THE LONG-TERM EFFECTIVENESS OF SHORT-TERM PHYSICAL ACTIVITY INTERVENTIONS IN CARDIAC PATIENTS

A THESIS SUBMITTED TO THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE MASTER OF SCIENCE IN CLINICAL EXERCISE PHYSIOLOGY

BY

STACY L. HOEKSEMA

ADVISOR: DR. LEONARD A. KAMINSKY

BALL STATE UNIVERSITY

MUNCIE, INDIANA

MAY 2012
ACKNOWLEDGMENTS

First, I want to thank my advisor, Dr. Leonard Kaminsky, for all of his advice, guidance, and patience through the process of completing this research project. I have been blessed to learn under such a distinguished leader in the clinical exercise physiology field. The knowledge I have gained under his leadership will have a lasting impact on my career.

I also want to thank Katrina Riggin for sharing with me her expertise in cardiopulmonary rehabilitation as well as her extensive experience and passion for motivating patients to live healthier lives. I am grateful for her willingness to devote her time to serve as a committee member for this project.

I want to thank Dr. Holmes Finch for going out of his way to teach me how to analyze my data and make sense of the results. I have greatly appreciated the perspective he has brought to this research project as a committee member.

I am grateful for the encouragement and support that my classmates: Kayla, Monica, and Ross have provided throughout this process. It has been a privilege to learn from each of them and grow together during our time in the Clinical Exercise Physiology Program.

Lastly, I want to thank my husband, Adam, for his constant love, support, and understanding throughout my graduate studies. I would not have been able to accomplish this without you.
TABLE OF CONTENTS

LIST OF TABLES AND FIGURES ................................................................. iii
ABSTRACT ............................................................................................... iv
CHAPTER 1 ............................................................................................... 1
INTRODUCTION ...................................................................................... 1
  Purpose ............................................................................................... 5
    Hypothesis ....................................................................................... 5
  Delimitations .................................................................................... 6
  Definitions ......................................................................................... 7
CHAPTER 2 ............................................................................................... 8
LITERATURE REVIEW ........................................................................... 8
  Impact of Cardiovascular Disease ...................................................... 8
  Risk Factors of Cardiovascular Disease ............................................. 9
  Physical Activity and Primary Prevention ......................................... 10
  Physical Activity and Secondary Prevention ...................................... 13
  Exercise-Based Cardiac Rehabilitation .............................................. 14
    Benefits of Cardiac Rehabilitation ................................................... 14
    Underuse of Cardiac Rehabilitation ................................................. 16
    Poor Attendance in Cardiac Rehabilitation ...................................... 17
    Physical Activity Levels of Cardiac Rehabilitation Patients ............ 18
    Exercise Adherence Following Cardiac Rehabilitation .................. 22
  Pedometer Interventions Aimed at Increasing Physical Activity ....... 32
  Pedometer Interventions in Cardiac Patients .................................... 41
  Validation of the Kenz Lifecorder PLUS (NL-2160) Accelerometer .... 49
CHAPTER 3 ............................................................................................... 54
METHODOLOGY ..................................................................................... 54
  Subjects and Recruitment ................................................................. 55
  Study Overview ................................................................................ 55
  Study Procedures ............................................................................. 56
  Data Validation Criteria .................................................................... 59
Statistical Analysis .................................................................................................................60
CHAPTER 4 ..............................................................................................................................61
RESEARCH MANUSCRIPT ......................................................................................................61
ABSTRACT ...............................................................................................................................63
INTRODUCTION ......................................................................................................................64
METHODS ...............................................................................................................................66
RESULTS ..................................................................................................................................73
DISCUSSION ...........................................................................................................................76
REFERENCES .........................................................................................................................92
CHAPTER 5 ................................................................................................................................105
SUMMARY AND CONCLUSIONS ............................................................................................105
Recommendations for Future Studies .....................................................................................109
REFERENCES .........................................................................................................................113
APPENDEX A ..........................................................................................................................120
PHYSICAL ACTIVITY STAGES OF CHANGE QUESTIONNAIRE .........................................120
APPENDEX B ..........................................................................................................................122
MOTIVATIONAL NEWSLETTERS ...........................................................................................122
LIST OF TABLES AND FIGURES

FIGURE LEGENDS........................................................................................................95

FIGURE 1  Average Steps/Day for Each Study Group Over Time.......................97

FIGURE 2  Total Mean Moderate-Intensity Physical Activity Minutes Over
Time..................................................................................................................................98

FIGURE 3  Total Mean Body Fat Percentage Over Time.....................................99

FIGURE 4  Total Mean High-Density Lipoprotein Cholesterol Over Time........100

TABLE 1  Descriptive Characteristics of Subjects............................................101

TABLE 2  Physical Activity Data Across Time..................................................102

TABLE 3  Secondary Variables of Individual Study Groups Across Time........103

TABLE 4  Secondary Variables of All Study Groups Across Time..................104
ABSTRACT

THESIS: The Long-Term Effectiveness of Short-Term Physical Activity Interventions in Cardiac Patients

STUDENT: Stacy L. Hoeksema

DEGREE: Master of Science

COLLEGE: Applied Science and Technology

DATE: May, 2012

PAGES: 126

While many short-term physical activity (PA) interventions in cardiac rehabilitation (CR) patients have proven to be successful at increasing PA levels, little is known about the long-term impact these interventions have. The purpose of the current study was to determine if the Increased Physical Activity in Cardiac Patients (IPAC) study utilizing pedometer feedback, motivational messages, and a combination of both were successful at increasing PA levels and improving cardiovascular disease (CVD) risk factors after 12 months. Thirty-six out of 70 possible participants (mean age of 64.3 ± 9.1 years) that had completed the IPAC study 12 months prior participated in the current study. PA levels were assessed via accelerometer for 7 days and compared to baseline and post-intervention levels. Each subject had resting heart rate and blood pressure, fasting blood sample, body composition assessment, and submaximal exercise test results collected and compared to baseline and post-intervention. Results of
repeated measures ANOVA demonstrated that none of the IPAC interventions were successful at increasing PA levels after 12 months compared to the usual care group and all groups reverted back to baseline levels. Additionally, irrespective of study group no significant differences were seen in CVD risk profile across time with the exception of body fat percentage which worsened significantly (p < 0.05) at 12 months and High Density Lipoprotein (HDL) cholesterol which increased significantly post-intervention (p <0.05) and was maintained at 12 months to the benefit of subjects. Further research is needed to develop PA interventions in CR patients that foster long-term PA maintenance.
CHAPTER 1

INTRODUCTION

Cardiovascular disease (CVD), a term that encompasses a number of diseases which affect the heart or blood vessels, remains a major concern in the United States. It is estimated that CVD is responsible for one out of every 2.9 deaths in the U.S., making it the leading cause of death in the country (49). An estimated 2200 Americans lose their lives every day because of CVD (49). In addition to the unsettling number of deaths, CVD has posed a significant financial burden on society. In 2007, the direct and indirect costs of CVD reached $286.6 billion, and by 2030 the total cost of CVD is expected to exceed $1 trillion (31, 49). These sobering statistics highlight the urgent need to provide effective treatment and ultimately prevention of CVD in the U.S.

Coronary artery disease (CAD) is the most prevalent form of CVD and claimed over 400,000 lives in 2007 (49). CAD occurs when the major blood vessels that supply nutrients and oxygen to the heart become narrowed or blocked due to plaque buildup. This serious condition can lead to myocardial infarctions (MI) and/or the need for coronary revascularization. Fortunately, evidence suggests that increased habitual physical activity (PA) not only prevents the development of CAD, but reduces angina, mortality, and improves
the quality of life of those already diagnosed with CAD (36, 64). Since an estimated 785,000 Americans experience new coronary attacks each year and 470,000 will have a recurrent attack, secondary prevention programs focused on regular aerobic exercise and CVD risk factor reduction are essential for patients with established CAD (36, 49).

The U.S. Department of Health and Human Services (HHS), the American Heart Association (AHA), the Centers for Disease Control (CDC), and the American College of Sports Medicine (ASCM), all support the notion that individuals should engage in 30 minutes or more of moderate-intensity PA on most (preferably all) days of the week (64, 69). While this recommendation is crucial for the primary prevention of chronic diseases, it is also pertinent for secondary prevention of those with established CAD. In fact, a more aggressive recommendation from the 2010 ACSM Guidelines indicates that cardiac patients should work up to exercising 60 minutes every day (66). Physical activity is of utmost importance in this population because it helps to prevent and treat CVD risk factors such as obesity, hypertension, dislipidemia, and glucose intolerance. Furthermore, exercise training in this population has been shown to increase one’s peak oxygen uptake by 11%-36% which has a profound impact on the ability to function and live independently (36). This highlights the vital role exercise-based secondary prevention programs play in facilitating behavior change and increasing PA levels (36).
Cardiac Rehabilitation (CR) is a secondary prevention program that not only focuses on increasing PA in cardiac patients, but also uses multifaceted strategies to lower and eliminate CVD risk factors (36). While CR has been deemed effective at reducing mortality rates and increasing cardiovascular function in CVD patients, the potential benefits can only be maintained through continued exercise and lifestyle modification. Unfortunately, after 12 weeks of CR only 15-50% of patients are exercising 6 months later, and even fewer are exercising 12 months later (41). Furthermore, Hansen et al. examined cardiac patients 18 months post CR and found a worsening of CVD risk factors and low levels of habitual PA in the total cohort. Only 27% participated in the minimal PA levels needed to attain significant health benefits (28). Due to these unfortunate findings, research exploring why cardiac patients are not adopting lifestyle changes in PA following CR is tremendously important.

Numerous studies have sought to answer why cardiac patients do not adopt regular PA after CR. Out of these studies, a wide variety of theories have developed indicating that there is no single reason for decreased adherence to PA. Instead, multiple reasons may exist to explain the attrition rate. For instance, after interviewing cardiac patients three years after CR, Clark et. al. found that the main barrier to long-term PA was the loss of social contact. Participants grew to rely on the company of others at CR, and without that ongoing contact, patients were not motivated to continue exercising (18). Furthermore, Sniehotta et al., determined that cardiac patients did not engage in adequate planning prior
to leaving CR in order to ensure that regular PA was implemented (58). Along these lines, some cardiac patients reported that they lacked knowledge about what activities were safe and to what degree they could exercise alone (18). In addition to these reasons, a large number of studies have focused on different aspects of motivation to explain the lack of long-term PA. Most patients do not begin CR because of their own desire to exercise, but because their diseased state demands it. Thus, patients are less likely to continue PA since they were not intrinsically motivated from the beginning (10, 51, 52). Clearly, the answer to why cardiac patients do not continue regular PA after CR has many different facets. This demonstrates the need for implementing physical activity interventions that address one or more of these concerns in order to encourage a lifestyle change.

A 12 week AHA funded intervention, titled Increased Physical Activity in Cardiac Patients (IPAC), evaluated the use of pedometer feedback and motivational messages to increase PA levels in cardiac patients attending maintenance CR. The study examined 4 groups: a usual care group (group 1), a pedometer feedback group (group 2), a motivational messages group (group 3), and a group that combined both pedometer feedback and motivational messages (group 4). Following the short-term intervention, all IPAC subjects were given a pedometer to encourage long-term PA. Preliminary reports from this study indicated that CR patients who received weekly motivational messages, increased their average steps/day by 19.6% from baseline in comparison to a
3.7% increase in the usual care group (39). Furthermore, patients receiving pedometer feedback increased their steps/day by 45% from baseline and the usual care group only increased by 2% (30). While short-term PA interventions such as the IPAC study appear to be successful to increase PA levels in cardiac patients attending CR, little research has studied the long-term effect of these interventions. Due to the low numbers of cardiac patients engaging in exercise after CR, studies evaluating the long-term impact of successful short-term interventions are essential.

**Purpose**

The primary purpose of this research project was to determine if any IPAC participants who had an intervention increased their PA levels after one year, and if so, which intervention was superior. The secondary purpose was to determine if any participants in the intervention groups exhibited a positive change in CVD risk factors (body composition, blood lipids, blood glucose, and blood pressure). If positive changes were observed, the intervention group with the most significant change was determined.

**Hypothesis 1:** Cardiac patients in groups 2-4 will have higher levels of PA compared to the usual care group after one year.

- **Specific Aim 1:** To determine if intervention groups that employed pedometer feedback and motivational messages are more effective at
increasing PA levels after one year compared to usual care exercise recommendations.

**Hypothesis 2:** Cardiac patients in groups 2-4 will have a more favorable CVD risk factor profile compared to the usual care group after one year.

- **Specific Aim 3:** To determine if higher PA levels found in groups 2-4 will have a positive impact on cardiovascular health compared to the usual care group after one year.

**Delimitations**

1. The cohort consisted of 36 cardiac patients (27 males and 9 females) that completed the IPAC study one year prior. Subjects had a primary diagnosis of MI, coronary artery bypass graft (CABG), percutaneous coronary intervention (PCI), heart valve repair/replacement, or stable angina.

2. Data collection procedures were replicated from the IPAC study: each subject completed a medical history questionnaire (MHQ), Physical Activity Stages of Change questionnaire, and had resting blood pressure, fasting blood sample, body composition assessment, and submaximal exercise test results collected.

3. The observational period consisted of one week in which subject’s PA levels were objectively measured using a Lifecorder PLUS downloadable
accelerometer (New-Lifestyles, Inc. Lee’s Summit, MO) and an Actigraph accelerometer (GT3X, MTI, Fort Walton Beach, FL).

Definitions

Cardiac Rehabilitation (CR): refers to coordinated, multifaceted interventions designed to optimize a cardiac patient’s physical, psychological, and social functioning (36)

Accelerometer: an instrument that assesses frequency, duration, and intensity of physical activity by measuring the acceleration and deceleration of the body (22)

Physical Activity (PA): any bodily movement produced by the contraction of skeletal muscles that result in a substantial increase over resting energy expenditure (16)
CHAPTER 2
LITERATURE REVIEW

Impact of Cardiovascular Disease

Cardiovascular disease (CVD) has had a tremendous impact worldwide and its prevalence is expected to rise significantly. The World Health Organization (WHO) reports that since 1990, more people have died from CVD than any other disease (76). CVD includes a number of diseases which affect the circulatory system, but the most prevalent is coronary artery disease (CAD). CAD is now the leading cause of death in the world (76). In fact, 3.8 million men and 3.4 million women are victims of CAD each year (76). Currently in the United States, the chance of developing CVD in men and women over the age of 40 is 49% and 32%, respectively. (49). Alarmingly, the likelihood of developing CVD in the U.S. is on the rise: in the next 20 years it is estimated that greater than 40% of the population will have at least one form of the disease (31). In addition to the increasing prevalence, the financial burden posed by CVD is expected to grow. In 2007, the direct and indirect costs of the disease totaled 286.6 billion and currently constitute 17% of overall national health expenditures (31, 49). By 2030, however, that number is expected to exceed 1 trillion (31). While the future
forecast for CVD is concerning, the disease is largely preventable; if the risk factors are treated aggressively, a problematic future can potentially be avoided (31).

**Risk Factors of Cardiovascular Disease**

Most of the major risk factors for CVD are modifiable including hypertension, hyperlipidemia, smoking, impaired fasting glucose, obesity, and sedentary lifestyle. Evidence has indicated that reducing these risk factors decreases one’s chance of having an initial or recurrent MI, stroke, and need for a coronary revascularization procedure (43). The prevalence of these risk factors in the U.S. is astounding, and thus the need for eliminating them is crucial to stop the growth of CVD and other chronic diseases. The following statistics from the American Heart Association (AHA) 2012 update were estimated from the National Health and Nutrition Examination Survey (NHANES) 2005-2008 (50): An estimated 29% of Americans were considered hypertensive, 68% of them were being treated with antihypertensive medications, and only 64% of those who sought treatment had their condition controlled. The number of Americans with total cholesterol of ≥ 240 mg/dl was estimated to be 33.5 million or 16.2%. Even though significant progress in the reduction of smoking has been made over the last 40 years, 21.2% of men and 17.5% of women ≥18 smoked and almost 20% of high school students. Furthermore, an overwhelming 18.3 million Americans were diagnosed with diabetes, approximately 7.1 million went undiagnosed, and nearly 37% of the U.S. population was considered pre-diabetic. The prevalence
of hypertension, hyperlipidemia, and diabetes may be partially attributed to the 68% of Americans ≥ 20 years of age being overweight and 34% being obese (25). In addition, less than 33% of Americans are meeting the minimum weekly recommendation of PA issued from the U.S. department of Health and Human Services (150 minutes of moderate-intensity aerobic activity)(43, 69). Regular PA has been shown to play a key role in the prevention and management of CVD risk factors, thus highlighting the importance of PA in preventing CVD (36, 43).

**Physical Activity and Primary Prevention**

Regular PA plays a key role in the reduction of other CVD risk factors (64). Stephanick et al. examined the effect of aerobic exercise (included activities that were equivalent to 10 miles of brisk walking per week), diet, and a combination of both on low-density lipoprotein (LDL) cholesterol of 377 men and women and found that exercise can help to significantly reduce LDL cholesterol. The results indicated that both the exercise-only and combination groups saw a significant reduction in LDL, with the greatest change occurring in the combination group. However, the diet-only group did not see a significant reduction in LDL, which suggests that regular aerobic exercise is important in the regulation of LDL cholesterol (59). Blumenthal et al. evaluated the effect of weight management and exercise (aerobic training for 30 min, 3-4 days/week, at 70-85% of initial heart rate reserve) on changes in blood pressure in 133 overweight, sedentary men and women. While the combination of weight management and exercise resulted in greater decreases in systolic and diastolic blood pressure (7/5 mm
Hg), the group that participated in only aerobic exercise still exhibited a decrease in both systolic and diastolic blood pressure by 4 mm Hg (9). Regular PA alone may lead to modest decreases in blood pressure, but PA adjunct to weight reduction strategies is most effective at reducing blood pressure. Regular PA has also been shown to help regulate blood glucose. The Diabetes Prevention Program Research Group assessed the use of pharmacological agents versus the use of lifestyle intervention (150 minutes of moderate intensity PA/week) on 3234 pre-diabetic individuals (21). The results indicated that the incidence of diabetes was decreased by 58% with regular PA, while the use of medication decreased the incidence of diabetes by only 31%. Furthermore, regular PA in addition to diet is essential for losing and maintaining weight. The National Weight Control Registry, which studies individuals that have maintained at least a 30-pound weight loss for one year, found that only 9% of the 3000 subjects have reported losing weight without regular PA (75). This highlights the importance of regular PA in weight reduction and maintenance. All of these studies add evidence to support the use of regular PA in the treatment of CVD risk factors.

