR.

Our results indicated that both programs were effective in lowering BMI and waist circumference which was a promising finding as compared with the previous studies (Dalal et al., 2007; Kodis et al., 2001; Oerkild et al., 2011; Wakefield et al., 2014). However, in this study the observed improvements in both BMI and waist circumference were lost by the 1 year follow-up.

The observed increase in total cholesterol level over time was not expected. However, despite the statistical significance of the change, the effect size was small ($\eta^2_\rho = 0.003$).

Significant improvement in HDL level of both groups was consistent with previous findings (Jolly et al., 2009; Jolly et al., 2007; Kodis et al., 2001). LDL, triglycerides, and fasting blood glucose did not show any improvements in either of the groups. As shown in the baseline, blood lipids and glucose approximate acceptable values (Table 5.3). Therefore, lack of further improvement in these variables was not surprising. Also, other factors such as diet, and the use of the medication might have influenced anthropometrics, HR variability, and blood lipids and glucose level.

5.4.1. Limitations

Certainly findings from this study might be affected by the non-randomized nature of the study which may lead to selection bias. Despite controlling for age and gender differences between 2 groups, the home-based group had a higher exercise capacity. This might explain home-based group's relative superiority in maintaining exercise capacity 1 year post-CR. Also, reaching a firm conclusion on the effectiveness of self-selection might be limited due to lack of a control group with random assignment of participants.

The observational-retrospective design of the study may also be considered as a limitation. However, it gave us the advantage of a large sample size. Moreover, modifications in clinical practice guidelines which might have happened over the course of the data collection (i.e., 1996-2009) might have affected our data.

Furthermore, the attrition in the follow-up assessments might have affected the findings in this study. Only participants who had complete data for exercise capacity and self-reported exercise at the three assessment points were included in the analysis (i.e., 49% of total participants). There is a possibility that our analyzed subsample was more motivated group than

the dropouts. Therefore the pattern of changes in exercise capacity could have been different in the subjects who did not attend the 1 year follow-up assessment.

Some might suggest that our method of estimating exercise capacity overestimates peak METs. However, previous papers on the same dataset have demonstrated that our determination of METs is strongly prognostic and consistent with other papers in the literature (Martin et al., 2013; Martin, Hauer, et al., 2012). Finally, the use of self-reported measuring tool to assess activity is highly influenced by social desirability and recall bias (Ainsworth, 2009; Vanhees et al., 2005).

5.5. Conclusions

The present findings imply that when patients were given a choice as to the format of their CR program, they were relatively successful in maintaining their achieved gains in exercise capacity for at least one year post-CR, independent of exercise venue. It appears allowing patients to self-select the location of their exercise training within a CR program (i.e., center versus home) does not negatively influence the impact of CR on exercise capacity.

Table 5.1. Baseline sample characteristics by CR delivery model

	CR Delivery Model		p value
	Center-based (n = 2,803)	**Home-based (n = 685)**	
Age, mean, y	61.1 ± 10.1	57.9 ± 10.9	0.000
Male, %	78.9	72.8	0.001
Ejection fraction, %			0.008
>50	71.7	78.0	
35-50	18.9	13.6	
20-34	2.9	1.8	
<20	0.4	0.6	
Not done	4.2	3.9	
Missing	1.9	2.2	
Indication for catheterization, %			0.102
Stable angina	23.3	26.7	
Myocardial infarction (MI)	52.1	49.1	
Unstable angina	18.7	19.7	
Other	6.0	4.5	
Patient characteristics, %			
Prior MI	29.1	24.8	0.030
Prior CABG	1.4	1.0	0.522
Prior PCI	3.6	2.5	0.168
Hypertension	59.7	54.0	0.007
Diabetes mellitus	14.9	15.2	0.888
Hyperlipidemia	72.0	73.4	0.469
Current smoker	20.2	20.0	0.936
Previous smoker	37.1	34.6	0.247
COPD	10.2	10.1	0.998
Cerebrovascular disease	4.2	3.4	0.364
Peripheral vascular disease	3.8	2.6	0.165
Renal disease	1.0	0.7	0.666
Liver or gastrointestinal disease	6.6	5.7	0.435
Malignancy	3.7	2.2	0.070

Abbreviations: CR, cardiac rehabilitation; CABG, coronary artery bypass graft; PCI, percutaneous coronary intervention; COPD, chronic obstructive pulmonary disease.

Table 5.2. Changes in exercise capacity and self-reported exercise time from baseline to 12 weeks to 1 year follow-up in center-based versus home-based CR[a,b]

	Center-based CR (n = 2,803)			Home-based CR (n = 685)		
	Baseline	**12 weeks**	**1 year**	**Baseline**	**12 weeks**	**1 year**
Exercise capacity[c] (peak METs)	7.91 ± 1.91	8.86 ± 1.96[d]	8.74 ± 2.12[e,f]	8.56 ± 2.03	9.29 ± 2.08[d]	9.24 ± 2.24[f]
Exercise time (min/week)	145.83 ± 141.11	164.76 ± 91.16[d]	137.92 ± 113.83[e,f]	150.55 ± 125.10	170.55 ± 109.76[d]	141.41 ± 114.96[e,f]

[a]Data are presented as mean ± standard deviation; $p < 0.05$ is considered significant.
[b]Differences in age and gender were adjusted in the analyses.
[c]Significant difference between groups at all three assessment points.
[d]Significant change from baseline to 12 weeks in a given group (i.e., center or home).
[e]Significant change from 12 weeks to 1 year in a given group (i.e., center or home).
[f]Significant change from baseline to 1 year in a given group (i.e., center or home).
Abbreviations: CR, cardiac rehabilitation; METs: metabolic equivalents.

Table 5.3. Changes in body composition, blood lipids, and fasting blood glucose from baseline to 12 weeks to 1 year follow-up in center-based versus home-based CR[a,b]

	Center-based CR			Home-based CR		
	Baseline	**12 weeks**	**1 year**	**Baseline**	**12 weeks**	**1 year**
BMI, kg/m^2	27.54 ± 4.05 (n=2,561)	27.40 ± 4.02[c] (n=2,561)	27.79 ± 4.16[d,e] (n=2,561)	27.55 ± 4.30 (n=629)	27.40 ± 4.30[c] (n=629)	27.70 ± 4.47[d,e] (n=629)
Waist circumference, cm	98.41 ± 12.17 (n=2,561)	97.55 ± 12.14[c] (n=2,561)	98.95 ± 12.45[d,e] (n=2,561)	97.28 ± 12.00 (n=629)	96.62 ± 11.96[c] (n=629)	97.69 ± 12.54[d,e] (n=629)
HDL, mmol/L	1.15 ± 0.31 (n=1,240)	1.21 ± 0.31[c] (n=1,240)	1.24 ± 0.32[d,e] (n=1,240)	1.15 ± 0.36 (n=297)	1.22 ± 0.37[c] (n=297)	1.26 ± 0.37[d,e] (n=297)
LDL, mmol/L	1.74 ± 0.82 (n=1,240)	1.73 ± 0.72 (n=1,240)	1.88 ± 0.79 (n=1,240)	1.71 ± 0.69 (n=297)	1.77 ± 0.74 (n=297)	1.86 ± 0.76 (n=297)
Total cholesterol, mmol/L	3.51 ± 0.99 (n=1,240)	3.53 ± 0.87[c] (n=1,240)	3.74 ± 0.93[d,e] (n=1,240)	3.46 ± 0.92 (n=297)	3.58 ± 0.92[c] (n=297)	3.69 ± 0.93[d,e] (n=297)
Triglycerides, mmol/L	1.35 ± 0.64 (n=1,240)	1.29 ± 0.62 (n=1,240)	1.35 ± 0.68 (n=1,240)	1.32 ± 0.66 (n=297)	1.27 ± 0.70 (n=297)	1.27 ± 0.66 (n=297)
Fasting glucose, mmol/L	5.93 ± 1.50 (n=1,240)	5.89 ± 1.42 (n=1,240)	6.03 ± 1.69 (n=1,240)	5.88 ± 1.46 (n=297)	5.78 ± 1.25 (n=297)	5.83 ± 1.25 (n=297)

[a]Data are presented as mean ± standard deviation; $p < 0.05$ is considered significant.
[b]Differences in age and gender were adjusted in the analyses. There were no significant differences between groups for any variable.
[c]Significant change from baseline to 12 weeks in a given group (i.e., center or home).
[d]Significant change from 12 weeks to 1 year in a given group (i.e., center or home).
[e]Significant change from baseline to 1 year in a given group (i.e., center or home).
Abbreviations: CR, cardiac rehabilitation; BMI, body mass index; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

5.6. References

Ainsworth, B. E. (2009). How do I measure physical activity in my patients? Questionnaires and objective methods. *Br J Sports Med, 43*(1), 6-9. doi: bjsm.2008.052449 [pii] 10.1136/bjsm.2008.052449

American College of Sports Medicine. (2010). *ACSM's Guidelines for Exercise Testing and Prescription* (8th ed.). Philadelphia, PA: Wolters Kluwer Health/ Lippincott Williams & Wilkins.

Arthur, H. M., Smith, K. M., Kodis, J., & McKelvie, R. (2002). A controlled trial of hospital versus home-based exercise in cardiac patients. *Med Sci Sports Exerc, 34*(10), 1544-1550. doi: 10.1249/01.MSS.0000030847.23854.CB

Ashworth, N. L., Chad, K. E., Harrison, E. L., Reeder, B. A., & Marshall, S. C. (2005). Home versus center based physical activity programs in older adults. *Cochrane Database Syst Rev*(1), CD004017. doi: 10.1002/14651858.CD004017.pub2

Blair, J., Corrigall, H., Angus, N. J., Thompson, D. R., & Leslie, S. (2011). Home versus hospital-based cardiac rehabilitation: a systematic review. *Rural Remote Health, 11*(2), 1532. doi: 1532 [pii]

Brubaker, P. H., Rejeski, W. J., Smith, M. J., Sevensky, K. H., Lamb, K. A., Sotile, W. M., & Miller, H. S., Jr. (2000). A home-based maintenance exercise program after center-based cardiac rehabilitation: effects on blood lipids, body composition, and functional capacity. *J Cardiopulm Rehabil, 20*(1), 50-56.

Carlson, J. J., Johnson, J. A., Franklin, B. A., & VanderLaan, R. L. (2000). Program participation, exercise adherence, cardiovascular outcomes, and program cost of traditional versus modified cardiac rehabilitation. *Am J Cardiol, 86*(1), 17-23.

Carlson, J. J., Norman, G. J., Feltz, D. L., Franklin, B. A., Johnson, J. A., & Locke, S. K. (2001). Self-efficacy, psychosocial factors, and exercise behavior in traditional versus modified cardiac rehabilitation. *J Cardiopulm Rehabil, 21*(6), 363-373.

Chase, J. A. (2011). Systematic review of physical activity intervention studies after cardiac rehabilitation. *J Cardiovasc Nurs, 26*(5), 351-358. doi: 10.1097/JCN.0b013e3182049f00

Conn, V. S., Hafdahl, A. R., Brown, S. A., & Brown, L. M. (2008). Meta-analysis of patient education interventions to increase physical activity among chronically ill adults. *Patient Educ Couns, 70*(2), 157-172. doi: 10.1016/j.pec.2007.10.004

Dalal, H. M., Evans, P. H., Campbell, J. L., Taylor, R. S., Watt, A., Read, K. L., . . . Pereira Gray, D. J. (2007). Home-based versus hospital-based rehabilitation after myocardial infarction: A randomized trial with preference arms--Cornwall Heart Attack Rehabilitation Management Study (CHARMS). *Int J Cardiol, 119*(2), 202-211. doi: S0167-5273(06)01423-9 [pii]

10.1016/j.ijcard.2006.11.018

Dalal, H. M., Zawada, A., Jolly, K., Moxham, T., & Taylor, R. S. (2010). Home based versus centre based cardiac rehabilitation: Cochrane systematic review and meta-analysis. *BMJ, 340*, b5631. doi: 10.1136/bmj.b5631

Fletcher, G. F., Balady, G. J., Amsterdam, E. A., Chaitman, B., Eckel, R., Fleg, J., . . . Bazzarre, T. (2001). Exercise standards for testing and training: a statement for healthcare professionals from the American Heart Association. *Circulation, 104*(14), 1694-1740.

Froelicher, V., Jensen, D., & Sullivan, M. (1985). A randomized trial of the effects of exercise training after coronary artery bypass surgery. *Archives of Internal Medicine, 145*(4), 689-692.

Gamst, G., Meyers, L. S., & Guarino, A. J. (2008a). Analysis of covariance *Analysis of Variance Designs: A Conceptual and Computational Approach with SPSS and SAS* (1st ed., pp. 453-487). Cambridge, UK: Cambridge University Press.

Gamst, G., Meyers, L. S., & Guarino, A. J. (2008b). Simple mixed design *Analysis of Variance Designs: A Conceptual and Computational Approach with SPSS and SAS* (1st ed., pp. 361-390). Cambridge, UK: Cambridge University Press.

Ghali, W. A., & Knudtson, M. L. (2000). Overview of the Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease. On behalf of the APPROACH investigators. *Can J Cardiol, 16*(10), 1225-1230.

Gravetter, F. J., & Wallnau, L. B. (2009a). The chi-square statistics: tests for goodness of fit and independence *Statistics for the Behavioral Sciences* (8th ed., pp. 604-643). Belmont: Wadsworth - Cengage Learning.

Gravetter, F. J., & Wallnau, L. B. (2009b). The t test for two independent samples *Statistics for the Behavioral Sciences* (8th ed., pp. 307-338). Belmont: Wadsworth - Cengage Learning.