Important cardiovascular and peripheral adaptations resulting from a lifestyle of PA facilitate an increase in maximal oxygen uptake ($VO_{2\text{max}}$) (8, 24). $VO_{2\text{max}}$ is a direct measure of one’s fitness level and predicts how well a person will be able to function and live independently. In addition, research has indicated that $VO_{2\text{max}}$ may also be a strong predictor of mortality (44, 72). Myers et al. tested the exercise capacity of 6213 men and found that in both healthy
men and those with established CAD, peak exercise capacity was a greater predictor of mortality than any other CVD risk factor (44). A single MET increase in performance on the treadmill was associated with a 12% improvement in survival which demonstrates the prognostic potential of exercise capacity. Interestingly, the greatest difference in mortality rates was found between the least fit group and the next-least fit group. Thus, the most significant decrease in risk for all-cause mortality occurs when a sedentary person becomes moderately fit (43). This finding is compatible with the report issued by the Department of Health and Human Services on PA stating that the dose-response relationship between PA and all-cause mortality is curvilinear: the most significant health benefits occur by increasing activity among those that are least fit (69).

Even though the benefits of PA have been well established, 250,000 Americans die each year because they are not engaging in regular PA (43, 76). The U.S. Department of Health and Human Services (HHS), the American Heart Association (AHA), the Centers for Disease Control (CDC), and the American College of Sports Medicine (ASCM), all support the notion that individuals should engage in 30 minutes or more of moderate-intensity physical activity on most (preferably all) days of the week (43, 64, 69). According to these guidelines, moderate-intensity activity is comparable to walking briskly between 3-4 mph. If people adhered to these minimum recommendations, there would be an estimated 30-40% reduction in cardiac events (43).
Physical Activity and Secondary Prevention

Not only is exercise important for the primary prevention of CVD, but it is crucial for individuals already diagnosed with the disease. As stated previously, exercise plays a key role in the management of major CVD risk factors including weight, blood pressure, blood glucose and blood lipids levels. Furthermore, exercise helps to enhance the aerobic capacity of cardiac patients through both central and peripheral adaptations. Peak oxygen consumption has been shown to increase 15-20% in cardiac patients that participated in aerobic training at 70-85% VO$_{2\text{max}}$, 3 days/week, for 3 months (1). An increase in VO$_{2\text{max}}$ not only results in an increased ability to tolerate exercise, but it impacts activities of daily living (ADL's) as well. Ades et al. found that after 3 months of exercise training, all patients exhibited an improvement in their perceived ability to perform ADL's (2). In addition to the 785,000 Americans that will experience a new coronary attack each year, an estimated 470,000 cardiac patients will have a recurrent coronary attack (49). Fortunately, studies have demonstrated that the higher one's exercise capacity, the greater reduction in risk for a recurrent attack (35, 72) and cardiac-related mortality (33, 35, 44, 72). Regular PA has also been shown to affect the progression of CAD. Studies indicate that this may be due in part to increased endothelial function of the blood vessels and the natural release of nitric oxide (27, 74). After 4 weeks of exercise training, Hambrecht et al. found an improvement in the ability of the endothelium to dilate in cardiac patients with endothelial dysfunction. Thus, Hambrecht et al. hypothesized that the increase in
myocardial perfusion seen in cardiac patients after exercise training may be partially due to improved endothelial function (27). In summary, regular PA in cardiac patients aids in the management of CVD risk factors, increases aerobic capacity, improves one’s ability to perform ADL’s, decreases one’s risk for cardiac-related mortality, and has the potential to slow or reverse CAD progression by improving endothelial function.

Exercise-Based Cardiac Rehabilitation

Benefits of Cardiac Rehabilitation

Exercise-based CR is an essential component of the care and treatment of cardiac patients. Traditionally, CR was limited to myocardial infarction (MI) and coronary artery bypass graft (CABG) patients but has been expanded to included patients with PCI, Chronic Heart Failure (CHF), stable angina, Peripheral Artery Disease (PAD), valvular heart disease, heart transplantation, and other forms of CVD. In 1994, the AHA stated that CR should emphasize 3 main components: 1) exercise training and activity prescription, 2) risk factor modification, and 3) psychosocial and vocational evaluation and counseling (6). The statement was made in an effort to not limit CR to exercise alone. In response, detailed guidelines on the core components and outcomes of CR have been published in the last decade (1, 3, 7, 36, 57). Thus, CR has developed into a multifaceted intervention involving a variety of therapies including education on CVD risk factors, nutritional and psychological counseling, drug therapy, and exercise (36, 62).
Research has confirmed that CR is effective at reducing mortality rates, modifying CVD risk factors, increasing functional capacity, and improving quality of life. Taylor et al. conducted a meta-analysis of 48 randomized control trials in CR to evaluate its effectiveness in CAD patients (62). Compared with usual care, CR was associated with a greater decrease in all-cause and cardiac mortality, total cholesterol, triglyceride levels, systolic blood pressure, and self-reported smoking. However, no difference was found in the rates of nonfatal MI’s and revascularization. Most recently in 2011, Lawler et al. performed a meta-analysis of 36 CR randomized controlled trials in post-MI patients and also found a decrease in all-cause and cardiac mortality rates, as well as a reduction in modifiable CVD risk factors (35). In contrast to Taylor et al., Lawler et al. was the first meta-analysis to find a significant reduction in the risk for recurrent MI’s with the use of exercise-based CR. While more randomized controlled trials are needed to strengthen this finding, it is encouraging nonetheless. A study conducted by Silberman et al. evaluated changes in health in almost 3,000 cardiac patients at 24 different health care sites enrolled in CR at baseline, 12 weeks, and after one year (55). The study found significant improvements in numerous health outcomes after 12 weeks including blood lipids, blood pressure, BMI, depression, functional capacity and quality of life. After one year, these improvements were less but still significant compared to baseline. In addition to the favorable health outcomes, the study found a high retention rate after one year: 78.1% remained enrolled. This finding is significant due to the over generalization that patients are unable to maintain long-term lifestyle changes.
Thus, CR has the potential to not only impact the health of cardiac patients in the short-term, but to create lasting change.

_Underuse of Cardiac Rehabilitation_

Even though CR has proved to be effective at improving numerous health outcomes in cardiac patients, it is widely underused. In 2007, the AHA published a study that utilized Medicare claims from 1997 to evaluate Phase II CR use after MI’s or CABG’s. Of the 247,427 ≥65 year-olds included, only 18.7% received at least one session of CR (61). In addition, Thomas et al. surveyed 500 randomly chosen CR programs in the U.S. during 1990 and found that only a small percentage of patients with MI, CABG, or PCI participated in CR (10.8%, 10.3%, and 23.4% respectively) (63). The combination of these studies found lowest enrollment for women, non-whites, those over 65 years of age, and patients with comorbidities. While there are a wide range of patient-related barriers to attending CR (location and transportation, inadequate finances, and lack of social support), one of the main reasons for underutilization is the lack of physician referrals (13). Using data from the AHA Get with the Guidelines Program, Brown et al. investigated referral rates in 72,817 patients discharged after MI, CABG, and/or PCI from 156 hospitals between January 2000 and September 2007 (14). Only 56% of eligible patients discharged from these hospitals were referred by their physicians. There was considerable variation in referral rates between hospitals: in 35% of the hospitals, less than 20% of patients were referred. The study suggested that in order to increase referral rates, physicians need to be
better educated on the benefits of CR. AHA recommends improving referral methods by utilizing automatic referral methods after hospital admission, developing Web-based referral processes, and implementing referral methods from states with high CR utilization (61).

**Poor Attendance in Cardiac Rehabilitation**

In addition to the enrollment dilemma, many patients exhibit poor attendance after being referred or beginning participation in CR. Lane et al. evaluated the cardiac patients at 2 hospitals in which both written and oral invitations for CR were given (34). Of the 263 patients in the cohort, only 108 attended at least 50% of CR sessions and 152 did not attend any of the sessions. The reasons given for not beginning CR or not attending all sessions were: 1) not wanting to attend 2) other comorbidities 3) return to work 4) caring for a loved one and 5) living too far away. This study suggests that attendance is not random, but rather can be predicted based on demographic, behavioral, and clinical status. Similarly, a meta-analysis conducted by Cooper et al. that included 15 studies on CR attendance found consistent variables that predicted attendance (19). For instance, elderly and female patients were least likely to attend CR. It is hypothesized that females have lower levels of attendance due to gender-specific differences as well as conflicts with family responsibilities. In addition, the authors suggest that lower attendance in the elderly may be attributed to a higher prevalence of depression in this population. Furthermore, patients with lower levels of income, social support, education and self-efficacy
were less likely to attend. Thus, all of these factors should be taken into account in order to identify individuals that may need special attention and more encouragement.

*Physical Activity Levels of Cardiac Rehabilitation Patients*

In 2001, the AHA and American College of Cardiology (ACC) issued an update on the PA guidelines for preventing MI’s and death in patients with CAD. The recommendation included 30-60 minutes of moderate activity, 3-4 days/week, supplemented with an increase in daily lifestyle activity (56). In 2006, the AHA and ACC further updated these guidelines by issuing the goal of 30-60 minutes of moderate activity, 7 days/week, with a minimum of 5 days/week (57). Similarly, ACSM and the American Association of Cardiovascular and Pulmonary Rehabilitation (AAV CPR) currently recommend 20-60 minutes of moderate-vigorous intensity PA on most days of the week (4-7 days/week) (3, 65). In addition, the ACSM guidelines suggest that cardiac patients should strive to reach a PA energy expenditure of 1,000-1,500 kcal/week. Results from a study by Hambrecht et al., however, indicate that more aggressive energy expenditures are needed in patients with CAD (26).

Hambrecht et al. conducted a study examining the amount of PA required to halt the progression of CAD (26). Patients were randomized to either an intervention group utilizing regular PA (n = 29) or a usual care group (n = 33). Patients in the intervention group were given a cycle ergometer and asked to perform 30 minutes of exercise at 75% of VO_2max_ daily. In addition, patients
participated in 2 group training sessions consisting of jogging, calisthenics, and ball games for 60 min/session. Patients in the control group received usual care instructions on the importance of regular PA and low-fat diet. Both groups were asked to refrain from taking lipid-lowering medications for the duration of the study. Cardiac catheterizations were used before and after the intervention to determine disease progression. Regardless of the group assignment, patients with the lowest levels of energy expenditure exhibited disease progression. Patients with no disease progression expended on average 1,500 kcal/week. Those with an energy expenditure of ≥ 2,200 kcal/week actually exhibited a regression in their disease process. This equates to approximately 5 to 6 hours per week of PA. The results of this study suggest that in order to halt CAD progression, ~1,500 kcal/week is required and in order to see regression ~2,200 kcal/week is needed.

The ACSM guidelines for cardiac patients also advise the accumulation of 10,000 steps/day for overall health and fitness benefits. Walking for 30 minutes/day equates to 3,000-4,000 steps (65). While achieving 10,000 steps/day is an attainable goal for most people, it may be too lofty of a goal for older individuals, sedentary individuals, and/or patients with CAD (5, 60, 67). Strath et al. examined the step counts of an older adult cohort (n = 415) with a mean age of 71 years old and found an average step-count of just under 4,000 steps/day (60). Furthermore, Tudor-Locke et al. conducted a meta-analysis examining how many steps are enough for older adults and special populations
The study found that healthy older adults average 2,000-9,000 steps/day, whereas populations with chronic illness reach an average of 1,200-8,800 steps/day. Since reaching 10,000 steps/day has proved to be difficult in special populations, Ayabe et al. (5) examined the relationship between step counts and PA energy expenditure (PAEE) in cardiac patients to determine the step count associated with halting or reversing CAD progression (1,500 and 2,200 kcal/week, respectively (26). The cohort consisted of 77 cardiac patients (53 men, 24 women) between the ages of 46-88 years in the Wake Forest CR program. The patients had participated for >3 months in the CR program which consisted of 3 weekly supervised aerobic exercise sessions (walking at 50-85% of heart rate reserve for 40 min). All subjects were instructed to wear a 1-axial accelerometer (Lifecorder EX, Suzuken Co) continuously for 10 days. Taking into account body weight and acceleration pattern, the device calculated time spent in light (<3 METs), moderate (3-6 METs), and vigorous (>6 METs) intensity PA to determine PAEE. Next, the researchers investigated the relationship between 3 variables: PAEE, time spent in moderate-vigorous intensity PA (MVPA), and the corresponding daily step counts. This relationship was used to determine the number of steps that correlated to the recommended weekly PAEE for cardiac patients (26): 6,500-8,500 steps/day to reach 1,500-2,200 kcal/week of PAEE. Before recommending this step count to cardiac patients, several limitations to this study should be considered. First, PAEE was estimated using an accelerometer and was not measured directly. In addition, the validity of using accelerometry to estimate PAEE in obese populations as well as those with slow
walking patterns has not been adequately established. Furthermore, specific outcome measures related to the progression/regression of CAD were not investigated in this study. Thus, the 6,500-8,500 steps/day that correlated to PAEE needed to halt or reverse CAD progression is only theoretical. More research is needed to determine if this step count results in adequate PAEE. Despite the limitations, the present study elicited an important finding: step counts on CR days were significantly higher than non-CR days (8,499 ± 3,173 and 5491 ± 2805 steps/day, respectively). Thus, promoting increased lifestyle PA may be key to reaching adequate steps/day.

An important goal of CR should be to encourage regular PA outside of CR sessions. Ayabe et al. investigated the PA patterns of patients attending CR to determine the difference in PA achieved on CR days versus non-CR days (4). PA levels were assessed for 10 days using accelerometers (Lifecorder, Suzuken Co., Nagoya, Japan) to estimate PAEE and the intensity of movement. Data from the first 3 days of measurement were deleted as subjects tend to increase their PA levels due to the novelty of wearing an accelerometer. Caloric expenditure was estimated according to each subject’s body weight and intensity level (METs) of every 4 second interval. A significant variability in PAEE was seen in patients ranging from 397-4,557 kcal/week. Forty-three percent of patients exceeded 1,500 kcal/week and only 16% exceeded 2,200 kcal/week, which were the energy requirements evidenced by Hambrecht et al. to halt or reverse CAD progression (26). The daily total of PA for men and women combined was
significantly higher on CR days compared to non-CR days (299 ± 161 and 176 ± 112 kcal/day, respectively). In addition, on CR days, PA characterized as ≥ moderate intensity averaged 92% of recommended PA levels (30 min/day). On non-CR days, however, average time spent in ≥ moderate intensity PA reached only 36% of recommended levels. These results indicate that CR alone was not enough to reach weekly energy expenditure recommendations. This study suggests that increasing PA levels on non-CR days is imperative to achieve PAEE great enough to halt or reverse CAD progression. When interpreting the results of this study, it is important to note that PAEE was measured indirectly using accelerometers. Accelerometers underestimate PAEE when significant upper body work is performed and do not detect light PA accurately. Thus, PAEE may have been underestimated in some cases.

Exercise Adherence Following Cardiac Rehabilitation

Unfortunately, evidence has indicated that patients who attend CR oftentimes fail to participate in regular PA long-term and experience a decline in their CVD risk profile. For example, a study by Hansen et al. evaluated the differences in long-term health of male and female cardiac patients that participated in long-duration (60 minutes) versus short-duration (40 minutes) CR sessions (28). At baseline, all subjects had been diagnosed with an acute MI, stable CAD, or underwent a revascularization procedure. Patients were randomly assigned to either a 40 or 60 minute exercise session group (n = 61 and 58, respectively) that met 3 days/week for 7 weeks. Exercise intensity was
determined using a heart rate that corresponded to 65% of each patient’s VO$_{2peak}$ at baseline. Each session consisted of 3 exercise modes with 42% of the session on the treadmill, 33% on the cycle ergometer, and 25% on the arm cranking device. Additionally, patients participated in education courses covering the topics of nutrition and CVD risk factor management. At baseline and 18 months, body composition, resting heart rate and blood pressure, smoking status, medications, and blood parameters were assessed. Additionally, at 18 months PA levels from the previous 2 weeks were assessed using the International Physical Activity Questionnaire (IPAQ): during a standard week, moderate and vigorous PA was reported. Patients were seen by a cardiologist every 6 months and the reoccurrence of cardiovascular events were noted during the 18 month follow-up. Results of the study indicated that in the total cohort, various CVD risk factors (total cholesterol, LDL cholesterol, triglycerides, fasting glucose and systolic blood pressure) significantly worsened after 18 months and only 27% of the group participated in minimal PA recommendations. Both the low-volume and high-volume exercise groups exhibited a similar decline in PA levels and CVD risk factors. Therefore, this study suggests that regardless of exercise volume during CR, patients tend to digress similarly during long-term follow-up. Several limitations should be considered when interpreting the findings. First, a significant number of participants dropped out and were not assessed at follow-up (46 of the original 165 subjects). Secondly, nutritional intake was not assessed and this data may have helped researchers gain a better understanding of the progressive worsening of risk factors. Lastly, PA levels were determined using
the IPAQ and were not measured objectively. The use of pedometers, heart rate monitors, and/or accelerometers would have strengthened this study.

Recently, Moholdt et al. studied the long-term impact of CR on VO$_{2\text{max}}$ in 2 groups: an aerobic interval training (AIT) group and usual care continuous exercise group (mean age: 56.7 ± 10.4 and 57.3 ± 9.7 years, respectively) (40). Patients in the study had been diagnosed with an MI 2-12 weeks prior. The AIT group (n = 35) completed 4 times 4 minutes of treadmill walking at 90% maximum heart rate 2 days/week for 12 weeks. The usual care group (n = 72) participated in 60 minutes of continuous aerobic exercise 2 days/week for 12 weeks. VO$_{2\text{max}}$ treadmill tests were performed at 4 different time points: baseline, immediately post intervention, 6 and 30 months post. Results indicated that after CR, VO$_{2\text{max}}$ increased more significantly in the AIT group than the usual care group. Following 6 and 30 months, VO$_{2\text{max}}$ declined significantly in both groups. At 30 months, VO$_{2\text{max}}$ was comparable to baseline levels in the AIT group and significantly worse than baseline in the usual care group. Most likely the difference between groups at 30 months was due to the AIT group increasing more significantly during the 12 week intervention. These results suggest that the use of high intensity interval training in CR may be promising if patients are adherent long-term PA. At 30 months it was reported that 58% of the usual care group and 82% of the AIT group exercised at least 2 days/week. However, this was only determined through subjective reporting and not through accelerometry. Additionally, intensity of exercise was not assessed. Based on the decline of
VO$_{2\text{max}}$, it can be assumed that subjects were not exercising at the same intensity as they were during the intervention. The decrease in cardiorespiratory fitness seen in this study demonstrates the difficulty of creating lasting changes in PA habits following CR.

Numerous studies have sought to answer why cardiac patients do not adopt regular PA after CR. Out of these studies, a wide variety of theories have developed indicating that there is no single reason for decreased adherence to PA. Instead, multiple reasons may exist to explain the attrition rate. One study by Moore et al. evaluated 60 women (mean age of 64.8 years) that participated in CR to identify predictors of continued PA after the program (42). Wristwatch heart rate monitors (Polar Vantage NV) were worn for 3 months to determine exercise frequency (total number of sessions exercised), exercise amount (total number of minutes exercised), exercise persistence (total number of weeks in which participants exercised) and exercise intensity (average increase in heart rate over resting during exercise sessions). A target heart rate range for aerobic exercise intensity was determined for each woman with an age-predicted formula that was adjusted for beta-blocker use. Participants were asked to mail the wristwatch monitor in at the end of each month and a new monitor was sent to them. The results of the study indicated that 25% of the women did not exercise at all after completing CR and only 48% were exercising 3 months later. In attempt to determine what factors affected the attrition rate, the researchers measured comorbidities, motivation, mood states, social support, self efficacy,
and health beliefs regarding exercise using several questionnaires. This was accomplished through a 1 hour interview at discharge from CR. From analyzing these adherence predictors, the investigators found that they had varying effects on exercise frequency, amount, intensity and persistence. For instance, the number of comorbidities was a predictor of decreasing exercise frequency and intensity. Assisting women in managing their comorbidities may help to increase adherence to these 2 dimensions of exercise. Additionally, health beliefs about the perceived barriers to, and benefits of exercise were the only significant predictors of decreasing exercise amount. Thus, instilling the health benefits of exercise and addressing perceived barriers may effectively increase the total amount of exercise in women. Furthermore, social support was the only predictor of decreasing exercise persistence suggesting that this variable is crucial to PA adherence over time. It should be noted that 50% of women recruited for the study refused to participate. In general, younger women consented and many older women stated that they did not want to be bothered with exercising. Therefore, the ability to generalize these results may be compromised. Importantly, this study highlights the complexity of predicting exercise adherence.

Clark et al. conducted a study in which 47 patients (mean age: 68.1 ± 8.2 years) diagnosed with CAD who had attended a 12 week CR program in Scotland were interviewed 3 years after exiting the program (18). The purpose of the study was to discuss the patients’ experiences and perceptions to determine factors that affect the long-term effectiveness of CR. In order to participate in the
study, subjects must have completed 60% of CR sessions which emphasized exercise, diet, smoking cessation, and psychological well-being. Focus groups were utilized to obtain the perspectives of the subjects. Each of the focus groups lasted between 55-90 minutes and were audio taped. This method of data collection allowed researchers to gain in-depth insight into the barriers affecting the long-term effectiveness of CR. Common themes as well as differences in reported experiences were noted between the focus groups. Consistently, subjects discussed the relationships that developed between the patients attending CR which motivated them to be compliant and facilitated an encouraging atmosphere. Additionally, observing CR patients at differing stages of rehabilitation equipped new patients with confidence that cardiac patients can achieve a high level of fitness. While some subjects stated that CR helped them understand their boundaries and overcome their fear of exercise, others left feeling vulnerable and unsure of the appropriate intensity to perform exercise as well as ADL’s. Individuals reported that upon leaving CR, they were encouraged to maintain the new health behaviors they initiated during the program and continue reducing their modifiable CVD risk factors. However, patients affirmed that the number one barrier to maintaining the health changes they had made was the loss of social contact. Participants grew to rely on the company of others at CR, and without that ongoing contact, patients were not motivated to continue exercising (18). The study suggests that patients leaving CR should equip themselves with adequate social support through other individuals or groups. When interpreting the results of the study, it is important to note that patients
were retrospectively reporting on their CR experience. Thus, some accounts may be inaccurate or influenced by the perspectives of other subjects in the room.

In an attempt to facilitate long-term behavior change in CR patients, Sniehotta et al. explored the difference between the motivational and volitional stages of behavior change (58). A patient in the motivational stage develops an intention to change his or her behavior, whereas a patient in the volitional stage must plan, initiate, and maintain that intended change. The authors argued that the disconnect between intentions and behavior change is the lack of important self-regulatory strategies such as planning. Additionally it is argued in the study that planning can be broken up into 2 “subconstructs” that serve different purposes. *Action planning* defines the intended behavior change in terms of when, where, and how to act. *Coping planning*, on the other hand, focuses on coping strategies to ensure the intended behavior overcomes the habitual behavior when barriers are faced.

Researchers randomized 246 cardiac patients into 1 of 3 groups: action planning only, a combination of action and coping planning, or a control group. All patients had been diagnosed with CHD and participated in a 3 week outpatient CR program. Subjects attended the CR program 3-5 days/week and engaged in aerobic exercise and in some cases resistance training. The study took place over the course of 10 weeks. Two weeks into the CR program, all subjects were evaluated through questionnaires about risk perceptions, outcome expectancies, self-efficacy, behavioral intentions, cycling, and past exercise. The
action planning group created up to 3 action plans focused on when, where, and how they intended to exercise and/or increase their daily PA. In addition to the action plans, the combined planning group developed up to 3 coping plans containing strategies to overcome anticipated barriers. These planning sessions were conducted one-on-one with qualified staff and lasted 30 minutes. Before exiting the program, all patients were encouraged to continue to participate in regular vigorous exercise such as biking, running, or swimming. In addition, they were encouraged to increase the PA in their daily routine (i.e. cycling instead of driving). Two months after discharge, all subjects were evaluated on behavioral intentions, daily cycling, and physical exercise via questionnaire.

The results of the study indicated that subjects in the combination planning group reported higher levels of exercise 2 months post-discharge than the action planning group and control group (179 ± 15, 113 ± 14, and 95 ± 13 min/week, respectively). Additionally, the combination planning group also reported significantly more cycling for transportation compared to the action planning group and control (94 ± 13, 60 ± 12, and 49 ± 11 min/week, respectively). The action planning group did not have statistically significant higher levels of exercise compared to the control group suggesting that pairing action planning with coping planning is more effective. The results of the study demonstrate that the use of planning in CR deserves further exploration; however, several limitations of the study should be taken into account. First, exercise and daily cycling levels were evaluated by questionnaire. Self-reported
PA measures are subjective and prone to error. Ambulatory exercise should be measured objectively via accelerometry. Secondly, the follow-up occurred only 2 months after discharge. Assessment of PA at 6 months, 12 months, and/or 18 months post-discharge would have provided crucial insight into the long-term effectiveness of planning interventions. Lastly, employing a coping planning only group would have been beneficial in understanding the effect that this strategy alone has on long-term PA.

A large number of studies have focused on different aspects of motivation to explain the lack of long-term PA. For instance, most patients do not begin CR because of their own desire to exercise, but because their diseased state demands it. Thus, patients are less likely to continue PA since they were not intrinsically motivated from the beginning (10, 51, 52). Russell et al. examined the importance of self-determined motivation in maintenance of regular PA following CR (52). The self-determined theory states that self-determined motivation is comprised of 3 psychological needs that must be met: competence, autonomy, and relatedness. Competence is a sign of one’s desire to have control over and be effective in producing outcomes. Autonomy reflects one’s need for “ownership” over his or her behaviors and activities he or she engages in. Relatedness refers to the need for social support and sense of belonging. One of the purposes of the study was to investigate the relationship between self-determined motivation and exercise behavior following discharge from a CR program.
Sixty-eight cardiac patients with a diagnosis of MI, PTCA, or CABG were recruited after discharge from an exercise-based CR program. Subjects were also participating in a concurrent study which required a 6 week continuation of the CR program in a university-based facility. The interventions in the concurrent study were not designed to influence the self-determination variables of the present study. Following the 6 week intervention, self-determined motivation was assessed via validated questionnaires. Home-based PA was then self-reported 3 and 6 weeks later. The main finding of the study was that the degree of self-determined motivation to exercise was associated with the self-reported PA levels 3 and 6 weeks after the intervention. The authors state that this finding demonstrates that patients with more self-determined motivation to exercise are better equipped to take control of their behavior and maintain long-term PA. Thus, the degree of self-motivation to exercise could potentially predict exercise behavior following CR. Once again, to strengthen a study of this nature, objective PA measurements via accelerometry are needed. Additionally, a longer follow-up time such as 6 months, 12 months, and/or 18 months is needed to better understand the relationship between self-determined motivation and exercise behavior following CR.

Clearly, the answer to why cardiac patients do not engage in regular PA after CR has many different facets. The previous studies combined suggest that comorbidities, lack of knowledge regarding the benefits of exercise, loss of social support, inadequate planning, and decreased motivation may all contribute to the
attrition rate following CR. Most likely this is not an exhaustive list and many more reasons could be added due to the individuality of each patient. It is evident that there is a great need for implementing physical activity interventions that address one or more of these concerns in order to encourage a lifestyle change.

**Pedometer Interventions Aimed at Increasing Physical Activity**

Pedometers, which are designed to objectively measure ambulatory activity, have proven to be successful at increasing walking behavior. Walking is one of the most commonly encouraged and reported forms of PA and is easily translatable to ADL’s (68). A limitation to the use of pedometers is that they are not effective at capturing non-ambulatory activity, such as cycling, swimming, and weight training. However, it is important to note that the occurrence of these activities are relatively low in the U.S. population and these types of activities can be easily recalled; a combination of self-report and pedometer use should adequately capture them (68). Thus, pedometers are useful goal-setting tools because of their ability to provide immediate feedback and awareness of personal activity levels. As a result, the use of pedometers to motivate individuals to increase their PA levels has proved to be quite successful. For example, a meta-analysis by Richardson et al. that evaluated 9 randomized and controlled pedometer-based programs (ranging from 4 weeks to 1 year) found that participants increased their PA by approximately 2,000-4,000 steps/day (48). Bravata et al. confirmed these findings after evaluating 8 randomized controlled studies with pedometer interventions (average duration of 18 weeks); the results
indicated that subjects increased their steps by 2,500 per day (12). These two meta-analyses demonstrate that pedometer-based interventions are effective, at least in the short-term, at increasing PA.

When evaluating successful pedometer-based interventions, it is important to identify the components that contribute to their success. The meta-analysis performed by Bravata et al. found that having a step-goal was the ultimate predictor of whether or not subjects increased their step count. Of the 3 studies evaluated without a step-goal, there were no significant increases in activity levels (12). In addition, studies that did not require the use of a step diary were not effective at increasing PA. These two findings suggest that step goals and step diaries may be the two crucial motivating components of pedometer-based interventions. Furthermore, most interventions utilizing pedometer feedback also include a cognitive-behavioral component ranging from simple written hand-outs to intensive one-on-one PA counseling sessions. Because of the wide-range of approaches, the meta-analysis of Bravata et al. did not find PA counseling to increase step counts. However, the role of counseling should not be ignored because its influence on the success of pedometer-based studies is difficult to eliminate. Thus, understanding the combined effect of pedometer feedback and education concerning regular PA benefits and barriers is crucial for determining why these interventions are successful.

McMurdo et al. conducted a randomized controlled trial to determine if a behavior-change intervention (BCI) with and without a pedometer (Omron HJ-
113 piezoelectric pedometer) were successful at increasing PA levels in sedentary older women (38). Subjects were ≥70 years old (n = 204) and considered to be inactive (not participating in minimal PA recommendations). Subjects were randomly assigned to 1 of 3 groups: no intervention (control), BCI only (BCI group), and BCI plus a pedometer (pedometer plus group). To objectively measure baseline activity, subjects wore an accelerometer (RT3 Accelerometry Research Tracker, Stay Healthy, Inc., Monrovia, CA) for 2 weeks; the first 7 days were discarded to eliminate any increase in activity due to the novelty of wearing the device. In addition, activity was measured via accelerometer at 12 and 24 weeks of the interventions. Both the BCI group and the pedometer plus group were asked to record their activity before the intervention: the BCI group recorded minutes spent walking outdoors, while the pedometer plus group recorded the daily step count on their pedometers. These activity levels were used to set PA targets in both groups to increase either their activity minutes or steps by 20% during the first month of the intervention. If subjects met these goals, the targets were increased by an additional 20% at the end of the first and second months. If the goals were not met, they remained unchanged and were evaluated the second month. The BCI was modeled after the self-regulation theory which focuses on the role of goal setting, planning, and self-monitoring behavior. Both the BCI group and pedometer plus group received counseling in the form of individualized activity action plans and plans to overcome barriers to regular PA. The intervention consisted of education about the health benefits of PA given both verbally and in pamphlet form. Following
this, a study coordinator met with subjects in their home to discuss and write action and coping plans; the action plans were designed to increase PA and the goal of the coping plans was to identify barriers and plan how to overcome them. In addition, subjects were instructed about their goal walking targets for the first month and were given a monthly diary to record either steps or walking minutes (depending on group assignment) outdoors. Diaries were sent to the subjects each month and returned in the same fashion. Subjects were contacted by telephone weekly for the first month, biweekly for 2 months, and monthly until the end of 6 months to provide encouragement and motivation.

The results of the study demonstrated that the BCI group and the pedometer plus group saw an increase in PA levels after 3 months (3.9% and 10.6% respectively) with a more significant increase in the BCI group and the control group decreased by 1.8% (38). These results were surprising, because it was expected that the pedometer plus group would exhibit higher increases in PA. This result not only highlights the importance of cognitive-behavioral approaches, but it raises the question of the influence that pedometers have in successful pedometer-based studies. An important limitation of the study involves the baseline activity measures: the activity levels, represented by accelerometer minutes of activity, started higher in the pedometer plus group compared to the BCI group (180.2 ± 68.0 and 160.9 ± 69.1, respectively) and continued to increase during the 2 preliminary weeks of wearing the accelerometer. This may have blunted the increase in PA levels seen in the
pedometer plus group. While increases in PA were seen in the intervention groups after 3 months, both groups reverted to baseline PA levels after an additional 3 months. Thus, future research is needed to determine what approaches are required to maintain PA increases long-term.

A study completed in 2010 by De Greef et al. investigated the effectiveness of a pedometer and cognitive-behavioral group intervention for increasing PA in type II diabetic patients (20). Subjects recruited (n = 41) had been diagnosed with type II diabetes for ≥ 6 months, were between the ages of 35 and 75, and were being treated for diabetes. Subjects were stratified based on age and gender and were randomized into a control group (n = 21) or an intervention group (n = 20). The control group received their usual care from their endocrinologist and received 1 group education class on the impact of PA on type II diabetes. The intervention group participated in 5, 90-minute cognitive-behavioral group sessions with a pedometer (Yamax Digi-Walker SW-200) for 12 weeks. The cognitive-behavioral approach focused on self-monitoring, pedometer feedback, and social support. The first 3 meetings were provided biweekly to offer intensive advice to the participants. The last 2 sessions were provided with an interval of 3 to 4 weeks between sessions. The group sessions began with a motivational-interviewing phase; in this approach, the interviewer utilizes empathetic listening, fosters intrinsic motivation, and responds to ambivalence regarding behavior change (29). Following this phase, the coaches and the participants developed a lifestyle change plan in which they determined
where, when, and how the behavior change would take place. The intervention
group also received a pedometer and pedometer diary for motivation. They were
asked to wear their pedometer and record the type and duration of PA they
engaged in as well as the number of steps at the end of each day. Using
baseline activity levels, coaches helped participants set goals; at the end of each
session, new goals were set based on the progress of each individual. A booster
session was provided after 6 months to review participant progress as well as the
topics of social support and relapse prevention. Activity levels in both the control
group and intervention group were assessed at baseline, following the
intervention, and after 1 year by wearing a pedometer and accelerometer
(Actigraph, model 7164) for 1 week.

Results of the study revealed considerable short-term success due to the
intervention group increasing their steps/day by 2,502, whereas the control group
saw virtually no change (increase of 324 steps/day)(20). The average step/day of
the intervention group reached 9601 which is quite significant considering that
reaching 10,000 steps/day has proved to be difficult in chronic disease
populations such as diabetics (67). Unfortunately, between the end of the study
and 12 months, steps/day decreased significantly in both groups (Intervention
group: -1,577 steps/day; control group: -1,188 steps/day). This gradual
worsening over time is common in short-term intervention studies, which
highlights the importance of evaluating them long-term to determine the
cost/effectiveness of implementing such programs on a larger scale.
Furthermore, even though the intervention group decreased significantly after 1 year, the group sustained a 1,000 steps/day increase over baseline. The intervention appeared to be somewhat successful long-term, but future research is needed to evaluate long-term strategies to maintain PA levels.

Limitations to the intervention utilized in this study should be considered. First, it is impossible to determine what aspects of the intervention were most influential at increasing PA levels. To strengthen the study, 2 additional groups are needed: a pedometer-only group (utilizing step goals and step diaries) and a group that received the 5 sessions (motivational-interviewing and life change plans aimed at increasing PA) without the use of a pedometer. These additional groups would bring more clarity to the individual role that pedometers and educational/motivational sessions play in the intervention group that employed a combination of both. In addition, the scope of the intervention may be too expensive and time-consuming to implement on a larger scale. The finances required to compensate qualified staff to prepare and oversee 5, 90 minutes group sessions over the course of 6 months may not be cost-effective. Therefore, time-efficient/inexpensive interventions that foster increases in PA should be explored.