Hughes, A. R., Mutrie, N., & Macintyre, P. D. (2007). Effect of an exercise consultation on maintenance of physical activity after completion of phase III exercise-based cardiac rehabilitation. *Eur J Cardiovasc Prev Rehabil, 14*(1), 114-121. doi: 10.1097/HJR.0b013e3280116485

00149831-200702000-00017 [pii]

Jolly, K., Lip, G. Y., Taylor, R. S., Raftery, J., Mant, J., Lane, D., . . . Stevens, A. (2009). The Birmingham Rehabilitation Uptake Maximisation study (BRUM): a randomised

controlled trial comparing home-based with centre-based cardiac rehabilitation. *Heart, 95*(1), 36-42. doi: 10.1136/hrt.2007.127209

Jolly, K., Taylor, R., Lip, G. Y., Greenfield, S., Raftery, J., Mant, J., . . . Stevens, A. (2007). The Birmingham Rehabilitation Uptake Maximisation Study (BRUM). Home-based compared with hospital-based cardiac rehabilitation in a multi-ethnic population: cost-effectiveness and patient adherence. *Health Technol Assess, 11*(35), 1-118. doi: 99/32/09 [pii]

Jolly, K., Taylor, R. S., Lip, G. Y., & Stevens, A. (2006). Home-based cardiac rehabilitation compared with centre-based rehabilitation and usual care: a systematic review and meta-analysis. *International journal of cardiology, 111*(3), 343-351. doi: 10.1016/j.ijcard.2005.11.002

Karapolat, H., Demir, E., Bozkaya, Y. T., Eyigor, S., Nalbantgil, S., Durmaz, B., & Zoghi, M. (2009). Comparison of hospital-based versus home-based exercise training in patients with heart failure: effects on functional capacity, quality of life, psychological symptoms, and hemodynamic parameters. *Clin Res Cardiol, 98*(10), 635-642. doi: 10.1007/s00392-009-0049-6

Kavanagh, T., Mertens, D. J., Hamm, L. F., Beyene, J., Kennedy, J., Corey, P., & Shephard, R. J. (2002). Prediction of long-term prognosis in 12 169 men referred for cardiac rehabilitation. *Circulation, 106*(6), 666-671.

Kavanagh, T., Mertens, D. J., Hamm, L. F., Beyene, J., Kennedy, J., Corey, P., & Shephard, R. J. (2003). Peak oxygen intake and cardiac mortality in women referred for cardiac rehabilitation. *J Am Coll Cardiol, 42*(12), 2139-2143.

Kodis, J., Smith, K. M., Arthur, H. M., Daniels, C., Suskin, N., & McKelvie, R. S. (2001). Changes in exercise capacity and lipids after clinic versus home-based aerobic training in coronary artery bypass graft surgery patients. *Journal of Cardiopulmonary Rehabilitation, 21*(1), 31-36.

Lavie, C. J., Milani, R. V., & Littman, A. B. (1993). Benefits of cardiac rehabilitation and exercise training in secondary coronary prevention in the elderly. *J Am Coll Cardiol, 22*(3), 678-683.

Maines, T. Y., Lavie, C. J., Milani, R. V., Cassidy, M. M., Gilliland, Y. E., & Murgo, J. P. (1997). Effects of cardiac rehabilitation and exercise programs on exercise capacity, coronary risk factors, behavior, and quality of life in patients with coronary artery disease. *South Med J, 90*(1), 43-49.

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

Martin, B. J., Arena, R., Haykowsky, M., Hauer, T., Austford, L. D., Knudtson, M., . . . Stone, J. A. (2013). Cardiovascular fitness and mortality after contemporary cardiac rehabilitation. *Mayo Clin Proc, 88*(5), 455-463. doi: 10.1016/j.mayocp.2013.02.013

Martin, B. J., Hauer, T., Arena, R., Austford, L. D., Galbraith, P. D., Lewin, A. M., . . . Aggarwal, S. G. (2012). Cardiac rehabilitation attendance and outcomes in coronary artery disease patients. *Circulation, 126*(6), 677-687. doi: 10.1161/circulationaha.111.066738

McConnell, T. R., & Clark, B. A. (1987). Prediction of maximal oxygen consumption during handrail-supported treadmill exercise. *Journal of Cardiopulmonary Rehabilitation, 7*(7), 324-331.

Miller, N. H., Haskell, W. L., Berra, K., & DeBusk, R. F. (1984). Home versus group exercise training for increasing functional capacity after myocardial infarction. *Circulation, 70*(4), 645-649.

Oerkild, B., Frederiksen, M., Hansen, J. F., Simonsen, L., Skovgaard, L. T., & Prescott, E. (2011). Home-based cardiac rehabilitation is as effective as centre-based cardiac rehabilitation among elderly with coronary heart disease: results from a randomised clinical trial. *Age Ageing, 40*(1), 78-85. doi: afq122 [pii]

10.1093/ageing/afq122

Oldridge, N., Guyatt, G., Jones, N., Crowe, J., Singer, J., Feeny, D., . . . Torrance, G. (1991). Effects on quality of life with comprehensive rehabilitation after acute myocardial infarction. *Am J Cardiol, 67*(13), 1084-1089.

Perk, J., Hedback, B., & Engvall, J. (1990). Effects of cardiac rehabilitation after coronary artery bypass grafting on readmissions, return to work, and physical fitness. A case-control study. *Scandinavian journal of social medicine, 18*(1), 45-51.

Smith, K. M., Arthur, H. M., McKelvie, R. S., & Kodis, J. (2004). Differences in sustainability of exercise and health-related quality of life outcomes following home or hospital-based cardiac rehabilitation. *Eur J Cardiovasc Prev Rehabil, 11*(4), 313-319. doi: 00149831-200408000-00008 [pii]

Smith, K. M., McKelvie, R. S., Thorpe, K. E., & Arthur, H. M. (2011). Six-year follow-up of a randomised controlled trial examining hospital versus home-based exercise training after

coronary artery bypass graft surgery. *Heart, 97*(14), 1169-1174. doi: 10.1136/hrt.2010.202036

Stahle, A., Mattsson, E., Ryden, L., Unden, A., & Nordlander, R. (1999). Improved physical fitness and quality of life following training of elderly patients after acute coronary events. A 1 year follow-up randomized controlled study. *Eur Heart J, 20*(20), 1475-1484.

Stone, J. A., Arena, R., Hauer, T., Martin, B. J., Austford, L. D., & Aggarwal, S. (2011). Long-term retention of aerobic fitness improvements following participation in cardiac rehabilitation. *Int J Cardiol, 150*(3), 355-356. doi: S0167-5273(11)00454-2 [pii] 10.1016/j.ijcard.2011.05.041

Vanhees, L., Lefevre, J., Philippaerts, R., Martens, M., Huygens, W., Troosters, T., & Beunen, G. (2005). How to assess physical activity? How to assess physical fitness? *Eur J Cardiovasc Prev Rehabil, 12*(2), 102-114. doi: 00149831-200504000-00004 [pii]

Wakefield, B., Drwal, K., Scherubel, M., Klobucar, T., Johnson, S., & Kaboli, P. (2014). Feasibility and effectiveness of remote, telephone-based delivery of cardiac rehabilitation. *Telemed J E Health, 20*(1), 32-38. doi: 10.1089/tmj.2013.0079

Yu, C. M., Li, L. S., Ho, H. H., & Lau, C. P. (2003). Long-term changes in exercise capacity, quality of life, body anthropometry, and lipid profiles after a cardiac rehabilitation program in obese patients with coronary heart disease. *Am J Cardiol, 91*(3), 321-325. doi: S0002914902031594 [pii]

Chapter 6

General Discussion and Conclusions

6.1. Discussion and Conclusions

Cardiopulmonary rehabilitation programs were originally founded based on the well-established benefits of regular physical activity (PA) in patients with cardiopulmonary disorders (American Association of Cardiovascular and Pulmonary Rehabilitation, 1999; Nici et al., 2006). Indeed PA is associated with a lower risk of mortality in this population (Garber et al., 2011; Garcia-Aymerich et al., 2006; Haapanen et al., 1996; Haennel & Lemire, 2002; Leon et al., 1987). Despite these health benefits, the adherence to regular PA following completion of the programs seems challenging (Bethell, 1999; Bock et al., 2003; Brubaker et al., 1996; N. B. Oldridge, 1991). This might adversely influence the sustainability of the achieved benefits over the long-term (Stone et al., 2011). Rehabilitation delivery model has been proposed as a potential factor that might influence participants' PA adherence (Blair et al., 2011; Carlson et al., 2000; Marchionni et al., 2003; K. M. Smith et al., 2004; K. M. Smith et al., 2011). Thus, detailed investigation on the PA behavior of cardiopulmonary patients as they progress through different exercise rehabilitation programs from entry to completion and following-up seems warranted.

The first part of this thesis focused on daily PA level in cardiopulmonary rehabilitation participants at the end of the program. The second and third studies investigated the long-term PA adherence and exercise capacity sustainability in cardiac rehabilitation (CR) participants following graduation from different delivery models of CR. The results from these three studies allow us to comment on 1) the immediate impact of an exercise rehabilitation program on daily PA of patients with cardiopulmonary disorders; and 2) the long-term impact of different delivery

models of CR on participants' PA adherence and exercise capacity sustainability following completion of the programs.

The first study in this thesis objectively measured quantity and quality of daily PA in cardiopulmonary patients who participated in exercise rehabilitation program. A key finding from this study was that although exercise rehabilitation did not impact moderate-vigorous physical activity (MVPA), it did cause a PA behavior change at the lower end of the PA continuum. Indeed participants spent less time sedentary and increased the time spent in light PA at the end of the program. Considering the deleterious effects of sedentary behavior on mortality which is independent of MVPA, participants in exercise rehabilitation programs may obtain substantial benefits by simply lowering the time spent sedentary (M. T. Hamilton et al., 2004; Healy et al., 2008; Katzmarzyk et al., 2009; Manns et al., 2012; Owen, 2012; Owen et al., 2010; Tremblay et al., 2010). Moreover, substituting light PA for sedentary behavior can lead to substantial metabolic and mortality benefits due to the inverse relationship between light PA and metabolic risk factors (Healy et al., 2007; Healy et al., 2008; Manini et al., 2006; Matthews et al., 2012; Matthews et al., 2007). One unique implication of this study was highlighting the importance of considering the entire spectrum of PA from sedentary behavior to spontaneous light intensity PA and MVPA over the whole day rather than focusing exclusively on regimented bouts of MVPA. The key message from this study was that at the beginning of the rehabilitation programs encouraging patients to reduce their sedentary time and increase light PA may be a more feasible goal to achieve. Less sedentary patients might be better prepared for behavior change in more structured higher intensity PA (i.e., MVPA). Furthermore, our findings indicated that increase in exercise capacity may not necessarily result in a more active lifestyle, as the observed improvement in PA was independent of the increase in exercise capacity.

The secondary analysis from the first study indicated that the patterns of changes in PA behavior over time were similar in cardiac and pulmonary patients. Therefore, our second and third studies focused exclusively on cardiac patients. Although our first study demonstrated that participants were less sedentary at the end of the program the long-term adherence to the obtained behavior change might be challenging (Bock et al., 2003). Thus, investigating the PA behavior of the participants several months after graduation from the program seems warranted. The second study of this thesis investigated the long-term PA adherence of coronary artery disease (CAD) patients following completion of the fast-track versus traditional center-based CR program. Both programs were center-based with the fast-track program offering fewer on-site sessions. The intent of this program was to encourage more independent exercise. The key finding from this study was that participation in CR programs did not result in long-term PA behavior change irrespective of the delivery model. Although participants in both traditional and fast-track CR had higher exercise capacity at 6 months following CR entry, their overall daily PA was not significantly different from what was recorded at baseline. Indeed irrespective of the delivery model for their exercise training, patients tend to resume their baseline PA behavior following removal from CR programs. Thus, CR participants may benefit from structured strategies which promote long-term PA adherence in addition to facilitating exercise capacity improvement.

Furthermore, in this study our participants spent ~ 74-75% of their waking time sedentary and only ~ 18-19% in light PA versus the 71% and 28% reported respectively for sedentary and light PA time in Canadian adults of similar age (Colley et al., 2011). It is noteworthy that the elevated sedentary time and substantially low level of light PA was observed despite the fact that at least 50% of our participants met the recommended level of MVPA (i.e., 30 min/day). The risk

of limiting the spontaneous PA (i.e., light PA) in favour of keeping the MVPA at the recommended level may raise concern as the benefits of MVPA may be offset by the elevated sedentary time (Matthews et al., 2012). In parallel with the findings from our first study, this study further highlighted the importance of considering the entire spectrum of PA when promoting the PA behavior change. In fact the recommended MVPA needs to be performed beyond the spontaneous daily activities (i.e., light PA) rather than replacing it (Tudor-Locke et al., 2011).

The ultimate goal of CR programs is to maintain patients at optimal level of functioning (American Association of Cardiovascular and Pulmonary Rehabilitation, 2004). Although participation in CR improves exercise capacity, the sustainability of this improvement in long-term might be challenging (Stone et al., 2011). Moreover, the influence of CR delivery model on the long-term sustainability of the outcomes is not completely understood. The third study of this thesis focused on the sustainability of the obtained gains in exercise capacity in CAD patients 1 year following completion of the center-based versus home-based CR. The key finding from this study was that participants were relatively successful in maintaining their achieved gains in exercise capacity for at least 1 year post-CR, independent of CR venue. Although exercise capacity decreased in center-based group from CR completion to 1 year follow-up, the observed decline was clinically insignificant. At the 1 year follow-up, exercise capacity was significantly higher than the baseline values in both groups. This was observed despite the decline in the self-reported PA from end of CR to the 1 year follow-up.