Compared to the previous study, Vallance et al. explored a more convenient, minimal contact PA intervention in breast cancer survivors: the use of motivational/educational print materials with and without pedometers (71). Subjects (n = 377) were randomized to 1 of 4 groups: print materials only (PM),
pedometer only (PED), combination of both (COM), and standard PA recommendation only (SR). To obtain baseline and post PA levels, all subjects were mailed a pedometer and asked to wear it for 7 days and record their steps at the end of each day. All of the groups received a standard recommendation to engage in moderate/vigorous PA for 30 minutes, 5 days/week. Subjects that were meeting these recommendations at baseline were encouraged to increase their PA minutes and/or days. The SR groups received no further guidance or intervention materials. The PM group was sent a copy of *Exercise for Health: An Exercise Guide for Breast Cancer Survivors* (70). The PED group was sent a pedometer (Digi-Walker SW-200) and 12 week step diary. The COM group received both interventions. The COM and PED groups were instructed to wear their pedometers for the 12-week duration of the study and record the daily steps taken at the end of each day. Subjects were not given a step goal during the intervention. Compliance to reading the guide book in the PM and COM groups was determined by asking subjects how many times and how long they spent reading the material and whether or not they found it instructive and/or helpful for setting goals and overcoming barriers. Responses to these questions were given on a 5-point Likert scale ranging from 1 (“not at all”) to 5 (“very much”). On average, survivors in these groups reported reading the entire book 2.1 times for 113 minutes. In addition to the pedometer data in the PED and COM group, PA levels were self-reported in all groups using the leisure score index (LSI) of the Godin Leisure-Time Exercise Questionnaire. The LSI consists of 3 questions that evaluate the average frequency of mild, moderate, and strenuous PA during a
typical week in the last month. In addition, brisk walking was also assessed using the LSI format and was characterized as “walking like you were late for an appointment.”

While the results of the study reported that all 3 intervention groups significantly increased their self-reported PA from baseline to post-intervention, none of the groups increased their steps/day. Thus, it is questionable that the groups accurately self-reported PA if no increase in objectively measured PA was seen. For example, subjects in the PM, PED, and COM groups increased their self-reported moderate/vigorous PA/minutes per week by 40-60 minutes and their brisk walking by about 60-90 minutes per week. Intuitively, it would be expected that such an increase in PA would also illicit a significant increase in objectively measured steps/day, but the pedometer data showed the same step levels pre and post. The study could have been significantly improved by implementing step goals in the PED and COM groups each week (12) to ensure subjects were increasing their steps/day. Additionally, increasing the assessment of objectively measured PA throughout the study would have provided a more accurate picture of PA levels in all 3 groups. In addition, the use of a pedometer which blinded individuals to the step-count would provide a more objective measurement. By having subjects record the number of steps they achieved at the end of each day, they were made aware of their activity levels which could have influenced their behavior.
An important strength of the study was the idea of a limited contact, inexpensive PA intervention. The study design did not require any face-to-face contact and was implemented through the postal service. Therefore, the study was able to include a large number of subjects. The use of the 3 intervention groups provided the opportunity to evaluate the individual and combined effect of the guide book and pedometer. The results indicated that there were no differences in PA levels between intervention groups, but the COM group reported greater improvements in fatigue and quality of life. This result suggests that the success of an intervention can be defined by changes in other measures in addition to increases in PA levels. While there are ways in which the intervention could have been improved to see a greater effect (i.e. step goals), exploring convenient interventions is important for implementation on a wider scale.

**Pedometer Interventions in Cardiac Patients**

In response to low levels of CR utilization, many studies have evaluated alternative home-based programs that promote regular PA in cardiac patients. Houle et al. assessed the impact of a home-based socio-cognitive/pedometer intervention on PA behavior and CVD risk factors in cardiac patients (32). Sixty-five patients under the age of 80 hospitalized for an acute coronary syndrome (including non-ST elevation or ST elevation myocardial infarctions and stable angina) were recruited and randomized into an intervention group or control group. The intervention group received a home-based CR program led by a
clinical nurse and the control group received usual care consisting of standard advice regarding PA, diet, and medication at discharge. In addition, the usual care group had the option of joining a facility-based CR program.

The intervention began with a clinical nurse specialist meeting with each patient while they were hospitalized. A family member or significant other was encouraged to be present at this meeting. The patients were given a pedometer (Yamax Digi-Walker SW-200), a diary, and information about PA after an acute coronary syndrome. The nurse provided PA goals such as walking 3,000 steps in 30 minutes and walking at a moderate intensity according to the Borg’s scale. Patients were encouraged to set a step goal of 3,000 steps/day of intentional PA. Furthermore, subjects were instructed to use the diary for recording type, duration, and intensity of exercise. The clinical nurse specialist followed up via telephone within 2 weeks after discharge and conducted 5 face-to-face consultations over the course of 12 months (6 weeks, 3, 6, 9, and 12 months). Each follow-up session was 30-60 minutes in duration and took place at an outpatient setting. During the meetings, the clinical nurse specialist assisted subjects in identifying barriers to increasing steps and discussed ways to overcome them.

Outcome measures included PA behavior, CVD risk factors (waist circumference, blood pressure, resting heart rate, lipid profile, and fasting blood glucose), and self-efficacy (assessed through questionnaire at 6 and 12 months). CVD risk factors were assessed at baseline, 6, and 12 months after discharge.
PA was objectively measured at baseline, 3, 6, 9, and 12 months by having subjects wear blinded pedometers (Yamax Digi-Walker NL-2000) for 7 days. Because all PA assessment was done using a different pedometer model than the pedometer the intervention group wore to track steps, the intervention group wore both pedometers during assessment weeks. The results of the study indicated that average steps/day improved significantly in the intervention group compared to the control group at 3 months and 12 months (steps/day did not differ between groups at baseline). At 3 months, the intervention group increased their steps from baseline by an average 3388 ± 844 steps/day compared to the control group: 1934 ± 889 steps/day. The intervention group maintained their increased step count at 6 months, whereas the control group decreased slightly. At 12 months, the intervention group continued to maintain a significant increase over the control group. Results regarding CVD risk factors were as follows: waist circumference was significantly improved from baseline to 6 months and baseline to 12 months in the intervention group; in addition, resting heart rate from baseline to 6 months was significantly improved in the intervention group without statistically significant changes in medication. With the exception of waist circumference, all other CVD risk factors were well controlled at baseline.

This study demonstrated that a pedometer-based intervention led by a clinical nurse specialist can be successful at increasing and maintaining PA levels 12 months post discharge in cardiac patients. The observed increase in steps/day is hopeful considering that the novelty of wearing the pedometer in the
control group may have influenced their behavior; thus, it is likely that an even greater difference in PA levels existed between groups. One of the strengths of this randomized controlled trial was the duration of the study. The meta-analysis of pedometer-based interventions by Bravata et al. revealed that average interventions last for 18 weeks (12). This study, however, lasted for 52 weeks which provides a better picture of successful long-term PA maintenance. Another strength of the study was the number of times that PA behavior was assessed: baseline, 3 months, 6 months, and 12 months. The frequency of PA assessment helps to ascertain that the increase seen from baseline in the intervention group was consistent throughout the duration of the study. Despite the success shown in the study, possible limitations need to be considered. First, subjects that agreed to participate may be a “source of selection bias.” In other words, cardiac patients that are more apt to engage in regular PA may have volunteered for the study. In 36% of patients that refused to participate, the reason for refusal was unknown. Secondly, the influence of the pedometer versus the one-on-one sessions remains unknown due to the lack of intervention groups that utilized one or the other. Lastly, the use of accelerometers versus pedometers to measure PA would have provided the opportunity to objectively measure the intensity of the PA. While it is important to investigate home-based CR programs for those who refuse facility-based CR, it is equally important to evaluate PA interventions in patients that are currently attending or have attended CR in an outpatient setting.
Several intervention studies have been conducted among cardiac patients that attended CR to examine long-term PA maintenance strategies. As discussed previously, research has indicated that following CR, adherence to regular PA gradually declines. Thus, identifying successful long-term maintenance strategies is crucial for cardiac patients to continue to experience the benefits of regular PA. Most recently in 2011, Chase et al. conducted a meta-analysis of PA intervention studies after CR to discover what interventions have proved to be helpful (17). Fourteen studies between 2000 and 2009 from North America, Australia, and Japan met the inclusion criteria and were evaluated. The results indicated that interventions using cognitive strategies only (such as problem-solving, managing barriers, and increasing self-efficacy) were inconsistently successful. However, different combinations of behavioral interventions proved to be more consistently successful. Behavioral interventions that employed self-monitoring techniques (i.e. pedometers and/or activity logs) were the most successful. Other effective techniques included goal setting, feedback, and prompting. A randomized controlled trial by Butler et al. incorporated many of these effective elements of behavioral interventions.

Butler et al. evaluated the effect of a pedometer-based intervention on PA levels after CR (15). Patients from 2 outpatient CR programs in Australia were recruited for the study and were randomized into a control group (n = 60) or an intervention group (n = 62). The majority of patients were diagnosed with an MI, CABG, or PTCA and had a mean age of 64 years. Patients were qualified to
participate in the study if they attended at least 1 session of CR. The Illawarra CR program consisted of patients going to a gym 2 days/week for 6 weeks as well as weekly home visits. After 6 weeks, patients had the option of continuing at the gym or joining a low-moderate intensity exercise program for up to 4 months. In contrast, the Shoalhaven CR program was composed of a single 4-5 hour session each week for 4 weeks, but there was no gym component. The intervention group of the study received a pedometer (Yamax Digi-Walker 700B), a step calendar, and a walking safely sheet. They were instructed to record their steps for 6 weeks in the step calendar which also contained weekly and long term goals. The subjects were encouraged to aim for 30 minutes of moderate-intensity PA on most days of the week. In addition, researchers encouraged all subjects to establish individual goals and allowed them to choose whether they wanted to set step goals or walking minute goals. Subjects were then contacted via telephone at weeks 1, 3, 12, and 18. At weeks 1 and 3, the phone calls lasted 15 minutes and included goal setting and behavioral counseling. At weeks 12 and 18 the calls were shorter in duration and designed to offer feedback on reaching goals and any needed advice regarding PA. The control group received 2 brochures regarding PA, but did not receive phone calls or other intervention materials. PA, which was the primary outcome of the study, was assessed weekly using a survey called the Active Australia Survey. Subjects in both groups recalled weekly sessions and minutes of walking, moderate activity and vigorous activity. Additionally, cardiorespiratory capacity was assessed by determining the anaerobic threshold via gas analysis during a submaximal bicycle ergometer test.
Results of the study indicated that the intervention group significantly improved total PA after 6 weeks and 6 months compared to the control group. PA from baseline increased by 87 minutes/week at 6 weeks and 112 minutes/week at 6 months in the intervention group. The control group maintained baseline PA levels after 6 weeks and decreased after 6 months. Cardiorespiratory capacity remained unchanged in both groups at 6 weeks. However, at 6 months, the intervention group significantly increased their MET capacity by 9.5% at the anaerobic threshold; this increase was not significantly higher than the control group. Taking into account the changes in PA levels, this study demonstrated that a pedometer-based intervention following CR can be successful at increasing PA in the short-term and after 6 months. The intervention design is feasible to implement on a larger scale due to the minimal contact required between researchers and subjects as well as the relatively inexpensive materials utilized (pedometers and print material). Another unique aspect to this study was the assessment of cardiorespiratory fitness. Many studies of this nature evaluate PA levels, but fail to investigate any physiological adaptations. The measure of anaerobic threshold via oxygen uptake allowed researchers to demonstrate more concretely how increases in PA levels impact fitness capacity. Even though the increase was not significantly greater than the control, it is still significant enough to result in important health benefits (26). While the results of this pedometer-based intervention are promising, limitations of the study need to be acknowledged.
First, PA levels should be evaluated more objectively at baseline and throughout the study using accelerometers and pedometers. In the intervention group, baseline steps were measured by instructing the subjects to record their steps at the end of each day for 7 days. This approach makes subjects more aware of their activity levels and has the potential to influence their behavior. The use of a blinded pedometer in both groups at baseline, 6 weeks, and 6 months may have provided a more accurate picture of PA levels between groups. Secondly, 6 months may not be adequate time to determine if an intervention is successful long-term. Since the phone calls were continued until 18 weeks, assessing measures after at least 12 months may be more predictive of long-term PA maintenance. Lastly, it may have been beneficial to employ a third intervention group that consisted of pedometer-only to determine the influence of counseling via telephone.

Pedometer-based interventions aimed at increasing PA have proven to be successful in many populations, including cardiac patients. The most effective interventions have implemented step goals, step diaries, feedback, and various methods of prompting (including print materials, telephone calls, group sessions and/or individual sessions). Due to the common study design that consists of one intervention group and control group, it is challenging to determine which component of the intervention has the biggest impact on increases in PA. Thus, future research needs to employ at least 3 intervention groups: one with a pedometer only, one with a cognitive-behavioral component only, and a
combination of both. This may allow the crucial components of an intervention to be identified more easily. Additionally, it may assist researchers in identifying components that have little or no effect and can be eliminated. In turn, this approach may aid in developing more simplified, time-efficient, and cost-effective interventions that can be implemented on a wider scale in CR. Furthermore, employing the use of blinded pedometers and accelerometers to objectively measure PA is essential; PA should also be measured frequently during the study in addition to before and after the intervention. Lastly, while many pedometer-based interventions have been valuable at increasing PA levels in the short-term, more research is needed to determine the impact these strategies have on maintaining long-term lifestyle changes. Evaluating the PA levels of subjects at least 12 and 24 months post-intervention will provide a clearer picture of long-term effectiveness.

**Validation of the Kenz Lifecorder PLUS (NL-2160) Accelerometer**

Recent validation studies have indicated that the Lifecorder accelerometer is one of the most accurate and reliable devices out of a number of competing brands. These studies have evaluated the Lifecorder model NL-2200 which contains the same internal mechanism and algorithm as the Lifecorder PLUS accelerometer (NL-2160) (73). Schneider et al. conducted a validation study assessing 10 commercially available electronic pedometers (54). Ten male adults and 10 female adults volunteered to participate in the study (ages 22-69) and performed a series of walks around a 400-m outdoor track. Subjects walked
at their normal pace and walking speed was determined by the amount of time it took to complete a lap. Each subject walked around the track with devices of the same model worn on both the left and right side of the body to determine intramodel reliability. Four pedometers of each model were tested. A researcher using a hand-tally counter determined actual steps taken. The results demonstrated that the Kenz Lifecorder NL-2200, New Lifestyles NL-2000, and the Yamax Digi-walker SW-701 were exceptionally accurate and reliable compared to the others. These 3 devices (all New Lifestyles products) were the only pedometers accurate 95% of the time within ± 3% of actual steps taken (54). Thus, these 3 devices are all recommended for use in research studies.

While the accuracy of pedometers can be determined in controlled conditions as the previous study demonstrated, assessing the accuracy of these devices during 24 hour free living conditions is more challenging. Another study by Schneider et al. sought to evaluate the accuracy of 13 pedometers, including the Kenz Lifecorder, in free living conditions (53). The Yamax SW-200 was chosen as the criterion pedometer due to its accuracy and common use in research studies. All subjects wore the Yamax SW-200 on the left side of the body and a comparison device on the right side of the body for 24 hours except during sleeping and showering. The previous study discussed by Schneider et al. found that there were no significant differences between devices worn on the right and left side of the body (54). Subjects were asked to record the number of steps each night before sleeping. Results from the study indicated that only 5 of
the 13 pedometers yielded average values that were not significantly different (within ± 10%) from the criterion pedometer, the Kenz Lifecorder being one of them (53). Therefore, the Kenz Lifecorder is recommended in research studies assessing PA in free living conditions.

The validity of accelerometers and pedometers has been questioned in deconditioned individuals that walk at slow speeds. A study conducted by Park et al. investigated the ability of 3 accelerometers to estimate step counts at slow walking speeds with different step rates (45). Eighteen adult subjects (9 men and 9 women) participated in the study. After being familiarized with walking on a treadmill, subjects had their normal step frequency assessed at 3 different speeds: 2, 2.8, and 3.5 mph. A low and high step frequency for each speed was calculated for each subject (± 15% of normal step frequency). At each speed, a trial of low, normal, and high step frequency was completed. All trials were video recorded to ensure steps were accurately counted. Subjects wore 3 accelerometers: Kenz Lifecorder Ex (NL-2200), Actimarker, and Active Style Pro. These 3 devices had been previously validated by research to be highly accurate and reliable to implement in large groups. Results of the study indicated that at the low walking speed, the Lifecorder underestimated step counts at normal (534 ± 36 steps and 580 ± 34, respectively) and high (616 ± 72 and 662 ± 59 steps, respectively) step frequencies. The Actimarker significantly underestimated step/counts during all 3 trials at the low walking speed. Conversely, the Active Style Pro did not underestimate step counts at low walking speed. The study
found that the error in step counts was attributed to walking speed, and not step frequency. It was confirmed that all 3 pedometers were very accurate at estimating step counts at normal step frequencies at speeds > 2.0 mph. However, the Lifecorder and Actimarker may not be sensitive enough to detect step counts at slower walking paces. Therefore, it is important to take walking speed into consideration when using the Lifecorder in deconditioned populations where the comfortable walking speed may be ≤ 2 mph.

In addition to slow walking speed, the tilt angle of accelerometers due to excess adipose tissue has been of concern. A study by Feito et al. investigated whether or not 2 accelerometers (Actigraph and Actical) were affected by BMI and tilt angle in a laboratory setting. Seventy-one adult subjects participated in the study (32 men and 39 women)(23). Participants were instructed to walk on a treadmill at 3 different speeds (1.5, 2.5, and 3.5 mph) while wearing the 2 accelerometers at the waist. Using a protractor, researchers measured the tilt angle of each device; a positive tilt angle resulted from the top of the device being further away from the body and a negative tilt angle indicated the device was close to the body. Results from the study revealed that the Actical count values were significantly affected by BMI and tilt angle. Patients considered to be obese based on BMI that had an accelerometer tilt angle of <10 degrees had higher activity counts than normal and overweight individuals. However, the Actigraph showed no effects of BMI and tilt angle on activity counts. The difference between the monitors could be due to the Actical’s “omnidirectional”
internal mechanism which detects acceleration changes in several planes. Thus, the Actical may detect subtle movements of the abdominal fat in obese subjects. The study suggests that using the Actigraph in populations with a wide range of BMI values may be more accurate. Knowing the limitations of accelerometers is crucial when determining devices to use in overweight/obese populations.
CHAPTER 3

METHODOLOGY

While short-term interventions to increase PA in cardiac patients have been deemed effective, less is known about the long-term effect these interventions have on PA habits and reduction of cardiovascular disease (CVD) risk factors (41). Thus, the primary purpose of this study was to evaluate the Increased Physical Activity in Cardiac Patients (IPAC) interventions to determine if any of the methods (pedometer feedback, motivational messaging, or a combination of both) were successful at increasing PA levels in cardiac patients after one year compared to a usual care group. Secondly, the study sought to examine if any of the interventions had a positive impact on functional status, quality of life, and CVD risk factors.

The data collection protocols used in this study were approved by the Institutional Review Boards (IRB) of Ball State University and IU Health Ball Memorial Hospital. Before participation, all subjects were given an informed consent which educated them on the purpose, procedures, risks and benefits of the study. A researcher from Ball State University met with each subject to discuss the informed consent and answer any questions about the study.
Subjects and Recruitment

The subjects recruited for this study were male and female cardiac patients that completed the IPAC Study at least 12 months prior. Potential subjects that were still attending maintenance cardiac rehab (CR) at IU Health Ball Memorial Hospital were included as well as those who were no longer participating in CR. Additional inclusion criteria were as follows: still able to ambulate without assistance, an ejection fraction of $\geq 20\%$, and no history of Chronic Obstructive Pulmonary Disorder (COPD). Subjects were contacted via telephone to determine if they were interested in participating. If previous participants were still attending maintenance CR, they were informed about the study in person and recruited if interested.

Study Overview

After recruitment of a subject, a time was determined to meet with research staff at IU Health Ball Memorial Cardiac Rehabilitation. At this first meeting, subjects were given the informed consent and a Protected Health Information form; both documents encouraged subjects to ask questions to ensure they understood their involvement in the study. Before leaving, they were issued 2 accelerometers to measure their PA for one week as well as a medical history questionnaire (MHQ) to fill out and bring to their second visit. Subjects were instructed to follow their normal patterns of activity and record any PA that was out of the ordinary.
Following one week, subjects came to Ball State University’s Human Performance Lab (BSU HPL) for testing. At this appointment they answered questions about their PA using the Physical Activity Stages of Change questionnaire. After having resting blood pressure and heart rate assessed, a fasting blood sample was taken. Body composition measurements ensued including height, weight, waist circumference, and a dual energy x-ray absorptiometry (DXA) scan. Lastly, subjects underwent an 8 minute submaximal exercise test in which expired gases were collected via the metabolic cart.

**Study Procedures**

*Visit One: IU Health Ball Memorial Hospital CR*

*Physical Activity Monitoring*

For one week, subjects had their physical activity (PA) levels measured using both a Lifecorder PLUS downloadable accelerometer (New-Lifestyles, Inc. Lee’s Summit, MO) and an Actigraph accelerometer (GT3X, MTI, Fort Walton Beach, FL), but were blinded to the step count. All subjects were instructed on how to properly place these devices at waist level and were encouraged to maintain their usual PA levels while wearing the devices. Subjects were given a recording log to keep track of when the devices were removed, when exercise was performed, and if they engaged in any atypical physical activity.

*Visit 2: Ball State University’s Human Performance Laboratory*

*Medical History Questionnaire*
Subjects were given the MHQ at their first visit and were asked to fill out the document to hand in at the BSU HPL. The MHQ inquired about their current and past medical history, dietary information, medication use, smoking history and PA history. In addition, they were asked whether they utilized the pedometer that was given to them as a reward for the completion of the IPAC study.

*Physical Activity Questionnaire (Appendix A)*

Subjects completed the Physical Activity Stages of Change (SOC) questionnaire in which they were asked to respond to 4 statements about whether or not they were currently physically active and if so, do they participate in regular PA. The scoring algorithm for the SOC questionnaire was developed by Bess H. Marcus and LeighAnn H. Forsyth and are discussed in *Motivating People to Be Physically Active* (37).

*Resting Measurements*

Resting heart rate was assessed via the radial pulse after each subject had been seated for 5 minutes. Beats per minute were calculated by doubling a 30 second count. Resting blood pressure was measured using an aneroid sphygmomanometer in accordance with the American Heart Association Guidelines after subjects had been seated for 5 minutes (46). Two measurements were taken and if the systolic values differed by more than 6 mm Hg and/or the diastolic values differed by more than 4 mm Hg, a third measurement was obtained.
Fasted Blood Draw

Subjects were previously instructed to fast for 9-12 hours before blood was drawn (only water and medication was allowed). Blood samples were obtained through a venipuncture and analyzed by Labcorp (Muncie, IN) for total cholesterol (TC), high-density lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol (LDL), triglycerides, and blood glucose.

Body Composition Assessment

Standardized procedures were used to assess height and weight. BMI was then calculated as weight over height (kg/m²). Waist circumference was determined by measuring the narrowest part of the waist between the top of the iliac crest and the bottom of the rib cage. Body composition (lean and fat tissue) and bone mineral density (BMD) were estimated using dual-energy x-ray absorptiometry (iDXA, Lunar iDXA, Madison, WI, software version 13.40).

Submaximal Exercise Test

Subjects underwent an 8 minute submaximal exercise test to assess cardiovascular response and functional capacity. The test consisted of 2, 4-minute stages: the first stage at 1.5 mph and 2% grade, and the second at 2.3 mph and 4% grade. Expired gases were analyzed using the TrueOne 2400 Metabolic Measurement System (ParvoMedics Inc. Sandy, UT) which was calibrated to determine oxygen uptake (VO₂), expired carbon dioxide (VCO₂), minute ventilation (VE), and respiratory exchange ratio (RER). Heart rate was
obtained from a single lead electrocardiogram during supine rest, standing rest, each minute of the test, and 5 minutes of recovery. Blood pressure was assessed during supine rest, standing rest, every 2 minutes of the test, standing recovery, and supine recovery. In addition, a Borg rating of perceived exertion (6-20) was asked during each minute of the exercise test.

**Data Validation Criteria**

Average steps/day was determined from the Lifecorder PLUS accelerometer. In order for a day of data to be valid, subjects had to obtain ≥ 1000 steps and have at least 10 hours of wear time. Wear time was assessed according to the number of hours between the first and last activity counts of each day. For a week to be valid, ≥ 4 valid days/week were needed.

Sedentary and moderate-intensity PA data (average min/day and % of total observed time) were downloaded from the Actigraph accelerometer using Actilife 4.0 (ActiGraph Inc. Pensacola, FL) software to obtain the .csv (excel file); these files were then processed using standardized commands with Stata/SE 10.0 (StataCorp, College Station, TX). The percent of total observed time was determined by dividing the average sedentary time and average moderate-intensity PA time by the average total observed time. Activity counts between 0-100 were considered sedentary and 760-5724 moderate-intensity PA. Since most subjects had none or very little activity above 5724 activity counts, vigorous activity (≥ 5724) was not included in the analysis. Valid days consisted of at least 10 hours of wear time. Again, wear time was assessed according to the number
of hours between the first and last activity counts of each day. Periods of the day that contained ≥ 60 activity counts of 0 were discarded. For a week to be valid, ≥ 4 valid days/week were needed.

**Statistical Analysis**

Data analysis was performed using SPSS 17.0 for windows (SPSS Inc. Chicago, IL). A 2-way ANOVA with repeated measures was used to determine differences in outcome variables between study groups at baseline, immediately post-intervention, and 12 months post. Time was used as the within-subject factor and group as the between subject factor. The outcome variables analyzed included Lifecorder accelerometer average steps/day, Actigraph accelerometer sedentary and moderate PA time, resting heart rate and blood pressure, exercise heart rate, weight, waist circumference, body fat percentage, total cholesterol, HDL and LDL cholesterol, triglycerides, and fasting glucose. Statistical significance was denoted by an alpha of 0.05.
CHAPTER 4

RESEARCH MANUSCRIPT

Journal Format: Journal of Cardiopulmonary Rehabilitation
LONG-TERM EFFECTIVENESS OF SHORT-TERM PHYSICAL ACTIVITY INTERVENTIONS IN CARDIAC PATIENTS

Stacy L. Hoeksema

Ball State University Human Performance Laboratory, Muncie, IN
Indiana University Health Ball Memorial Hospital, Muncie, IN

Correspondence: Stacy L. Hoeksema

Ball State University
Human Performance Laboratory
Muncie, IN 47304
Tel: 765-285-1140
Email: slhoeksema@bsu.edu
ABSTRACT

While many short-term physical activity (PA) interventions in cardiac rehabilitation (CR) patients have proven to be successful at increasing PA levels, little is known about the long-term impact these interventions have. The purpose of the current study was to determine if the Increased Physical Activity in Cardiac Patients (IPAC) study utilizing pedometer feedback, motivational messages, and a combination of both were successful at increasing PA levels and improving cardiovascular disease (CVD) risk factors after 12 months. Thirty-six out of 70 possible participants (mean age of 64.3 ± 9.1 years) that had completed the IPAC study 12 months prior participated in the current study. PA levels were assessed via accelerometer for 7 days and compared to baseline and post-intervention levels. Each subject had resting heart rate and blood pressure, fasting blood sample, body composition assessment, and submaximal exercise test results collected and compared to baseline and post-intervention. Results of repeated measures ANOVA demonstrated that none of the IPAC interventions were successful at increasing PA levels after 12 months and all groups reverted back to baseline levels. Additionally, irrespective of study group no significant differences were seen in CVD risk profile across time with the exception of body fat percentage which worsened significantly (p < 0.05) at 12 months and High Density Lipoprotein (HDL) cholesterol which increased significantly post-intervention (p <0.05) and was maintained at 12 months to the benefit of
subjects. Further research is needed to develop PA interventions in CR patients that foster long-term PA maintenance.

Keywords: cardiac rehabilitation, exercise maintenance, secondary prevention

INTRODUCTION

Cardiovascular disease (CVD), a term that encompasses a number of diseases which affect the heart or blood vessels, remains a major concern in the United States. It is estimated that CVD is responsible for 1 out of every 2.9 deaths in the U.S., making it the leading cause of death in the country\(^1\). Coronary artery disease is the most prevalent form of CVD and claimed over 400,000 lives in 2007\(^1\). CAD occurs when the major blood vessels of the heart become narrowed or blocked due to plaque buildup resulting in myocardial infarctions (MI) and/or the need for coronary revascularization. Fortunately, evidence suggests that habitual physical activity (PA) not only prevents the development of CAD, but reduces angina, mortality, and improves the quality of life of those already diagnosed with CAD\(^2,3\).

Physical activity has been shown to prevent and help manage major CVD risk factors such as obesity, hypertension, dyslipidemia, and glucose intolerance\(^2\). For the prevention of CAD it is recommended that individuals engage in 30 minutes or more of moderate-intensity PA on most (preferably all) days of the week\(^2,4\). For individuals already diagnosed with CAD, the PA recommendations are more aggressive: 30-60 minutes of moderate PA, preferably 7 days/week.
(minimum of 5 days/week), supplemented with an increase in daily lifestyle activity\textsuperscript{5}. This highlights the vital role exercise-based secondary prevention programs play in facilitating behavior change and increasing PA levels in cardiac patients\textsuperscript{3}.

Cardiac Rehabilitation (CR) is a secondary prevention program that not only focuses on increasing PA in cardiac patients, but also uses multifaceted strategies to lower and eliminate CVD risk factors\textsuperscript{3}. While CR has been deemed effective at reducing mortality rates and increasing cardiovascular function in CVD patients, the potential benefits can only be maintained through continued adherence to changes made\textsuperscript{6-8}. Unfortunately, research has indicated that following CR, many patients do not adhere to regular PA and experience a worsening of CVD risk factors\textsuperscript{9,10}. Numerous studies have sought to answer why CR patients fail to adopt regular long-term PA and the wide variety of theories that have developed indicate that there is no single reason. Instead, multiple factors may exist to explain the attrition rate: comorbidities, insufficient knowledge regarding the benefits of exercise, loss of social support, inadequate planning to overcome barriers, and a lack of intrinsic motivation\textsuperscript{11-14}. Thus, the implementation of PA interventions addressing one or more of these concerns is needed to encourage a lifestyle change.

A 12 week American Heart Association (AHA) funded intervention, titled Increased Physical Activity in Cardiac Patients (IPAC), evaluated the use of pedometer feedback and motivational messages to increase PA levels in cardiac
patients attending maintenance CR. The study examined 4 groups: a usual care group (UC), a pedometer feedback group (PF), a motivational messages group (MM), and a group that combined both pedometer feedback and motivational messages (PF+MM). Following the short-term intervention, all IPAC subjects were given a pedometer to encourage long-term PA. Preliminary reports from this study indicated that CR patients in the intervention groups increased their average steps/day compared to control groups. While short-term PA interventions such as the IPAC study appear to be successful to increase PA levels in cardiac patients attending CR, little research has studied the long-term effect of these interventions. Therefore, the primary purpose of this study was to determine if IPAC subjects in the intervention groups increased their PA levels after 1 year, and if so, which intervention was superior. The secondary purpose was to determine if participants in the intervention groups exhibited a positive change in CVD risk factors (body composition, blood lipids, blood glucose, and blood pressure).

METHODS

Explanation of the IPAC Study

The IPAC study consisted of a 12 week PA intervention that employed 4 groups. In order to participate, all participants had to commit to attend the long-term maintenance CR program (Phase III) at Indiana University Health Ball Memorial Hospital (IUHBMH) at least 2 times/week for 12 weeks. Before the start of the intervention, all subjects were given a Lifecorder PLUS accelerometer and
an Actigraph GT3X accelerometer to wear for 1 week to determine baseline PA levels. Both devices were blinded to the step count in order to minimize each subject’s awareness of his/her PA levels. Subjects were instructed to complete the baseline week outside of CR and continue activities as normal. At the end of the baseline week, all subjects were tested at Ball State’s Human Performance Lab (BSU HPL). For the post-testing week following the intervention, subjects were allowed to attend CR but all other procedures were the same as baseline.

During the intervention, the UC group was given typical information regarding home exercise prescription and the importance of maintaining PA on non-CR days. Additionally, the UC group was instructed to wear a blinded Lifecorder PLUS accelerometer that was downloaded weekly by staff and record daily PA using a log. The PF group was issued a Lifecorder PLUS that displayed the daily step count and an individualized step goal. The step goal was determined by adding 10% to the baseline step count. Subjects were asked to record their step count 4 times/day. If the step goal was met during the week, it was increased by an additional 10% of the baseline step count; if the goal was not reached, it remained the same. The MM group received the same treatment as the UC group, but in addition received 12-standard motivational targeted newsletters at the beginning of each week. The newsletters contained information on the importance of PA, goal setting, and overcoming barriers. The PF+MM groups received both the PF and MM intervention, but were given newsletters that were individually tailored based on whether or not their step goals were met. If goals were achieved, subjects received a congratulatory newsletter, and if not they
received a newsletter encouraging them to identify barriers that kept them from reaching their step goal.

Subjects

Thirty-six male and female cardiac patients (mean age of 64.3 ± 9.1 years) that completed the IPAC Study at least 12 months prior participated in the study. Potential subjects that were still attending maintenance CR at IUHBHMH were included as well as those who were no longer participating in CR. Subjects had a primary diagnosis of myocardial infarction (MI), coronary artery bypass graft (CABG), percutaneous coronary intervention (PCI), heart valve repair/replacement, or stable angina. Additional inclusion criteria were as follows: still able to ambulate without assistance, an ejection fraction of ≥ 20%, and no history of Chronic Obstructive Pulmonary Disorder (COPD). All testing protocols used in this study were approved by the Institutional Review Board (IRB) of Ball State University and IUHBHMH.

Study Procedures

**Visit 1: IU Health Ball Memorial Hospital CR**

After recruitment, subjects met with research staff at IUHBHMH CR. At this first meeting, subjects were given the informed consent and a Protected Health Information form; both documents encouraged subjects to ask questions to ensure they understood their involvement in the study.
**Physical Activity Monitoring:** Subjects were given 2 blinded accelerometers to track their PA for 1 week: a Lifecorder PLUS downloadable accelerometer (New-Lifestyles, Inc. Lee’s Summit, MO) and an Actigraph accelerometer (GT3X, MTI, Fort Walton Beach, FL). Both devices have been previously validated and recommended for use in research studies due to their accuracy and reliability\(^{17-19}\). All subjects were instructed on how to properly place these devices at waist level and were encouraged to maintain their usual PA levels while wearing the devices. Subjects were given a recording log to keep track of when the devices were removed, when exercise was performed, and if they engaged in any atypical PA.

*Visit 2: Ball State University’s Human Performance Laboratory*

At least 1 week after Visit 1, subjects came to the BSU HPL for further testing.

**Medical History Questionnaire:** Subjects were given the MHQ at their first visit and were asked to fill out the document to hand in at Visit 2. The MHQ inquired about their current and past medical history, dietary information, medication use, smoking history and PA history. In addition, they were asked whether they utilized the pedometer that was given to them as a reward for the completion of the IPAC study.

**Physical Activity Questionnaires:** PA status was assessed via the Physical Activity Stages of Change (SOC) questionnaire in which subjects were asked to respond to 4 statements about whether or not they were currently
physically active and if so, do they participate in regular PA. The scoring algorithm for the SOC questionnaire was developed by Bess H. Marcus and LeighAnn H. Forsyth and is discussed in *Motivating People to Be Physically Active* 20.

**Resting Measurements:** Resting heart rate was assessed via the radial pulse after each subject had been seated for 5 minutes. Beats per minute were calculated by doubling a 30 second count. Resting blood pressure was measured by trained technicians using an aneroid sphygmomanometer in accordance with the AHA Guidelines after subjects had been seated for 5 minutes 21. Two measurements were taken and if the systolic values differed by more than 6 mm Hg and/or the diastolic values differed by more than 4 mm Hg, a third measurement was obtained. The two measurements that met the criteria were averaged.

**Fasted Blood Draw:** Subjects were previously instructed to fast for 9-12 hours before blood was drawn (only water and medication were allowed). Blood samples were obtained through a venipuncture and analyzed by Labcorp (Muncie, IN) for total cholesterol (TC), high-density lipoprotein cholesterol (HDL), low-density lipoprotein cholesterol (LDL), triglycerides, and blood glucose.

**Body Composition Assessment:** Standardized procedures were used to assess height and weight. BMI was then calculated as weight over height (kg/m²). Waist circumference was determined by measuring the narrowest part of the waist between the top of the iliac crest and the bottom of the rib cage. Body
composition (lean and fat tissue) was estimated using dual-energy x-ray absorptiometry (iDXA, Lunar iDXA, Madison, WI, software version 13.40).

**Submaximal Exercise Test:** Subjects underwent an 8 minute submaximal exercise test to assess cardiovascular response and estimate functional capacity. The test consisted of 2, 4-minute stages: the first stage at 1.5 mph and 2% grade, and the second at 2.3 mph and 4% grade. Expired gases were analyzed using the TrueOne 2400 Metabolic Measurement System (ParvoMedics Inc. Sandy, UT) which was calibrated to determine oxygen uptake (VO$_2$), expired carbon dioxide (VCO$_2$), minute ventilation (VE), and respiratory exchange ratio (RER). Heart rate was obtained from a single lead electrocardiogram during supine rest, standing rest, each minute of the test, and 5 minutes of recovery. Blood pressure was assessed during supine rest, standing rest, every 2 minutes of the test, standing recovery, and supine recovery. In addition, a Borg rating of perceived exertion (6-20) explained to subjects before the test was asked during each minute of the exercise test.