We did not find any evidence of a potential influence of delivery model on PA adherence and exercise capacity sustainability following graduation from the programs. One possible explanation may be the non-randomized nature of our study. In our third study patients were

given a chance to choose their CR format. Although reaching a firm conclusion might be limited due to lack of a control group with random assignment of participants, comparing our results with findings from randomized controlled trials might be indicative of the potential positive effect of self-selection. Indeed, unlike the results observed in our study randomized controlled trials reported substantial decline in exercise capacity in center-based CR participants following competition of the program (Hughes et al., 2007; Oerkild et al., 2011; K. M. Smith et al., 2004; Stahle, Mattsson, et al., 1999). Our findings suggested that self-selecting the CR delivery model my offset the relatively large decline in exercise capacity typically seen between CR completion and several months follow-up. Taking patient preference in to consideration has been recommended when referring patients to different CR delivery models (Shanmugasegaram, Oh, Reid, McCumber, & Grace, 2013). Considering the comparable effectiveness of center-based and home-based CR, low to intermediate risk patients may choose either center-based or home-based CR. However, high risk patients are eligible only for center-based CR (Canadian Association of Cardiac Rehabilitation, 2009). Future studies with both randomized and preferred arms are required to clarify the potential interactions of delivery model and self-selection and their ultimate impact on the CR outcomes.

The major findings from the three studies in this thesis were that 1) participation in exercise rehabilitation program appears to improve habitual PA at the end of the program; 2) following removal from the program participants resume their baseline PA level despite maintaining the achieved gains in the exercise capacity regardless of the program delivery model. This later finding on the different responses which were observed in PA versus exercise capacity in both second and third studies is in parallel with the results from the first study which indicated that the improvements in exercise capacity and daily PA were not related. Combined

these findings further confirm the proposed notion of difference between exercise capacity and participation in PA (Ashe et al., 2007). It may imply that an increase in exercise capacity alone may not be sufficient to change the habitual sedentary lifestyle (Larson, 2007). It has been suggested that in order to improve exercise capacity and PA behavior, they need to be targeted independently (Zwerink et al., 2013). Further investigations on determinants of these two markers may be helpful in designing programs that can target both.

Furthermore, one unique aspect of this thesis was using a multi-sensor activity monitor that provided us with a more accurate measure of the entire spectrum of PA including low-intensity PA which is often underestimated by other measurement tools (Mackey et al., 2011). Specifically we measured sedentary behavior and light habitual PA in addition to MVPA which is usually the main focus of cardiopulmonary rehabilitation programs. Interestingly our results demonstrated that the change in PA behavior has occurred in this lower end of the PA continuum. Given the significant impact of sedentary time and light PA on mortality risk factors, this is a major achievement (Healy et al., 2007; Healy et al., 2008; Matthews et al., 2012; Owen, 2012). However, as observed in the second study, current approaches in cardiac rehabilitation may not be effective in maintaining PA behavior change regardless of the delivery model. They are mainly founded on meeting the MVPA recommendation, whereas sedentary behavior and habitual PA appear to be overlooked in these programs. The risk of MVPA benefits being offset by elevated sedentary behavior warrants designing more effective delivery models to maintain these valuable changes in the habitual PA.

6.1.1. Recommendations

Aerobic exercise intensity of above moderate (40%-80% VO_2 reserve) is often recommended in order to improve exercise capacity (American College of Sports Medicine,

2010). However, majority of participants in rehabilitation programs have been habitually sedentary for years. It has been suggested that previously sedentary individuals are more likely to adhere to activities that are personally enjoyable and provide them with social interactions (Canadian Association of Cardiac Rehabilitation, 2009). For instance, encouraging light intensity recreational activities such as joining a community walking group, participating in a walk for charity, going for a walk around the block, taking a dance class, walking to work, or taking up a favourite sport may be more acceptable for patients who are starting to make changes in their PA behavior. This is in parallel with our suggestion that for some patients our first step should be substituting light PA for sedentary behavior which may independently lead to substantial metabolic and mortality benefits.

In addition to metabolic benefits, light PA has been reported to decrease the rate of decline in physical function. It has been suggested that increasing light PA can be a valuable approach to benefit the individuals who may be hesitant to initiate MVPA (C. K. Blair et al., 2014). Moreover, there is evidence that light intensities as low as 25% VO_2 reserve improve exercise capacity in individuals with reduced exercise capacity (Mezzani et al., 2012). A review on training studies with the intensities as low as 30% VO_2 reserve showed that in individuals with mean baseline VO_{2peak} of $<$ 40 ml/kg/min, no intensity was found to be ineffective (Swain & Franklin, 2002). Thus, although training at higher intensities results in greater improvements in exercise capacity, initially deconditioned patients will still be able to benefit from light intensity exercise (Mezzani et al., 2012; Swain & Franklin, 2002). In fact, by initially targeting the lower end of PA continuum, exercise rehabilitation programs can prepare participants for further improvements in PA duration and intensity.

Furthermore, a thorough PA assessment in patients who are referred to exercise rehabilitation programs may be a valuable approach to guide the clinicians in designing customized programs for the individual patients. In fact through this approach clinicians can identify sedentary patients who may benefit the most from light intensity recreational activities at the beginning of the program. Future studies may investigate the impact of these tailored programs on long-term PA adherence in patients with different PA behaviors.

6.1.2. Limitations

Generalizability of findings from this thesis may be limited; as we examined only low to moderate risk patients. Moreover, we focused on the exercise training which is one of the multiple elements in the multifaceted CR program. Therefore there is a possibility that the outcomes were affected by other elements of the CR program as well. However, any potential confounding effect was equivalent for different delivery models introduced in this thesis, as they all had access to all elements of the CR.

In both the first and second studies of this thesis we used 6MWT as a measure of exercise capacity. This test is influenced by mobility, physical function, and psychological factors in addition to cardiovascular fitness (Lord & Menz, 2002). Moreover, when assessing the improvement in the 6MWT performance the potential learning effect which influences confidence through familiarization and practice needs to be considered (Wu, Sanderson, & Bittner, 2003). Thus, our findings on the independent responses in PA versus exercise capacity which were observed in the second study should be interpreted with caution.

Furthermore, considering that the change in peak METs is one of the main quality indicators in CR programs (Canadian Association of Cardiac Rehabilitation, 2009; Grace & Somanader, 2014), our measurements in the first and second study were not sufficient for

assessing the quality of care in these studies. Nevertheless, both center-based and home-based CR programs in the third study met the minimum change indicator for high quality CR program (i.e., 0.5 MET) (Grace & Somanader, 2014).

Bibliography

Aaronson, N., Alonso, J., Burnam, A., Lohr, K. N., Patrick, D. L., Perrin, E., & Stein, R. E. (2002). Assessing health status and quality-of-life instruments: attributes and review criteria. *Qual Life Res, 11*(3), 193-205.

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

Ainsworth, B. E. (2009). How do I measure physical activity in my patients? Questionnaires and objective methods. *Br J Sports Med, 43*(1), 6-9. doi: bjsm.2008.052449 [pii]
10.1136/bjsm.2008.052449

American Association of Cardiovascular and Pulmonary Rehabilitation. (1999). *Guidelines for Cardiac Rehabilitation and Secondary Prevention Programs*. Champaign, IL: Human Kinetics.

American Association of Cardiovascular and Pulmonary Rehabilitation. (2004). *Guidelines for Cardiac Rehabilitation and Secondary Prevention Programs* (Vol. 4). Champaign, IL: Human Kinetics.

American College of Sports Medicine. (2010). *ACSM's Guidelines for Exercise Testing and Prescription* (8th ed.). Philadelphia, PA: Wolters Kluwer Health/ Lippincott Williams & Wilkins.

Arthur, H. M., Smith, K. M., Kodis, J., & McKelvie, R. (2002). A controlled trial of hospital versus home-based exercise in cardiac patients. *Med Sci Sports Exerc, 34*(10), 1544-1550. doi: 10.1249/01.MSS.0000030847.23854.CB

Ashe, M. C., Eng, J. J., Miller, W. C., & Soon, J. A. (2007). Disparity between physical capacity and participation in seniors with chronic disease. *Med Sci Sports Exerc, 39*(7), 1139-1146.

Ashworth, N. L., Chad, K. E., Harrison, E. L., Reeder, B. A., & Marshall, S. C. (2005). Home versus center based physical activity programs in older adults. *Cochrane Database Syst Rev*(1), CD004017. doi: 10.1002/14651858.CD004017.pub2

ATS statement: guidelines for the six-minute walk test. (2002). *Am J Respir Crit Care Med, 166*(1), 111-117. doi: 10.1164/ajrccm.166.1.at1102

Balady, G. J., Fletcher, B. J., Froelicher, E. S., Hartley, L. H., Krauss, R. M., Oberman, A., . . . Taylor, C. B. (1994). Cardiac rehabilitation programs. A statement for health care professionals from the American Heart Association. *Circulation, 90*(3), 1602-1610.

Bandura, A. (1986). *Social foundations of thought and action*: *A social cognitive theory.* Englewood Cliffs, N.J.: Prentice-Hall.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: W.H. Freeman.

Bandura, A. (2004). Health promotion by social cognitive means. *Health Educ Behav, 31*(2), 143-164.

Baranowski, T. (1988). Validity and reliability of self-report measures of physical activity: an information-processing perspective. *Res. Q. Exerc. Sport, 59*(4), 314.

Bautmans, I., Lambert, M., & Mets, T. (2004). The six-minute walk test in community dwelling elderly: influence of health status. *BMC geriatrics, 4*, 6. doi: 10.1186/1471-2318-4-6

Beswick, A. D., Rees, K., Griebsch, I., Taylor, F. C., Burke, M., West, R. R., . . . Ebrahim, S. (2004). Provision, uptake and cost of cardiac rehabilitation programmes: improving

services to under-represented groups. *Health technology assessment (Winchester, England), 8*(41), iii-iv, ix-x, 1-152.

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

Blair, C. K., Morey, M. C., Desmond, R. A., Cohen, H. J., Sloane, R., Snyder, D. C., & Demark-Wahnefried, W. (2014). Light-intensity activity attenuates functional decline in older cancer survivors. *Med Sci Sports Exerc, 46*(7), 1375-1383. doi: 10.1249/mss.0000000000000241

Blair, J., Corrigall, H., Angus, N. J., Thompson, D. R., & Leslie, S. (2011). Home versus hospital-based cardiac rehabilitation: a systematic review. *Rural Remote Health, 11*(2), 1532. doi: 1532 [pii]

Blair, S. N., Cheng, Y., & Holder, J. S. (2001). Is physical activity or physical fitness more important in defining health benefits? *Med Sci Sports Exerc, 33*(6 Suppl), S379-399; discussion S419-320.

Blanchard, C. M., Reid, R. D., Morrin, L. I., McDonnell, L., McGannon, K., Rhodes, R. E., . . . Edwards, N. (2010). 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, 30*(4), 240-245. doi: 10.1097/HCR.0b013e3181d0c4ae

Blanchard, C. M., Rodgers, W. M., Courneya, K. S., Daub, B., & Black, B. (2002). Self-efficacy and mood in cardiac rehabilitation: should gender be considered? *Behav Med, 27*(4), 149-160.

Bobbio, M. (1989). Does post myocardial infarction rehabilitation prolong survival? A meta-analytic survey. *Giornale italiano di cardiologia, 19*(11), 1059-1067.

Bock, B. C., Albrecht, A. E., Traficante, R. M., Clark, M. M., Pinto, B. M., Tilkemeier, P., & Marcus, B. H. (1997). Predictors of exercise adherence following participation in a cardiac rehabilitation program. *Int J Behav Med, 4*(1), 60-75. doi: 10.1207/s15327558ijbm0401_4

Bock, B. C., Carmona-Barros, R. E., Esler, J. L., & Tilkemeier, P. L. (2003). Program participation and physical activity maintenance after cardiac rehabilitation. *Behav Modif, 27*(1), 37-53.

Bouten, C. V., Verboeket-van de Venne, W. P., Westerterp, K. R., Verduin, M., & Janssen, J. D. (1996). Daily physical activity assessment: comparison between movement registration and doubly labeled water. *J Appl Physiol (1985), 81*(2), 1019-1026.

Bouten, C. V., Westerterp, K. R., Verduin, M., & Janssen, J. D. (1994). Assessment of energy expenditure for physical activity using a triaxial accelerometer. *Med Sci Sports Exerc, 26*(12), 1516-1523.

Brazier, J. E., Harper, R., Jones, N. M., O'Cathain, A., Thomas, K. J., Usherwood, T., & Westlake, L. (1992). Validating the SF-36 health survey questionnaire: new outcome measure for primary care. *BMJ (Clinical research ed.), 305*(6846), 160-164.

Brubaker, P. H., Rejeski, W. J., Smith, M. J., Sevensky, K. H., Lamb, K. A., Sotile, W. M., & Miller, H. S., Jr. (2000). A home-based maintenance exercise program after center-based cardiac rehabilitation: effects on blood lipids, body composition, and functional capacity. *J Cardiopulm Rehabil, 20*(1), 50-56.

Brubaker, P. H., Warner, J. G., Jr., Rejeski, W. J., Edwards, D. G., Matrazzo, B. A., Ribisl, P. M., . . . Herrington, D. M. (1996). Comparison of standard- and extended-length

participation in cardiac rehabilitation on body composition, functional capacity, and blood lipids. *Am J Cardiol, 78*(7), 769-773.

Buijs, D. M., Ramadi, A., MacDonald, K., Lightfoot, R., Senaratne, M., & Haennel, R. G. (2015). Quantity and quality of daily physical activity in older cardiac patients at different stages of recovery following a cardiac event. *Canadian Journal of Cardiovascular Nursing, 25*(3), 10-16.

Butland, R. J., Pang, J., Gross, E. R., Woodcock, A. A., & Geddes, D. M. (1982). Two-, six-, and 12-minute walking tests in respiratory disease. *British medical journal (Clinical research ed.), 284*(6329), 1607-1608.

Cahalin, L. P., Mathier, M. A., Semigran, M. J., Dec, G. W., & DiSalvo, T. G. (1996). The six-minute walk test predicts peak oxygen uptake and survival in patients with advanced heart failure. *Chest, 110*(2), 325-332.

Campbell, K. L., Crocker, P. R., & McKenzie, D. C. (2002). Field evaluation of energy expenditure in women using Tritrac accelerometers. *Med Sci Sports Exerc, 34*(10), 1667-1674.