**Accelerometer Data Validation Criteria**

Average steps/day was determined from the Lifecorder PLUS accelerometer. In order for a day of data to be valid, subjects had to obtain ≥ 1000 steps and have at least 10 hours of wear time. Wear time was assessed according to the number of hours between the first and last activity counts of each day. For a week to be valid, ≥ 4 valid days/week were needed.
Sedentary and moderate-intensity PA data (average min/day and % of total observed time) were downloaded from the Actigraph accelerometer using Actilife 4.0 (ActiGraph Inc. Pensacola, FL) software to obtain the .csv (excel file); these files were then processed using standardized commands with Stata/SE 10.0 (StataCorp, College Station, TX). The percent of total observed time was determined by dividing the average sedentary time and average moderate-intensity PA time by the average total observed time. Activity counts between 0-100 were considered sedentary and 760-5724 moderate-intensity PA. Since most subjects had none or very little activity above 5724 activity counts, vigorous activity (> 5724) was not included in the analysis. Valid days consisted of at least 10 hours of wear time. Again, wear time was assessed according to the number of hours between the first and last activity counts of each day. Periods of the day that contained ≥ 60 activity counts of 0 were discarded. For a week to be valid, ≥ 4 valid days/week were needed.

**Statistical Analysis**

Data analysis was performed using IBM SPSS Statistic 20 for windows (SPSS Inc. Chicago, IL). A 2-way ANOVA with repeated measures was used to determine differences in outcome variables between study groups at baseline, immediately post-intervention, and 12 months post. Time was used as the within-subject factor and group as the between subject factor. The outcome variables analyzed included Lifecorder accelerometer average steps/day, Actigraph accelerometer sedentary and moderate PA time, resting heart rate and blood
pressure, exercise heart rate, weight, waist circumference, body fat percentage, total cholesterol, HDL and LDL cholesterol, triglycerides, and fasting glucose. Statistical significance was denoted by an alpha of 0.05.

RESULTS

Out of a possible 70 IPAC participants that were eligible for the 12 month follow up study, 36 were willing to participate (27 males and 9 females). Ten of the subjects did not answer the telephone or did not have a working number. Among the reasons for refusal included being primary caretaker of a loved one, comorbidities, injury/surgeries, time constraints, travel, and transportation issues. Characteristics of participants are reported in Table 1.

Average Steps/Day

The 3 intervention groups did not statistically increase steps/day after 12 months and there were no statistical differences in the change in step counts between intervention groups and the UC group. Irrespective of study group, the number of steps at baseline significantly increased following the 12 week IPAC intervention (p= 0.001) and significantly decreased from post-intervention after 12 months (p= 0.006). The total mean trend showed a 42.0% increase in steps/day from baseline to post and a 17.1% decrease from post to 12 months. While there were no statistical differences in step counts at baseline and 12 months across groups, average steps/day were 17.7% higher than baseline at 12 months (Table 2 and Figure 1). It should be noted that at 12 months, UC had 2 subjects with >
10,000 steps and PF+MM had 1 subject with > 15,000 steps which skewed the data. The mean steps/day in the UC group at 12 months with and without the 2 subjects with > 10,000 steps was 6567 ± 3813 and 4179 ± 1092 steps/day, respectively. The mean steps/day in the PF+MM group at 12 months with and without the 1 subject with > 15,000 steps was 7357 ± 4290 and 5776 ± 2067 steps/day, respectively.

**Moderate-Intensity Physical Activity**

The 3 intervention groups did not statistically increase moderate-intensity PA after 12 months and there were no statistical differences in the change in moderate-intensity PA between intervention groups and the UC group. Irrespective of study group, the percent of total observed time spent in moderate-intensity activity significantly increased following the 12 week intervention (p= 0.006) and significantly decreased from post-intervention to the 12 month follow up (p= 0.011). Similarly, irrespective of study group, moderate-intensity PA minutes increased significantly from baseline to 12 weeks (p= 0.002) and significantly decreased from post-intervention to the 12 month follow up (p= 0.031). The total mean trend showed a 47.5% increase in moderate-intensity PA minutes from baseline to post and a 21.0% decrease from post to 12 months. While there were no statistically significant differences in PA minutes between baseline and 12 months, at 12 months moderate-intensity PA minutes were 16.4% higher than baseline (Table 2 and Figure 2).
**Sedentary Time**

The 3 intervention groups did not statistically decrease in the percent of total observed time spent sedentary after 12 months and there were no statistical differences in the change in sedentary time between intervention groups and the UC group. The combined group average of time spent sedentary displayed a 5.4% decrease from baseline to post and a 4.4% increase from post to 12 months (Table 2).

**Body Composition**

The 3 intervention groups did not improve body composition measures after 12 months and there were no statistical differences in the change in body composition measures between intervention groups and the UC group. Irrespective of group, body fat percentage significantly increased from post to 12 months (p= 0.010). These data are represented in Figure 3. For weight, BMI, and waist circumference there were no main effects of time or group (Table 3). The combined group mean of weight across time shows a 4.4 kg increase from post to 12 months (5.0% increase from baseline) (Table 4).

**Heart rate and Blood Pressure**

The 3 interventions groups did not improve resting heart rate and blood pressure or exercise heart rate after 12 months and there were no statistical differences in the change in these variables between intervention groups and the UC group. For resting heart rate, resting systolic and diastolic blood pressure,
and submaximal exercise heart rate, there were no main effects of time or group (Table 3). A large decrease in exercise heart rate was seen in the MM group due to 1 subject having a high baseline exercise heart rate (111 bpm).

Fasting Blood Measures

The 3 interventions groups did not improve fasting blood measures after 12 months and there were no statistical differences in the change in these variables between intervention groups and the UC group. Irrespective of group, HDL cholesterol significantly increased from baseline to post (p= 0.014) and remained significantly higher than baseline at 12 months (0.005). These data are illustrated in Figure 4. For total cholesterol, triglycerides, LDL cholesterol, and fasting blood glucose, there were no main effects of time or group. A large increase in triglycerides was seen in UC group at 12 months due to 1 subject having extremely high levels (754 mg/dL). The mean triglycerides for UC group at 12 months with and without this subject was 266 ± 233 mg/dL and 196 ± 133 mg/dL, respectively. Similarly, a large increase in total cholesterol was seen in UC group at 12 months due to 2 subjects having high levels (323 and 340 mg/dL)(Table 2). The mean total cholesterol for UC group at 12 months with and without these subjects was 195 ± 88 mg/dL and 150 ± 31 mg/dL, respectively.

DISCUSSION

Evidence has indicated that cardiac patients who attend CR oftentimes fail to participate in regular PA long-term and experience a decline in their CVD risk
profile. In an attempt to encourage regular PA long-term, short-term interventions utilizing various strategies to increase PA have been conducted among cardiac patients. A meta-analysis evaluating 14 PA interventions following CR found that behavioral interventions which employed self-monitoring techniques (i.e. pedometers and/or activity logs) were the most successful. Other effective techniques included goal setting, feedback, and prompting. While pedometer-based interventions have been successful in cardiac patients in the short-term, little is known about the impact these strategies have on maintaining long-term lifestyle changes. Therefore, the primary purpose of this study was to determine if participants in the 3 intervention groups of the IPAC study (PF, MM, and PF+MM) increased their PA levels after 12 months.

Physical Activity Levels

The results indicated that the 3 interventions groups did not increase PA levels after 12 months and there were no statistical differences in the change in these variables between the intervention groups and UC group. Regardless of the study group (including UC), PA levels increased significantly from baseline to post-intervention and decreased significantly back to baseline levels at 12 months. This was demonstrated by both step count and minutes spent in moderate-intensity PA (Table 2). The total mean steps/day including all groups showed an approximate 2200 step/day increase above baseline at post-intervention. This finding is consistent with a meta-analysis by Richardson et al. that evaluated 9 randomized controlled pedometer-based programs in sedentary,
overweight individuals (ranging from 4 weeks to 1 year) and found that participants increased their PA by approximately 2,000-4,000 steps/day. Bravata et al. confirmed these findings after evaluating 8 randomized controlled studies with pedometer interventions in predominantly sedentary, overweight women (average duration of 18 weeks); the results indicated that subjects increased their steps by 2,500 per day. However, both meta-analyses focused on changes from baseline to post-intervention and did not explore whether these changes are maintained long-term.

IPAC subjects in the present study reverted back to baseline PA levels 12 months post-intervention. This finding is consistent with other pedometer-based interventions in diabetics and older women that followed up with subjects post-intervention. McMurdo et al. conducted a randomized controlled trial to determine if a behavior-change intervention with and without a pedometer (Omron HJ-113 piezoelectric pedometer) were successful at increasing PA levels in sedentary older women (≥70 years; n= 204). While increases in PA were seen in the intervention groups after 3 months, both groups reverted to baseline PA levels after an additional 3 months. Furthermore, a study completed by De Greef et al. investigated the effectiveness of a pedometer (Yamax Digi-Walker SW-200) and cognitive-behavioral group intervention for increasing PA in type II diabetic patients (35-75 years old; n= 41). Results of the study revealed considerable short-term success due to the intervention group increasing their steps/day by 2,500, whereas the control group saw virtually no change.
Unfortunately, between the end of the study and 12 months, steps/day decreased significantly in both groups (Intervention group: -1,577 steps/day; control group: -1,188 steps/day). In addition to diabetics and older women, CR patients in the current study followed a similar pattern of PA digression following the intervention. However, it should be noted that even though there were no statistical differences in PA levels between baseline and 12 months, a positive trend was observed: the mean steps/day across groups was 17.7% (~1000 steps) higher at 12 months compared to baseline and moderate-intensity activity minutes were 19.7% higher (~12 min) at 12 months compared to baseline. Considering that 10,000 steps/day and at least 30 min/day of moderate-intensity PA are recommended for cardiac patients according to ACSM\textsuperscript{30}, this increase above baseline at 12 months represents 10% of recommended daily steps and 40% of activity minutes. This finding can be considered clinically significant due to the relatively low step counts of chronically ill patients (1,200-8,800 steps/day)\textsuperscript{31} and may reflect the positive impact that CR can have on cardiac patients.

The UC group followed the same trend as the intervention groups: increase in PA levels from baseline to post-intervention and decrease from post-intervention to 12 months. Of the 8 subjects in the UC group, only 4 had step count data for all 3 time points and were included in the step count analysis. Furthermore, 2 of the 4 subjects included in the analysis had average step counts of >10,000 post-intervention and at 12 months. It is possible, then, that the reason the UC may have shown the same trend as the intervention groups
may be due to a small sample size and 2 subjects with high step counts. In a preliminary study comparing the IPAC study UC group (n=24) to the PF group (n=28), the PF group increased step/count by 45% from baseline whereas the UC group only increased by 2%\(^\text{16}\). Therefore, a larger sample size may be needed to understand the difference between groups. While the UC group did not receive motivational messages or step goals, they were instructed to wear a blinded pedometer and use a log to track their PA each week of the study. Additionally, in order to participate in the study, the UC group had to attend CR at least 2 times/week and have their device downloaded by staff weekly. The qualifications for participating in the study, the minimal contact with staff, and tracking of daily PA may have been sufficient to increase PA levels in some UC group subjects similarly to the intervention groups.

Subjects completed The Physical Activity Stages of Change (SOC) questionnaire at baseline, post, and 12 months. Subjects were asked to respond to 4 statements about whether or not they were currently physically active and if so, do they participate in regular PA (30 minutes of moderate-intensity PA, at least 5 days/week)\(^\text{20}\). Of the 30 subjects who reported regular PA at post-intervention, 17 were no longer regularly active at 12 months. According to the SOC questionnaire, the attrition rate following the 12 week intervention was 57%. Moore et al. evaluated 60 women after Phase II CR using wristwatch heart rate monitors (Polar Vantage NV) and found that 25% stopped exercising immediately following CR and only 48% were exercising 3 months after \(^\text{11}\). Hansen et al.
found that 18 months after a Phase II CR program, only 27% of the total group (n= 119) adhered to minimal PA recommendations which were assessed by the International Physical Activity Questionnaire (IPAQ) \(^9\). The subjects of both studies were similar to the current study subjects: mean age of approximately 65 years with a diagnosis of MI, CABG and/or PCI. The Phase II CR program in the study by Hansen et al. contained 2 groups with differing exercise volumes: 40 or 60 min, at 65% VO\(_2\)\(_{\text{peak}}\), 3 times/week for 7 weeks. Similar to the low volume group, the Phase II CR program at IUHBMH consists of 40 min of exercise, 3 times a week, for 4-12 weeks depending on the diagnosis. Subjects from Moore et al. were recruited from 4 Phase II CR sites in Ohio, but no descriptions of the programs were available. Compared to the study by Moore et al, the attrition rate of the subjects in the present study appears to be attenuated. Additionally, based on the effect that time had on adherence to regular PA long-term in the present study, it would be reasonable to assume that at 18 months the percent of IPAC subjects meeting minimal recommendations would be similar to the findings of Hansen et al. A limitation to these comparisons is the use of questionnaire (IPAQ) by Hansen et al. and the current study (SOC) to draw conclusions about the attrition rate. Objective measurements such as heart rate monitors (Moore et al.) and accelerometers are more accurate and reliable.

**CVD Risk Profile**

The secondary purpose of the present study was to determine if participants in the intervention groups exhibited a positive change in their CVD
risk factor profile after 12 months. Meta-analyses evaluating the short-term impact of CR on CVD risk have found significant reductions in many CVD risk factors including blood lipids, body composition, blood pressure and smoking\textsuperscript{6-8,32}. However, following discharge from CR programs, research has demonstrated a worsening of risk factors over time in cardiac patients\textsuperscript{6,9,32}. In the present study, no significant differences were seen over time or between groups for resting heart rate, resting blood pressure, weight, BMI, waist circumference, total cholesterol, LDL cholesterol, triglycerides, and fasting blood glucose. While a small sample size is a limitation to detecting differences, it is reasonable to assume that since subjects demonstrated a decrease in PA levels between post-intervention and 12 months, a positive change in CVD risk profile would not be observed. Two variables that were significantly affected by time in the present study included body fat percentage and HDL cholesterol. Irrespective of study group, body fat percentage (assessed via DXA scan) was maintained between baseline and post-intervention and increased significantly after 12 months by an average of 1%. Extensive research has established that excess body fat, especially abdominal fat, is a risk factor for CVD\textsuperscript{30}. While there were no statistically significant differences in weight over time, the average weight gain at 12 months across groups was approximately 4.5 kg (~10 lbs.) from post-intervention. This weight gain coincides with the significant increase in body fat percentage. The National Weight Control Registry, which studies individuals that have maintained at least a 30-pound weight loss for 1 year, found that 91\% of the 3000 subjects report engaging in regular PA\textsuperscript{33}. Due to the impact that exercise
has on weight loss and maintenance, it appears logical that the decline in PA seen in IPAC subjects had detrimental effects on body fat percentage. It should be noted, however, that nutritional intake was not assessed and may have had a significant impact on weight gain and increases in body fat percentage as well.\(^33\)

HDL cholesterol significantly increased by approximately 9% following the IPAC intervention and was maintained after 12 months. The Third Report of the Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) confirms that low HDL cholesterol and CVD risk are strongly and inversely related. Clinical trials have supported that increasing HDL levels reduces CVD risk.\(^34\) Furthermore, research has indicated that regular PA can have a positive impact on HDL cholesterol, although these changes do not occur in everyone.\(^30\) In accordance with the present study, Willich et al. also found an increase in HDL over time following CR even though total cholesterol did not change significantly and other CVD risk factors worsened.\(^32\) The positive effects observed by Willich et al. and the present study on HDL cholesterol despite a worsening of other risk factors and decrease in PA may be evidence of the effectiveness of CR to educate patients on increasing HDL through dietary changes and adherence to medication.

**IPAC Study Interventions**

The goal of the IPAC study was to explore successful behavior change strategies aimed at increasing PA in cardiac patients that are feasible to implement on a large scale in a CR setting and are effective at keeping patients
compliant to PA long-term. Chase et al. conducted a meta-analysis evaluating 14 PA interventions following CR. Similar to the IPAC study, the majority of subjects were males and between the ages of 60-70 years. While the average duration of interventions was not determined, in order to be included, studies had to conduct a follow up ≥ 4 weeks post-intervention. The meta-analysis determined that behavioral interventions which employed self-monitoring techniques (i.e. pedometers and/or activity logs) were the most successful. Other effective techniques included goal setting, feedback, and prompting\textsuperscript{23}. While the IPAC study used many of these elements in the different intervention groups (i.e. pedometers, activity logs, goal setting, and prompting through motivational messages), the study was not successful at maintaining compliance long-term. One reason for why subjects' PA levels digressed following the intervention may be the lack of accountability to staff. One of the study requirements for each group was to have their Lifecorder downloaded weekly. Since patients knew a staff member would be able to see their activity levels, it is possible that this may have influenced them to be more compliant with exercise during the intervention. Without this weekly interaction, patients may have been less motivated to maintain or increase activity levels long-term. Giving patients pedometers without any accountability is not enough to motivate them to be regularly active. For instance, following the 12 week study, IPAC patients were given an inexpensive pedometer to continue to track activity levels and only 6 of 36 subjects reported using it at 12 months. At times, patients complained about the inconvenience of wearing the Lifecorder during the intervention which may have been part of the
reason only 17% reported using the pedometer post-intervention. In addition to PA tracking, continued accountability and feedback from staff may be needed to foster long-term PA. A study by Pinto et al. evaluated a 6 month telephone-based intervention in cardiac patients following Phase II CR. The intervention group (n=64) received a total of 14 phone calls providing motivation and feedback regarding reported PA levels (tracked with a PA log) over the course of 6 months (weekly for months 1-2, biweekly for months 2-4, and monthly for months 4-6). Patients were also mailed print material that provided exercise tips and advice. Following the 6 month intervention, patients were called bimonthly to prompt and encourage regular PA. The control group (n=66) also received phone calls during the study, but they pertained to general health concerns. Results of the study indicated that the intervention group maintained baseline PA levels after 6 months and increased PA after 12 months. Additionally, 12 months post-intervention exercise participation remained significantly higher in the intervention group compared to the control group by approximately 80 minutes/week. As this study by Pinto et al. suggests, continued contact with patients may be necessary for long-term maintenance. However, due to the time commitment and expense of providing staff to follow up with patients, (average phone call in Pinto et al. study was 15-20 minutes), fostering intrinsic motivation in patients is crucial.

Education regarding the benefits of PA and overcoming barriers is important to equip patients with intrinsic motivation. Moore et al. found that the most significant predictors of decreasing exercise amount following CR in women.
were health beliefs about the perceived barriers to, and benefits of exercise\textsuperscript{11}. The goal of the motivational messages supplied to the MM group and the PM+MM group of the IPAC study was to educate patients on these 2 areas. Preliminary studies demonstrated that this technique was successful in the short-term at increasing PA levels\textsuperscript{15}. However, the discontinuation of these newsletters may have played a role in the digression in PA levels after 12 months. It may be critical to continually remind and educate patients post-intervention regarding the benefits of PA to combat forgetfulness, especially since this information may be unfamiliar to them. In addition to continued education at CR, partnering with primary care physicians and cardiologists in providing education on PA may help patients to understand and retain why PA is important and may motivate them to be more compliant with long-term PA.

\textit{Cardiac Rehabilitation Attendance}

Evidence has indicated that the longer patients attend Phase II and especially Phase III CR, the more likely they are to engage in regular PA after 12 months. For example, Bock et al. conducted a study among cardiac patients that had graduated from 6-18 weeks of Phase II CR 12 months prior\textsuperscript{22}. Subjects were similar to the current study based on diagnoses (MI, CABG, and/or PCI), mean age (Bock: 63.0 ± 10.8; IPAC: 64.3 ± 9.1 years) and gender (majority were males). The Phase II CR program included 1.25 hour sessions, 3 times/week and included both exercise and education. Phase II CR at IUBMH is similar in length, frequency, duration and includes both exercise and education. At the
hospital where the patients in the study by Bock et al. attended Phase II CR, approximately 25% of patients decide to join the Phase III maintenance program. In both studies, patients attending Phase III CR can come and exercise as often as they would like, but no formal programming is provided. Participants of the Bock et al. study were stratified into 3 groups: patients who had never enrolled in Phase III (n= 37), those who had enrolled but were no longer attending (n= 30), and those who were currently enrolled (n= 30). A number of records from the CR center and self-reported surveys/questionnaires from subjects were collected including dates of program attendance (both Phase II and Phase III), demographic variables, and current participation in moderate-vigorous intensity PA (assessed via 7-day Physical Activity Recall Questionnaire). Results of the study indicated that 78.8% of patients currently enrolled in Phase III had PA levels ≥ to the ACSM PA guidelines (150 minutes of moderate-intensity PA or 75 minutes of vigorous-intensity PA weekly) compared to 66.8% of patients that quit Phase III and only 27% of Phase II-only patients. Furthermore, those meeting or exceeding recommended PA in the Phase II-only group attended Phase II significantly longer than those not meeting recommendations. These results demonstrate that longer participation in both Phase II and Phase III CR increases the likelihood that PA levels will be maintained following the programs.

To provide compensation for participation in the IPAC study, all Phase III CR participation fees were covered for the duration of the study ($25/month). Therefore, the lack of financial obligation due to study participation may have
been a key motivator for joining Phase III CR. Immediately following the completion of the study, 25% of the current study participants discontinued Phase III. Additionally, many of the other 75% attended less regularly over time or withdrew. Of the subjects that discontinued Phase III at the completion of the study or shortly after, their average steps/day at 1 year were 0.5% lower than baseline levels. Those still attending Phase III at 1 year maintained an 18.7% increase above baseline levels. This observation suggests that Phase III attendance may be important for PA maintenance long-term. Research indicates that one of the main reasons Phase III participation is fundamental in maintaining long-term PA is the social support it provides. Clark et al. interviewed cardiac patients 3 years following CR, and found that the main barrier to long-term PA was the loss of social contact. Participants grew to rely on the company of others at CR, and without that ongoing contact, patients were not motivated to continue exercising. Future research should focus on effective strategies to motivate cardiac patients to attend Phase III CR long-term. Phase III attendance also provides an avenue for continued feedback regarding tracked PA levels as well as continued education on the importance of regular PA. Additionally, determining successful ways to foster social support and instill the value of PA outside of CR is crucial not only for those not attending CR, but also to promote regular PA on non-rehab days.
Strengths and Limitations

Many pedometer-based PA interventions contain more than one component and utilize the common study design consisting of an intervention group and control group; this design makes it challenging, if not impossible, to determine which component of the intervention has the biggest impact on increases in PA. Thus, employing at least 3 intervention groups: a pedometer-only group, a cognitive-behavioral-component-only group, and a combination of both provides further insight into which components are most effective. The IPAC study design with a usual care group and 3 intervention groups is valuable providing that adequate subjects are available. Furthermore, many short-term PA interventions are initially successful, but their long-term success is unknown. The IPAC study not only evaluated patients post-intervention, but after 12 months to determine the lasting impact of the interventions. Lastly, PA behavior was measured objectively at baseline, post-intervention and 12 months using 2 blinded accelerometers which has proven to be more accurate than self-reported PA via logs or questionnaires.

Limitations to the present study should be considered when interpreting the results. The most significant limitation of the study was the sample size. Due to only 36 of 70 potential subjects participating, the sample size may not have been large enough to determine differences between intervention groups. Secondly, those willing to participate in the 12 month follow-up study may have had higher PA levels compared to those who refused. During phone calls to
recruit potential subjects, many subjects that refused to participate had health complications and/or mentioned that they were no longer exercising. Thus, the results may not be representative of the IPAC population. Third, there was a lack of female participation in both the original IPAC study as well as the present study. Fewer females were enrolled at IUHBMH where the IPAC study took place. During 2010-2011, IUHBMH CR reported that approximately 30% of their Phase II patients were females, and 70% were males. Currently, 23% of the Phase III population is female and 77% are males. Poor female participation is a problem in most CR centers across the U.S(19). Lastly, due to the novelty of wearing a PA device at 12 months, participants may have been more aware of their activity which potentially influenced them to increase their PA beyond usual levels. Most likely this was not a limitation at post-intervention because patients were accustomed to wearing the Lifecorder during the 12 week intervention. The accuracy of objectively measured PA levels at 12 months may have been affected due to this limitation.

Conclusion

The primary purpose of the current study was to determine if any of the IPAC interventions were successful at increasing PA levels after 12 months compared to the UC group and if so, which intervention was superior. Data from the present study suggests that none of the IPAC interventions (PF, MM, or PF+MM) were successful at increasing or maintaining PA levels after 12 months compared to the UC group. While the interventions were effective in the short-
term at increasing PA levels, patients reverted back to baseline levels after 12 months. Additionally, CVD risk profiles of study participants did not improve overall which may have been a result of the decrease in PA. These findings, along with other studies that report a worsening of PA levels and CVD risk factors following pedometer-based interventions in diabetics and older women\textsuperscript{11,29}, suggest that short-term PA interventions may not be sufficient to facilitate long-term behavior change. Therefore, it may be worth exploring the use of similar intervention strategies (i.e. pedometer feedback paired with staff accountability) for longer intervention periods (6-12 months). Additionally, future research is needed to explore the effectiveness and feasibility of implementing continued staff contact regarding PA levels following PA interventions. Perhaps telephone-based accountability as evidenced by Pinto et al\textsuperscript{35} may encourage long-term compliance of PA following short-term interventions. Furthermore, the use of internet strategies that provide accountability without the need for staff may be promising. For instance, a web-based platform paired with a pedometer that is programmed to generate individual weekly step goals for patients based on initial steps/day may provide adequate accountability and feedback to facilitate long-term PA. Lastly, due to the immediate 25% dropout rate from Phase III CR following the IPAC study, further research is needed to explore strategies to keep cardiac patients enrolled in Phase III CR long-term. Phase III CR provides an avenue for continued social support, feedback from staff, and education regarding the barriers to and benefits of regular PA.
REFERENCES


Figure Legends

Figure 1:
Demonstrates the mean steps/day ± SD across time for all 4 study groups (UC Usual care (n=8); PF Pedometer Feedback (n=12); MM Motivational Messages (n=10); PF+MM Pedometer Feedback + Motivational Messages (n=6)). Includes only subjects with values for all 3 time points. No statistical differences existed between groups, but the total mean average steps/day increased significantly from baseline to post-intervention (p= 0.001) and decreased significantly decreased from post-intervention to 12 months (p= 0.006).

Figure 2:
Characterizes total mean moderate-intensity physical activity minutes ± SE across time. Includes only subjects with values for all 3 time points. No statistical differences existed between groups. Moderate-intensity activity minutes increased significantly from baseline to post-intervention (p= 0.002) and significantly decreased from post-intervention to 12 months (p= 0.031).

* Denotes significance between baseline and post-intervention and post-intervention and 12 months.

Figure 3:
Illustrates total mean body fat percentage ± SE across time. Includes only subjects with values for all 3 time points. No statistical differences existed between groups. No statistical differences existed between baseline and post-
intervention. Body fat percentage increased significantly from post-interventions to 12 months (p= 0.010). ★ Denotes significance between post-intervention and 12 months.

**Figure 4**

Shows total mean high density lipoprotein (HDL) cholesterol ± SE across time. Includes only subjects with values for all 3 time points. No statistical differences existed between groups. A significant increase in HDL occurred between baseline and post-intervention (p= 0.014). This significant increase above baseline was maintained at 12 months (p= 0.005). ★ Denotes significance between baseline and post-intervention and baseline and 12 months.
Figure 1

Average Steps/Day (mean ± SD)

- UC Group
- PF Group
- MM Group
- PF+MM Group

Study Group

- Baseline
- Post
- 12 Months
Figure 2

Average Moderate-Intensity PA Minutes (Mean ± SE)

Baseline | Post | 12 Months

* *
Figure 3

Body Fat Percentage (Mean ± SE)

Baseline | Post | 12 months
---|---|---
28.0 | 30.0 | 32.0
Figure 4

HDL Cholesterol (mg/dL) (Mean ± SE)

Baseline | Post | 12 months

* Indicates statistical significance.
TABLE 1: Descriptive Characteristics of Subjects (mean ± SD)

<table>
<thead>
<tr>
<th>Variable</th>
<th>UC Group (n=8)</th>
<th>PF Group (n=12)</th>
<th>MM Group (n=10)</th>
<th>PF + MM Group (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n= 6 males, 2 females</td>
<td>n= 8 males, 4 females</td>
<td>n= 9 males, 1 female</td>
<td>n= 4 males, 2 females</td>
</tr>
<tr>
<td>Age (years)</td>
<td>61.9 ± 11.5</td>
<td>65.6 ± 9.0</td>
<td>67.1 ± 7.4</td>
<td>60.0 ± 8.4</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>172.3 ± 9.8</td>
<td>167.5 ± 9.3</td>
<td>172.5 ± 8.9</td>
<td>170.8 ± 3.8</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>94.1 ± 17.4</td>
<td>88.2 ± 28.5</td>
<td>92.7 ± 10.1</td>
<td>83.6 ± 19.4</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>31.8 ± 5.6</td>
<td>31.8 ± 10.0</td>
<td>29.1 ± 4.3</td>
<td>31.2 ± 4.3</td>
</tr>
</tbody>
</table>

UC Usual Care; PF Pedometer Feedback; MM Motivational Messages; PF + MM Pedometer Feedback + Motivational Messages; BMI Body Mass Index
TABLE 2: Physical Activity Data Across Time (Mean ± SD)

<table>
<thead>
<tr>
<th>Variable</th>
<th>UC Group (n=8)</th>
<th>PF Group (n=12)</th>
<th>MM Group (n=10)</th>
<th>PF + MM Group (n=6)</th>
<th>All Groups (n=36)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Baseline</td>
<td>Post</td>
<td>12 month</td>
<td>% ∆ from Baseline</td>
<td></td>
</tr>
<tr>
<td>Steps/Day</td>
<td>4545 ± 2246</td>
<td>7484 ± 2937</td>
<td>6567 ± 3813</td>
<td>44.4%</td>
<td></td>
</tr>
<tr>
<td>Moderate PA Min/Day</td>
<td>42 ± 16</td>
<td>91 ± 56</td>
<td>65 ± 48</td>
<td>54.8%</td>
<td></td>
</tr>
<tr>
<td>% of Day Sedentary</td>
<td>76.6% ± 6.8%</td>
<td>68.2% ± 11.9%</td>
<td>73.6% ± 8.9%</td>
<td>-3.9%</td>
<td></td>
</tr>
</tbody>
</table>

UC Usual Care; PF Pedometer Feedback; MM Motivational Messages; PF+MM Pedometer Feedback + Motivational Messages; PA Physical Activity; Irrespective of group, steps/day increased significantly (p= 0.001) from baseline to post-intervention and decreased significantly (p= 0.006) from post-intervention to 12 months; Irrespective of group, moderate PA min/day increased significantly (p= 0.002) from baseline to post-intervention and decreased significantly (p= 0.031) from post-intervention to 12 months. Percent change calculated by: (12 month – Baseline) ÷ Baseline
**TABLE 3:** Secondary Variables of Study Groups Across Time (Mean ± SD)

<table>
<thead>
<tr>
<th>Variable</th>
<th>UC Group (n=8)</th>
<th>PF Group (n=12)</th>
<th>MM Group (n=10)</th>
<th>PF + MM Group (n=6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)</td>
<td>Baseline</td>
<td>Post</td>
<td>12 month</td>
<td>Baseline</td>
</tr>
<tr>
<td></td>
<td>94.0 ± 16.1</td>
<td>93.3 ± 16.3</td>
<td>94.1 ± 17.4</td>
<td>79.4 ± 13.1</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>Baseline</td>
<td>Post</td>
<td>12 month</td>
<td>Baseline</td>
</tr>
<tr>
<td></td>
<td>31.7 ± 5.0</td>
<td>31.5 ± 5.2</td>
<td>31.8 ± 5.6</td>
<td>28.4 ± 3.1</td>
</tr>
<tr>
<td>Resting HR (bpm)</td>
<td>Baseline</td>
<td>Post</td>
<td>12 month</td>
<td>Baseline</td>
</tr>
<tr>
<td></td>
<td>67 ± 13</td>
<td>65 ± 4</td>
<td>65 ± 9</td>
<td>64 ± 14</td>
</tr>
<tr>
<td>Resting SBP (mmHg)</td>
<td>Baseline</td>
<td>Post</td>
<td>12 month</td>
<td>Baseline</td>
</tr>
<tr>
<td></td>
<td>125 ± 21</td>
<td>126 ± 15</td>
<td>126 ± 18</td>
<td>123 ± 17</td>
</tr>
<tr>
<td>Resting DBP (mmHg)</td>
<td>Baseline</td>
<td>Post</td>
<td>12 month</td>
<td>Baseline</td>
</tr>
<tr>
<td></td>
<td>72 ± 8</td>
<td>75 ± 7</td>
<td>73 ± 5</td>
<td>71 ± 6</td>
</tr>
<tr>
<td>Waist Circumference (cm)</td>
<td>Baseline</td>
<td>Post</td>
<td>12 month</td>
<td>Baseline</td>
</tr>
<tr>
<td></td>
<td>108.8 ± 13.3</td>
<td>107.6 ± 16.1</td>
<td>106.4 ± 17.2</td>
<td>98.5 ± 12.2</td>
</tr>
<tr>
<td>Body Fat percentage (%)*</td>
<td>Baseline</td>
<td>Post</td>
<td>12 month</td>
<td>Baseline</td>
</tr>
<tr>
<td></td>
<td>37.1 ± 8.3</td>
<td>37.4 ± 9.5</td>
<td>38.3 ± 9.8</td>
<td>36.0 ± 8.5</td>
</tr>
<tr>
<td>Exercise HR (bpm)</td>
<td>Baseline</td>
<td>Post</td>
<td>12 month</td>
<td>Baseline</td>
</tr>
<tr>
<td></td>
<td>87 ± 19</td>
<td>84 ± 8</td>
<td>85 ± 13</td>
<td>84 ± 16</td>
</tr>
<tr>
<td>Total Cholesterol (mg/dL)</td>
<td>Baseline</td>
<td>Post</td>
<td>12 month</td>
<td>Baseline</td>
</tr>
<tr>
<td></td>
<td>169 ± 62</td>
<td>175 ± 73</td>
<td>195 ± 88</td>
<td>145 ± 33</td>
</tr>
<tr>
<td>HDL Cholesterol (mg/dL)*</td>
<td>Baseline</td>
<td>Post</td>
<td>12 month</td>
<td>Baseline</td>
</tr>
<tr>
<td></td>
<td>44 ± 10</td>
<td>44 ± 8</td>
<td>46 ± 12</td>
<td>41 ± 10</td>
</tr>
<tr>
<td>LDL Cholesterol (mg/dL)</td>
<td>Baseline</td>
<td>Post</td>
<td>12 month</td>
<td>Baseline</td>
</tr>
<tr>
<td></td>
<td>72 ± 39</td>
<td>87 ± 47</td>
<td>56 ± 34</td>
<td>76 ± 24</td>
</tr>
<tr>
<td>Triglycerides (mg/dL)</td>
<td>Baseline</td>
<td>Post</td>
<td>12 month</td>
<td>Baseline</td>
</tr>
<tr>
<td></td>
<td>184 ± 149</td>
<td>175 ± 73</td>
<td>266 ± 233</td>
<td>143 ± 68</td>
</tr>
<tr>
<td>Fasting BG (mg/dL)</td>
<td>Baseline</td>
<td>Post</td>
<td>12 month</td>
<td>Baseline</td>
</tr>
<tr>
<td></td>
<td>144 ± 108</td>
<td>151 ± 91</td>
<td>148 ± 101</td>
<td>103 ± 14</td>
</tr>
</tbody>
</table>

*Denotes significance p < 0.05

UC: Usual Care (6 males, 2 females); PF: Pedometer Feedback (8 males, 4 females); MM: Motivational Messages (9 males, 1 female); PF + MM: Pedometer Feedback + Motivational Messages (4 males, 2 females); BMI: Body Mass Index; HR: Heart rate; SBP: Systolic Blood Pressure; DBP: Diastolic Blood Pressure; HDL: High Density Lipoprotein; LDL: Low Density Lipoprotein; BG: Blood Glucose; Body fat percentage increased significantly (p=0.010) from post-intervention to 12 months in all groups; HDL cholesterol increased significantly (p=0.014) from baseline to post-intervention and was maintained at 12 months (p=0.005)
Body fat percentage increased significantly (p= 0.010) from post-intervention to 12 months in all groups; HDL cholesterol increased significantly (p= 0.014) from baseline to post-intervention and was maintained at 12 months (p= 0.005)