Canadian Association of Cardiac Rehabilitation. (2009). *Canadian Guidelines for Cardiac Rehabilitation and Cardiovascular Disease Prevention: Translating Knowledge into Action* (3rd ed.). Winnipeg, MB: Canadian Association of Cardiac Rehabilitation.

Carlson, J. J., Johnson, J. A., Franklin, B. A., & VanderLaan, R. L. (2000). Program participation, exercise adherence, cardiovascular outcomes, and program cost of traditional versus modified cardiac rehabilitation. *Am J Cardiol, 86*(1), 17-23.

Carlson, J. J., Norman, G. J., Feltz, D. L., Franklin, B. A., Johnson, J. A., & Locke, S. K. (2001). Self-efficacy, psychosocial factors, and exercise behavior in traditional versus modified cardiac rehabilitation. *J Cardiopulm Rehabil, 21*(6), 363-373.

Carson, P., Phillips, R., Lloyd, M., Tucker, H., Neophytou, M., Buch, N. J., . . . Simpson, T. (1982). Exercise after myocardial infarction: a controlled trial. *J R Coll Physicians Lond, 16*(3), 147-151.

Chase, J. A. (2011). Systematic review of physical activity intervention studies after cardiac rehabilitation. *J Cardiovasc Nurs, 26*(5), 351-358. doi: 10.1097/JCN.0b013e3182049f00

Cheetham, C., Taylor, R., Burke, V., O'Driscoll, G., & Green, D. J. (2005). The 6-minute walk test does not reliably detect changes in functional capacity of patients awaiting cardiac transplantation. *The Journal of heart and lung transplantation : the official publication of the International Society for Heart Transplantation, 24*(7), 848-853. doi: 10.1016/j.healun.2004.05.012

Chien, C. L., Lee, C. M., Wu, Y. W., Chen, T. A., & Wu, Y. T. (2008). Home-based exercise increases exercise capacity but not quality of life in people with chronic heart failure: a systematic review. *The Australian journal of physiotherapy, 54*(2), 87-93.

Clark, A. M., King-Shier, K. M., Duncan, A., Spaling, M., Stone, J. A., Jaglal, S., & Angus, J. (2013). Factors influencing referral to cardiac rehabilitation and secondary prevention programs: a systematic review. *Eur J Prev Cardiol, 20*(4), 692-700. doi: 10.1177/2047487312447846

Clark, M., Kelly, T., & Deighan, C. (2011). A systematic review of the Heart Manual literature. *Eur J Cardiovasc Nurs, 10*(1), 3-13. doi: 10.1016/j.ejcnurse.2010.03.003

Coats, A. J., Adamopoulos, S., Meyer, T. E., Conway, J., & Sleight, P. (1990). Effects of physical training in chronic heart failure. *Lancet, 335*(8681), 63-66. doi: 0140-6736(90)90536-E [pii]

Coats, A. J., Adamopoulos, S., Radaelli, A., McCance, A., Meyer, T. E., Bernardi, L., . . . Forfar, C. (1992). Controlled trial of physical training in chronic heart failure. Exercise performance, hemodynamics, ventilation, and autonomic function. *Circulation, 85*(6), 2119-2131.

Cole, P. J., LeMura, L. M., Klinger, T. A., Strohecker, K., & McConnell, T. R. (2004). Measuring energy expenditure in cardiac patients using the Body Media Armband versus indirect calorimetry. A validation study. *J Sports Med Phys Fitness, 44*(3), 262-271.

Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011). Physical activity of Canadian adults: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Rep, 22*(1), 7-14.

Conn, V. S., Hafdahl, A. R., Brown, S. A., & Brown, L. M. (2008). Meta-analysis of patient education interventions to increase physical activity among chronically ill adults. *Patient Educ Couns, 70*(2), 157-172. doi: 10.1016/j.pec.2007.10.004

Coronado, M., Janssens, J. P., de Muralt, B., Terrier, P., Schutz, Y., & Fitting, J. W. (2003). Walking activity measured by accelerometry during respiratory rehabilitation. *Journal of Cardiopulmonary Rehabilitation, 23*(5), 357-364.

Corvera-Tindel, T., Doering, L. V., Woo, M. A., Khan, S., & Dracup, K. (2004). Effects of a home walking exercise program on functional status and symptoms in heart failure. *American Heart Journal, 147*(2), 339-346. doi: 10.1016/j.ahj.2003.09.007

Cowie, A., Thow, M. K., Granat, M. H., & Mitchell, S. L. (2011). A comparison of home and hospital-based exercise training in heart failure: immediate and long-term effects upon physical activity level. *Eur J Cardiovasc Prev Rehabil, 18*(2), 158-166. doi: 1741826710389389 [pii]

10.1177/1741826710389389

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

Dalal, H. M., & Evans, P. H. (2003). Achieving national service framework standards for cardiac rehabilitation and secondary prevention. *BMJ (Clinical research ed.), 326*(7387), 481-484. doi: 10.1136/bmj.326.7387.481

Dalal, H. M., Evans, P. H., Campbell, J. L., Taylor, R. S., Watt, A., Read, K. L., . . . Pereira Gray, D. J. (2007). Home-based versus hospital-based rehabilitation after myocardial infarction: A randomized trial with preference arms--Cornwall Heart Attack Rehabilitation Management Study (CHARMS). *Int J Cardiol, 119*(2), 202-211. doi: S0167-5273(06)01423-9 [pii]

10.1016/j.ijcard.2006.11.018

Dalal, H. M., Zawada, A., Jolly, K., Moxham, T., & Taylor, R. S. (2010). Home based versus centre based cardiac rehabilitation: Cochrane systematic review and meta-analysis. *BMJ, 340*, b5631. doi: 10.1136/bmj.b5631

Dallas, M. I., McCusker, C., Haggerty, M. C., Rochester, C. L., & Zuwallack, R. (2009). Using pedometers to monitor walking activity in outcome assessment for pulmonary rehabilitation. *Chron Respir Dis, 6*(4), 217-224. doi: 6/4/217 [pii]

10.1177/1479972309346760

Davey, P., Meyer, T., Coats, A., Adamopoulos, S., Casadei, B., Conway, J., & Sleight, P. (1992). Ventilation in chronic heart failure: effects of physical training. *Br Heart J, 68*(5), 473-477.

Davies, S. W., Jordan, S. L., & Lipkin, D. P. (1992). Use of limb movement sensors as indicators of the level of everyday physical activity in chronic congestive heart failure. *Am J Cardiol, 69*(19), 1581-1586.

Dishman, R. K., Motl, R. W., Sallis, J. F., Dunn, A. L., Birnbaum, A. S., Welk, G. J., . . . Jobe, J. B. (2005). Self-management strategies mediate self-efficacy and physical activity. *Am J Prev Med, 29*(1), 10-18.

Dixon, T., Lim, L. L., & Oldridge, N. B. (2002). The MacNew heart disease health-related quality of life instrument: reference data for users. *Qual Life Res, 11*(2), 173-183.

Dixon, T., Lim, L. L., Powell, H., & Fisher, J. D. (2000). Psychosocial experiences of cardiac patients in early recovery: a community-based study. *Journal of advanced nursing, 31*(6), 1368-1375.

Dogra, S., & Stathokostas, L. (2012). Sedentary behavior and physical activity are independent predictors of successful aging in middle-aged and older adults. *J Aging Res, 2012*, 190654. doi: 10.1155/2012/190654

Dontje, M. L., van der Wal, M. H., Stolk, R. P., Brugemann, J., Jaarsma, T., Wijtvliet, P. E., . . . de Greef, M. H. (2014). Daily physical activity in stable heart failure patients. *J Cardiovasc Nurs, 29*(3), 218-226. doi: 10.1097/JCN.0b013e318283ba14

Dracup, K., Evangelista, L. S., Hamilton, M. A., Erickson, V., Hage, A., Moriguchi, J., . . . Fonarow, G. C. (2007). Effects of a home-based exercise program on clinical outcomes

in heart failure. *American Heart Journal, 154*(5), 877-883. doi: 10.1016/j.ahj.2007.07.019

Evangelista, L. S., Doering, L. V., Lennie, T., Moser, D. K., Hamilton, M. A., Fonarow, G. C., & Dracup, K. (2006). Usefulness of a home-based exercise program for overweight and obese patients with advanced heart failure. *Am J Cardiol, 97*(6), 886-890. doi: 10.1016/j.amjcard.2005.10.025

Ewart, C. K. (1989). Psychological effects of resistive weight training: implications for cardiac patients. *Med Sci Sports Exerc, 21*(6), 683-688.

Ewart, C. K., Stewart, K. J., Gillilan, R. E., & Kelemen, M. H. (1986). Self-efficacy mediates strength gains during circuit weight training in men with coronary artery disease. *Med Sci Sports Exerc, 18*(5), 531-540.

Faggiano, P., D'Aloia, A., Gualeni, A., Lavatelli, A., & Giordano, A. (1997). Assessment of oxygen uptake during the 6-minute walking test in patients with heart failure: preliminary experience with a portable device. *Am Heart J, 134*(2 Pt 1), 203-206. doi: S0002-8703(97)70125-X [pii]

Fletcher, G. F., Balady, G. J., Amsterdam, E. A., Chaitman, B., Eckel, R., Fleg, J., . . . Bazzarre, T. (2001). Exercise standards for testing and training: a statement for healthcare professionals from the American Heart Association. *Circulation, 104*(14), 1694-1740.

Foster, C., Oldridge, N. B., Dion, W., Forsyth, G., Grevenow, P., Hansen, M., . . . Sharkey, R. E. (1995). Time course of recovery during cardiac rehabilitation. *Journal of Cardiopulmonary Rehabilitation, 15*(3), 209-215.

Froelicher, V., Jensen, D., & Sullivan, M. (1985). A randomized trial of the effects of exercise training after coronary artery bypass surgery. *Archives of Internal Medicine, 145*(4), 689-692.

Fruin, M. L., & Rankin, J. W. (2004). Validity of a multi-sensor armband in estimating rest and exercise energy expenditure. *Med Sci Sports Exerc, 36*(6), 1063-1069.

Furber, S., Butler, L., Phongsavan, P., Mark, A., & Bauman, A. (2010). Randomised controlled trial of a pedometer-based telephone intervention to increase physical activity among cardiac patients not attending cardiac rehabilitation. *Patient Educ Couns, 80*(2), 212-218. doi: S0738-3991(09)00589-8 [pii]

10.1016/j.pec.2009.11.012

Gamst, G., Meyers, L. S., & Guarino, A. J. (2008a). Analysis of covariance *Analysis of Variance Designs: A Conceptual and Computational Approach with SPSS and SAS* (1st ed., pp. 453-487). Cambridge, UK: Cambridge University Press.

Gamst, G., Meyers, L. S., & Guarino, A. J. (2008b). Simple mixed design *Analysis of Variance Designs: A Conceptual and Computational Approach with SPSS and SAS* (1st ed., pp. 361-390). Cambridge, UK: Cambridge University Press.

Garber, C. E., Blissmer, B., Deschenes, M. R., Franklin, B. A., Lamonte, M. J., Lee, I. M., . . . Swain, D. P. (2011). 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, 43*(7), 1334-1359. doi: 10.1249/MSS.0b013e318213fefb

Garcia-Aymerich, J., Lange, P., Benet, M., Schnohr, P., & Anto, J. M. (2006). Regular physical activity reduces hospital admission and mortality in chronic obstructive pulmonary

disease: a population based cohort study. *Thorax, 61*(9), 772-778. doi: 10.1136/thx.2006.060145

Gardner, J. K., McConnell, T. R., Klinger, T. A., Herman, C. P., Hauck, C. A., & Laubach Jr, C. A. (2003). Quality of life and self-efficacy: gender and diagnoses considerations for management during cardiac rehabilitation. *J Cardiopulm Rehabil, 23*(4), 299-306.

Gary, R. A., Sueta, C. A., Dougherty, M., Rosenberg, B., Cheek, D., Preisser, J., . . . McMurray, R. (2004). Home-based exercise improves functional performance and quality of life in women with diastolic heart failure. *Heart Lung, 33*(4), 210-218.

Gary, R. A., Sueta, C. A., Rosenberg, B., & Cheek, D. (2004). Use of the 6-minute walk test for women with diastolic heart failure. *Journal of Cardiopulmonary Rehabilitation, 24*(4), 264-268.

Gayda, M., Temfemo, A., Choquet, D., & Ahmaidi, S. (2004). Cardiorespiratory requirements and reproducibility of the six-minute walk test in elderly patients with coronary artery disease. *Archives of Physical Medicine and Rehabilitation, 85*(9), 1538-1543.

Ghali, W. A., & Knudtson, M. L. (2000). Overview of the Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease. On behalf of the APPROACH investigators. *Can J Cardiol, 16*(10), 1225-1230.

Goran, M. I., & Poehlman, E. T. (1992). Endurance training does not enhance total energy expenditure in healthy elderly persons. *Am J Physiol, 263*(5 Pt 1), E950-957.

Grace, S. L., & Somanader, D. S. (2014). Using the pan-Canadian cardiac rehabilitation and secondary prevention quality indicators in practice: what are we learning? *Current Issues & Trends in Cardiovascular Disease Prevention and Rehabilitation (CV Edge)*, 1-6.

Grant, P. M., Dall, P. M., Mitchell, S. L., & Granat, M. H. (2008). Activity-monitor accuracy in measuring step number and cadence in community-dwelling older adults. *Journal of Aging and Physical Activity, 16*(2), 201-214.

Gravely-Witte, S., Leung, Y. W., Nariani, R., Tamim, H., Oh, P., Chan, V. M., & Grace, S. L. (2010). Effects of cardiac rehabilitation referral strategies on referral and enrollment rates. *Nature reviews.Cardiology, 7*(2), 87-96. doi: 10.1038/nrcardio.2009.223

Gravetter, F. J., & Wallnau, L. B. (2009a). The chi-square statistics: tests for goodness of fit and independence *Statistics for the Behavioral Sciences* (8th ed., pp. 604-643). Belmont: Wadsworth - Cengage Learning.

Gravetter, F. J., & Wallnau, L. B. (2009b). The t test for two independent samples *Statistics for the Behavioral Sciences* (8th ed., pp. 307-338). Belmont: Wadsworth - Cengage Learning.

Guyatt, G. H., Sullivan, M. J., Thompson, P. J., Fallen, E. L., Pugsley, S. O., Taylor, D. W., & Berman, L. B. (1985). The 6-minute walk: a new measure of exercise capacity in patients with chronic heart failure. *Can Med Assoc J, 132*(8), 919-923.

Guyatt, G. H., Townsend, M., Keller, J., Singer, J., & Nogradi, S. (1991). Measuring functional status in chronic lung disease: conclusions from a randomized control trial. *Respiratory medicine, 85 Suppl B*, 17-21; discussion 33-17.

Haapanen, N., Miilunpalo, S., Vuori, I., Oja, P., & Pasanen, M. (1996). Characteristics of leisure time physical activity associated with decreased risk of premature all-cause and cardiovascular disease mortality in middle-aged men. *Am J Epidemiol, 143*(9), 870-880.

Haennel, R. G., & Lemire, F. (2002). Physical activity to prevent cardiovascular disease. How much is enough? *Can Fam Physician, 48*, 65-71.

Hage, C., Mattsson, E., & Stahle, A. (2003). Long-term effects of exercise training on physical activity level and quality of life in elderly coronary patients--a three- to six-year follow-up. *Physiotherapy research international : the journal for researchers and clinicians in physical therapy, 8*(1), 13-22.

Hambrecht, R., Niebauer, J., Marburger, C., Grunze, M., Kalberer, B., Hauer, K., . . . Schuler, G. (1993). 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, 22*(2), 468-477. doi: 0735-1097(93)90051-2 [pii]

Hamilton, D. M., & Haennel, R. G. (2000). Validity and reliability of the 6-minute walk test in a cardiac rehabilitation population. *J Cardiopulm Rehabil, 20*(3), 156-164.

Hamilton, M. T., Hamilton, D. G., & Zderic, T. W. (2004). Exercise physiology versus inactivity physiology: an essential concept for understanding lipoprotein lipase regulation. *Exerc Sport Sci Rev, 32*(4), 161-166.

Harada, N. D., Chiu, V., & Stewart, A. L. (1999). Mobility-related function in older adults: assessment with a 6-minute walk test. *Arch Phys Med Rehabil, 80*(7), 837-841.

Haskell, W. L., Lee, I. M., Pate, R. R., Powell, K. E., Blair, S. N., Franklin, B. A., . . . Bauman, A. (2007). Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc, 39*(8), 1423-1434. doi: 10.1249/mss.0b013e3180616b27

Healy, G. N., Dunstan, D. W., Salmon, J., Cerin, E., Shaw, J. E., Zimmet, P. Z., & Owen, N. (2007). Objectively measured light-intensity physical activity is independently associated with 2-h plasma glucose. *Diabetes Care, 30*(6), 1384-1389. doi: 10.2337/dc07-0114

Healy, G. N., Wijndaele, K., Dunstan, D. W., Shaw, J. E., Salmon, J., Zimmet, P. Z., & Owen, N. (2008). Objectively measured sedentary time, physical activity, and metabolic risk: the Australian Diabetes, Obesity and Lifestyle Study (AusDiab). *Diabetes Care, 31*(2), 369-371. doi: dc07-1795 [pii]

10.2337/dc07-1795

Heller, R. F., Knapp, J. C., Valenti, L. A., & Dobson, A. J. (1993). Secondary prevention after acute myocardial infarction. *Am J Cardiol, 72*(11), 759-762.

Heller, R. F., Lim, L., Valenti, L., & Knapp, J. (1997). Predictors of quality of life after hospital admission for heart attack or angina. *International journal of cardiology, 59*(2), 161-166.

Hill, K., Dolmage, T. E., Woon, L., Goldstein, R., & Brooks, D. (2010). Measurement properties of the SenseWear armband in adults with chronic obstructive pulmonary disease. *Thorax, 65*(6), 486-491. doi: 10.1136/thx.2009.128702

Hillers, T. K., Guyatt, G. H., Oldridge, N., Crowe, J., Willan, A., Griffith, L., & Feeny, D. (1994). Quality of life after myocardial infarction. *Journal of clinical epidemiology, 47*(11), 1287-1296.

Hofer, S., Lim, L., Guyatt, G., & Oldridge, N. (2004). The MacNew Heart Disease health-related quality of life instrument: a summary. *Health and quality of life outcomes, 2*, 3. doi: 10.1186/1477-7525-2-3

Hofer, S., Saleem, A., Stone, J., Thomas, R., Tulloch, H., & Oldridge, N. (2012). The MacNew Heart Disease Health-Related Quality of Life Questionnaire in patients with angina and patients with ischemic heart failure. *Value in health : the journal of the International Society for Pharmacoeconomics and Outcomes Research, 15*(1), 143-150. doi: 10.1016/j.jval.2011.07.003

Houle, J., Doyon, O., Vadeboncoeur, N., Turbide, G., Diaz, A., & Poirier, P. (2011). Innovative program to increase physical activity following an acute coronary syndrome: randomized controlled trial. *Patient Educ Couns, 85*(3), e237-244. doi: 10.1016/j.pec.2011.03.018

Hughes, A. R., Mutrie, N., & Macintyre, P. D. (2007). Effect of an exercise consultation on maintenance of physical activity after completion of phase III exercise-based cardiac rehabilitation. *Eur J Cardiovasc Prev Rehabil, 14*(1), 114-121. doi: 10.1097/HJR.0b013e3280116485

00149831-200702000-00017 [pii]

Hwang, R., & Marwick, T. (2009). Efficacy of home-based exercise programmes for people with chronic heart failure: a meta-analysis. *Eur J Cardiovasc Prev Rehabil, 16*(5), 527-535. doi: 10.1097/HJR.0b013e32832e097f

Ingle, L., Rigby, A. S., Nabb, S., Jones, P. K., Clark, A. L., & Cleland, J. G. (2006). Clinical determinants of poor six-minute walk test performance in patients with left ventricular systolic dysfunction and no major structural heart disease. *Eur J Heart Fail, 8*(3), 321-325. doi: 10.1016/j.ejheart.2005.08.006

Izawa, K. P., Watanabe, S., Omiya, K., Hirano, Y., Oka, K., Osada, N., & Iijima, S. (2005). Effect of the self-monitoring approach on exercise maintenance during cardiac rehabilitation: a randomized, controlled trial. *Am J Phys Med Rehabil, 84*(5), 313-321. doi: 00002060-200505000-00001 [pii]

Jackson, L., Leclerc, J., Erskine, Y., & Linden, W. (2005). Getting the most out of cardiac rehabilitation: a review of referral and adherence predictors. *Heart, 91*(1), 10-14. doi: 91/1/10 [pii]

10.1136/hrt.2004.045559

Jacobs, D. R., Jr., Ainsworth, B. E., Hartman, T. J., & Leon, A. S. (1993). A simultaneous evaluation of 10 commonly used physical activity questionnaires. *Med Sci Sports Exerc, 25*(1), 81-91.

Jakicic, J. M., Marcus, M., Gallagher, K. I., Randall, C., Thomas, E., Goss, F. L., & Robertson, R. J. (2004). Evaluation of the SenseWear Pro Armband to assess energy expenditure during exercise. *Med Sci Sports Exerc, 36*(5), 897-904.

Jakicic, J. M., Winters, C., Lagally, K., Ho, J., Robertson, R. J., & Wing, R. R. (1999). The accuracy of the TriTrac-R3D accelerometer to estimate energy expenditure. *Med Sci Sports Exerc, 31*(5), 747-754.

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

Jerome, G. J., Marquez, D. X., McAuley, E., Canaklisova, S., Snook, E., & Vickers, M. (2002). Self-efficacy effects on feeling states in women. *Int J Behav Med, 9*(2), 139-154.

Jette, D. U., & Downing, J. (1994). Health status of individuals entering a cardiac rehabilitation program as measured by the medical outcomes study 36-item short-form survey (SF-36). *Phys Ther, 74*(6), 521-527.

Johannsen, D. L., Calabro, M. A., Stewart, J., Franke, W., Rood, J. C., & Welk, G. J. (2010). Accuracy of armband monitors for measuring daily energy expenditure in healthy adults. *Med Sci Sports Exerc, 42*(11), 2134-2140. doi: 10.1249/MSS.0b013e3181e0b3ff

Jolly, K., Lip, G. Y., Taylor, R. S., Raftery, J., Mant, J., Lane, D., . . . Stevens, A. (2009). The Birmingham Rehabilitation Uptake Maximisation study (BRUM): a randomised

controlled trial comparing home-based with centre-based cardiac rehabilitation. *Heart, 95*(1), 36-42. doi: 10.1136/hrt.2007.127209

Jolly, K., Taylor, R., Lip, G. Y., Greenfield, S., Raftery, J., Mant, J., . . . Stevens, A. (2007). The Birmingham Rehabilitation Uptake Maximisation Study (BRUM). Home-based compared with hospital-based cardiac rehabilitation in a multi-ethnic population: cost-effectiveness and patient adherence. *Health Technol Assess, 11*(35), 1-118. doi: 99/32/09 [pii]

Jolly, K., Taylor, R. S., Lip, G. Y., & Stevens, A. (2006). Home-based cardiac rehabilitation compared with centre-based rehabilitation and usual care: a systematic review and meta-analysis. *International journal of cardiology, 111*(3), 343-351. doi: 10.1016/j.ijcard.2005.11.002

Karapolat, H., Demir, E., Bozkaya, Y. T., Eyigor, S., Nalbantgil, S., Durmaz, B., & Zoghi, M. (2009). Comparison of hospital-based versus home-based exercise training in patients with heart failure: effects on functional capacity, quality of life, psychological symptoms, and hemodynamic parameters. *Clin Res Cardiol, 98*(10), 635-642. doi: 10.1007/s00392-009-0049-6

Karjalainen, J. J., Kiviniemi, A. M., Hautala, A. J., Niva, J., Lepojarvi, S., Makikallio, T. H., . . . Tulppo, M. P. (2012). Effects of exercise prescription on daily physical activity and maximal exercise capacity in coronary artery disease patients with and without type 2 diabetes. *Clin Physiol Funct Imaging, 32*(6), 445-454. doi: 10.1111/j.1475-097X.2012.01148.x

Katzmarzyk, P. T., Church, T. S., Craig, C. L., & Bouchard, C. (2009). Sitting time and mortality from all causes, cardiovascular disease, and cancer. *Med Sci Sports Exerc, 41*(5), 998-1005. doi: 10.1249/MSS.0b013e3181930355

Kavanagh, T., Mertens, D. J., Hamm, L. F., Beyene, J., Kennedy, J., Corey, P., & Shephard, R. J. (2002). Prediction of long-term prognosis in 12 169 men referred for cardiac rehabilitation. *Circulation, 106*(6), 666-671.

Kavanagh, T., Mertens, D. J., Hamm, L. F., Beyene, J., Kennedy, J., Corey, P., & Shephard, R. J. (2003). Peak oxygen intake and cardiac mortality in women referred for cardiac rehabilitation. *J Am Coll Cardiol, 42*(12), 2139-2143.

Kirk, A. F., Higgins, L. A., Hughes, A. R., Fisher, B. M., Mutrie, N., Hillis, S., & MacIntyre, P. D. (2001). A randomized, controlled trial to study the effect of exercise consultation on the promotion of physical activity in people with Type 2 diabetes: a pilot study. *Diabet Med, 18*(11), 877-882. doi: 570 [pii]

Kodis, J., Smith, K. M., Arthur, H. M., Daniels, C., Suskin, N., & McKelvie, R. S. (2001). Changes in exercise capacity and lipids after clinic versus home-based aerobic training in coronary artery bypass graft surgery patients. *Journal of Cardiopulmonary Rehabilitation, 21*(1), 31-36.

Lacasse, Y., Martin, S., Lasserson, T. J., & Goldstein, R. S. (2007). Meta-analysis of respiratory rehabilitation in chronic obstructive pulmonary disease. A Cochrane systematic review. *Eura Medicophys, 43*(4), 475-485.

LaPorte, R. E., Montoye, H. J., & Caspersen, C. J. (1985). Assessment of physical activity in epidemiologic research: problems and prospects. *Public Health Rep, 100*(2), 131-146.

Larson, J. L. (2007). Functional performance and physical activity in chronic obstructive pulmonary disease: theoretical perspectives. *COPD, 4*(3), 237-242. doi: 10.1080/15412550701480372

Lavie, C. J., & Milani, R. V. (2011). Cardiac rehabilitation and exercise training in secondary coronary heart disease prevention. *Prog Cardiovasc Dis, 53*(6), 397-403. doi: S0033-0620(11)00046-6 [pii]

10.1016/j.pcad.2011.02.008

Lavie, C. J., Milani, R. V., & Littman, A. B. (1993). Benefits of cardiac rehabilitation and exercise training in secondary coronary prevention in the elderly. *J Am Coll Cardiol, 22*(3), 678-683.

Lear, S. A., Spinelli, J. J., Linden, W., Brozic, A., Kiess, M., Frohlich, J. J., & Ignaszewski, A. (2006). The Extensive Lifestyle Management Intervention (ELMI) after cardiac rehabilitation: a 4-year randomized controlled trial. *American Heart Journal, 152*(2), 333-339. doi: 10.1016/j.ahj.2005.12.023

Lemanski, K. M. (1990). The use of self-efficacy in cardiac rehabilitation. *Prog Cardiovasc Nurs, 5*(4), 114-117.

Leon, A. S., Connett, J., Jacobs, D. R., Jr., & Rauramaa, R. (1987). Leisure-time physical activity levels and risk of coronary heart disease and death. The Multiple Risk Factor Intervention Trial. *JAMA, 258*(17), 2388-2395.

Levine, J. A., Baukol, P. A., & Westerterp, K. R. (2001). Validation of the Tracmor triaxial accelerometer system for walking. *Med Sci Sports Exerc, 33*(9), 1593-1597.

Lim, L. L., Johnson, N. A., O'Connell, R. L., & Heller, R. F. (1998). Quality of life and later adverse health outcomes in patients with suspected heart attack. *Australian and New Zealand Journal of Public Health, 22*(5), 540-546.

Lim, L. L., Valenti, L. A., Knapp, J. C., Dobson, A. J., Plotnikoff, R., Higginbotham, N., & Heller, R. F. (1993). A self-administered quality-of-life questionnaire after acute myocardial infarction. *Journal of clinical epidemiology, 46*(11), 1249-1256.

Lipkin, D. P., Scriven, A. J., Crake, T., & Poole-Wilson, P. A. (1986). Six minute walking test for assessing exercise capacity in chronic heart failure. *Br Med J (Clin Res Ed), 292*(6521), 653-655.

Livingstone, M. B. (1997). Heart-rate monitoring: the answer for assessing energy expenditure and physical activity in population studies? *The British journal of nutrition, 78*(6), 869-871.

Lord, S. R., & Menz, H. B. (2002). Physiologic, psychologic, and health predictors of 6-minute walk performance in older people. *Archives of Physical Medicine and Rehabilitation, 83*(7), 907-911.

Loughlan, C., & Mutrie, N. (1997). An evaluation of the effectiveness of three interventions in promoting physical activity in a sedentary population. *Health Educ J, 56*, 154-165.

Mackey, D. C., Manini, T. M., Schoeller, D. A., Koster, A., Glynn, N. W., Goodpaster, B. H., . . . Cummings, S. R. (2011). Validation of an armband to measure daily energy expenditure in older adults. *J Gerontol A Biol Sci Med Sci, 66*(10), 1108-1113. doi: 10.1093/gerona/glr101

Mador, M. J., Patel, A. N., & Nadler, J. (2011). Effects of pulmonary rehabilitation on activity levels in patients with chronic obstructive pulmonary disease. *J Cardiopulm Rehabil Prev, 31*(1), 52-59. doi: 10.1097/HCR.0b013e3181ebf2ef

Maes, S., De Gucht, V., Goud, R., Hellemans, I., & Peek, N. (2008). Is the MacNew quality of life questionnaire a useful diagnostic and evaluation instrument for cardiac rehabilitation? *Eur J Cardiovasc Prev Rehabil, 15*(5), 516-520. doi: 10.1097/HJR.0b013e328303402b

Maines, T. Y., Lavie, C. J., Milani, R. V., Cassidy, M. M., Gilliland, Y. E., & Murgo, J. P. (1997). Effects of cardiac rehabilitation and exercise programs on exercise capacity, coronary risk factors, behavior, and quality of life in patients with coronary artery disease. *South Med J, 90*(1), 43-49.

Malavolti, M., Pietrobelli, A., Dugoni, M., Poli, M., Romagnoli, E., De Cristofaro, P., & Battistini, N. C. (2007). A new device for measuring resting energy expenditure (REE) in healthy subjects. *Nutr Metab Cardiovasc Dis, 17*(5), 338-343.

Manini, T. M., Everhart, J. E., Patel, K. V., Schoeller, D. A., Colbert, L. H., Visser, M., . . . Harris, T. B. (2006). Daily activity energy expenditure and mortality among older adults. *JAMA, 296*(2), 171-179. doi: 10.1001/jama.296.2.171

Manns, P. J., Dunstan, D. W., Owen, N., & Healy, G. N. (2012). Addressing the nonexercise part of the activity continuum: a more realistic and achievable approach to activity programming for adults with mobility disability? *Phys Ther, 92*(4), 614-625. doi: 10.2522/ptj.20110284

Marchionni, N., Fattirolli, F., Fumagalli, S., Oldridge, N., Del Lungo, F., Morosi, L., . . . Masotti, G. (2003). Improved exercise tolerance and quality of life with cardiac rehabilitation of

older patients after myocardial infarction: results of a randomized, controlled trial. *Circulation, 107*(17), 2201-2206.

Marchionni, N., Fattirolli, F., Valoti, P., Baldasseroni, L., Burgisser, C., Ferrucci, L., . . . Masotti, G. (1994). Improved exercise tolerance by cardiac rehabilitation after myocardial infarction in the elderly: results of a preliminary, controlled study. *Aging (Milano), 6*(3), 175-180.

Martin, B. J., Aggarwal, S. G., Stone, J. A., Hauer, T., Austford, L. D., Knudtson, M., & Arena, R. (2012). Obesity negatively impacts aerobic capacity improvements both acutely and 1-year following cardiac rehabilitation. *Obesity (Silver Spring), 20*(12), 2377-2383. doi: 10.1038/oby.2012.119

Martin, B. J., Arena, R., Haykowsky, M., Hauer, T., Austford, L. D., Knudtson, M., . . . Stone, J. A. (2013). Cardiovascular fitness and mortality after contemporary cardiac rehabilitation. *Mayo Clin Proc, 88*(5), 455-463. doi: 10.1016/j.mayocp.2013.02.013

Martin, B. J., Hauer, T., Arena, R., Austford, L. D., Galbraith, P. D., Lewin, A. M., . . . Aggarwal, S. G. (2012). Cardiac rehabilitation attendance and outcomes in coronary artery disease patients. *Circulation, 126*(6), 677-687. doi: 10.1161/circulationaha.111.066738

Matthews, C. E., George, S. M., Moore, S. C., Bowles, H. R., Blair, A., Park, Y., . . . Schatzkin, A. (2012). Amount of time spent in sedentary behaviors and cause-specific mortality in US adults. *Am J Clin Nutr, 95*(2), 437-445. doi: 10.3945/ajcn.111.019620

Matthews, C. E., Jurj, A. L., Shu, X. O., Li, H. L., Yang, G., Li, Q., . . . Zheng, W. (2007). Influence of exercise, walking, cycling, and overall nonexercise physical activity on

mortality in Chinese women. *Am J Epidemiol, 165*(12), 1343-1350. doi: 10.1093/aje/kwm088

McAuley, E., Elavsky, S., Motl, R. W., Konopack, J. F., Hu, L., & Marquez, D. X. (2005). Physical activity, self-efficacy, and self-esteem: longitudinal relationships in older adults. *The journals of gerontology.Series B, Psychological sciences and social sciences, 60*(5), P268-275.

McAuley, E., Jerome, G. J., Elavsky, S., Marquez, D. X., & Ramsey, S. N. (2003). Predicting long-term maintenance of physical activity in older adults. *Prev Med, 37*(2), 110-118.

McConnell, T. R., & Clark, B. A. (1987). Prediction of maximal oxygen consumption during handrail-supported treadmill exercise. *Journal of Cardiopulmonary Rehabilitation, 7*(7), 324-331.

Meijer, E. P., Westerterp, K. R., & Verstappen, F. T. (1999). Effect of exercise training on total daily physical activity in elderly humans. *European journal of applied physiology and occupational physiology, 80*(1), 16-21.

Melanson, E. L., Jr., & Freedson, P. S. (1996). Physical activity assessment: a review of methods. *Critical reviews in food science and nutrition, 36*(5), 385-396.

Mezzani, A., Hamm, L. F., Jones, A. M., McBride, P. E., Moholdt, T., Stone, J. A., . . . Williams, M. A. (2012). 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. *J Cardiopulm Rehabil Prev, 32*(6), 327-350. doi: 10.1097/HCR.0b013e3182757050

Miller, N. H., Haskell, W. L., Berra, K., & DeBusk, R. F. (1984). Home versus group exercise training for increasing functional capacity after myocardial infarction. *Circulation, 70*(4), 645-649.

Myers, J., Kaykha, A., George, S., Abella, J., Zaheer, N., Lear, S., . . . Froelicher, V. (2004). Fitness versus physical activity patterns in predicting mortality in men. *Am J Med, 117*(12), 912-918. doi: S0002-9343(04)00622-9 [pii]

10.1016/j.amjmed.2004.06.047

Naughton, J. (1978). The National Exercise and Heart Disease Project. The pre-randomization exercise program. Report number 2. *Cardiology, 63*(6), 352-367.

Neill, W. A., Branch, L. G., De Jong, G., Smith, N. E., Hogan, C. A., Corcoran, P. J., . . . Osberg, S. (1985). Cardiac disability. The impact of coronary heart disease on patients' daily activities. *Arch Intern Med, 145*(9), 1642-1647.

Neubeck, L., Freedman, S. B., Clark, A. M., Briffa, T., Bauman, A., & Redfern, J. (2012). Participating in cardiac rehabilitation: a systematic review and meta-synthesis of qualitative data. *Eur J Prev Cardiol, 19*(3), 494-503.

Nichols, J. F., Morgan, C. G., Sarkin, J. A., Sallis, J. F., & Calfas, K. J. (1999). Validity, reliability, and calibration of the Tritrac accelerometer as a measure of physical activity. *Med Sci Sports Exerc, 31*(6), 908-912.

Nici, L., Donner, C., Wouters, E., Zuwallack, R., Ambrosino, N., Bourbeau, J., . . . ATS/ERS Pulmonary Rehabilitation Writing Committee. (2006). American Thoracic Society/European Respiratory Society statement on pulmonary rehabilitation. *Am J Respir Crit Care Med, 173*(12), 1390-1413. doi: 10.1164/rccm.200508-1211ST

Nishi, I., Noguchi, T., Iwanaga, Y., Furuichi, S., Aihara, N., Takaki, H., & Goto, Y. (2011). Effects of exercise training in patients with chronic heart failure and advanced left ventricular systolic dysfunction receiving beta-blockers. *Circ J, 75*(7), 1649-1655.

Oerkild, B., Frederiksen, M., Hansen, J. F., Simonsen, L., Skovgaard, L. T., & Prescott, E. (2011). Home-based cardiac rehabilitation is as effective as centre-based cardiac rehabilitation among elderly with coronary heart disease: results from a randomised clinical trial. *Age Ageing, 40*(1), 78-85. doi: afq122 [pii]

10.1093/ageing/afq122

Oka, R. K., De Marco, T., Haskell, W. L., Botvinick, E., Dae, M. W., Bolen, K., & Chatterjee, K. (2000). Impact of a home-based walking and resistance training program on quality of life in patients with heart failure. *Am J Cardiol, 85*(3), 365-369.

Oka, R. K., Stotts, N. A., Dae, M. W., Haskell, W. L., & Gortner, S. R. (1993). Daily physical activity levels in congestive heart failure. *Am J Cardiol, 71*(11), 921-925. doi: 0002-9149(93)90907-T [pii]

Oldridge, N., Guyatt, G., Jones, N., Crowe, J., Singer, J., Feeny, D., . . . Torrance, G. (1991). Effects on quality of life with comprehensive rehabilitation after acute myocardial infarction. *Am J Cardiol, 67*(13), 1084-1089.

Oldridge, N. B. (1991). Compliance with cardiac rehabilitation services. *Journal of Cardiopulmonary Rehabilitation, 11*, 115-127.

Oldridge, N. B., Guyatt, G. H., Fischer, M. E., & Rimm, A. A. (1988). Cardiac rehabilitation after myocardial infarction. Combined experience of randomized clinical trials. *JAMA, 260*(7), 945-950.

Oliveira, J., Ribeiro, F., & Gomes, H. (2008). Effects of a home-based cardiac rehabilitation program on the physical activity levels of patients with coronary artery disease. *J Cardiopulm Rehabil Prev, 28*(6), 392-396. doi: 10.1097/HCR.0b013e31818c3b83 01273116-200811000-00007 [pii]

Opasich, C., Pinna, G. D., Mazza, A., Febo, O., Riccardi, R., Riccardi, P. G., . . . Tavazzi, L. (2001). Six-minute walking performance in patients with moderate-to-severe heart failure; is it a useful indicator in clinical practice? *European heart journal, 22*(6), 488-496. doi: 10.1053/euhj.2000.2310

Owen, N. (2012). Sedentary behavior: understanding and influencing adults' prolonged sitting time. *Prev Med, 55*(6), 535-539. doi: 10.1016/j.ypmed.2012.08.024

Owen, N., Sparling, P. B., Healy, G. N., Dunstan, D. W., & Matthews, C. E. (2010). Sedentary behavior: emerging evidence for a new health risk. *Mayo Clin Proc, 85*(12), 1138-1141. doi: 10.4065/mcp.2010.0444

Pashkow, F. J. (1993). Issues in contemporary cardiac rehabilitation: a historical perspective. *J Am Coll Cardiol, 21*(3), 822-834.

Pate, R. R., O'Neill, J. R., & Lobelo, F. (2008). The evolving definition of "sedentary". *Exerc Sport Sci Rev, 36*(4), 173-178. doi: 10.1097/JES.0b013e3181877d1a

Pate, R. R., Pratt, M., Blair, S. N., Haskell, W. L., Macera, C. A., Bouchard, C., . . . et al. (1995). Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA, 273*(5), 402-407.

Paterson, D. H., Jones, G. R., & Rice, C. L. (2007). Ageing and physical activity: evidence to develop exercise recommendations for older adults. *Canadian journal of public health.Revue canadienne de sante publique, 98 Suppl 2*, S69-108.

Perk, J., Hedback, B., & Engvall, J. (1990). Effects of cardiac rehabilitation after coronary artery bypass grafting on readmissions, return to work, and physical fitness. A case-control study. *Scandinavian journal of social medicine, 18*(1), 45-51.

Pitta, F., Troosters, T., Probst, V. S., Langer, D., Decramer, M., & Gosselink, R. (2008). Are patients with COPD more active after pulmonary rehabilitation? *Chest, 134*(2), 273-280. doi: 10.1378/chest.07-2655

Prince, S. A., Adamo, K. B., Hamel, M. E., Hardt, J., Connor Gorber, S., & Tremblay, M. (2008). A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. *Int J Behav Nutr Phys Act, 5*, 56. doi: 10.1186/1479-5868-5-56

Ramadi, A., Haennel, R. G., Stone, J. A., Arena, R., Threlfall, T. G., Hitt, E., . . . Martin, B. J. (2015). The sustainability of exercise capacity changes in home versus center-based cardiac rehabilitation. *J Cardiopulm Rehabil Prev, 35*(1), 21-28. doi: 10.1097/hcr.0000000000000084

Ramadi, A., Stickland, M. K., Rodgers, W. M., & Haennel, R. G. (2015). Impact of supervised exercise rehabilitation on daily physical activity of cardiopulmonary patients. *Heart Lung, 44*(1), 9-14. doi: 10.1016/j.hrtlng.2014.11.001

Riley, M., McParland, J., Stanford, C. F., & Nicholls, D. P. (1992). Oxygen consumption during corridor walk testing in chronic cardiac failure. *European heart journal, 13*(6), 789-793.

Rodgers, W. M., Wilson, P. M., Hall, C. R., Fraser, S. N., & Murray, T. C. (2008). Evidence for a multidimensional self-efficacy for exercise scale. *Res Q Exerc Sport, 79*(2), 222-234.

Rowe, D. A., Kemble, C. D., Robinson, T. S., & Mahar, M. T. (2007). Daily walking in older adults: day-to-day variability and criterion-referenced validity of total daily step counts. *J Phys Act Health, 4*(4), 434-446.

Russell, K. L., Holloway, T. M., Brum, M., Caruso, V., Chessex, C., & Grace, S. L. (2011). Cardiac rehabilitation wait times: effect on enrollment. *J Cardiopulm Rehabil Prev, 31*(6), 373-377. doi: 10.1097/HCR.0b013e318228a32f

Salvetti, X. M., Oliveira, J. A., Servantes, D. M., & Vincenzo de Paola, A. A. (2008). How much do the benefits cost? Effects of a home-based training programme on cardiovascular fitness, quality of life, programme cost and adherence for patients with coronary disease. *Clin Rehabil, 22*(10-11), 987-996. doi: 10.1177/0269215508093331

Scheers, T., Philippaerts, R., & Lefevre, J. (2012). Variability in physical activity patterns as measured by the SenseWear Armband: how many days are needed? *Eur J Appl Physiol, 112*(5), 1653-1662. doi: 10.1007/s00421-011-2131-9

Schuster, P. M., Wright, C., & Tomich, P. (1995). Gender differences in the outcomes of participants in home programs compared to those in structured cardiac rehabilitation programs. *Rehabilitation nursing : the official journal of the Association of Rehabilitation Nurses, 20*(2), 93-101.

Sewell, L., Singh, S. J., Williams, J. E., Collier, R., & Morgan, M. D. (2005). Can individualized rehabilitation improve functional independence in elderly patients with COPD? *Chest, 128*(3), 1194-1200. doi: 10.1378/chest.128.3.1194

Shabani, R., Gaeini, A. A., Nikoo, M. R., Nikbackt, H., & Sadegifar, M. (2010). Effect of cardiac rehabilitation program on exercise capacity in women undergoing coronary artery bypass graft in hamadan-iran. *Int J Prev Med, 1*(4), 247-251.

Shanmugasegaram, S., Oh, P., Reid, R. D., McCumber, T., & Grace, S. L. (2013). A comparison of barriers to use of home- versus site-based cardiac rehabilitation. *J Cardiopulm Rehabil Prev, 33*(5), 297-302. doi: 10.1097/HCR.0b013e31829b6e81

Sharma, R., & Anker, S. D. (2001). The 6-minute walk test and prognosis in chronic heart failure--the available evidence. *European heart journal, 22*(6), 445-448. doi: 10.1053/euhj.2000.2451

Sherman, W. M., Morris, D. M., Kirby, T. E., Petosa, R. A., Smith, B. A., Frid, D. J., & Leenders, N. (1998). Evaluation of a commercial accelerometer (Tritrac-R3 D) to measure energy expenditure during ambulation. *International Journal of Sports Medicine, 19*(1), 43-47. doi: 10.1055/s-2007-971878

Smith, H. J., Taylor, R., & Mitchell, A. (2000). A comparison of four quality of life instruments in cardiac patients: SF-36, QLI, QLMI, and SEIQoL. *Heart, 84*(4), 390-394.

Smith, K. M., Arthur, H. M., McKelvie, R. S., & Kodis, J. (2004). Differences in sustainability of exercise and health-related quality of life outcomes following home or hospital-based cardiac rehabilitation. *Eur J Cardiovasc Prev Rehabil, 11*(4), 313-319. doi: 00149831-200408000-00008 [pii]

Smith, K. M., McKelvie, R. S., Thorpe, K. E., & Arthur, H. M. (2011). Six-year follow-up of a randomised controlled trial examining hospital versus home-based exercise training after coronary artery bypass graft surgery. *Heart, 97*(14), 1169-1174. doi: 10.1136/hrt.2010.202036

Solway, S., Brooks, D., Lacasse, Y., & Thomas, S. (2001). A qualitative systematic overview of the measurement properties of functional walk tests used in the cardiorespiratory domain. *Chest, 119*(1), 256-270.

Spurr, G. B., Prentice, A. M., Murgatroyd, P. R., Goldberg, G. R., Reina, J. C., & Christman, N. T. (1988). Energy expenditure from minute-by-minute heart-rate recording: comparison with indirect calorimetry. *Am J Clin Nutr, 48*(3), 552-559.

St-Onge, M., Mignault, D., Allison, D. B., & Rabasa-Lhoret, R. (2007). Evaluation of a portable device to measure daily energy expenditure in free-living adults. *Am J Clin Nutr, 85*(3), 742-749.

Stahle, A., Mattsson, E., Ryden, L., Unden, A., & Nordlander, R. (1999). Improved physical fitness and quality of life following training of elderly patients after acute coronary events. A 1 year follow-up randomized controlled study. *Eur Heart J, 20*(20), 1475-1484.

Stahle, A., Nordlander, R., Ryden, L., & Mattsson, E. (1999). Effects of organized aerobic group training in elderly patients discharged after an acute coronary syndrome. A randomized controlled study. *Scand J Rehabil Med, 31*(2), 101-107.

Steele, B. G., Belza, B., Cain, K. C., Coppersmith, J., Lakshminarayan, S., Howard, J., & Haselkorn, J. K. (2008). A randomized clinical trial of an activity and exercise adherence intervention in chronic pulmonary disease. *Archives of Physical Medicine and Rehabilitation, 89*(3), 404-412. doi: 10.1016/j.apmr.2007.11.003; 10.1016/j.apmr.2007.11.003

Steele, B. G., Belza, B., Hunziker, J., Holt, L., Legro, M., Coppersmith, J., . . . Lakshminaryan, S. (2003). Monitoring daily activity during pulmonary rehabilitation using a triaxial accelerometer. *Journal of Cardiopulmonary Rehabilitation, 23*(2), 139-142.

Stone, J. A., Arena, R., Hauer, T., Martin, B. J., Austford, L. D., & Aggarwal, S. (2011). Long-term retention of aerobic fitness improvements following participation in cardiac rehabilitation. *Int J Cardiol, 150*(3), 355-356. doi: S0167-5273(11)00454-2 [pii] 10.1016/j.ijcard.2011.05.041

Swain, D. P., & Franklin, B. A. (2002). VO(2) reserve and the minimal intensity for improving cardiorespiratory fitness. *Med Sci Sports Exerc, 34*(1), 152-157.

Tremblay, M. S., Colley, R. C., Saunders, T. J., Healy, G. N., & Owen, N. (2010). Physiological and health implications of a sedentary lifestyle. *Appl Physiol Nutr Metab, 35*(6), 725-740. doi: 10.1139/H10-079

Tremblay, M. S., Esliger, D. W., Tremblay, A., & Colley, R. (2007). Incidental movement, lifestyle-embedded activity and sleep: new frontiers in physical activity assessment. *Can J Public Health, 98 Suppl 2*, S208-217.

Tudor-Locke, C., Craig, C. L., Aoyagi, Y., Bell, R. C., Croteau, K. A., De Bourdeaudhuij, I., . . . Blair, S. N. (2011). How many steps/day are enough? For older adults and special populations. *Int J Behav Nutr Phys Act, 8*, 80. doi: 10.1186/1479-5868-8-80

Valenti, L., Lim, L., Heller, R. F., & Knapp, J. (1996). An improved questionnaire for assessing quality of life after acute myocardial infarction. *Qual Life Res, 5*(1), 151-161.

van den Berg-Emons, H., Bussmann, J., Balk, A., Keijzer-Oster, D., & Stam, H. (2001). Level of activities associated with mobility during everyday life in patients with chronic congestive heart failure as measured with an "activity monitor". *Phys Ther, 81*(9), 1502-1511.

van den Berg-Emons, R., Balk, A., Bussmann, H., & Stam, H. (2004). Does aerobic training lead to a more active lifestyle and improved quality of life in patients with chronic heart failure? *Eur J Heart Fail, 6*(1), 95-100. doi: 10.1016/j.ejheart.2003.10.005

Vanhees, L., Lefevre, J., Philippaerts, R., Martens, M., Huygens, W., Troosters, T., & Beunen, G. (2005). How to assess physical activity? How to assess physical fitness? *Eur J Cardiovasc Prev Rehabil, 12*(2), 102-114. doi: 00149831-200504000-00004 [pii]

Wakefield, B., Drwal, K., Scherubel, M., Klobucar, T., Johnson, S., & Kaboli, P. (2014). Feasibility and effectiveness of remote, telephone-based delivery of cardiac rehabilitation. *Telemed J E Health, 20*(1), 32-38. doi: 10.1089/tmj.2013.0079

Walker, P. P., Burnett, A., Flavahan, P. W., & Calverley, P. M. (2008). Lower limb activity and its determinants in COPD. *Thorax, 63*(8), 683-689. doi: 10.1136/thx.2007.087130; 10.1136/thx.2007.087130

Walsh, J. T., Andrews, R., Evans, A., & Cowley, A. J. (1995). Failure of "effective" treatment for heart failure to improve normal customary activity. *British heart journal, 74*(4), 373-376.

Webb-Peploe, K. M., Chua, T. P., Harrington, D., Henein, M. Y., Gibson, D. G., & Coats, A. J. (2000). Different response of patients with idiopathic and ischaemic dilated cardiomyopathy to exercise training. *Int J Cardiol, 74*(2-3), 215-224.

Welk, G. J., Blair, S. N., Wood, K., Jones, S., & Thompson, R. W. (2000). A comparative evaluation of three accelerometry-based physical activity monitors. *Med Sci Sports Exerc, 32*(9 Suppl), S489-497.

Welk, G. J., McClain, J. J., Eisenmann, J. C., & Wickel, E. E. (2007). Field validation of the MTI Actigraph and BodyMedia armband monitor using the IDEEA monitor. *Obesity (Silver Spring, Md.), 15*(4), 918-928. doi: 10.1038/oby.2007.624

Williams, M. A., Maresh, C. M., Aronow, W. S., Esterbrooks, D. J., Mohiuddin, S. M., & Sketch, M. H. (1984). The value of early out-patient cardiac exercise programmes for the elderly in comparison with other selected age groups. *European heart journal, 5 Suppl E*, 113-115.

Witham, M. D., Gray, J. M., Argo, I. S., Johnston, D. W., Struthers, A. D., & McMurdo, M. E. (2005). Effect of a seated exercise program to improve physical function and health status in frail patients > or = 70 years of age with heart failure. *Am J Cardiol, 95*(9), 1120-1124. doi: 10.1016/j.amjcard.2005.01.031

Wolkanin-Bartnik, J., Pogorzelska, H., & Bartnik, A. (2011). Patient education and quality of home-based rehabilitation in patients older than 60 years after acute myocardial infarction. *J Cardiopulm Rehabil Prev, 31*(4), 249-253. doi: 10.1097/HCR.0b013e31821c1391

Wood, R., & Bandura, A. (1989). Social cognitive theory of organizational management. *Academy of Management Review, 14*(3), 361-384.

Wu, G., Sanderson, B., & Bittner, V. (2003). The 6-minute walk test: how important is the learning effect? *Am Heart J, 146*(1), 129-133. doi: 10.1016/s0002-8703(03)00119-4

Yohannes, A. M., Doherty, P., Bundy, C., & Yalfani, A. (2010). The long-term benefits of cardiac rehabilitation on depression, anxiety, physical activity and quality of life. *J Clin Nurs, 19*(19-20), 2806-2813. doi: 10.1111/j.1365-2702.2010.03313.x

JCN3313 [pii]

Yu, C. M., Li, L. S., Ho, H. H., & Lau, C. P. (2003). Long-term changes in exercise capacity, quality of life, body anthropometry, and lipid profiles after a cardiac rehabilitation program in obese patients with coronary heart disease. *Am J Cardiol, 91*(3), 321-325. doi: S0002914902031594 [pii]

Zugck, C., Kruger, C., Durr, S., Gerber, S. H., Haunstetter, A., Hornig, K., . . . Haass, M. (2000). Is the 6-minute walk test a reliable substitute for peak oxygen uptake in patients with dilated cardiomyopathy? *European heart journal, 21*(7), 540-549.

Zwerink, M., van der Palen, J., van der Valk, P., Brusse-Keizer, M., & Effing, T. (2013). Relationship between daily physical activity and exercise capacity in patients with COPD. *Respir Med, 107*(2), 242-248. doi: 10.1016/j.rmed.2012.09.018

Appendix A

Ethics Approval

June 16, 2008

Dr. Bob Haennel
Physical Therapy
2-50 Corbett Hall

File# B-300508

Re: Determining the Impact of Cardiac Rehabilitation on Physical Activity and Function Ability in Elderly Cardiac Patients

Dear Dr. Haennel:

Thank you for Ms. Megan Johnston's email correspondence dated June 11th, 2008, which addressed the requested revisions to the above-mentioned study. These changes have been reviewed and approved on behalf of the Research Ethics Board. Your approval letter is enclosed.

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.

Next year, a few weeks prior to the expiration of your approval, a Progress Report will be sent to you for completion. If there have been no major changes in the protocol, your approval will be renewed for another year. All protocols may be subject to re-evaluation after three years.

For studies where investigators must obtain informed consent, signed copies of the consent form must be retained, and be available on request. They should be kept for the duration of the project and for a full calendar year following its completion.

Approval by the Health Research Ethics Board does not encompass authorization to access the patients, staff or resources of Capital Health or other local health care institutions for the purposes of research. Enquiries regarding Capital Health administrative approval, and operational approval for areas impacted by research, should be directed to the Capital Health Regional Research Administration office, #1800 College Plaza, phone 407-6041.

Sincerely,

Charmaine N. Kabatoff
Senior Administrator
Health Research Ethics Board (Panel B)

Appendix B

Ethics Approval

Date:	January 10, 2013
Study ID:	Pro00035417
Principal Investigator:	Robert Haennel
Study Title:	Comparing the effectiveness of home versus center-based Cardiac Rehabilitation (CR) on physical activity, functional capacity and self-efficacy of cardiac patients
Approval Expiry Date:	January 9, 2014

Thank you for submitting the above study to the Health Research Ethics Board - Health Panel . Your application, including revisions received December 21, 2012, 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 HREB - 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 (January 9, 2014), 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,

Dr. Glen J. Pearson, BSc, BScPhm, PharmD, FCSHP
Associate Chair, Health Research Ethics Board - Health Panel

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

Notification of Approval (Renewal)

Date:	December 9, 2013
Amendment ID:	Pro00035417_REN1
Principal Investigator:	Robert Haennel
Study ID:	MS2_Pro00035417
Study Title:	Comparing the effectiveness of home versus center-based Cardiac Rehabilitation (CR) on physical activity, functional capacity and self-efficacy of cardiac patients
Approval Expiry Date:	January 8, 2015

Thank you for submitting this renewal application. Your application has been reviewed and approved.

This re-approval is valid for another year. If your study continues past the expiration date as noted above, you will be required to complete another renewal request. Beginning at 30 days prior to the expiration date, you will receive notices that the study is about to expire. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

All study related documents should be retained so as to be available to the Health REB upon request. They should be kept for the duration of the project and for at least 5 years following study completion.

Sincerely,

Glen J. Pearson, BSc, BScPhm, PharmD, FCSHP
Associate Chair, Health Research Ethics Board - Health Panel

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

Notification of Approval (Renewal)

Date:	December 2, 2014
Amendment ID:	Pro00035417_REN2
Principal Investigator:	Robert Haennel
Study ID:	MS6_Pro00035417
Study Title:	Comparing the effectiveness of home-based, center-based, or hybrid Cardiac Rehabilitation (CR) on physical activity, functional capacity and self-efficacy of cardiac patients
Approval Expiry Date:	January-07-16

Thank you for submitting this renewal application. Your application has been reviewed and approved.

This re-approval is valid for another year. If your study continues past the expiration date as noted above, you will be required to complete another renewal request. Beginning at 30 days prior to the expiration date, you will receive notices that the study is about to expire. If you do not renew on or before the renewal expiry date, you will have to re-submit an ethics application.

All study related documents should be retained so as to be available to the Health REB upon request. They should be kept for the duration of the project and for at least 5 years following study completion.

Sincerely,

Anthony S. Joyce, Ph.D.
Chair, Health Research Ethics Board - Health Panel

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

Appendix C

Ethics Approval

UNIVERSITY OF CALGARY

Conjoint Health Research Ethics Board (CHREB)
Research Services Office
Main Floor, Energy Resources Research Building
Research Park
3512-33 Street NW
Calgary, Alberta

Telephone (403) 220-7990
Fax (403) 289-0693
Email: CHREB@ucalgary.ca

April 10, 2013

Dr. Sandeep Aggarwal
Cardiac Wellness Institute of Calgary Inc. (CWIC)
Talisman Centre, Box 50
2225 MacLeod Trail S, Calgary, AB T2G 5B6

Dear Dr. Aggarwal:

RE: Comparing the effectiveness of home versus center-based Cardiac Rehabilitation (CR) on physical activity, functional capacity and self-efficacy of cardiac patients

Ethics ID: E-25199

The above-named research, including the Informed Consent Form (Version:2 dated: April 05, 2013), Questionnaire (Self-Efficacy for Exercise; Physical Activity Scale for the Elderly; MacNew Heart Disease Health-related quality of Life Instrument; Late Life function disability Instrument), Cover Letter (dated: January 23, 2013), Team Statement (Regulatory Statement), Letters (Approval Letter from Health Research Ethics Board - Biomedical Panel (dated Jan 10, 2013)), Script (Recruitment Script (First contact); Second contact(phone call, by study co-investigator)) has been granted ethical approval by the Conjoint Health Research Ethics Board of the Faculties of Medicine, Nursing and Kinesiology, University of Calgary, and the Affiliated Teaching Institutions. The Board conforms to the Tri-Council Guidelines, ICH Guidelines and amendments to regulations of the Food and Drugs Act re clinical trials, including membership and requirements for a quorum.

You and your co-investigators are not members of the CHREB and did not participate in review or voting on this study.

Please note that this approval is subject to the following conditions:
(1) a Progress Report must be submitted by **April 10, 2014**, containing the following information:

i) the number of subjects recruited;
ii) a description of any protocol modification;
iii) any unusual and/or severe complications, adverse events or unanticipated problems involving risks to subjects or others, withdrawal of subjects from the research, or complaints about the research;
iv) a summary of any recent literature, finding, or other relevant information, especially information about risks associated with the research;
v) a copy of the current informed consent form;
vi) the expected date of termination of this project.

(2) a Final Report must be submitted at the termination of the project.

Please accept the Board's best wishes for success in your research.

Yours sincerely,

Stacey Page, PhD
Chair, Conjoint Health Research Ethics Board

SP/be
c.c. Research Services

Conjoint Health Research Ethics Board (CHREB)
Research Services, University of Calgary
3rd Floor, MacKimmie Library Tower (MLT 300)
2500 University Drive N.W. Calgary, AB T2N 1N4
annlrept@ucalgary.ca | (403) 220-7990

FORM 6: ANNUAL REPORT AND RENEWAL FORM

Instructions:

1. Provide information only for the 12 months immediately prior to current anniversary date.
2. Do not aggregate data since start of study unless specifically requested
3. Do not include copy/copies of current consent forms
4. Submit electronically to Annlrept@ucalgary.ca
5. Subject line to read: <Ethics ID #> Annual Report
6. Annlrept@ucalgary.ca will generate an automatic response for your records
7. Annlrept@ucalgary.ca will contact you for follow up if required within 5 working days.

Ethics ID #: E-25199 **Anniversary Date: April 10, 2014**

Submission Date: March 11, 2014

Complete Research Protocol Title: **Comparing the effectiveness of home versus center-based Cardiac Rehabilitation (CR) on physical activity, functional capacity and self-efficacy of cardiac patients**	
Principal Investigator: Robert.G. Haennel **Sandeep Aggarwal***	**Signature:** **Date:**
Coordinator: Ailar Ramadi **Trina Hauer**	**Signature:** **Date:**
Telephone:780-492 2609/ 780-695 2243(Ramadi)	**Email: ramadi@ualberta.ca**

Within the current reporting period:

1. Has the research protocol closed to accrual? ❑ Yes **X** No
   If yes, when was it closed to accrual? Date (DD/MM/YY): _____
2. Has the research protocol closed to follow-up? ❑ Yes **X** No
   If yes, when was it closed to follow-up? Date (DD/MM/YY): _____
   Total number of subjects on follow-up: Number: _____
3. Has this study completely closed to all research activity? ❑ Yes **X** No
4. If so, when was the study completely closed? Date (DD/MM/YY): _____
5. If the study is continuing, what is the expected end date: Date (MM/YY): **Dec, 2014**
6. How many subjects did you expect to accrue? Number: **72**
7. Have all modifications been reported? **X** Yes ❑ No ❑ N/A
   (If no, contact the office immediately)
8. Have all complications been reported? ❑ Yes ❑ No **X** N/A
   (If no, contact the office immediately)
9. Have all adverse events been reported? ❑ Yes ❑ No **X** N/A
   (If no, contact the office immediately)
10. Have any subject withdrawn? **X** Yes ❑ No
    If yes, how many? Number: **3**

11. Number of subjects in last 12 months accrued by age and gender:

Age years	*0-<1*	*1-<4*	*4-<12*	*12-<18*	*18-<65*	*>65*
Number of Male					10	6
Number of Female					1	1

ANONYMOUS DATA COLLECTION
If your research method required anonymity, so that study subjects cannot be categorized by gender or age, check appropriate box: Anonymous: ❑ Yes X No
AND
provide a total count of the number of subjects accrued into the study in the reporting period.

Total Summaries

12. Total number of subjects accrued since start of study: Number: 18
13. Total number of subjects withdrawn since start of study: Number: 3
14. Have there been any complaints? ❑ Yes X No
(If yes, please provide details)
15. Have the results been published/presented? ❑ Yes X No
(*If yes, please provide details*)

Thank you very much for the **progress report** on this protocol. As Chair of the Conjoint Health Research Ethics Board, University of Calgary, and the Affiliated Teaching institutions, I am pleased to advise you that ethical approval for this proposal has been extended to April 10, 2015. Please note that this approval is contingent upon strict adherence to the original protocol. Prior permission must be obtained from the Board for any contemplated modification(s) of the original protocol.

A **progress report** concerning this study will be required by April 10, 2015.
This request received full Board approval on March 20, 2014.
Please accept the Board's best wishes for continued success in your research.

Stacey Page, PhD
Chair, Conjoint Health Research Ethics Board

date Mar 20, 2014

cc: Research Coordinator • Research Services

Appendix D

Multidimensional Exercise Self-efficacy Scale

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 for 30-60 minutes a day, 5 days of the week.

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

How confident are you that you can…	
Complete your exercise using proper technique	%
Follow directions to complete the exercise	%
Perform all of the movements required for your exercise	%
Exercise when you feel discomfort from the exercise	%
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 E

MacNew Heart Disease Health-related Quality of Life Instrument

We would now like to ask you some questions about how you have been feeling **DURING THE LAST 2 WEEKS.**

Please circle the number that matches your answer

1. In general, how much of the time during the last 2 weeks have you felt frustrated, impatient or angry?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

2. How often during the last 2 weeks have you felt worthless or inadequate?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

3. In the last 2 weeks, how much of the time did you feel very confident and sure that you could deal with your heart problem?

(1) none of the time (2) a little of the time (3) some of the time

(4) a good bit of the time (5) most of the time (6) almost all of the time

(7) all of the time

4. In general how much of the time did you feel discouraged or down in the dumps during the last 2 weeks?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

5. How much of the time during the past 2 weeks did you feel relaxed and free of tension?

(1) none of the time (2) a little of the time (3) some of the time

(4) a good bit of the time (5) most of the time (6) almost all of the time

(7) all of the time

6. How often during the last 2 weeks have you felt worn out or low in energy?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

7. How happy, satisfied, or pleased have you been with your personal life during the last 2 weeks?

(1) very dissatisfied, unhappy most of the time

(2) generally dissatisfied, unhappy

(3) somewhat dissatisfied, unhappy

(4) generally satisfied, pleased

(5) happy most of the time

(6) very happy most of the time

(7) extremely happy, could not have been more satisfied or pleased

8. In general, how often during the last 2 weeks have you felt restless, or as if you were having difficulty trying to calm down?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

9. How much shortness of breath have you experienced during the last 2 weeks while doing your day-to-day physical activities?

(1) extreme shortness of breath

(2) very short of breath

(3) quite a bit of shortness of breath

(4) moderate shortness of breath

(5) some shortness of breath

(6) a little shortness of breath

(7) no shortness of breath

10. How often during the last 2 weeks have you felt tearful or like crying?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

11. How often during the last 2 weeks have you felt as if you are more dependent than you were before your heart problem?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

12. How often during the last 2 weeks have you felt you were unable to do your usual social activities or social activities with your family?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

13. How often during the last 2 weeks have you felt as if others no longer have the same confidence in you as they did before your heart problem?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

14. How often during the last 2 weeks have you experienced chest pain while doing your day-to-day activities?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

15. How often during the last 2 weeks have you felt unsure of yourself or lacking in self-confidence?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

16. How often during the last 2 weeks have you been bothered by aching or tired legs?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

17. During the last 2 weeks, how much have you been limited in doing sports or exercise as a result of your heart problem?

(1) extremely limited (2) very limited (3) limited quite a bit

(4) moderately limited (5) somewhat limited (6) limited a little

(7) not limited at all

18. How often during the last 2 weeks have you felt apprehensive or frightened?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

19. How often during the last 2 weeks have you felt dizzy or lightheaded?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

20. In general, during the last 2 weeks how much have you been restricted or limited as a result of your heart problem?

(1) extremely limited (2) very limited (3) limited quite a bit

(4) moderately limited (5) somewhat limited (6) limited a little

(7) not limited at all

21. How often during the last 2 weeks have you felt unsure as to how much exercise or physical activity you should be doing?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

22. How often during the last 2 weeks have you felt as if your family is being overprotective toward you?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

23. How often during the past 2 weeks have you felt as if you were a burden on others?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

24. How often during the past 2 weeks have you felt excluded from doing things with other people because of your heart problem?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

25. How often during the past 2 weeks have you felt unable to socialize because of your heart problem?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time

26. In general, during the last 2 weeks how much have you been physically restricted or limited as a result of your heart problem?

(1) extremely limited (2) very limited (3) limited quite a bit

(4) moderately limited (5) somewhat limited (6) limited a little

(7) not limited at all

27. How often during the last 2 weeks have you felt your heart problem limited or interfered with sexual intercourse?

(1) all of the time (2) most of the time (3) a good bit of the time

(4) some of the time (5) a little of the time (6) hardly any of the time

(7) none of the time not applicable