**TABLE 4: Secondary Variables of All Groups Across Time (Mean ± SD)**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline</th>
<th>Post</th>
<th>12 month</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)</td>
<td>85.2 ± 13.7</td>
<td>85.2 ± 14.2</td>
<td>90.0 ± 20.3</td>
</tr>
<tr>
<td>BMI (kg/m^2)</td>
<td>29.2 ± 3.9</td>
<td>29.2 ± 4.0</td>
<td>30.9 ± 6.9</td>
</tr>
<tr>
<td>Resting HR (bpm)</td>
<td>68 ± 13</td>
<td>67 ± 10</td>
<td>67 ± 10</td>
</tr>
<tr>
<td>Resting SBP (mmHg)</td>
<td>125 ± 16</td>
<td>125 ± 14</td>
<td>123 ± 15</td>
</tr>
<tr>
<td>Resting DBP (mmHg)</td>
<td>73 ± 7</td>
<td>73 ± 9</td>
<td>72 ± 8</td>
</tr>
<tr>
<td>Waist Circumference (cm)</td>
<td>101.5 ± 12.2</td>
<td>100.6 ± 11.5</td>
<td>100.0 ± 12.8</td>
</tr>
<tr>
<td>Body Fat percentage (%)*</td>
<td>36.3 ± 8.1</td>
<td>35.8 ± 8.1</td>
<td>37.0 ± 8.2</td>
</tr>
<tr>
<td>Exercise HR (bpm)</td>
<td>86 ± 16</td>
<td>84 ± 12</td>
<td>84 ± 12</td>
</tr>
<tr>
<td>Total Cholesterol (mg/dL)</td>
<td>156 ± 42</td>
<td>160 ± 47</td>
<td>162 ± 57</td>
</tr>
<tr>
<td>HDL Cholesterol (mg/dL)*</td>
<td>41 ± 8</td>
<td>44 ± 9</td>
<td>44 ± 8</td>
</tr>
<tr>
<td>LDL Cholesterol (mg/dL)</td>
<td>77 ± 28</td>
<td>83 ± 31</td>
<td>73 ± 37</td>
</tr>
<tr>
<td>Triglycerides (mg/dL)</td>
<td>160 ± 97</td>
<td>160 ± 47</td>
<td>184 ± 129</td>
</tr>
<tr>
<td>Fasting BG (mg/dL)</td>
<td>110 ± 54</td>
<td>113 ± 49</td>
<td>114 ± 52</td>
</tr>
</tbody>
</table>

*BMI Body Mass Index; HR heart rate; SBP Systolic Blood Pressure; DBP Diastolic Blood Pressure; HDL High Density Lipoprotein; LDL Low Density Lipoprotein; BG Blood Glucose; Body fat percentage increased significantly (p= 0.010) from post-intervention to 12 months in all groups; HDL cholesterol increased significantly (p= 0.014) from baseline to post-intervention and was maintained at 12 months (p= 0.005)*
CHAPTER 5
SUMMARY AND CONCLUSIONS

While exercise-based CR has been deemed effective at reducing mortality rates, modifying CVD risk factors, increasing functional capacity, and improving quality of life in cardiac patients (35, 55, 62), these benefits are most likely maintained only through continued lifestyle modification. Unfortunately, research has indicated that in the months following CR, cardiac patients experience a worsening of CVD risk factors and PA levels (28, 42). Numerous studies have sought to answer why cardiac patients do not adopt regular PA after CR. Out of these studies, a wide variety of theories have developed including the length of Phase II and Phase III programs, loss of social support, comorbidities, lack of knowledge regarding the benefits of exercise, inadequate planning, and decreased motivation indicating that many factors contribute to the attrition rate following CR (11, 18, 42, 52, 58). A meta-analysis evaluating 14 PA interventions following CR found that behavioral interventions which employed self-monitoring techniques (i.e. pedometers and/or activity logs) were the most successful at increasing PA levels. Other effective techniques included goal setting, feedback, and prompting (17). While short-term PA interventions using these techniques
can be successful in the short-term, it is often unknown whether they result in long-term behavioral change.

Therefore, the primary purpose of the current study was to evaluate the effectiveness of pedometer feedback and motivational message interventions of the IPAC study at increasing PA levels after 12 months compared to the UC group. The secondary purpose was to determine if participants in the intervention groups exhibited a positive change in their CVD risk factor profile after 12 months compared to the UC group. The IPAC study was comprised of 4 groups: usual care (UC), pedometer-feedback-only (PF), motivational-messages-only (MM) and a group that employed both interventions (PF+MM). Thirty-six subjects (27 males, 9 females; mean age of 64.3 ± 9.1 years) that completed the IPAC study at least 12 months prior participated in the present study. A total of 8 subjects were part of the UC group (6 males, 2 females; 61.9 ± 11.5 years), 12 subjects in the PF group (8 males, 4 females; 65.6 ± 9.0 years), 10 in the MM group (9 males, 1 females; 67.1 ± 7.4 years) and 6 subjects in the PF+MM group (4 males, 2 females; 60.0 ± 8.4 years).

Results from the study indicated that the 3 interventions groups did not increase PA levels after 12 months and there were no statistical differences in the change in these variables between the intervention groups and UC group. Regardless of study group, steps/day and moderate-intensity PA minutes increased significantly from baseline to post-intervention by 42% and 47.5%, respectively. Unfortunately, from post-intervention to 12 months, steps/day and
moderate-intensity PA minutes decreased significantly by 17.1% and 21%, respectively. While there were no statistical differences in PA levels between baseline and 12 months, a positive trend was observed: the mean steps/day across groups was 17.7% (~1000 steps) higher at 12 months compared to baseline and moderate-intensity PA minutes were 19.7% higher (~12 min) at 12 months compared to baseline.

The UC group followed the same PA trend as the intervention groups: increase in PA levels from baseline to post-intervention and decrease from post-intervention to 12 months. Of the 8 subjects in the UC group, only 4 had step count data for all 3 time points and were included in the step count analysis. Furthermore, 2 of the 4 subjects included in the analysis had average step counts of >10,000 post-intervention and at 12 months. It is possible, then, that the reason the UC may have shown the same trend as the intervention groups may be due to a small sample size and 2 subjects with high step counts. However, while the UC group did not receive motivational messages or step goals, they were instructed to wear a blinded pedometer and use a log to track their PA each week of the study. Additionally, in order to participate in the study, the UC group had to attend CR at least 2 times/week and have their device downloaded by staff weekly. The qualifications for participating in the study, the minimal contact with staff, and tracking of daily PA may have been sufficient to increase PA levels in some UC group subjects similar to the intervention groups.
Furthermore, results indicated that the 3 interventions groups did not improve CVD risk factors after 12 months and there were no statistical differences in the change in these variables between the intervention groups and UC group. No statistical differences were detected in most CVD risk factors (blood pressure, total cholesterol, LDL cholesterol, triglycerides, or blood glucose) across time with the exception of body fat percentage and HDL cholesterol. Body fat percentage significantly increased from post-intervention to 12 months by an absolute 1.1% (3.1% change from post-intervention). HDL cholesterol increased significantly from baseline to post-intervention by 8.8% and at 12 months remained significantly higher than baseline by 9.1%. The lack of positive changes in CVD risk profile and the worsening of body fat percentage is not surprising considering regular PA levels were not maintained long-term. Regular PA plays a key role in the reduction of CVD risk factors including blood pressure, blood lipid profile, fasting glucose, and body composition (64). The increase seen in HDL at post-intervention and 12 months despite worsening PA levels suggests that CR may have been effective at educating patients on dietary changes and medication adherence to increase HDL levels. Lastly, it is also important to consider that across groups at baseline, some CVD risk factors were already at reasonable levels including resting blood pressure (both systolic and diastolic), LDL cholesterol and HDL cholesterol. Thus, it can be considered a positive finding that these controlled levels were maintained after 12 months.
These data suggest that while short-term PA interventions like the IPAC study may be effective at increasing PA initially, they may not be sufficient to facilitate long-term behavior change. This raises the question of whether or not future research on short-term PA interventions in CR is worth the required time and expense. Instead, it may be valuable to explore long-term strategies (>12 months) that utilize similar elements of successful short-term interventions (motivational messages and pedometer-feedback) to encourage a lasting behavior change.

**Recommendations for Future Studies**

In the short-term, the IPAC study was clearly successful at increasing PA levels in cardiac patients evidenced by both preliminary studies evaluating IPAC subjects and the present study (30, 39). However, the impact of the 12-week intervention was not sufficient to maintain or increase PA levels long-term. Future research is needed to evaluate the long-term implementation of similar interventions. For instance, simply giving cardiac patients pedometers to track PA without any feedback did not prove to be effective in the present study. Subjects were given an inexpensive pedometer at the conclusion of the study, and only 6 of 36 subjects reported using it at 12 months. Perhaps PA tracking in addition to feedback from staff is needed to maintain PA levels long-term. One of the study requirements for each group was to have their Lifecorder downloaded weekly. Because patients knew that a staff member would be able to see their activity levels, this may have influenced them to be more compliant with exercise.
during the intervention. Without this weekly interaction, patients may not have been as motivated to maintain or increase activity levels long-term. Research focused on long-term feedback and prompting is needed to encourage maintenance PA in cardiac patients. Telephone-based feedback paired with PA level tracking evidenced by Pinto et al. may be a promising avenue for future research (47). Furthermore, the use of internet strategies that provide accountability without the need for staff may be promising. For instance, a web-based platform paired with a pedometer that is programmed to generate individual weekly step goals for patients based on initial steps/day may provide adequate accountability and feedback to facilitate long-term PA.

Furthermore, research focused on fostering intrinsic motivation in cardiac patients to be regularly active is crucial. Long-term interventions focused on continued education on the benefits of and barriers to regular exercise may help facilitate this. Moore et al. found that the most significant predictors of decreasing exercise amount following CR in women were health beliefs about the perceived barriers to, and benefits of exercise (42). The goal of the motivational messages supplied to the MM group and the PM+MM group of the IPAC study was to educate patients on these 2 areas. Preliminary studies demonstrated that this technique was successful in the short-term at increasing PA levels (39). However, the discontinuation of these newsletters may have played a role in the digression of PA levels after 12 months. It may be critical to continually remind and educate patients post-intervention regarding the benefits of PA to combat
forgetfulness, especially since this information may be unfamiliar to them. In addition to continued education at CR, partnering with primary care physicians and cardiologists in providing education on PA may help patients to understand and retain why PA is important and may motivate them to be more compliant with long-term PA.

Lastly, evidence has indicated that the longer patients attend Phase II and especially Phase III CR, the more likely they are to engage in regular PA after 12 months (11). Immediately following the completion of the present study, 25% of the current study participants discontinued Phase III. Additionally, many of the other 75% attended less regularly over time or withdrew. Of the subjects that discontinued Phase III at the completion of the study or shortly after, their average steps/day at 1 year were 0.5% lower than baseline levels. Those still attending Phase III at 1 year maintained an 18.7% increase above baseline levels. This observation suggests that Phase III attendance may be important for PA maintenance long-term.

There are several reasons why Phase III participation may be fundamental in maintaining long-term PA. First, the program provides the social support needed to help facilitate behavior change. Clark et al. interviewed cardiac patients 3 years following CR, and found that the main barrier to long-term PA was the loss of social contact (18). Participants grew to rely on the company of others at CR, and without that ongoing contact, patients were not motivated to continue exercising. Furthermore, Phase III attendance also
provides an avenue for continued feedback regarding PA levels. Introducing the long-term use of pedometers into an environment in which staff can continue to provide individual guidance regarding step goals may effectively increase PA levels in CR patients. Lastly, Phase III CR provides the opportunity for continued education regarding the benefits of and barriers to regular PA. For these reasons, future research should focus on effective strategies to motivate cardiac patients to attend Phase III CR long-term. In addition, it may be equally important to determine successful ways to foster social support and instill the value of PA outside of CR. While this is crucial for those not attending CR, it is also important for promoting regular PA on non-rehab days in CR patients.
REFERENCES


Staff: Read the instructions to the subject and ask them to respond to the 4 statements [be sure they understand the definitions of physical activity (#1&2) and regular physical activity (#3&4)]

PHYSICAL ACTIVITY STAGES OF CHANGE

For each of the following statements, please circle Yes or No. Please be sure to read the statements carefully.

Physical activity or exercise includes activities such as walking briskly, jogging, bicycling, swimming, or any other activity in which the exertion is at least as intense as these activities.

1. I am currently physically active.  
   
   Note: if they answer YES to #1, do not ask them question 2

   Yes: 0  
   No: 1

2. I intend to become more physically active in the next 6 months.  
   
   Note: if they answer NO to #1, do not ask them questions 3 and 4

   Yes: 0  
   No: 1

For activity to be regular, it must add up to a total of 30 minutes or more per day and be done at least 5 days per week. For example, you could take one 30-minute walk or take three 10-minute walks for a daily total of 30 minutes.

3. I currently engage in regular physical activity.  
   
   Note: if they answer NO to #3, do not ask them question 4

   Yes: 0  
   No: 1

4. I have been regularly active for the past 6 months.  
   
   Yes: 0  
   No: 1
APPENDIX B

MOTIVATIONAL NEWSLETTERS
CONVINCING YOURSELF YOU CAN BE PHYSICALLY ACTIVE

It’s easier than you think

The good news is that gaining health benefits from physical activity is much easier and less time consuming than most people believe.

Recently, the American Heart Association recommended that cardiac patients obtain a minimum of 30-60 minutes of moderate-intensity (or higher) physical activity on 5 or more days/week and should supplement this by increases in daily lifestyle activities. The Physical Activity Guidelines for Americans also recommends that 2 ½ hours per week (roughly 30 minutes on 5 days of the week) of moderate intensity aerobic physical activity, or one hour and 15 minutes per week of vigorous intensity physical activity will promote health benefits.

By definition, physical activity does not have to be structured exercise, nor does it have to be done in a fitness center! It is literally any whole body activity resulting in energy expenditure.

Examples include:
- Walking briskly
- Robust housework
- Gardening
- Certain occupational tasks
- A variety of daily living activities (like taking the stairs)

These activities can be performed in long blocks of time (like 30 minutes) or in shorter episodes (like 6-10 minutes) a few times per day.

THE EVIDENCE IS CLEAR

Regular physical activity over months and years produces long-term health benefits and reduces the risk of many diseases, including heart disease.

REPORT ANY PROBLEMS

Did you have any problems doing physical activity last week? Did anything hurt? If so, be sure to report this to the Cardiac Rehab Program staff.
Preparing yourself to be physically active

Examine Your Intentions, Motives, & Commitment

We know that deciding to change a behavior and knowing what to do is often not enough to make that change a permanent part of your life.

Being armed with “how to” information and learning some behavioral skills to support your best intentions greatly increases your chances of being successful.

Before you actually take action, you need to prepare yourself for being physically active and begin to plan how you will take control and manage that change.

Intentions are the best predictors of actions. Only you can determine your intentions, motives and goals.
- What do you want to achieve?
- Do you want to be healthier?
- Do you wish to become physically active and fit?

What are your intentions and your motives? (Write them here!)

-----------------------------
-----------------------------
-----------------------------
-----------------------------
-----------------------------

FAST FACTS: The Use of Role Models
Another useful tactic for staying motivated is to pick a role model. Maybe there is a friend or family member who is regularly physically active. Talk to that person and ask them what work, and doesn’t work, for them.

Information in this brochure is based on original work by:
Reasons to be more physically active

Reasons to stay inactive:

“I don’t have time to be more active” Making physical activity a priority means making time to do it, and this may seem difficult. However, consider that you only need 150 minutes per week of moderate (or higher) intensity physical activity to gain health benefits, remembering that Cardiac patients should strive for 300 minutes per week. This can be performed all at once for 30-60 minutes, or in multiple times of at least 10 minutes throughout the day.

“I never liked to exercise” Many of us have bad memories of running or doing calisthenics in our high school gym classes. The good news is that you don’t have to exercise that hard if you don’t want to. There are other ways to improve your health like walking or gardening. Try taking the stairs, or parking farther away from your destination and walking.

Reasons to be more active:

It’s fun! Let yourself feel young. Physical activity can help you bring back those good feelings of youth when playing was fun. Try some activities that you did as a child. Toss around the baseball, jump rope or skip. If you have children or grandchildren, enjoy doing something active with them.

It’s good for your body! Your weight is much easier to manage when you are physically active. It can also help control your blood pressure, blood sugar, and cholesterol.

It’s good for your mind! Regular physical activity helps increase your confidence and give you a stronger sense of pride for your healthier body. It also helps decrease stress and decrease feelings of sadness.

Report Any Problems

Did you have any problems doing physical activity last week? Did anything hurt? If so, be sure to report this to the Cardiac Rehab Program staff.
Do I need more physical activity?

The Pros and Cons of Physical Activity

The following are some negative statements about being more active. What do you think?

1. Regular physical activity would take too much of my time. (Circle One)

   1  2  3  4  5
   Strongly Disagree  Strongly Agree

2. At the end of the day I am too exhausted to be physically active. (Circle One)

   1  2  3  4  5
   Strongly Disagree  Strongly Agree

3. I would have less time for my family and friends if I was more regularly active. (Circle One)

   1  2  3  4  5
   Strongly Disagree  Strongly Agree

Add up your answers to these three questions. This is your “CONS” score.

TOTAL: ____________________________

The following are some positive statements about being more active. What do you think?

1. I would feel more confident if I was regularly physically active. (Circle One)

   1  2  3  4  5
   Strongly Disagree  Strongly Agree

2. I would feel less stressed if I was more physically active. (Circle One)

   1  2  3  4  5
   Strongly Disagree  Strongly Agree

3. I would feel more comfortable with my body if I was more physically active. (Circle One)

   1  2  3  4  5
   Strongly Disagree  Strongly Agree

Add up your answers to these three questions. This is your “PROS” score.

TOTAL: ____________________________

If your CONS score was higher, you may want to spend more time thinking about physical activity. Over the next week try making a list of all the GOOD things you can think of about being physically active. If your PROS score was higher, you may want to begin reading more about different activities and opportunities for physical activity in your neighborhood. You could also ask your friends or family about why they are active or how they got started.

Want to burn 100 calories today?

Walk around the block = 30
Climb up 2 flights of stairs = 15
Dance to your favorite, fast song = 25
Walk around the block again = 30

100 calories!

Information in this brochure is based on original work by: