PEDOMETER INTERVENTION TO INCREASE PHYSICAL ACTIVITY OF PATIENTS ENTERING A MAINTENANCE CARDIAC REHABILITATION PROGRAM

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

BY

JASON L. JONES

ADVISOR: DR. LEONARD A. KAMINSKY

BALL STATE UNIVERSITY

MUNCIE, IN

JULY, 2009

AKNOWLEDGEMENTS

First and foremost, I would like to thank my fiancé, Josette Dudoit. It is through your love and care that I was able to persevere the trying time and times of tribulation. You are the role model who inspired me to pursue higher education, and you have always been there to provide the necessary tools for my success. I love you.

I would like to thank my Advisor, Dr. Leonard A. Kaminksy, for the guidance and direction throughout my tenure at Ball State University. My experiences and growth are due in part to your first-hand involvement. Without it, this could not be possible.

My committee members are not to go unrecognized. Mrs. Katrina Riggin played an integral role throughout this study. Your knowledge and expertise in working with the study population was both vital and necessary for the study's completion, thank you. Thank you to Dr. Trent Hargens for serving as a committee member and providing encouragement throughout the entire process.

I would also like to thank the Ball Memorial Hospital Cardiopulmonary Rehabilitation staff and my graduate assistant colleagues for assisting me with the subject recruitment and data collection.

Although a bit unorthodoxed, I would like to thank the greater Midwest America for providing such a unique and eye-opening experience. I never knew so many wonders existed before traveling from the west coast.

TABLE OF CONTENTS

LIST OF TABLES AND FIGURES

ABSTRACT

THESIS: Pedometer Intervention to Increase Physical Activity of Patients Entering a Maintenance Cardiac Rehabilitation Program

STUDENT: Jason Lee Jones

DEGREE: Master of Science

COLLEGE: Applied Sciences and Technology

DATE: July, 2009

PAGES: 98

Purpose: The primary purpose of this study was to determine if a pedometer-driven physical activity (PA) intervention with individualized stepcount goals would be more efficacious in yielding greater amounts of PA than the usual time-based PA recommendations given to maintenance CR patients. Additionally, the secondary purpose of this study was to assess differences in stepcount activity on days attending maintenance CR and on non-rehab days.

Methods: Subjects entering maintenance CR for the first referral were recruited for study participation and stratified into pedometer feedback (PF) and usual care (UC) groups. All subjects wore a New Lifestyles NL-1000 pedometer. PF subjects wore the pedometer for the duration of the 8-week study. For comparison, UC subjects wore the pedometer at baseline, week 4, and week 8.Both groups were encouraged to accumulate a minimum of 40 - 50 min/d at moderate intensity when attending maintenance CR. UC subjects were encouraged to follow-up with at least 30 min/d PA outside maintenance CR, while PF subjects were given daily stepcount goals. Stepcount goals were calculated as 10% of baseline stepcounts and added weekly to increase daily goal. All subjects completed a 6-

minute walk test at baseline and week 8, and behavioral change questionnaires were completed at baseline, week 4, and week 8.

Results: A total of 18 subjects (PF, n = 9, 53.7±8.0; UC, n = 9, 60.2±9.6 yrs) completed the 8-week study. There were no differences between groups at baseline. PF group increased daily stepcounts by week 4 (19%, 1,080±649 steps/d) and 8 (44%, 2,468±846 steps/d) in addition to days attending rehab by week 4 (14%, 1064±45 steps/d) and 8 (36%, 2,711±423 steps/d) and non-rehab days by week 8 (42%, 1,747±759 steps/d). PF subjects accumulated greater daily stepcounts compared to UC subjects at weeks 4 (26%, 1,405±393 steps/d) and 8 (48%, 2,612±284 steps/d). UC subjects accumulated greater stepcounts on rehab compared to non-rehab days, but no changes were found from baseline for daily stepcounts, rehab, or non-rehab days. There was a time effect for responses to social support from friends for all subjects (baseline to week 4) and a time by group effect for decision balance pro-questions by week 4 where PF significantly increased, UC significantly decreased, and both groups where significantly different.

Conclusions: The results of this study suggest that a pedometer-driven PA intervention yields significantly greater stepcounts compared to time-based PA recommendations among maintenance CR patients.

Key Words: Maintenance cardiac rehabilitation, phase III, pedometer, intervention, stepcounts, physical activity.

CHAPTER I

Introduction

Cardiovascular disease (CVD) is the leading cause of death among Americans and has affected millions of lives for more than 80 years.[1-3] According to the Heart Disease and Stroke Statistics 2009 Update[1] released by the American Heart Association (AHA), more than 80 million Americans were diagnosed with CVD in 2005 resulting in more than 35% of all deaths. Moreover, 1 in 3 Americans are considered to be diagnosed with at least 1 form of CVD, while more than 70% (32 million) of adults between the ages of 60-79 years are diagnosed with at least 1 form of CVD.[1] The more prevalent form of CVD is coronary heart disease (CHD), otherwise known as coronary artery disease (CAD), and accounted for more than 50% of all CVD related deaths in 2004.[1] More striking, 85% of deaths for adults $\geq$ 65 years old were a result of CAD.[1, 4]

Despite these statistics, CVD related mortality rates have declined by nearly 26% over the past decade (1995 to 2005) as morbidity rates have increased.[1] One theory for the reduction in mortality rates can be attributed to a marked increase in disease awareness.[1, 3, 5] Results from an AHA survey conducted in 1997 identified only 30% of its female respondents being aware of CVD as the leading cause of death among American women.[5] In 2004, a repeat AHA survey analysis suggested that the rate of awareness increased from 30 - 46%.[6] Likewise, there have been improvements in health care and increases in pharmacological treatment for known CAD risk factors, such as: cholesterol, blood pressure, diabetes, and obesity.[1] However, physical inactivity remains a common denominator and the most prevalent risk factor for CAD.

Even though physical inactivity is considered the more prevalent modifiable risk factor for the development of CAD,[1, 7] only an estimated 64.5% of Americans, and an estimated 51.2% of Americans over the age of 65, report meeting current PA guidelines[8] of ≥ 150 minutes/week moderate intensity, 75 min/wk vigorous intensity, or a combination of the 2.[9] Additionally, an estimated 30% of Americans are reported to accumulate no PA,[8] essentially remaining inactive and sedentary throughout the day. These data are obtained from a recent retrospective analysis of 2007 data for Americans accumulating recently recommended amounts of PA. A recent meta-analysis of 63 studies on secondary prevention programs for individuals with CAD identified the mean age among those studied was ≥59 years.[10] For those ≥ 60 years old and diagnosed with CAD, only an estimated 33% are reported to meet the PA recommendations for cardiac populations, being ≥30min/d at least 5 days/wk.[11] Given these statistics, increased levels of PA among those diagnosed with CAD would be of significant value.

The benefits of increased PA habits are well established, which include: decreased morbidity and mortality, hypertension, type 2 diabetes, obesity, osteoporosis, anxiety, depression, certain types of cancers, and risk reduction for CAD by an estimated 20-50%.[7, 12-14] Individuals diagnosed with CAD and CVD have been found to equally benefit from increased PA.[15] In addition to the aforementioned benefits from increased PA, energy expenditure in excess of 1500kcal/wk has been reported to halt atherosclerotic lesion progression while atherosclerotic lesion reduction has been reported to occur with energy expenditures in excess of ≥2200kcal/wk.[16]

PA monitoring devices, namely pedometers and accelerometers, have become popular tools to assess, recommend, and facilitate increased PA habits in Japan for more than 30 years.[17] More recently, pedometers have become widely available and used for PA assessment and promotion among healthy and clinical populations in America.[18-23] Pedometers are inexpensive, objective, and accurate tools that aid in the measurement of PA and setting of health-related goals.[18, 24, 25] Moreover, it is suggested that pedometers increase PA awareness, motivate increased levels of PA from low to moderate amounts, and may increase an individual's potential to engage in greater amounts of higher intensity PA as a result of positive behavior modification that is mediated through the use of a pedometer.[18, 24, 26-29] Recent reports indicate an estimated 26% (2,200 steps/d) increase in daily stepcounts when given individualized stepcount targets to healthy adults;[26] however, there are no known studies identifying the efficacy of a pedometer intervention with CR populations.

Statement of Problem

Physical inactivity is an independent risk factor for CAD and CVD.[1, 7, 30] Tudor-Locke et al.[29] proposes that sedentarism is associated with stepcounts <5,000 steps/d, and light activity is associated with stepcounts 5,000 - 7,499 steps/d. Available data for PA habits of patients in early-outpatient and maintenance CR suggest that patients are falling significantly short of publicly recommended stepcount activity (≥ 10,000 steps/d) on days not attending rehab.[22, 31] Stevenson et al.[22] reported that while subjects were considered lightly active (6,503±1,663 steps/d) on days attending early-outpatient CR, they accumulated significantly fewer steps and considered sedentary on non-rehab days, averaging only 4,517±1,517 steps/d. Jones et al.[31] reported similar results for subjects attending a maintenance CR program. Even though subjects achieved recommended amounts of PA (≥ 10,000 steps/d) on days attending maintenance CR, averaging 10,087±631 steps/d, they fell significantly short of recommended levels on non-rehab days, averaging 5,277±623 steps/d.

Purpose of the Study

The primary purpose of this study was to determine if a pedometer-driven physical activity (PA) intervention with individualized stepcount goals would be more efficacious in yielding greater amounts of PA than the usual time-based PA recommendations given to maintenance cardiac rehabilitation (CR) patients between 3 difference time-points: baseline, week 4, and week 8. Additionally, the secondary purpose of this study was to assess differences in stepcount activity on days attending maintenance CR and on non-rehab days.

Limitations

There are reported influences of seasonal variations on PA habits.[32] Data for this study was collected from September through May with distinct changes in weather and temperature patterns. Consequently, there may have been seasonal variation to the PA habits in this study.

Significance of the Study

There have been few studies to report the PA habits of early-outpatient and maintenance CR patients,[22, 23, 31, 33] and fewer have studied daily differences in stepcounts on rehab versus non-rehab days.[22, 31] Furthermore, there is a paucity of studies comparing the efficacy of a pedometer-driven PA intervention to time-based PA recommendations.[19, 34]

Hypothesis Statement

The hypothesis of this study was that a pedometer intervention with individualized stepcount goals would yield greater amounts of PA than the time-based PA recommendations given to patients entering a maintenance CR program.

Definition of Terms

1. *Cardiovascular Disease (CVD)* - a term that includes coronary heart disease (consisting of angina, coronary insufficiency, myocardial infarction, and sudden or non-sudden death from coronary disease), congestive heart failure, stroke, transient ischemic attack, and intermittent claudication.[35]
2. *Coronary Heart Disease (CAD)* - a term synonymous with CHD; a condition caused by thickening of the artery walls that supply blood to the heart muscle. When these arteries become blocked, the heart is deprived of oxygen and can become damaged.[35]
3. *Early-outpatient Cardiac Rehabilitation* - a program that delivers preventive and rehabilitative services to patients in the outpatient setting after a CVD event, generally within the first 3 to 6 months after but continuing for as much as 1 year after the event.[36]

4. *Exercise*- a subset of physical activity that is planned, structured, and repetitive and has a final or an intermediate objective of improvement or maintenance of physical fitness.[37]

5. *Inpatient Cardiac Rehabilitation* - a program that delivers preventive and rehabilitative services to hospitalized patients following an index CVD event, such as an MI/acute coronary syndrome.[36]

6. *Maintenance Cardiac Rehabilitation* - a program that provides longer term delivery of preventive and rehabilitative services for CHD patients in the outpatient setting that is initiated within 1 year post event or intervention, possibly following early-outpatient CR.[36]

7. *Pedometer*- an objective PA monitoring device designed to measure the amount of walking activity.[17, 25]

8. *Physical Activity*- any bodily movement produced by skeletal muscles that results in energy expenditure.[37]

CHAPTER II

Literature Review

Coronary artery disease (CAD), the most prevalent form of cardiovascular disease (CVD), is the number one cause of death in America.[1] Regular PA is associated with a 20 - 50% reduction in CAD mortality;[12-14] however, physical inactivity remains a major epidemic among Americans.[9] This chapter will provide a review of the modifiable risk factors associated with CAD, past PA recommendations and current PA guidelines, PA assessment methodology, cardiac rehabilitation (CR) services, and recent literature on PA assessment of CR patients.

Cardiovascular Disease Risk Factors and Physical Activity

CVD encompasses a constellation of diagnoses, including: CAD, congestive heart failure, disease of the arteries (arteriosclerosis and atherosclerosis), hypertension, and stroke.[1] Even though mortality rates have decreased approximately 25% over the past decade, CVD remains the leading cause of death, affecting approximately 33% of Americans resulting in 2.4 million deaths in 2004.[1] Of the many forms of CVD, CAD is the leading cause of death.[1] The various forms of CAD include angina, coronary insufficiency, myocardial infarction, and sudden or non-sudden death as a result of CAD.[38]

The independent, modifiable risk factors for CAD include hyperlipidemia, hypertension, diabetes, smoking, obesity, and most notably, physical inactivity.[30, 38-40] Of the many risk factors associated with CAD, increases in PA from low to moderate amounts may contribute the most in risk reduction.[12-14] More than 48% (106 million) of the American population is considered to have hyperlipidemia (low-density lipoprotein measurement ≥200 mg/dL),[1] approximately 30% of Americans have hypertension,[41] approximately 7.3% (15 million) of Americans are type 2 diabetic,[42] approximately 21% (46.6 million) of Americans use tobacco products,[1] approximately 61% of Americans are considered either overweight (BMI ≥25 Kg/m^2) or obese (BMI ≥30.0 kg/m^2),[43, 44] and more than 50% (51.3% men and 53.3% women) of Americans are reportedly not meeting current PA recommendations.[7, 9]

Without the use of pharmacological therapy, regular PA reduces not only reduces the risk for each of the independent CAD risk factors; regular PA is associated with a reduced risk for CAD mortality by 20 - 50%.[12-14] In addition to reduced risk for CAD morbidity and mortality, regular PA provides improved blood pressure management, body weight management, glucose control, and insulin sensitivity. Systolic blood pressure reductions through regular PA have been observed with an average 4 - 9 mmHg.[45] Additionally, further reductions in systolic blood pressure by 5 - 20 mmHg are reported to occur for every 10 kilograms of body weight loss.[45] On average, regular PA is associated with increases in insulin sensitivity and glucose control of 50%.[46] Although no prevalence data are available for smoking cessation associated with regular PA, it is proposed that regular PA may be a mediator for successful smoking cessation,[47] which is important to note since individuals who continue smoking habits following a myocardial infarction (MI) increase their risk for subsequent MI by over 80%.[30]

Physical Activity

Physical inactivity is 1 of 5 major risk factors for CAD morbidity and mortality.[48] Over the past 4 decades, numerous scientific reports by the Center for Disease Control and Prevention (CDC),[49] the Surgeon General's report,[7] the American College of Sports Medicine (ACSM),[50] and the American Heart Association (AHA)[51, 52] have been released, reinforcing the benefits of increased PA and providing recommendations for increasing daily PA and exercise among healthy adults, older adults, and cardiac populations. For the purposes of this literature review, reports from mid-1990's to present will be reviewed.

Benefits of Exercise

The CDC/ACSM statement,[49] the Surgeon General's report,[7] the AHA statement for healthcare professionals,[53] and the *Physical Activity Guidelines for Americans, 2008*[9] provide a review of scientific evidence for the benefits of PA and exercise. Early reports suggested the threshold for health benefits to occur when exceeding ≥ 30 min/d at least 5 days/wk for moderate to vigorous intensities.[7, 49, 54] More recently, the *Physical Activity Guidelines for Americans, 2008*[9] suggested a minimum of 150 min/d at moderate intensity or 75 min/d vigorous intensity to obtain substantial health benefits. A dose-response, where greater benefits are obtained with greater intensities and volumes of PA and exercise, has been reported when increasing moderate PA to 300 min/d and vigorous PA to 150 min/d.[9] The many benefits of regular PA include: reduced risk of premature mortality that may be due to heart disease, reduced risk for developing diabetes, reduced risk for colon and possibly breast and prostate cancer, obesity, improved body weight and blood pressure management, improved cardiovascular fitness (more so for those most sedentary and least fit), reduced depression, increased quality of life.[7, 9] In addition to the many aforementioned benefits, individuals with diagnosed CAD have a reduced mortality rate due to CAD by an average 20 - 25%.[30, 40]

Physical Activity Recommendations for Healthy Adults

The AHA released a statement for health professionals in 1995 on the standards and benefits of exercise for those free from clinical manifestations and those with known CAD.[53] Intensities and durations as little as 50% VO_{2max} for 20 min/d at least 3 days/wk were proposed as a minimum stimulus to provide benefit from regular exercise. Guidelines for exercise recommendations were suggested as a minimum of 3 days/wk at an intensity of 50 - 60% VO_{2max} at least 30 min/d. A later statement by the AHA for healthcare professionals in 2001 provided an update on training thresholds for health benefits (40 - 60% VO_{2max} in place of 50% VO_{2max}) and maximal intensities for exercise training (85 - 90%VO_{2max}).[51]

The CDC and ACSM released a scientific statement on *Physical Activity and Public Health* in 1995,[49] which was followed by a report released to the American public by the Surgeon General on *Physical Activity and Health* in 1996.[7] With approximately 28% males and 31% females reported to be sedentary,[49] the goal of the CDC/ACSM statement and Surgeon General PA report was to provide evidence-based recommendations for regular PA and exercise. As a result, the accumulation of a minimum of 30 minutes/day (min/d) of moderate intensity PA on most, if not all days of the week was recommended.

Following the release of the Surgeon General's report, the ACSM released revised exercise recommendations in 1998 to improve the health and fitness of healthy adults.[54] Recommendations for a minimum 30 min/d for 3 - 5 days/wk at moderate intensity were suggested to provide an adequate stimulus for significantly increased health benefits and aerobic capacity of those less trained and considered sedentary. A minimal intensity threshold of 40 - 50% $VO_{2Reserve}$ (40 - 50% HHR) was suggested to be a sufficient training stimulus for individuals less trained and with the lowest aerobic capacity. Individuals with higher fitness levels require a higher training stimulus.[54]

Nearly a decade following the CDC/ACSM statement, the Surgeon General's report and the 1998 ACSM position stand on PA recommendations for healthy adults, the ACSM and AHA[50] released a joint position stand for healthy adults. The position stand recommended a minimum of 30 min/d moderate intensity at least 5 days/wk or 20 min/d vigorous intensity for a minimum of 3 days/wk, which can be accumulated in bouts of at least 10 min/bout.[50] This was to bring clarity for types and amounts of PA provided in the initial recommendations, given as 30 min/d moderate intensity PA on most, if not all days of the week.

Soon after the release of the updated position stand on PA recommendations, the first-ever Physical Activity Guidelines Committee was formed in 2007 and released the first-ever national guidelines on PA in 2008, titled *Physical Activity Guidelines for Americans, 2008*.[9] The PA recommendations are as follows: a minimum of 2 hours and 30 minutes (150 minutes) moderate intensity or 1 hour 15 minutes (75 minutes) vigorous intensity, which can be accumulated in bouts of ≥ 10 minutes. For additional benefits, increasing weekly PA to 5 hours/wk (300 minutes) moderate intensity or 2 hours and 30 min/wk (150 minutes) vigorous intensity is recommended. To reduce the risk of injury, the guidelines suggest distributing the durations over at least 3 days/wk.

Physical Activity Recommendations for Older Adults

Individuals ≥ 65 years old are considered the least active age group in America.[55] The ACSM[56] projected in 1998 that the prevalence of older adults living in America would exponentially increase over the following decade, which prompted the exercise-driven position stand to improve the health and fitness of older adults. Aerobic capacity is suggested to decrease an average 5 - 15% each decade following age 25,[56] and the focus of this position stand was to provide suitable recommendations for the elderly, who may have decreased functional status, increased risk for falls, and considered frail. Through regular PA and exercise, it was suggested that the older adult could increase aerobic capacity by an average 10 to 30%, improve balance, and increase the ability to perform activities of daily living (ADL).[56]

The PA recommendations and benefits of increased PA for older adults are similar to those for healthy (younger) adults, except that older adults are encouraged to increase PA more gradually and place greater emphasis on the use of major muscle groups that represent daily activities.[7, 9, 48, 51] The older adult should be as physically active as abilities allow in order to avoid excessive fatigue and overtraining injuries.[9] Progression toward increased intensities and volumes are recommended by gradually increasing the duration and frequency of exercise before increasing intensity. Similarly, increasing the number of exercise bouts (4 - 5 bouts/day) and duration of bouts (10 - 15 minutes/bout) has been suggested to provide adequate stimulus to increase functional capacity.[51]

Physical Activity Recommendations for Cardiac Patients

ACSM released a position stand in 1994 on PA and exercise for individuals with known CAD.[30] It was estimated that functional capacity may increase 10 - 60% (average of 20%) in as few as 3 months with regular PA.[30] A later report by the ACSM corroborated the aforementioned, suggesting that CHF patients may increase functional capacity by an estimated 10 - 30% in as few as 3 months with regular exercise at moderated intensity (60% VO_{2max}).[57] Exercise recommendations for individuals with known CAD included a minimum 40 to 60 min/d moderate to vigorous intensity (40 - 85% $HR_{reserve}$; 55 - 90% HR_{max}) at least 3 non-consecutive days, as tolerated.[30]

The AHA[53] provided a statement on exercise statement for health care professionals recommending that it was safe to begin regular exercise within 24 - 48 hrs following a myocardial infarction (MI), percutaneous coronary intervention (PCI), or coronary artery bypass graft (CABG). Exercise intensities of 50 - 80% VO_{2max} or 50 - 75% $HR_{reserve}$ were recommended, with a corresponding rating of 12 - 13 (6 - 20 scale) using Borg's scale for perceived exertion. Should there be no available exercise testing data available, the AHA suggested setting an upper limit to exercising HR at 20 beats above resting heart rate. The 2001 AHA update for health care professionals recommended light to moderate exercise intensities (25 - 60% VO_{2max}) for cardiac patients, when returning to regular PA and exercise, in order to minimize the risk of subsequent MI.[51]

Following the AHA statement for healthcare providers, a joint scientific statement was released by the AHA and AACVPR[58] recommending regular exercise and PA for CAD patients. The 2000 report recommended regular exercise to include 30 - 60 min/d for 3 - 5 days/wk at an intensity of 50 - 80% VO_{2max}. In addition to exercise training, PA recommendations for a minimum 30 min/d at least 5 days/wk at moderate intensity were provided. Nearly a decade later, the AHA and AACVPR released an update to the initial joint scientific statement. The AHA/AACVPR 2007 update[52] exercise recommendations increased the duration of exercise bouts to included 20 - 60 min/d for 3 - 5 days/wk at an intensity of 50 - 80% VO_{2max}. There were no major differences in regular PA recommendations, being 30 - 60 min/d at least 5 days/wk at moderate intensity.

Defining Light, Moderate, and Vigorous Intensities

Differentiating the differences between light intensity, moderate intensity, and vigorous intensity can be difficult and necessitates operational definitions. The CDC/ACSM statement in 1995 suggested the use of metabolic equivalencies (METS), an absolute measurement of energy expenditure (EE).[49] The following MET ranges were recommended: < 3 METS, light PA; 3 to 6 METS, moderate PA; > 6 METS, vigorous PA.[49] Both the 1998 and 2007 ACSM position stands suggest the use of a relative measurement for light intensity (< 40 $VO_{2Reserve}$), moderate intensity (40 - 59% $VO_{2Reserve}$), and vigorous intensity (> 60% $VO_{2Reserve}$).[50, 54] The AHA suggested the following intensities: light (< 40% VO_{2max}), moderate (40 to 60% VO_{2max}), and vigorous

(> 60% VO_{2max}).[51] The *Physical Activity Guidelines for Americans,2008*[9] suggests the use of the Borg's perceived exertion scale (0 to 10).[59] A score of 5 to 6 represents moderate intensity while a score of 7 to 8 represents vigorous intensity.[9]

Assessment of Physical Activity

PA assessments include criterion, subjective, and objective measures.[60] Criterion methods are often considered the "Gold Standard" for assessing PA, yet they are expensive and limited in the applicability to large scale groups. The 3 major criterion methods used are doubly-labeled water, indirect calorimetry, and direct observation.[60, 61] Doubly-labeled water analyses provide a measure of total (daily) EE by the subject ingesting a standardized amount of a stable isotope in a liquid drink. Urine excretion rates are measuring over 1 - 2 weeks in order to determine total EE, which is considered accurate within 3 - 10% actual EE.[62] However, major limitations to doubly-labeled water assessments include the expenses involved with producing the isotopes and the inability to discern contribution of total daily EE from light, moderate, or vigorous exercise or PA.

Other criterion methods include indirect calorimetry and direct observation. Indirect calorimetry measures VO_2 and carbon dioxide production by use of either ambient air spirometry or closed-circuit spirometry[63, 64] and considered accurate within ± 4%.[65] Intensities of activities are classified by the percent (%) of maximum aerobic capacity (VO_{2max}) and $\%VO_{2reserve}$. For example, the following reserve capacities are used to classify light, moderate, and vigorous intensities: < 40% $VO_{2reserve}$, 40 to 60% $VO_{2reserve}$, and > 60% $VO_{2reserve}$.[50] The major limitations to indirect calorimetry include the impracticality for researching large populations, the expenses involved from being predominantly laboratory-based, and accessibility issues.

Direct observation of PA involves the use of a trained observer directly monitoring the daily PA habits of an individual. The observer utilizes a compendium of MET values for various PA to quantify EE and classify PA. The major limitations for use of this method include the required use of a trained observer, interpretation of the activity by the observer, and potential reactivity by the subject to purposefully increase PA habits.[60, 61] Further, PA and exercise intensities are largely dependent on the interpretation of the observer.

Subjective PA assessments include the use of reporting PA by use of daily logs and completing 1 of many types of PA questionnaires. The latter are widely used by reporting agencies, such as the CDC, due to the affordability and ease of distribution to large populations. Examples of questionnaires used to assess PA include the long or short version International Physical Activity Questionnaire (IPAQ)[66], Physical Activity Scale for the Elderly,[67] and Yale Physical Activity Survey.[67] Although many questionnaires have been validated among various demographical populations, caution should be used when interpreting the results of studies utilizing this method for reasons of under estimation of PA, overestimation of PA, individual ability to recall PA habits, and the individual ability to interpret survey questions.[60, 61, 68, 69]

An early study assessing the accuracy of self-reported PA by use of the Stanford Seven-day Physical Activity Recall, both immediately after and 1 week following PA suggested that reporting biases were common.[68] Subjects were observed from a distance and unaware of the observer. Immediate recall of PA was significantly correlated with direct-observation of PA habits; however, 19% of subjects underreported sedentary time and 69% of subjects over reported aerobic activities when completing the questionnaire following one week of PA. Males tended to overestimate aerobic PA while females underreported similar activities. Although, subject recall of PA intensities was significantly correlated with observer reports for intensities, being: sedentary, slow movement, and fast movement. More recent research has validated the use of PA recall questionnaires, such as the IPAQ.[66] Recall of vigorous intensities were better than that for moderate intensities, but no significant differences in correlations between what was observed and recalled were noted. Regardless of the tool used or the recall period, subject bias and interpretation of the assessment tool remain a major limitation for subjective PA assessments.

Objective PA assessments include the use of motion sensors, such as accelerometers and pedometers.[60, 61] Accelerometers and pedometers are light weight, easy to use, and validated among many populations.[18, 24, 70] Accelerometers and pedometers are considered accurate within ± 0.1 to 0.4% and ± 1 to 3% of actual activity counts/min and steps/d, respectively, and is largely dependent on the manufacturer and BMI status (non-obese vs. obese).[71, 72] Accelerometers contain piezoelectric sensors that measure body movement in both acceleration and frequency through the vertical, medio-later, and anterior-posterior dimensions (planes).[60] Although, not all accelerometer units contain all 3 sensors. Accelerometers can be attached to the ankle, waist, and other body regions where dynamic movements are detected. Data collected through dynamic movements is then translated to activity counts, an estimation of PA intensity, and total PA accumulated over a period of time.[70] Common intensities cut-points for light (693-

1,951 activity counts/min), moderate (1,952-5,724 activity counts/min), and vigorous (≥5,725 activity counts/min) activities are utilized with 60-second epochs.[73] Despite the effectiveness and accuracy of accelerometry to objectively quantify PA, accelerometers are substantially more costly to purchase and maintain than a pedometer. For this reason, pedometers are likely to be utilized when assessing and motivating PA habits in large-scale studies.

Dr. Yoshiro Hatano[17] reports that pedometers have been used in Japan for more than 30 years to measure and promote PA. More recently, pedometers have been utilized in America to objectively assess and research PA, and the use of pedometers have become increasingly popular for use in health promotion among Americans as many styles and types of pedometers have become widely available to the public.[18] They are affordable, increase PA awareness, and motivate increased levels of PA from minimal to moderate amounts through immediate feedback.[27] Moreover, it has been suggested that pedometer-based interventions may increase an individual's potential to engage in greater amounts of moderate to vigorous PA when compared to a time-based recommendations.[19, 74] Reports suggest a correlate of moderate to vigorous intensities is a rate ≥ 100 steps/minute.[17, 75]

Earlier pedometers largely utilized a spring-levered, mechanical arm to measure and display the total number of steps.[76] They contained no batteries, required a large amount of vertical displacement in order to accurately measure stepcounts, and were most accurate when the unit was positioned in a vertical plane, perpendicular to the ground.[76] Moreover, they did not measure time spent in moderate to vigorous PA. Late-model spring-levered pedometers display moderate to vigorous PA minutes yet still require strict vertical positioning.[76]

In addition to the late-model mechanical pedometers, select late-model pedometers include a piezoelectric strain-gauge (accelerometer) that measure and display daily stepcount activity. More sophisticated pedometers include an internal memory ranging from few to several days, recalling stepcounts, EE, distances walked, and time spent in moderate to vigorous PA.[76] The advantage of using a late-model electric pedometer compared to the conventional mechanical pedometer is the reliability of stepcounts. While the mechanical pedometer is most accurate in the vertical plane without axis tilt, the electronic pedometer can be accurate within ± 1 - 3% of actual stepcounts when tilted upwards of 10 degrees from the vertical plane.[76] Moreover, Crouter et al.[76] reports that the electronic pedometer is more accurate at slower speeds, lower vertical displacement, and greater degree of vertical tilt when compared to the mechanical pedometer, which underestimated stepcounts by 18.7±23.7% given the above circumstances.

As previously mentioned, the primary purpose of a pedometer it to measure and display daily stepcount activity, an objective quantification of daily PA.[17, 24, 29] Most PA studies report stepcounts in daily averages (steps/d) following a study length of a minimum of 3 days/wk, including at least 1 weekend day.[77] Tudor-Locke et al.[29] suggested the following cut-points for PA status:

Highly Active:	≥12,500 steps/d
Active:	10,000 - 12,499 steps/d
Moderately Active:	7,500 - 9,999 steps/d

Lightly Active:	5,000 - 7,499 steps/d
Sedentary:	<5,000 steps/d

Alternatively, a co-author to Tudor-Locke,[29] Dr. Yoshiro Hatano, developed separate cut-points for PA status. The following cut-points were provided by Dr. Hatano:

Highly Active:	≥12,000 steps/d
Active:	≥10,000 - 12,000 steps/d
Moderately Active:	>8,000 - 9,999 steps/d
Somewhat Active:	≥5,000 - 7,999 steps/d
Somewhat Sedentary:	3,500 - 4,999 steps/d
Sedentary:	1,500 - 3,499 steps/d
No Moving:	≤1,499 steps/d

Electronic pedometers cost substantially more than mechanical pedometers; however, they are far more cost-effective than the traditional uni- or tri-axial accelerometer and yield greater accuracy, compared to the mechanical pedometer, when assessing a slower, overweight, or obese population. Despite the limitations of mechanical and electronic pedometers, they are considered efficacious for large-scale studies and provide PA assessment objectivity.

Pedometer Interventions and Behavior Modification to Increase Physical Activity

Bravata et al.[26] recently published a 26 study meta-analysis (mean treatment length, 18wks; n = 2767; 2351 females; 415 males; 49±9yrs) of pedometer interventions incorporating generalized stepcount goals (i.e. 10,000 steps/d) and individualized stepcount targets for healthy adults and adults with clinical diagnoses. Important exclusion criteria to note included: studies with less than 5 subjects, if subjects were blinded from pedometer feedback, if the study was conducted utilizing hospitalized subjects, or if the pedometers were used to measure the effects of a pharmaceutical agent on PA. Treatment groups significantly increased their daily stepcounts by 26.9% (2998 steps/d) from baseline measurement (7473±1385 steps/d). Control subjects were given no stepcount goals and not blinded from pedometer feedback. There was no significant increase in daily stepcounts, which suggested a lack of reactivity to PA assessment.[78, 79]

Noteworthy studies included in the above study were conducted by Croteau et al.[80] and Williams et al.[81] Croteau et al.[80] recruited college employees (n = 37; 29 women; 8 men; 44.3±9.3yrs) for an 8-week pedometer intervention. Subjects were assigned to 1 of 3 groups, dependent on baseline daily stepcount activity, and provided individualized stepcount goals that were calculated from baseline measurement. Subjects with a baseline measurement of < 8,000 steps/d were requested to increase steps/d by 10% every 2 weeks until ≥ 10,000 steps/d was achieved. Subjects with a baseline measurement of 8,000 - 10,000 steps/d were requested to increase daily stepcounts by 5% every 2 weeks until ≥ 10,000 steps/d was achieved. Once subjects achieved ≥10,000 steps/d, they were asked to maintain ≥ 10,000 steps/d for the remainder of the study.

Mean baseline stepcounts for all subjects were 8,565±3,121 steps/d. Subjects in the 10% increase group averaged 5901±1125, subjects in the 5% increase group averaged 10,155±1439, and subjects in the maintenance group averaged 12,371±1261 steps/d. At the conclusion of the 8-week study, subjects increased daily stepcounts by 23% (2,272±1473 steps/d), averaging 10,538±3,681 steps/d. Subjects in the 10% group averaged 8,173±2,598, subjects in the 5% group averaged 12,687±3,219, and subjects in the maintenance group averaged 12,984±2,927 steps/d. Subjects in the 10% group showed the most significant increase (39.9%), followed by the 5% group (24.9%). The maintenance group showed no significant increase (5%) in daily stepcounts. This study appears to be one of few studies, if not the only available published study, to incorporate attainable individualized stepcount goals calculated from baseline measurement. The methodology of increasing stepcount averages every 2 weeks may have been too limited for the study population. Incorporating similar methodology for increased daily stepcount activity weekly compared to every 2 weeks would be of interest.

Williams et al.[81] recruited post-menopausal African American women (n = 43; mean age, 57.6yrs, range 50 - 68yrs) to participate in a 7-week pedometer intervention. Subjects were placed into 2 groups, contract and non-contract. Both contract and non-contract groups were counseled on setting individual stepcount goals following baseline, which frequently was set at ≥ 10,000 steps/d. The contract group signed a written agreement stating that the subject will adhere to the program. Non-contract subjects received no further intervention other than goal setting and were asked to complete and return weekly stepcount logs. There was no significant difference between groups at baseline, averaging 4,914 steps/d. By study completion, there was a significant increase in stepcount activity for both groups, averaging 8,100 steps/d. It was reported that 81% and 31% of contract and non-contract subjects achieved individual goals, respectively. There was no significant difference in weekly stepcounts between groups. A major incentive for contract subjects to achieve target stepcounts was to receive pre-arranged rewards (rewards undisclosed) for completing the study and adhering to the contract. A major limitation to the interpretation of the goal setting session is the presentation of information on the 10,000 steps/d to all subjects; even though, it has been noted that 10,000 steps/d may be an unrealistic goal for sedentary populations.[29, 76] Additionally, it may be better served to withhold setting target stepcounts with the non-contract group in order to serve as a control group.

Few studies have reported the efficacy of pedometer-based interventions compared to time-based interventions on increases in PA.[19, 34, 74] Stovitz et al.[19] compared the efficacy of a 9-week pedometer intervention compared to time-based PA recommendations. Subjects (n = 94; 63 women; 31 men; 41.2±13.1yrs) were recruited from a family medical practice and randomly assigned to either the pedometer or time-base PA group. Only 44 subjects (47%) completed the study and were included for data analysis. The pedometer group wore a Yamax Digiwalker SW-200 (Yamax USA, Inc, San Antonio, TX), received behavioral change questionnaires, and was instructed to increase daily stepcounts by 400 steps/d each week following baseline, irrespective of baseline stepcount activity. For comparison, the time-based group was not given a pedometer but received behavioral change questionnaires weekly and was instructed to increase PA time by 10% each week following baseline. All subjects, pedometer and time-based, were instructed to keep a daily log of daily stepcount activity (pedometer group) and PA time (time-based group).

By the completion of the study, the pedometer group significantly increased average daily stepcounts by 41% (2,076±530 steps/d) from baseline (6,779±4,079 steps/d) to week 9 (8,855±4,690 steps/d). In addition to the increase in daily stepcounts, PA behavioral change for pedometer subjects significantly increased from a classification of contemplation to action. There were no significant differences in PA behavioral change between groups. No results were provided for the time-based group regarding mean PA time at baseline or study conclusion; thus, major conclusions or comparisons between groups should be viewed with caution. Another major limitation for this study includes the absence of pedometry comparison for the time-base group.

Baker[34] presented results from a 4-week study, comparing the efficacy of a pedometer-driven PA intervention to time-based PA recommendations, at the 6th International Conference on Walking in the 21st Century in Zurich, Switzerland. Subjects (n = 71, 54 women, 17 men; 42±11yrs) were recruited from a Glasgow, Scotland community and randomly assigned to either the pedometer intervention, time-based, or control group. Baseline stepcounts were an estimated 5,900, 6,800, and 6,500 steps/d for pedometer, time-based, and control groups, respectively. Following baseline, pedometer subjects were encouraged to increase stepcounts by 1,500 steps/d for weeks 1 and 2 and 3,000 steps/d for weeks 3 and 4. Time-based subjects were blinded from pedometer stepcounts and encouraged to increase PA by 15 min/d at least 3 days/wk for week 1, 15 min/d at least 5 days/wk for week 2, 30 min/d at least 3 days/wk for week 3, and 30 min/d at least 5 days/wk for week 4. Control groups were instructed to continue with usual activities and not alter PA habits.

By week 4, an estimated 7,900 (pedometer), 7,500 (time-based), and 6,100 steps/d (control) were observed. No standard deviations were provided. Although no statistical analyses are provided for daily stepcounts between groups, it appears the pedometer group substantially increased daily stepcounts compared to time-based and control groups. Stage of change, self-efficacy, and decision balance was assessed at baseline and study completion among all groups. Stage of change results suggested a significant decrease in the number of pedometer subjects (n = 17) considering themselves being inactive at baseline to the number of subjects (n = 4) considering themselves inactive at study completion. There were no significant differences between groups for self-efficacy or decision balance. A 7-point Likert scale (1 = extremely unconfident, 7 = extremely confident) was used for self-efficacy, with a mean score of 6 for all groups. The decision balance questionnaire contained a 5-point Likert scale, and no significant differences were found between groups at baseline or study completion.

Baker[34] provides one of few studies to assess behavioral change in a pedometer intervention study; however, there are many limitations to note with this study. With a training period of only 3 weeks, it may not be adequate in length to assess significant differences between groups for behavioral change or stepcount activity. Increasing daily stepcounts by 1,500 and 3,000 steps/d may be unrealistic for some individuals, and a more individualized recommendation (i.e. weekly increase of % baseline stepcounts) may be more suitable. Furthermore, no statistical analyses are provided for stepcounts activity leaving conclusions of the results to the interpretation of the reader.

Hultquist et al.[74] studied the efficacy of a 6-week pedometer intervention (10,000 steps/d recommendation) to time-based (30 min/d) PA recommendations in previously sedentary women (n = 58; 45.0±6.0yrs). Subjects were randomly assigned to pedometer and time-based groups where pedometer subjects were instructed to accumulate ≥ 10,000 steps/d, and time-based subjects were instructed to accumulate ≥ 30 min/d of moderate to vigorous PA. Subjects with stepcounts ≤ 7,000 step/d at baseline were instructed increase daily stepcounts to ≥ 10,000 steps/d, and subjects with stepcounts ≥ 10,000 steps/d at baseline were instructed to maintain current stepcount activity throughout the study. Subjects in the time-based group were instructed to walk briskly for 30 min/d on most, preferably all, days of the week, which is consistent with the Surgeon General's recommendations.[7] Pedometer subjects wore two pedometers, one sealed (New Lifestyles NL-2000) and one unsealed (Yamax Digiwalker SW-200) for immediate feedback and data recording. Time-based subjects wore a sealed pedometer (NL-2000) and were asked to record time on, time off, and daily PA.

There were no significant differences between pedometer or time-based subjects at baseline, averaging 5,760±1,143 steps/d. Both groups significantly increased daily stepcounts from baseline to study conclusion, averaging 10,159±292 steps/d for pedometer subjects and 8,270±354 steps/d for time-based subjects. Additionally, pedometer subjects accumulated significantly greater stepcount activity compared to time-based subjects at study conclusion (10,159±292 vs. 8,270±354 steps/d). On days pedometer subjects met the stepcount goal, subjects averaged 11,775±207 steps/d. On days time-based subjects met the time-based goal, subjects averaged 9,505±305 steps/d, which is significantly less stepcount activity than when pedometer subjects met the stepcount goal.

The 10,000 steps/d recommendations served well for this study population, but it may be unrealistic for older, less active, or less functional individuals. No behavioral change analyses were performed to compare the impact of a pedometer-driven intervention to time-based PA recommendations, which would have been useful in drawing further conclusions for the efficacy of pedometer-driven compared to time-based PA recommendations.

In conclusion, it appears that individualizing target stepcounts is efficacious in facilitating increased PA and possibly provides behavioral modification. However, there is scant research on behavioral changes, and the optimal method for delivering a pedometer-driven intervention among healthy and clinical populations remains unknown.

Cardiac Rehabilitation Services

Cardiac Rehabilitation programs provide a comprehensive, multidimensional secondary prevention service that combine prescriptive exercise training with CAD risk factor modification.[40] Secondary prevention is the integration of a healthy, active lifestyle following a CVD or CAD related diagnosis(es) or injury. The goal of regular participation in CR programs is to increase functional capacity, which will improve activities of daily living, improve CAD modifiable risk factors through increased PA and education, and increase in quality of life.[30, 40, 52]

Patients experiencing a major cardiac event and/or receiving a coronary intervention are usually prescribed to 1 of 3 CR phases, which is largely dependent on physician referral and insurance coverage. According to the AACVPR,[36] patients admitted for overnight stay are usually referred to inpatient CR services. Patients discharged from inpatient CR are then evaluated for referral to early-outpatient CR services. Patients discharged from early-outpatient CR, or those without insurance coverage or underinsured to compensate early-outpatient CR services, may be referred to maintenance CR services. These stages of CR were formerly known as Phase I, Phase II, and Phase III CR, respectively. Primary diagnoses for referral to CR may include one or more of the following: myocardial infarction, coronary artery bypass graft, stable angina, heart valve surgical repair or replacement, percutaneous transluminal coronary angioplasty, or heart/lung transplantations.[36, 40, 52]

Inpatient CR includes extensive monitoring (electrocardiogram, blood pressure, and heart rate), PA counseling, activities of daily living with small bouts supervised ambulation activities within hospital quarters, and education on CAD risk factor management.[36, 52] Upon discharge from inpatient CR, patients are given a home exercise plan that encourages structured daily PA and encouraged to enroll into early-outpatient or maintenance CR, as appropriate.

Following discharge from inpatient CR, patients usually enter early-outpatient CR within 3 - 6 months, up to 1 year, if referred by physician and covered by medical insurance. Patients in early-outpatient CR receive extensive telemetry monitoring and supervision while exercising, similar to inpatient CR.[36, 40, 51, 52, 82] The number of monitored sessions may vary from as few as 6 to as many as 36, depending on individual risk stratification and insurance reimbursement.[53] For further management and preventative measures, early-outpatient CR patients receive education on lifestyle management, depression, and PA and dietary habits.

Patients discharged from early-outpatient CR, or those with non-covered diagnoses (i.e. congestive heart failure) discharged from inpatient CR, are usually referred to maintenance CR, which focuses on the importance of maintaining increased levels of PA habits by exercising on most days of the week, preferably within CR facilities.[52] Usual monitoring for maintenance CR services include blood pressure, heart rate, and other signs and symptoms when indicated.

Although the goal of CR is to increase the functional capacity of CR patients, recent studies on referral rates report only an estimated 30% of subjects are referred and attend early-outpatient CR.[83] Additionally, Dr. Esther Hellman[84] reported that nearly 50% of subjects discharged form inpatient CR services reported exercising regularly 12 months following discharge. At 18 months post discharge, attrition rates for regular exercise reached nearly 70%. These surprising statistics suggest that the majority of CR patients discharged from inpatient CR services return to a pre-contemplative state for PA stage-of-change, with no intention of exercising.[85]

<u>Early-Outpatient and Maintenance Cardiac Rehabilitation Physical Activity Assessment</u>

Recent studies assessing the PA levels of CR patients reported that patients participating in both early-outpatient and maintenance CR fell significantly short of recommended amounts of PA on days not attending CR services.[22, 23, 31] PA assessments were performed in terms of steps/d, min/wk, and kcal/wk.

Ayabe et al.[23] studied the PA patterns of patients, who have participated in a maintenance CR program ≥ 3 months. Subjects (n = 77; 53 men; 24 women; 68.1±9.2yrs) wore a Lifecorder pedometer (New Lifestyles, Inc. Lee's Summit, MO), which is a uni-axial accelerometer, to assess EE and activity minutes on days attending rehab and on non-rehab days. Maintenance CR sessions were conducted on Monday, Wednesday, and Friday mornings. Activity minutes in light, moderate, and vigorous intensities were observed as being 375.5±124.5, 125.2±109.4, and 5.7±12.8 min/wk, respectively. PA minutes on rehab days were significantly greater than non-rehab days, being 59.7±49.3 vs. 49.3±19.3 (light), 26.4±20.4 vs. 10.5±14.6 (moderate), and 1.4±3.0

vs. 0.4±1.7 min/d (vigorous). Average estimated weekly EE was 1597±846 kcal/wk for all subjects. Men expended significantly more kcal/wk than women (1778±875 vs. 1197±623 kcal/wk) before adjusting for body weight, and EE on days attending CR was significantly greater than non-rehab days (299±161 vs. 177±113 kcal/d) for all subjects. Hambrecht et al.[16] suggested 1,500 and 2,200 kcal/wk of EE to halt and regress coronary atherosclerotic lesions. Less than half (43%) of the subjects in this study exceeded recommended EE to halt lesion progress, and even fewer (16%) exceeded EE recommendations to regress atherosclerotic lesions. This is one of few, if not the first, studies to assess the EE and intensity of activity minutes of maintenance CR patients, comparing rehab vs. non-rehab days.

Jones et al.[31] conducted a PA assessment of male patients (n = 25; 60.0±8.3yrs; 13 PTCA; 7 CABG; 2 ICD; 1 CHF; 1 MI) participating in a maintenance CR program. Subjects wore an Actigraph GT1M (Pensacola, FL) dual-axis accelerometer to measure daily stepcounts on maintenance CR and on non-CR days. On days attending maintenance CR services, subjects were considered to meet stepcount criteria for PA recommendations (≥ 10,000 steps/d), which is considered to be equivalent to 30 min/d at moderate to vigorous intensity.[17] Over the 7-day assessment, subjects averaged 6,907±510 steps/d. Subjects averaged significantly more stepcount activity on rehab days (10,087±631 steps/d) compared to rehab days (5,287±520 steps/d). When subjects performed planned bouts of home exercise on non-rehab days, they accumulated significantly more stepcount activity (6,366±667 steps/d) than those not exercising at home on non-rehab days (3,668±529 steps/d). There are known seasonal variations to the amount of PA accumulated in colder and warmer months, which may be a possible explanation for limited PA outside CR services,[32] and a similar study in warmer months would be of interest.

Stevenson et al.[22] conducted a PA assessment of patients participating in an early-outpatient CR program. Subjects (n = 22; 14 male; 8 female; 65.6±13.2yrs; 16 PTCA; 4 CABG; 1 cardioversion; 1 MI) wore a New Lifestyles NL-1000 pedometer and an Actigraph GT1M accelerometer and to assess for daily stepcounts and activity minutes (light, moderate, vigorous) during the first and final week of early-outpatient CR. Subjects averaged 5,290±1,561 steps/d for the first week assessment of early-outpatient CR. There were no significant differences between first and final weeks of early-outpatient CR (5,290±1,561 vs. 5,730±1,447 steps/d). However, there was significantly greater stepcount PA on days attending early-outpatient rehab (6,503±1,663 steps/d) when compared to non-rehab days (4,517±1,517 steps/d).

Activity time was assessed using 60-second epoch activity count cut-points for light (260-1951 counts/min), moderate (1952-5724 counts/min), and vigorous ((>5724 counts/min) PA.[73] No subjects were determined to engage in vigorous PA for either entry or exit week analyses. Moderate intensity PA significantly increased from entry (13.9±2.3 min/d) to exit (18.7±2.5 min/d). Subjects engaged in significantly more moderate intensity on rehab vs. non-rehab days, averaging 19.7±3.3 vs. 12.8±2.0 min/d.

The trend for inactivity and sedentarism appears to be prevalent among early-outpatient and maintenance CR patients alike. Similar to the study by Jones et al.[31], Stevenson et al. conducted their study during colder months. With recent literature on depression[86] and hopelessness[87] among CAD patients, a similar study conducted in warmer months may be of benefit when considering seasonal affective disorder and the limited functional capacity of early-outpatient CR patients limiting the ability to be PA in colder climates.

Summary

Both the AHA and AACVPR recommend regular exercise and PA for maintenance CR patients, being 20 - 60 min/d a minimum of 3 to 5 days/wk at an intensity of 50 to 80% VO_{2max} and 30 - 60 min/d moderate intensity at least 5 days/wk, respectively.[52] Available studies assessing PA habits of early-outpatient and maintenance CR patients report the majority of patients as being inactive and sedentary on days not attending CR services, which is the majority of the week. Reports have identified the use of pedometry as a useful, efficacious tool to increase PA habits from sedentarism to a physically active lifestyle among non-clinical populations. However, there have been no studies on the effectiveness of a pedometer intervention among a CR population; thus, research utilizing a pedometer-driven intervention among this unique clinical population would be of interest.

CHAPTER III

Methodology

The primary purpose of this study was to determine if a pedometer-driven physical activity (PA) intervention with individualized stepcount goals would be more efficacious in yielding greater amounts of PA than the usual time-based PA recommendations given to maintenance cardiac rehabilitation (CR) patients between 3 difference time-points: baseline, week 4, and week 8. Additionally, the secondary purpose of this study was to assess differences in stepcount activity on days attending maintenance CR and on non-rehab days. Institutional Review Board approval from Ball State University and Ball Memorial Hospital was obtained prior to subject recruitment and data collection.

All subjects were apprised of the purpose, procedures, risks, and benefits of the study and completed an informed consent that detailed the study's protocol, timeline, and explanation of all inherent risks and benefits of study participation. In addition to the informed consent, all subjects signed a Health Insurance Portability and Accountability Act authorization form that released patient information and records related to study involvement to all parties involved. Furthermore, all subjects were encouraged to ask questions about the study protocol and procedures during the initial visit and throughout the study.

Subjects

Patients were recruited for this 8-week pedometer intervention study as they entered maintenance CR from either early-outpatient CR or as a direct admit from inpatient CR. Subjects admitted directly from inpatient CR were approached within the first 3 visits to maintenance CR, and subjects entering from early-outpatient CR were approached within their last 3 sessions of early-outpatient CR. Each patient entering maintenance CR was presented with the opportunity to be included in this intervention study, read a prepared script, and interviewed for inclusion criteria by research staff.

Screening procedures consisted of interviewing the potential subject for inclusion and exclusion criteria. Inclusion criteria for subject participation consisted of the following: male or female gender, ≥18 years of age, ability to self-ambulate (locomotion without reliance on assistive device) for periods of at least 6 minutes, CAD as the primary diagnosis, entering maintenance CR for the first referral, and absent of cognitive impairment (dementia). Exclusion criteria for study participation or data inclusion consisted of stepcounts greater than 7,500 steps/d as a daily average during baseline assessment and failure to attend maintenance CR at least 2 days/wk.

Following screening procedures, subjects were stratified into 1 of 2 groups, pedometer feedback (PF) or usual care (UC). Every other male and female was placed into PF and UC groups. Both groups wore a pedometer and completed behavioral change questionnaires (Appendix B) throughout the study. Both groups were encouraged to participate in maintenance CR at least 40 - 50 minutes at moderate intensity most days of the week, as tolerated. Additionally, subjects in the UC group (control) were encouraged to follow-up with 30 - 40 minutes PA outside maintenance CR. Both exercise and PA recommendations are equivalent to the PA recommendations for CR patients set forth by AACVPR[52] and for healthy older adults recently published by AHA and ACSM.[9, 55] Subjects in PF group received similar recommendations for attendance to maintenance CR services; however, PF subject received no time-based PA recommendations for use at home. PA recommendations for PF were in the form of stepcount goals that reflected a 10% increase above mean baseline stepcounts that were added to each weekly goal (weeks 2 - 8) and was to be achieved all days of the week, including days attending maintenance CR. For comparison, UC subjects wore a pedometer for 3 weeks (baseline, week 4, and week 8).

Study Overview

Prior to study participation, descriptive data was obtained from all subjects through direct measurement and data retrieval from patient records. This included age, gender, primary diagnosis, height, body weight, and calculation of body mass index (BMI). Age, gender, and primary diagnosis were retrieved from patient records while height and weight were measured during the initial visit. Minimal clothing and accessories (i.e. removal of coat, keys, cell phone, and etc) was required during measurement; however, all subjects wore athletic shoes for both the weight and height measurements. Weight was measured using a digital physician's scale (Detecto, Webb City, MO) and rounded to the nearest 0.1 pound. Height was measured using a modified stadiometer, repeated twice, and rounded to the nearest 0.25 inch, and the averaged. BMI was calculated as weight over height (kg/m^2).

Following the collection and measurement of characteristic data, all subjects performed a 6-minute walk test and a 20-step test to ensure pedometer accuracy. The walk test was performed by all subjects prior to baseline assessment and upon completion of week 8. Subjects discharged from early-outpatient CR within 2 weeks of maintenance CR enrollment were not required to complete the baseline walk test as their test results were obtained from patient records. Otherwise, subjects entering maintenance CR directly from inpatient CR or returning form an extended leave following early-outpatient CR performed the walk test at baseline.

A pedometer 20-step test was performed following the 6-minute walk test. The investigator walked alongside the subject for 20 consecutive steps and verified that the pedometer measured 20±2 steps. If the pedometer failed to read 20±2 steps, it was repositioned, and the 20-step test was repeated. If the successive step test failed to read 20±2 steps, an alternate pedometer was used. Following the successful step test, subjects were instructed to wear the pedometer at their waistline, preferably on a belt, and to ensure that the safety clip was attached. Subjects unaccustomed to wearing belts were provided an elastic band for use with the pedometer to ensure proper placement.

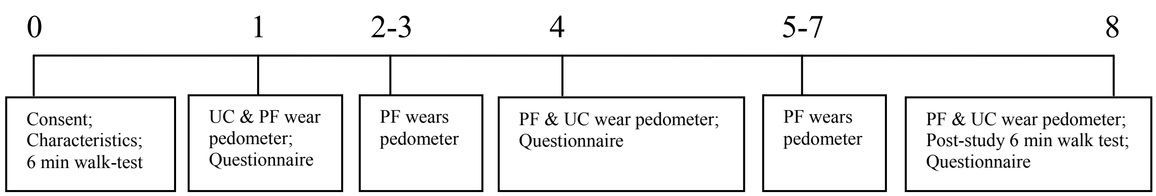
The first week of this study served as the baseline assessment for all subjects; therefore, the procedures for UC and PF were alike. They wore a pedometer each day from wakening until bedtime and completed a behavioral change questionnaire packet. The pedometers were not sealed (subjects were not blinded form stepcount feedback) as recent studies have reported no significant increase in daily stepcounts in the absence of stepcount goals and having access to pedometer feedback.[26, 78] However, subjects were requested to refrain from opening and/or tampering with the pedometer. Pedometer usage (time on and off) was recorded daily on the given log sheet (Appendix C), and the questionnaire packet was requested to be returned prior to the conclusion of baseline assessment. In addition to baseline, both groups were asked to complete the questionnaire packet at week 4 and 8. A cover letter with instructions and overview of the time required to complete the packet was provided to all subjects and was expressed verbally at time of distribution. The packet comprised 3 separate questionnaires (self-efficacy, social support, and decision balance) that contained items identifying the likelihood and determinants of a physically active lifestyle given various circumstances, including: family and friend influence, energy level, locus of control, and scheduling.

Subjects placed in the UC group were informed that they would wear the pedometer 2 additional times as stated previously, and the procedures for these additional assessments were similar to baseline assessment. Subjects recorded daily pedometer usage (date, time on in morning, and time off in evening) on the given pedometer log form and returned the questionnaire packet prior to the end of fourth and eighth week.

Subjects placed in the PF group were informed that they would continue wearing the pedometer for the entirety of the study following baseline assessment. They received similar directions to wear the pedometer and record daily usage as was given during baseline; in addition, PF was provided weekly log sheets (Appendix D) that encouraged the subject to obtain stepcount feedback from the pedometer throughout each day at noon (lunch), evening (dinner), and bedtime. To promote compliance of receiving pedometer feedback and ensuring proper placement, each subject was reminded of the procedures for receiving pedometer feedback, properly positioning the pedometer, and ways to increase daily steps each week when the subject received a new log form and stepcount goal. Additionally, PF subjects were apprised of the increase in target stepcounts each week following baseline, which was 10% of baseline steps/d added to each weeks previous target stepcount. If a subject averaged 4,000 steps/d at baseline, they would be given a stepcount goal of repeating baseline averages with an addition of 400 steps/d that would be added to each subsequent weekly stepcount goal. For example, the stepcount goal for week 2 would equal 4,400, week 3 would equal 4,800, and week 4 would equal 5,200 steps/d.

To ensure collection of all PA accumulated throughout the study, all subjects were encouraged to refrain from utilizing non-ambulatory modes (rower, AirDyne, or NuStep). However, if subjects required use of the NuStep as an ancillary mode to the treadmill, they were instructed to record the total amount of steps accumulated on the NuStep device on the given pedometer log form. The steps accumulated on the NuStep were then added to the stepcount total for each respective day.

Study Timeline



Activity Assessment Device

The NL-1000 pedometer (New Lifestyles, Lee's Summit, MO) was used for this study. The NL-1000 utilizes a piezoelectric strain gauge, much like a standard accelerometer, to determine and display steps/d and moderate to vigorous PA minutes.[76]

Additionally, the NL-1000 stores the most recent 7 days of stepcount activity and PA minutes in the form of 1 day epochs, which resets (zeros) each day at midnight.[76]

Procedures

The 6-minute walk test was performed by walking a predetermined distance between 2 doorways measuring 97.5 feet. Procedures of the walk test administration and the importance of providing a consistent effort throughout the test was explained to each subject. Borg's Rate of Perceived Exertion[59] scale of 6 - 20 was reviewed with each subject, and an intensity of 15 was instructed as the maximum intensity to be achieved throughout this process.[51, 53] The test administrator stood equidistant to both doorways in order to encourage, monitor, and provide feedback to the subject throughout the assessment. Moreover, efforts were made to provide the same test administrator for each subject's pre/post assessment in order to control for inter-examiner variability.[51, 88, 89]

Behavioral Change Questionnaire

All subjects asked to complete a behavioral change questionnaire packet, consisting of a self-efficacy (Likert scale 1-not at all confident to 5-extremely confident), social support scale (Likert scale 1-none to 5-very often), and decision balance scale (Likert scale 1-not at all important to 5-extremely important). Changes in self-efficacy (confidence) was assessed by observing a change in the sum of scores (higher score equals greater self-confidence). Social support changes were assessed by observing changes in the sum of scores for family and friend influences (higher score equals greater support from friends and family). Decision balance was assessed by observing changes in the difference of pros and cons questions. The greater the difference from 0, positively, the subject is suggested to experience less barriers to PA than the subject with a score closer to 0, and negatively.

Data Validation Criteria

All stepcount data was analyzed for inclusion in statistical analyses. Inclusion criteria consisted of wearing the pedometer ≥8 hrs/d, accumulating ≥1,500 steps/d, and meet the aforementioned ≥ 4 days/wk (≥ 3 weekdays and ≥ 1 weekend day). In addition to stepcount criteria, all subjects must have completed the behavioral questionnaires.

Statistical Analyses

Data analysis was performed using SPSS 16.0 for Windows (SPSS Inc., Chicago, IL). A 2-way ANOVA with repeated measures was used to assess differences in pedometer stepcounts, moderate to vigorous activity (MVPA) minutes, and 6-minute walk test distance (6MWTD). A 3-way ANOVA was used to assess differences between groups and all subjects for daily stepcount activity and MVPA on rehab vs. non-rehab days. A MANOVA was used to assess differences in behavioral change questionnaire responses between groups and for all subjects. Significance is denoted by $P < 0.05$.

CHAPTER IV

RESEARCH MANUSCRIPT

Journal Format: Journal of Cardiopulmonary Rehabilitation and Prevention

Title: Pedometer Intervention to Increase Physical Activity of Patients Entering a Maintenance Cardiac Rehabilitation Program

Abstract

Purpose: The primary purpose of this study was to determine if a pedometer-driven physical activity (PA) intervention with individualized stepcount goals would be more efficacious in yielding greater amounts of PA than the usual time-based PA recommendations given to maintenance CR patients. Additionally, the secondary purpose of this study was to assess differences in stepcount activity on days attending maintenance CR and on non-rehab days.

Methods: Subjects entering maintenance CR for the first referral were recruited for study participation and stratified into pedometer feedback (PF) and usual care (UC) groups. All subjects wore a New Lifestyles NL-1000 pedometer. PF subjects wore the pedometer for the duration of the 8-week study. For comparison, UC subjects wore the pedometer at baseline, week 4, and week 8.Both groups were encouraged to accumulate a minimum of 40 - 50 min/d at moderate intensity when attending maintenance CR. UC subjects were encouraged to follow-up with at least 30 min/d PA outside maintenance CR, while PF subjects were given daily stepcount goals. Stepcount goals were calculated as 10% of baseline stepcounts and added weekly to increase daily goal. All subjects completed a 6-minute walk test at baseline and week 8, and behavioral change questionnaires were completed at baseline, week 4, and week 8.

Results: A total of 18 subjects (PF, n = 9, 53.7±8.0; UC, n = 9, 60.2±9.6 yrs) completed the 8-week study. There were no differences between groups at baseline. PF group increased daily stepcounts by week 4 (19%, 1,080±649 steps/d) and 8 (44%, 2,468±846 steps/d) in addition to days attending rehab by week 4 (14%, 1064±45 steps/d) and 8 (36%, 2,711±423 steps/d) and non-rehab days by week 8 (42%, 1,747±759 steps/d). PF subjects accumulated greater daily stepcounts compared to UC subjects at weeks 4 (26%, 1,405±393 steps/d) and 8 (48%, 2,612±284 steps/d). UC subjects accumulated greater stepcounts on rehab compared to non-rehab days, but no changes were found from baseline for daily stepcounts, rehab, or non-rehab days. There was a time effect for responses to social support from friends for all subjects (baseline to week 4) and a time by group effect for decision balance pro-questions by week 4 where PF significantly increased, UC significantly decreased, and both groups where significantly different.

Conclusions: The results of this study suggest that a pedometer-driven PA intervention yields significantly greater stepcounts compared to time-based PA recommendations among maintenance CR patients.

Key Words: Maintenance cardiac rehabilitation, phase III, pedometer, intervention, stepcounts, physical activity.

Condensed Abstract

This study assessed the effect of providing a pedometer stepcount target to patients entering a maintenance cardiac rehabilitation program for the first referral. Treatment group subjects increased stepcounts by 44% from baseline while control subjects increased stepcounts by 13%.

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of death among Americans and has affected millions of lives for more than 80 years.[1-3] Of the 5 major CVD and coronary artery disease (CAD) risk factors (family history, hypertension, hypercholesterolemia, type 2 diabetes, obesity, and physical inactivity) physical inactivity is considered the most prevalent risk factor for coronary artery disease (CAD), a form of CVD.[4, 5]Regular physical activity (PA) is associated with CAD mortality reduction by approximately 20 - 50%;[6-8] moreover, adults with known CAD can reduce mortality as a result of CAD by 20 - 25%.[9, 10]Despite these statistics, only an estimated 48.8% of American adults, and 39.3% of adults over the age of 65,[11] self-report meeting the 2007 PA recommendations of at least 30 min/d moderate intensity a minimum of 5 d/wk, at least 20 min/d vigorous intensity a minimum of 3 d/wk, or a combination of the 2.[12]

Over the past 4 decades, numerous scientific reports by the Center for Disease Control and Prevention,[13] the Surgeon General,[5] the American College of Sports Medicine,[12, 14] the American Heart Association,[15, 16] and the recently first-ever appointed Physical Activity Guidelines Committee[17] have recommended regular exercise and PA for healthy adults, older adults, and clinical populations. More recently, the PA guidelines for healthy adults by the Physical Activity Guidelines Committee were released October or 2008, suggesting a weekly minimum of at least 150 minutes moderate intensity, 75 minutes vigorous intensity, or a combination of the 2 for substantial health benefits.[17] For added benefits, there is a proposed dose-response with increasing weekly PA to a minimum of 300 min/wk moderate intensity, 150 min/wk vigorous intensity, or a combination of the aforementioned.[17] For individuals with known CAD, the AHA and American Association for Cardiovascular Rehabilitation and Prevention suggest a minimum of 20 - 60 min/d moderate to vigorous intensity 3 - 5 days/wk and 30 - 60 min/d moderate intensity 5 days/wk for exercise and PA, respectively.[15]

Bravata et al.[18] concluded that pedometer-driven interventions with generalized (≥ 10,000 steps/d) and individualized (% of baseline steps/d) stepcount goals resulted in a 26.9% (2,998 steps/d) increase in daily stepcounts from baseline compared to subjects wearing the pedometer with no stepcount goal. There is no known literature, to date, for the efficacy of a pedometer-driven PA intervention compared to time-based PA recommendations for a maintenance CR patient population. Therefore, the primary purpose of this study was to compare 2 delivery methods for promoting PA, pedometer-driven PA intervention and the usual time-based PA recommendations given to maintenance CR patients upon first referral. Additionally, this study assessed differences in stepcount activity on days attending maintenance CR compared to non-rehab days. It was hypothesized that providing individualized stepcount goals, compared to time-based recommendations, would yield greater stepcount activity.

METHODS

Subjects

The Institutional Review Boards from Ball State University and Ball Memorial Hospital approved the study prior to subject participation. Subjects were recruited for study participation upon entry to a maintenance CR program from inpatient or early-outpatient CR discharge. Eligibility for study participation included first referral for maintenance CR services, CAD as primary diagnosis, and baseline stepcounts ≤ 7,500 steps/d. As illustrated in Figure 1, of the 35 subjects to volunteer for study participation, a total of 18 subjects (PF, n = 9, 53.7±8.0; UC, n = 9, 60.2±9.6 yrs) completed the study and were included for data analyses. Subject characteristics are summarized in Table 1.

Subjects meeting inclusion criteria were stratified into 1 of 2 groups, Pedometer Feedback (PF) or Usual Care (UC). All subjects completed a 6-minute walk test (6MWT) at baseline and post-study. Additionally, all subjects completed a behavioral change assessment at baseline, week 4, and week 8. Changes in self-efficacy (confidence) was assessed by observing a change in the sum of scores (higher score equals greater self-confidence). Social support changes were assessed by observing changes in the sum of scores for family and friend influences (higher score equals greater support from friends and family). Decision balance was assessed by observing changes in the difference of pros and cons questions. The greater the difference from 0, positively, the subject is suggested to experience less barriers to PA than the subject with a score closer to 0, and negatively.

Physical Activity Assessment and Intervention

Both groups were encouraged to accumulate a minimum of 40 - 50 min/d moderate intensity exercise most days of the week, consistent with AHA/AACVPR recommendations.[15] UC subjects were encouraged to perform at least 30 min/d PA outside maintenance CR, while PF subjects were given weekly stepcount goals to achieve on all days of the week, including days attending CR. All subjects wore a NL-1000 pedometer (New-Lifestyles, Inc. Lee's Summit, MO) at baseline for 7-consecutive days.

Prior to pedometer use, all subjects completed a 20-step test to ensure pedometer accuracy within ±2 of actual steps. Moderate to vigorous activity (MVPA) minutes were assessed using the NL-1000 pedometer. The NL-1000 pedometer used in the present study utilizes a strain gauge (accelerometer) to measure stepcounts and 4-second epochs to determine MVPA (> 3 METS) only. It has been proposed that in order to increase the accuracy of the electronic pedometer, step rates need to exceed 80 - 100 meters/min[19, 20] (2.9 - 3.7 miles/hour) to yield greater than 97% actual stepcounts.[21] However, a report by Crouter et al.[19] suggested that stepcount accuracy for the NL-1000 was within ± 3% of actual stepcounts with treadmill walking speeds greater than 67 meters/min (2.5 miles/hour). Data regarding walking speeds of subjects in the present study is not readily available; however, it can be speculated through daily observation that subjects walked faster than 2.5 miles/hour when attending maintenance CR.

Subjects in the PF group wore the pedometer throughout the remainder of the 8-week study, receiving weekly stepcount goals for weeks 2 - 8. Stepcount goals were calculated as 10% of baseline stepcounts and added to each weekly goal. For example, if the subject averaged 4,000 steps/d at baseline, the weekly stepcount goal would increase by 400 steps/d above baseline, staring at week 2 (4,400 steps/d) through week 8 (6,800 steps/d). To encourage compliance of achieving daily stepcount goals, PF subjects were instructed to receive pedometer feedback and record total stepcounts at lunch, dinner, and bedtime. If stepcount goals were not achieved by dinnertime, subjects were encouraged to walk, as appropriate, to achieve daily goals. For comparison with the PF group, UC subjects wore the pedometer at baseline, week 4, and week 8. UC subjects were not blinded from pedometer feedback as recent reports suggest a lack of PA reactivity due to wearing a pedometer with no stepcount goals.[18, 22]

To ensure measurement of all daily PA, subjects were encouraged to use ambulatory activities as the primary mode, refraining from using non-ambulatory modes such as the rower, NuStep, or AirDyne. Should the subject use the NuStep, they were instructed to record total steps accumulated when using the NuStep mode on the provided daily log form. Steps accumulated on the NuStep were then added to the daily total by the researcher. In addition to the pedometer not registering stepcounts while subjects use the NuStep, time spent in MVPA does not accumulate. Subjects were not monitored for MVPA as stepcounts were. Quality criteria for pedometer data to be included for data analysis were if the pedometer was worn at least 4 d/wk, including 1 weekend day, 8 hrs/d, and 1,500 steps/d. Additionally, data was included for statistical analyses if subjects attended maintenance CR at least 2 d/wk.

<u>Statistical analysis</u>

Data analysis was performed using SPSS 17.0 for Windows (SPSS Inc., Chicago, IL). A repeated-measures2-way ANOVA was used to assess differences in pedometer stepcounts, MVPA minutes, and 6MWT. A repeated-measures3-way ANOVA was used to assess differences between groups and all subjects for daily stepcount activity and MVPA on rehab vs. non-rehab days over time and between groups. A MANOVA was used to assess differences in behavioral change questionnaire responses between groups and for all subjects. All ANOVA's and MANOVA's were assessed for interaction over time and between groups. Significance is denoted by $P < 0.05$ for all analyses.

RESULTS

Data are presented as mean ± SD. Subjects attended maintenance CR sessions 2.9±0.7 d/wk. There were no significant differences between groups for age or body mass index at baseline (Table 1). There were no significant differences between groups for daily stepcounts (Figure 2), MVPA (Table 2), 6MWT distance (Table 2), or behavioral change questionnaire responses for self-efficacy, social support, or decision balance (Table 3). Results from the repeated-measures 2-way ANOVA suggest a time by group interaction for weeks 4 and 8, in addition to a main effect for time for all subjects. Post Hoc analyses suggest the following results.

By week 4, subjects in the PF group significantly increased stepcounts by 19% (1,080±649 steps/d) and accumulated significantly greater stepcounts compared to UC subjects, by 26% (1,405±393 steps/d). There were no significant changes in stepcounts from baseline for UC subjects (455±374 steps/d). There were no significant increases in MVPA from baseline for either group; however, PF subjects accumulated significantly greater MVPA than UC subjects, by 1.6-fold (10.9±8.89 min/d). The repeated-measures MANOVA suggest a main effect for time for all subjects in behavioral change question responses for social support from friends. Additionally, there was a time by group effect from baseline in responses for decision balance pro-questions among PF and UC subjects. PF subjects significantly increased (3.9±0.7- 4.1±0.7), while UC subjects significantly decreased (4.1±0.6 - 3.7±0.6) responses for decision balance pro-questions, which may suggest a decrease in perceived PA barriers for PF and increase in PA barriers for UC subjects.

By week 8, subjects in the PF group significantly increased stepcounts by 44% (2,468±846 steps/d) from baseline and 21% (1,389±76 steps/d) from week 4. Moreover, PF subjects accumulated significantly greater stepcounts than UC subjects, by 48% (2,612±284 steps/d). There were no significant changes in stepcounts for UC subjects from baseline (637±1,127 steps/d) or week 4 (182±753 steps). PF subjects significantly increased MVPA from baseline by 76% (10.1±5.2 min/d), but not from week 4 (5.7±0.8 min/d).PF subjects accumulated significantly greater MVPA compared to UC subjects at week 8, by 2.8-fold (17.3±8.9 min/d). There were no significant changes in behavioral change questionnaire responses for self-efficacy, social support, or decision balance. Both groups significantly increased 6MWT distance from baseline by 8% (PF, 122±39 ft) and 9% (UC, 122±5 ft), and there were no group differences for 6MWT distances. There were no significant intra- or inter-group changes in body mass index.

Maintenance Cardiac Rehab vs. Non-Rehab Days

There were no significant differences between groups during maintenance CR or non-rehab days for stepcounts or MVPA at baseline (Figures 5 and 6). Both groups averaged significantly greater stepcounts on days attending maintenance CR compared to non-rehab days during all 3 time-points (Figures 3 and 4), while only PF subjects averaged significantly greater MVPA during rehab vs. non-rehab days (Table 2).

By week 4, PF subjects significantly increased stepcounts and MVPA from baseline during rehab days by 14% (1,064±45 steps/d) and 42% (8.2±6.3 min/d), respectively. There were no significant differences for stepcounts or MVPA between groups during rehab or non-rehab days. There were no significant increases for stepcounts or MVPA for UC subjects.

By week 8, PF subjects significantly increased stepcounts from baseline and week 4during rehab days by 36% (2,711±423 steps/d) and 19% (1,647±378 steps/d), respectively. PF subjects significantly increased non-rehab stepcounts from baseline by 42% (1,747±759 steps/d) at week 8. There were no significant increases in stepcounts from baseline or week 4 for rehab or non-rehab days for UC subjects. PF subjects significantly increased MVPA during rehab days from baseline by 68% (13.0±5.8 min/d) but not week 4 (2.8±0.5 min/d). There were no significant increases in MVPA during non-rehab days for PF subjects. PF subjects accumulated significantly greater amounts of MVPA compared to UC subjects by 2-fold (21.4±8.8 min/d) during rehab days. There were no significant changes in MVPA for UC subjects during rehab or non-rehab days.

Discussion

The primary purpose of this study was to compare 2 different delivery methods for promoting PA, pedometer-driven and the usual time-based PA recommendations given to maintenance CR patients upon first referral. Post hoc analyses suggest that only PF subjects significantly increased daily stepcounts by week 4 and week 8. Subjects in the UC group failed to significantly increase daily stepcounts; even though, subjects UC were recommended to include 40 - 50 minutes of exercise at moderate intensity at least 5 d/wk, as tolerated, and 30 - 40 minutes moderate intensity PA on most days of the week. A major difference in the delivery of PA recommendations to PF and UC groups is that UC subjects were encouraged to achieve the aforementioned duration and frequency of moderate intensity PA, while PF subjects were encouraged to accumulate recommended stepcount goals. Data from this study corroborates those from Bravata et al.,[18] who concluded that when given stepcount goals, subjects significantly increased daily stepcounts by 26.9% (2,998 steps/d) compared to subjects who were asked to wear a pedometer with no stepcount goals, remaining at baseline stepcount values throughout the study.

Pedometer stepcount goals for PF subjects in the present study were determined from baseline stepcounts. Stepcount goals were calculated as 10% from baseline values, which were added to each weekly goal for weeks 2 - 8. PF subjects were instructed to record daily stepcounts at least 3 times/d (lunchtime, dinnertime, and bedtime) on the provided log form. Data from this study suggest that PF subjects met or exceeded daily stepcount goals 50% of the time. Additionally, while PF subjects achieved stepcount goals half of the time, subjects were more likely (83%) to achieve goals on weekdays compared to weekend days. This is similar to Chan et al.,[23] identifying that significantly less stepcounts are accumulated on Sundays during colder months. It would be of particular interest to identify potential barriers limiting the accumulation of recommended daily stepcounts in order to encourage and facilitate an increase in stepcounts throughout the week and attain stepcount goals more than half of the time.

It was hypothesized that subjects given individualized stepcount goals would yield significantly greater stepcount activity compared to UC subjects, who were given time-based PA recommendations. Data from the present study supports this hypothesis, suggesting that PF subjects accumulated significantly greater stepcounts across weeks 4 (26%, 1,405±393 steps/d) and 8 (48%, 2,612±284 steps/d) compared to UC subjects.

This is similar to Hultquist et al.,[24] who compared the efficacy of a 6-week pedometer intervention with generalized stepcount goals (≥ 10,000 steps/d) to time-based (≥ 30 min/d most days of week) PA recommendations in previously sedentary women, suggesting that pedometer-intervention subjects averaged significantly greater stepcounts (23%, 1889±72 steps/d) compared to time-based subjects. However, Hultquist et al.[24] suggested that both groups significantly increased stepcount activity from baseline, while only PF subjects in the present study increased daily stepcounts, and UC subjects remained at baseline values. A possible explanation for this finding is that subjects in the present study were provided exercise recommendations at baseline, while subjects in the study by Hultquist et al. were provided PA recommendations following baseline. It can be speculated that in addition to UC subjects remaining inactive outside of maintenance CR, they maintained the PA levels that were recommended at baseline throughout the duration of the study. Conversely, PF subjects walked more on days attending rehab and non-rehab days in order to attain individual stepcount goals, which increased weekly.

The secondary purpose for this study was to assess differences in stepcount activity for maintenance CR compared to non-rehab days. Both groups accumulated significantly greater stepcounts during days subjects attended rehab compared to non-rehab days (Figures 3 and 4). In addition to accumulating greater stepcounts on days attending rehab, PF subjects significantly increased stepcounts over time on rehab days during weeks 4 and 8 and non-rehab days during week 8. There were no significant changes in stepcount activity during rehab or non-rehab days for UC subjects. As indicated previously, both groups were instructed to perform the same exercise durations and frequencies during rehab days. PF subjects were provided with stepcount goals, which increased weekly by 10%, to achieve by days-end in addition to exercising most days of the week in maintenance CR. As suggested previously, this may be a possible explanation for the increase in daily stepcounts when compared to UC subjects, who may have been inactive outside rehab.

By week 8, PF subjects accumulated stepcounts that are consistent with the widely-recognized public recommendations of 10,000 steps/d during days attending rehab. Despite the promising data for PF subjects, UC subjects failed to reach similar stepcount activity. Data for PF subjects is consistent with data from Jones et al.[25] where subjects achieved the 10,000 steps/d during rehab days, suggesting a time interaction. Subjects in the present study, who were placed in the UC group, were provided similar time-based PA recommendations to achieve during rehab days; however, subjects in the present study were recruited upon first referral to maintenance CR services, without any previous exposure to maintenance CR. A possible explanation for the disparities between the present study and Jones et al.[25] is that subjects in the present were recruited upon first referral to maintenance CR and may still be improving their PA status toward maintenance stages. Jones et al.[25] recruited all maintenance CR patients who were not limited to a specific length of participation in rehab, and many of the subjects in this former study may have already been in a maintenance stage of PA status when entering the study.

To serve as an ancillary measurement of PA, time spent in MVPA was assessed using the NL-1000 pedometer. Similar to increased stepcounts, daily MVPA for PF subjects significantly increased from baseline. Additionally, MVPA during rehab was significantly greater than non-rehab for PF subjects. There were no significant changes in MVPA for UC subjects. Current recommendations and guidelines suggest the accumulation of a minimum of 150 min/wk of MVPA, which is suggested to be accumulated in 30 minute bouts, spread throughout the week.[17] Only PF subjects accumulated daily recommended durations (30.2±20.3 min/d) of MVPA durations by week 8 during days attending rehab. This is similar to research assessing the MVPA habits of patients participating in maintenance CR services for at least 3 months prior to study participation, averaging 28 min/d on days attending rehab and significantly less on non-rehab days.[26]

Subjects in the study by Ayabe et al.[26] participated in a maintenance CR program for at least 3 months prior to study participation and were given time-based exercise recommendations of at least 40 min/d at moderate to vigorous intensity for 3 days/wk in a maintenance CR setting. This is similar to the recommendations provided to the UC subjects in the present study. However, UC subjects in the present study accumulated what appears to be substantially less MVPA than subjects in the Ayabe et al.[26] cohort. A possible explanation is that subjects in the former study walked around a track as the primary mode of exercise, and subjects in the present had access to both ambulatory and non-ambulatory modes, such as the NuStep. Subjects in the present study were requested to refrain from utilizing non-ambulatory modes; however, if they did use the NuStep, they were instructed to record total steps accumulated, which was added to the pedometer-determined daily stepcount total by the researcher. A total 4 subjects in the UC group and 3 subjects in the PF group used the NuStep for periods lasting longer than 10 minutes.

Even though subjects in the present study exercised an average 30 - 40 min/d at least 2.9 ± 0.7 d/wk in maintenance CR, a possible explanation to the low MVPA for UC subjects may be that nearly half of the UC group used the NuStep. Subjects using this non-ambulatory mode were not monitored for MVPA minutes, which can be obtained through recording the average MET value, provided by the NuStep, and time spent using the NuStep. However, it can be speculated through daily observations that subjects did not perform at levels exceeding 3 METS when using the NuStep.

The benefits of increased PA are well-documented. According to the stepcount cut-points by Tudor-Locke et al..,[27] PF subjects were considered "low active" at baseline and only "somewhat active" by week 8. Subjects in the UC group were considered "low active" throughout the 3 time-points: baseline, week 4, and week. Thus, there is a clear need to facilitate an increase in daily stepcounts among individuals participating in a maintenance CR program. There is emerging evidence that more than 8,000 steps/d is a more appropriate stepcount recommendation and threshold to realize health benefits associated MVPA compared to the widely publicized 10,000 stepcount goal.[28, 29] The premise is that sedentarism is associated with stepcounts less than 5,000 steps/d,[27] and walking at a step-rate of 100 steps/m for 30 minutes is equivalent to 30 minutes of MVPA,[30] accumulating an estimated 8,000 steps/d. Subjects in the present study accumulated 8,100 steps/d during week 8 and significantly less during baseline and week 4. UC subjects averaged significantly less than the proposed 8,000 steps/d across all three time-points. Given these surprising data, there is appears to be a need to increase the PA habits of maintenance CR patients.

It has been suggested that a pedometer-driven PA intervention provides positive behavioral changes toward increase PA habits.[31]. The present study utilized 3 different behavioral change questionnaires: self-efficacy, social support, and decision balance. Subjects scoring higher for self-efficacy are considered to have an individual ability to make positive choices for being physically active. There were no changes in self-efficacy responses as a function of time or between groups at any time during the study. The social support questionnaire assesses the influence of family and friend support to the individual's ability to physically active. There was a time effect for all subjects at week 4, suggesting that social support from friends was higher. No other significance was found throughout the study for this measure. The decision balance questionnaire assessed the perceived barriers to an individual being physically active. The questionnaire includes questions dealing with positive (pro) and negative (con) influences. Although the difference of pro- and con-questions suggests an individual's perceived barriers to increase or decrease depending on the distance from 0, no significant changes were found between groups or across time. However, there was an increase in the average of pro-questions for PF and decrease for UC subjects by week 4. This suggests that PF subjects perceived less PA barriers, and UC subjects perceived more barriers to being physically active. Further research is warranted to interpret the behavioral change questionnaire responses.

CONCLUSIONS

Data from this study corroborates previous literature suggesting that pedometers are a useful, objective tool to promote and motivate increased levels and intensities of

PA.[32] A pedometer-driven intervention, where subjects receive individualized stepcount goals, is an effective method to increase daily stepcount activity among maintenance CR patients.

References Cited

1. Lloyd-Jones D, Adams R, Carnethon M, et al. Heart disease and stroke statistics--2009 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. *Circulation*. 2009;119(3):480-486.

2. Kung H, Hoyert D, Xu J. Deaths: Final Data for 2005. Helath E-Stats. Hyattsville, MD: National Center for Health Statistics; 2008.

3. Neyer J, Greenlund K, Denny C, Keenan N, Labarthe D, Croft J. Prevalence of Heart Disease--United States, 2005. *JAMA*. 2007;297(12):1308-1309.

4. Kesaniemi YK, Danforth E, Jr., Jensen MD, Kopelman PG, Lefebvre P, Reeder BA. Dose-response issues concerning physical activity and health: an evidence-based symposium. *Med Sci Sports Exerc*. 2001;33(6 Suppl):S351-358.

5. US Department of Health and Human Services. Physical Activity and Health: A Report of the Surgeon General. Atlanta, GA; 1996.

6. Lee IM, Rexrode KM, Cook NR, Manson JE, Buring JE. Physical activity and coronary heart disease in women: is "no pain, no gain" passe? *JAMA*. 2001;285(11):1447-1454.

7. Lee IM, Sesso HD, Paffenbarger RS, Jr. Physical activity and coronary heart disease risk in men: does the duration of exercise episodes predict risk? *Circulation*. 2000;102(9):981-986.

8. Sesso HD, Paffenbarger RS, Jr., Lee IM. Physical activity and coronary heart disease in men: The Harvard Alumni Health Study. *Circulation*. 2000;102(9):975-980.

9. Balady GJ, Fletcher BJ, Froelicher ES, et al. Cardiac rehabilitation programs. A statement for healthcare professionals from the American Heart Association. *Circulation*. 1994;90(3):1602-1610.

10. Van Camp SF, Cantwell JD, Fletcher GF, Smith LK, Thomoson PD. American College of Sports Medicine position stand. Exercise for patients with coronary artery disease. *Med Sci Sports Exerc*. 1994;26(3):1-5.

11. Centers for Disease Control and Prevention. Prevalence of self-reported physically active adults--United States, 2007. *MMWR*. 2008;57(48):1297-1300.

12. Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation*. 2007;116(9):1081-1093.

13. Pate RR, Pratt M, Blair SN, et al. Physical activity and public health: A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA*. 1995;273(5):402-407.

14. Nelson ME, Rejeski WJ, Blair SN, et al. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc*. 2007;39(8):1435-1445.

15. Balady GJ, Williams MA, Ades PA, et al. Core components of cardiac rehabilitation/secondary prevention programs: 2007 update: a scientific statement from the American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee, the Council on Clinical Cardiology; the Councils on Cardiovascular Nursing, Epidemiology and Prevention, and Nutrition, Physical Activity, and Metabolism; and the American Association of Cardiovascular and Pulmonary Rehabilitation. *Circulation*. 2007;115(20):2675-2682.

16. Fletcher GF, Balady GJ, Amsterdam EA, et al. Exercise standards for testing and training: a statement for healthcare professionals from the American Heart Association. *Circulation*. 2001;104(14):1694-1740.

17. Physical Activity Guidelines Advisory Committee. *Physical activity guidelines advisory committee report, 2008*. Washington, DC: U.S. Department of Health and Human Services, 2008. Washington, DC; 2008.

18. Bravata DM, Smith-Spangler C, Sundaram V, et al. Using pedometers to increase physical activity and improve health: a systematic review. *JAMA*. 2007;298(19):2296-2304.

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

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

21. Melanson EL, Knoll JR, Bell ML, et al. Commercially available pedometers: considerations for accurate step counting. *Prev Med*. 2004;39(2):361-368.

22. Matevey C, Rogers LQ, Dawson E, Tudor-Locke C. Lack of reactivity during pedometer self-monitoring in adults. *Measure Phys Ed Exerc Sci*. 2006;10(1):1-11.

23. Chan C, Ryan D, Tudor-Locke C. Relationship between objective measures of physical activity and weather: a longitudinal study. *Int J Behav Nutrition Phys Act*. 2006;3(1):21.

24. Hultquist CN, Albright C, Thompson DL. Comparison of walking recommendations in previously inactive women. *Med Sci Sports Exerc*. 2005;37(4):676-683.

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

26. Ayabe M, Brubaker PH, Dobrosielski D, et al. The physical activity patterns of cardiac rehabilitation program participants. *J Cardiopulm Rehabil*. 2004;24(2):80-86.

27. Tudor-Locke C, Hatano Y, Pangrazi RP, Kang M. Revisiting "how many steps are enough?". *Med Sci Sports Exerc*. 2008;40(7):S537-543.

28. Marshall S, Levy S, Tudor-Locke C, et al. Translating physical activity recommendations into a pedometer-based step goal: 3000 steps in 30 minutes. *Am J Prev Med*. 2009;36(5):410-415.

29. Macfarlane DJ, Chan D, Chan KL, Ho EY, Lee CC. Using three objective criteria to examine pedometer guidelines for free-living individuals. *Eur J Appl Physiol*. 2008;104(3):435-444.

30. Hatano Y. Use of the pedometer for promoting daily walking exercise. *Int Counc Health Phys Ed Rec*. 1993;29(4):4-8.

31. Rooney BL, Gritt LR, Havens SJ, Mathiason MA, Clough EA. Growing healthy families: family use of pedometers to increase physical activity and slow the rate of obesity. *Wisc Med J*. 2005;104(5):54-60.

32. Tudor-Locke C. Taking steps toward increased physical activity: using pedometers to measure and motivate. *Research Digest*. 2002;3(17).

FIGURE 1. Subject Recruitment and Completion

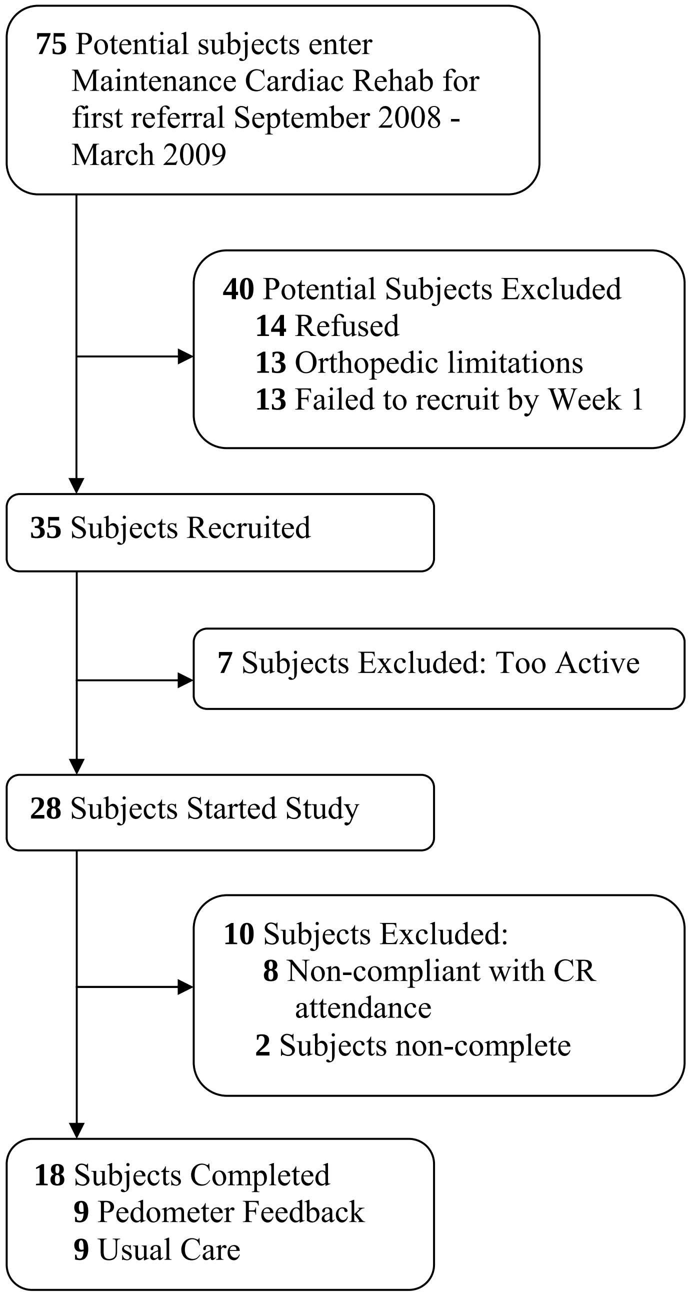
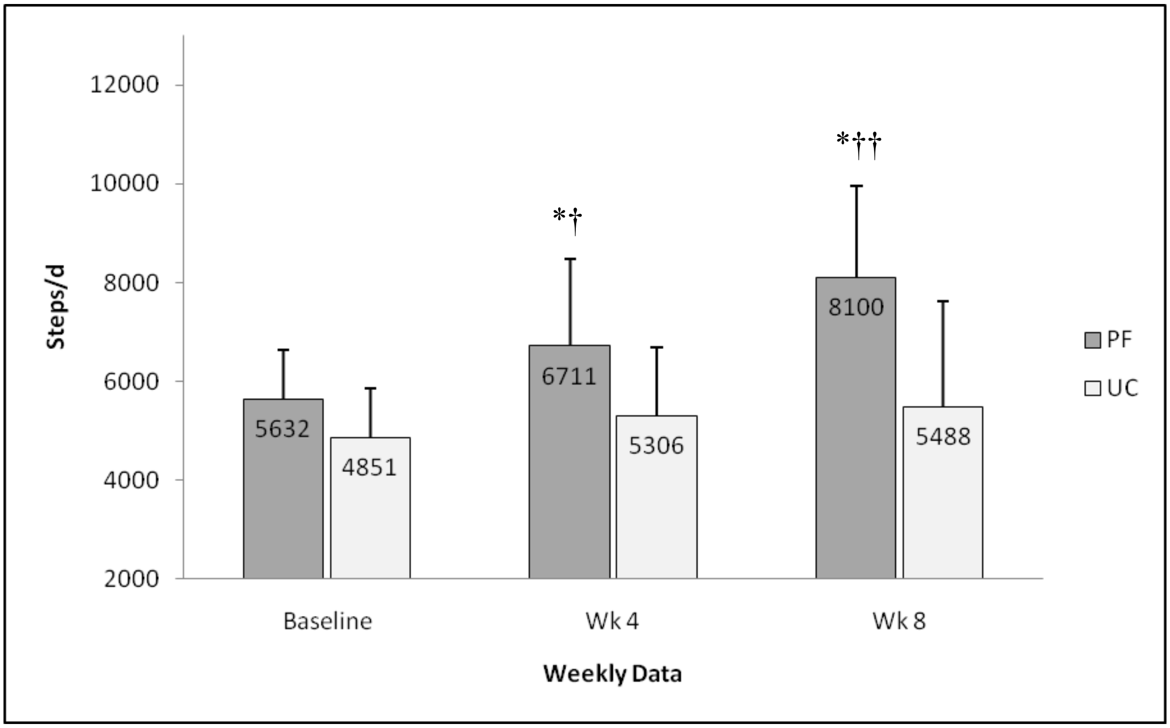
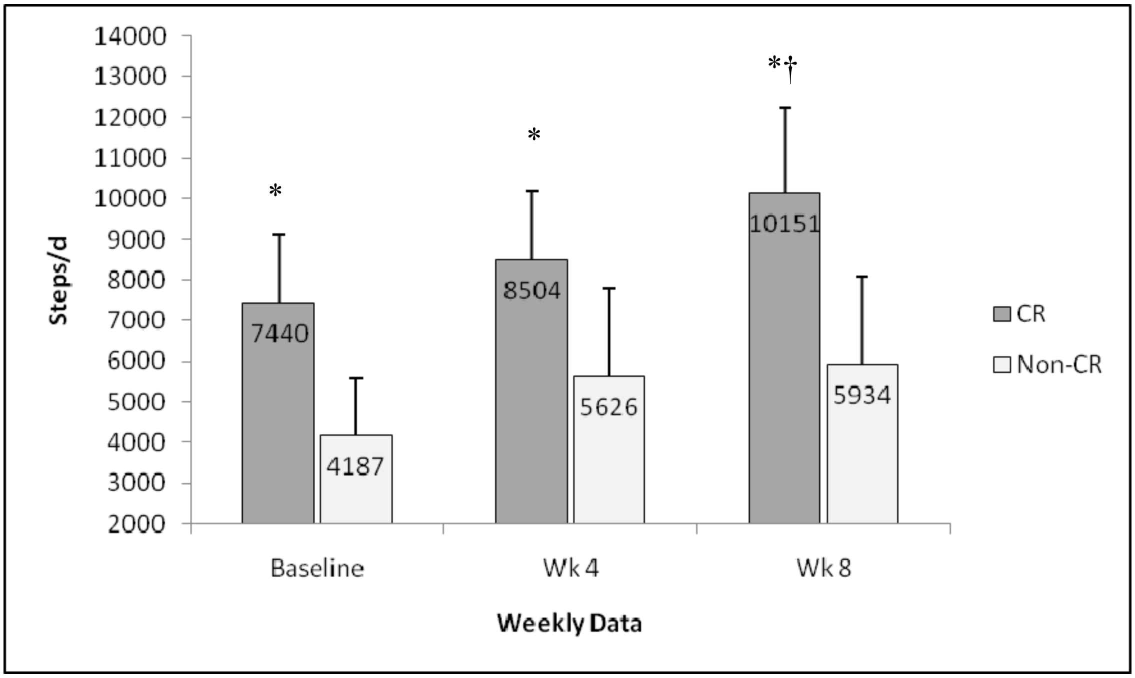


FIGURE 2. Comparison of daily stepcounts between groups



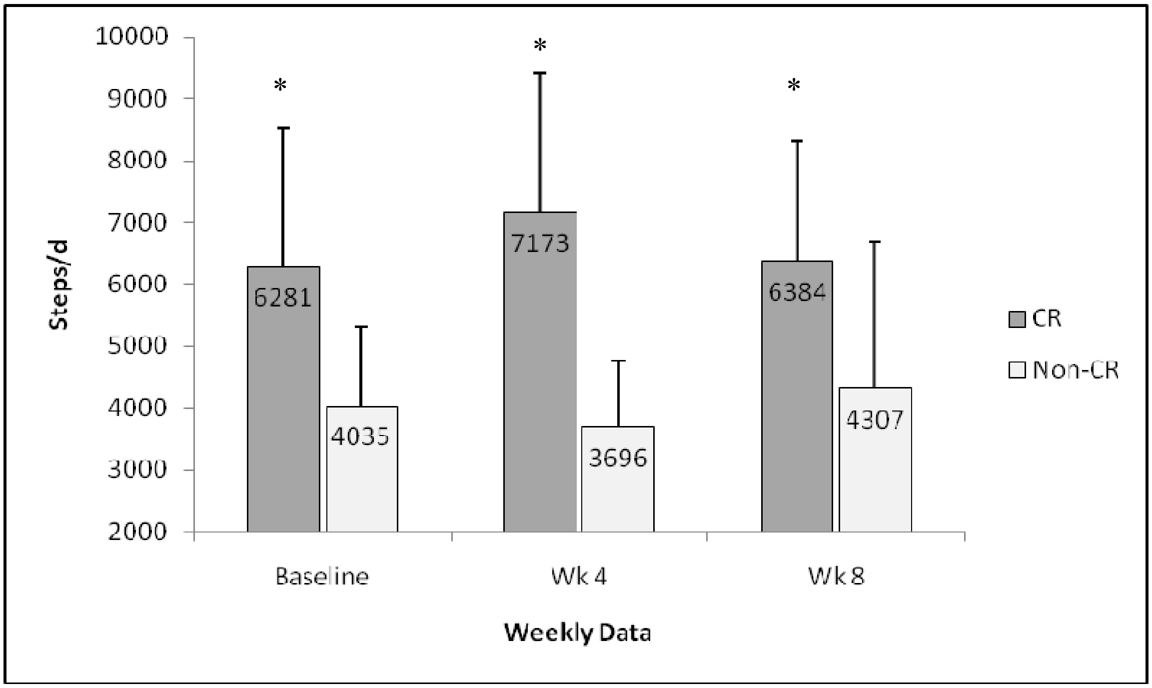
PF, pedometer feedback subjects; UC, usual care subjects
* Significantly different from UC subjects
† Significantly different from baseline
†† Significantly different from week 4 and baseline

FIGURE3. Comparison of stepcounts during rehab vs. non-rehab for PF subjects



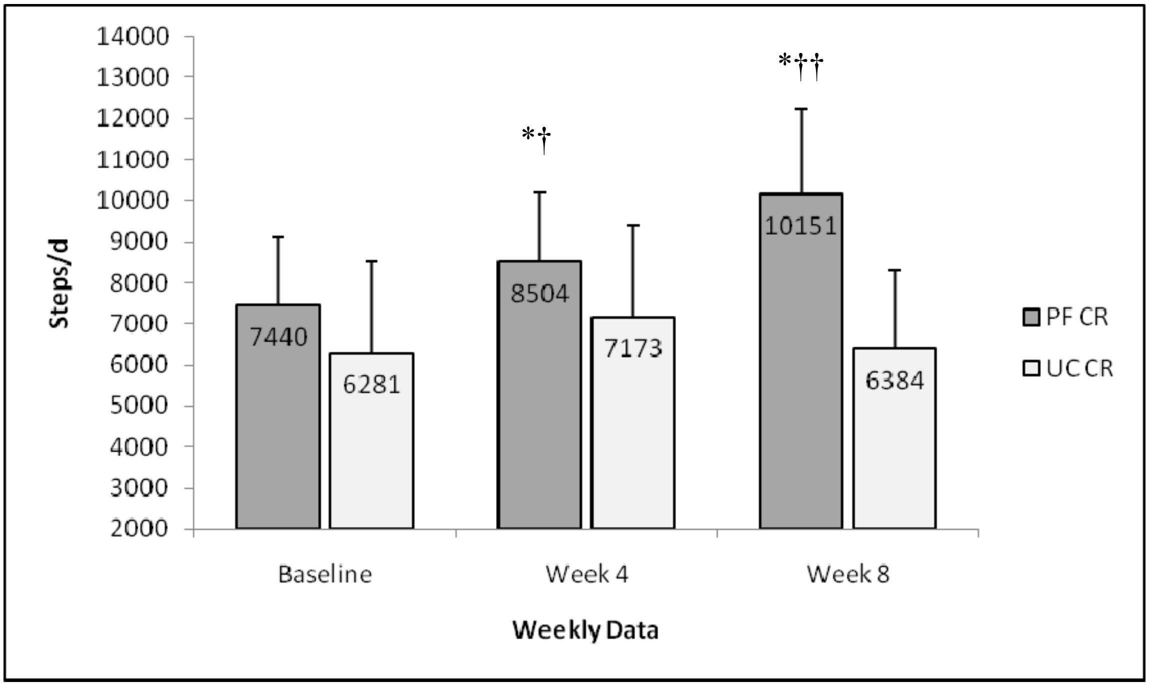
PF, pedometer feedback subjects; UC, usual care subjects
Due to missing data, only 7 PF subjects were analyzed
* Significantly different from non-rehab days
† Significantly different from week 4

FIGURE4. Comparison of stepcounts during rehab vs. non-rehab for UC subjects



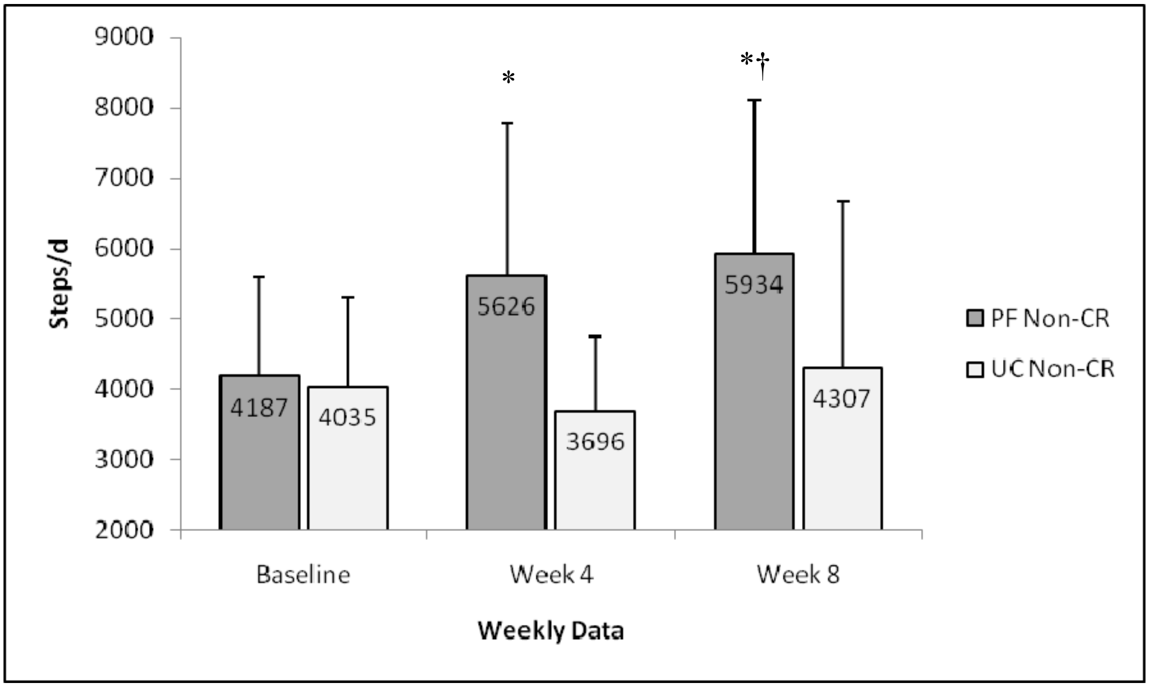
PF, pedometer feedback subjects; UC, usual care subjects
Due to missing Data, only 8 UC subjects were analyzed
* Significantly different from non-rehab days

FIGURE 5. Comparison of rehab stepcounts between groups



PF, pedometer feedback subjects; UC, usual care subjects
* Significantly different from UC
† Significantly different from baseline
†† Significantly different from week 4 and baseline

FIGURE 6. Comparison of non-rehab stepcounts between groups



PF, pedometer feedback subjects; UC, usual care subjects
Due to missing data, only 7 PF and 8 UC subjects were analyzed
* Significantly different from UC
† Significantly different from baseline

TABLE1. Baseline Subject Characteristics (mean ± SD)

Variable	PF ($N = 9$)	UC ($N = 9$)
Age (yrs)	53.7±8.0	60.2±9.6
BMI (kg/m^2)	30.0±5.7	31.5±6.6
Male	6	6
Female	3	3
MI	5	1
CABG	1	3
PCI	2	1
Transplant	--	1
AVR	1	--
MVR	--	1
Stable Angina	--	1

PF, pedometer feedback; UC, usual care; M, male; F, female; BMI, body mass index; PCI, percutaneous coronary intervention; CABG, coronary artery bypass graft; MI, myocardial infarction; AVR, aortic valve replacement; MVR, mitral valve replacement

TABLE2. Comparison of MVPA, 6MWT, and BMI between Groups

	PF			UC		
MVPA	**Baseline**	**Week 4**	**Week 8**	**Baseline**	**Week 4**	**Week 8**
Daily	13.3±9.2	17.7±15.2	23.4±14.4*[a]	5.8±4.5	6.8±6.4	6.1±5.5
CR	19.2±14.5†	27.4±20.8*†	30.2±20.3*†[a]	10.0±11.3	11.6±13.3	10.8±11.5
NCR	6.4±5.6	12.0±15.0	9.8±7.5	6.2±7.4	4.0±3.3	3.6±3.7
6MWT	1625±232	---	1747±193*	1422±263	---	1544±258*
BMI	30.0±5.7	---	29.9±6.0	31.5±6.6	---	32.0±6.6

MVPA, moderate to vigorous activity minutes; PF, pedometer feedback; UC, usual care; Daily, daily average MVPA (min/d); CR, MVPA accumulated during cardiac rehab days; NCR, MVPA accumulated during non-rehab days; 6MWT, distance accumulated during 6-minute walk test(ft); BMI, body mass index(kg/m^2).

Due to missing data, data from only 8 PF subjects were analyzed for MVPA changes from baseline to week 4 and week 8.

* Significantly different from baseline
[a] Significantly different from week UC
†Significantly different from non-rehab

TABLE3. Behavioral Change Data

Group	**Week**	**SE_S**	**SS_{FA}**	**SS_{FR} ****	**DB_P**	**DB_C**	**DB_D**
PF	1	15.8±3.5	38.9±6.3	26.7±11.6	3.9±0.7	2.2±0.5	1.7±1.0
	4	16.6±4.7	36.1±9.7	29.9±10.8	4.1±0.7*†	2.1±0.6	2.0±1.0
	8	17.0±4.4	36.7±8.6	21.0±13.4	4.0±08	2.4±0.2	1.6±0.8
UC	1	15.4±3.2	31.3±11.8	14.7±14.2	4.1±0.6	2.5±1.0	1.5±0.9
	4	14.1±3.6	33.4±11.4	24.0±11.2	3.7±0.6*	2.2±0.6	1.5±0.6
	8	16.2±3.7	27.2±12.5	20.1±16.9	3.8±0.7	2.8±1.1	1.0±1.1

PF, pedometer feedback; UC, usual care; SE_S, self-efficacy sum; SE_A, self-efficacy average; SS_{FA}, social-support family sum; SS_{FR}, social-support friend sum; DB_P, average of decision balance pros questions; DB_C, average of decision balance cons questions; DB_D, difference of decision balance pros - cons averages.

* Significantly different from baseline

** Main effect of time for all subjects at week 4

† Significantly different from UC

CHAPTER V

Summary and Conclusions

Currently, there is no available literature concerning the efficacy of a pedometer-driven intervention to increase the physical activity (PA) habits of a maintenance cardiac rehabilitation (CR) patient population; however, there have been few studies to objectively assess the PA habits of maintenance CR patients. Data from recent research suggest that maintenance CR patients are significantly more physically active and accumulate publically recommended amounts of PA, observed as stepcounts (≥ 10,000 steps/d), during rehab days compared to non-rehab days. Therefore, the primary purpose of this study was to determine if a pedometer intervention, involving individualized stepcount goals, would yield greater amounts of PA than the usual time-based PA recommendations given to maintenance CR patients. In addition to the present study being the first known study to assess the efficacy of a pedometer-driven intervention to increase PA habits among a maintenance CR population, this is the 1 of few studies to assess behavioral modification through the use of a pedometer intervention to increase PA habits.

A total 18 subjects (12 men, 6 women, 57.4±8.8 yrs) completed the study and included in data analyses. A total of 9 subjects (8 men, 3 women, 53.7±8.0 yrs) were included in the pedometer feedback (PF) group, and 9 subjects (6 men, 3 women, 60.2±9.6 yrs) were included in the usual care (UC) group. Results from this study suggest that there was a time interaction for all subjects, with post hoc analyses identifying PF subjects to significantly increase daily stepcount activity by 19% (1,080±649 steps/d) by week 4 and 44% (2,468±846 steps/d) by week 8. However, significant increases for MVPA were not observed until week 8 for PF subjects. There were no significant changes for steps/d or MVPA among UC subjects. Both groups averaged significantly greater stepcounts during rehab compared to non-rehab days, which is similar to previous research.[23, 31] Therefore, the Data in the present study suggests that a pedometer-driven intervention, where subjects receive individualized stepcount goals, is an effective method to increase not only overall daily PA, but weekly moderate to vigorous activity minutes.

Recommendations for Future Studies

A major limitation to the interpretation of this study is the low subject numbers. A similar study recruiting and completing more subjects would be of interest. Additionally, even though there were no significant differences between groups at baseline for stepcounts and MVPA, it is possible that significance would be present with more subjects in each group; therefore, it would of particular interest to match groups for stepcounts and MVPA. Subjects in the PF group failed to accumulate publically recommended MVPA (≥ 30 min/d moderate to vigorous intensity) until week 8. This may be due in part to the low sophistication of the pedometer's strain gauge mechanism, due to subjects not participating in high levels of MVPA, subjects using the NuStep, or a combination of the aforementioned. For this reason, a similar intervention study limiting the use of non-ambulatory modes and recommending individualized MVPA as the primary outcome utilizing a higher-caliber unit may be of interest. This study was employed during colder months (September - April). There are known seasonal variations to physical activity,[32] and a similar study during warmer months would be of interest. Last, there were no significant changes in body mass index throughout the study. With increased amounts of PA and no observed change in BMI, a multiple armed study incorporating a nutritional intervention may be of interest.

REFERENCES CITED

1. Lloyd-Jones D, Adams R, Carnethon M, et al. Heart disease and stroke statistics--2009 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. *Circulation*. 2009;119(3):480-486.

2. Kung H, Hoyert D, Xu J. Deaths: Final Data for 2005. Helath E-Stats. Hyattsville, MD: National Center for Health Statistics; 2008.

3. Neyer J, Greenlund K, Denny C, Keenan N, Labarthe D, Croft J. Prevalence of Heart Disease--United States, 2005. *JAMA*. 2007;297(12):1308-1309.

4. Federal Interagency Forum on Aging-Related Statistics. *Older Americans 2008: key indicators of well-being*. Federal Interagency Forum on Aging-Related Statistics. Washington, DC: U.S. Government Printing Office; 2008.

5. Mosca L, Jones WK, King KB, et al. Awareness, perception, and knowledge of heart disease risk and prevention among women in the united states. *Arch Fam Med*. 2000;9(6):506-515.

6. Mosca L, Ferris A, Fabunmi R, Robertson RM. Tracking women's awareness of heart disease: an american heart association national study. *Circulation*. 2004;109(5):573-579.

7. US Department of Health and Human Services. Physical Activity and Health: A Report of the Surgeon General. Atlanta, GA; 1996.

8. Prevalence of self-reported physically active adults--United States, 2007. *MMWR Morb Mortal Wkly Rep*. 2008;57(48):1297-1300.

9. Physical Activity Guidelines Advisory Committee. *Physical activity guidelines advisory committee report, 2008*. Washington, DC: U.S. Department of Health and Human Services, 2008. Washington, DC; 2008.

10. Clark AM, Hartling L, Vandermeer B, McAlister FA. Meta-analysis: secondary prevention programs for patients with coronary artery disease. *Ann Intern Med*. 2005;143(9):659-672.

11. Wofford TS, Greenlund KJ, Croft JB, Labarthe DR. Diet and physical activity of US adults with heart disease following preventive advice. *Prev Med*. 2007;45(4):295-301.

12. Sesso HD, Paffenbarger RS, Jr., Lee IM. Physical activity and coronary heart disease in men: The Harvard Alumni Health Study. *Circulation*. 2000;102(9):975-980.

13. Lee IM, Sesso HD, Paffenbarger RS, Jr. Physical activity and coronary heart disease risk in men: does the duration of exercise episodes predict risk? *Circulation*. 2000;102(9):981-986.

14. Lee IM, Rexrode KM, Cook NR, Manson JE, Buring JE. Physical activity and coronary heart disease in women: is "no pain, no gain" passe? *JAMA*. 2001;285(11):1447-1454.

15. Taylor RS, Brown A, Ebrahim S, et al. Exercise-based rehabilitation for patients with coronary heart disease: systematic review and meta-analysis of randomized controlled trials. *Am J Med*. 2004;116(10):682-692.

16. Hambrecht R, Niebauer J, Marburger C, et al. Various intensities of leisure time physical activity in patients with coronary artery disease: effects on cardiorespiratory fitness and progression of coronary atherosclerotic lesions. *J Am Coll Cardiol*. 1993;22(2):468-477.

17. Hatano Y. Use of the pedometer for promoting daily walking exercise. *Int Counc Health Phys Ed Rec*. 1993;29(4):4-8.

18. Tudor-Locke C. Taking steps toward increased physical activity: using pedometers to measure and motivate. *Research Digest*. 2002;3(17).

19. Stovitz SD, VanWormer JJ, Center BA, Bremer KL. Pedometers as a means to increase ambulatory activity for patients seen at a family medicine clinic. *J Am Board Fam Pract*. 2005;18(5):335-343.

20. Chan CB, Ryan DAJ, Tudor-Locke C. Health benefits of a pedometer-based physical activity intervention in sedentary workers. *Prev Med*. 2004;39(6):1215-1222.

21. Tudor-Locke C, Bell RC, Myers AM, et al. Controlled outcome evaluation of the First Step Program: a daily physical activity intervention for individuals with type II diabetes. *Int J Obes Relat Metab Disord*. 2004;28(1):113-119.

22. Stevenson TG, Riggin K, Nagelkirk P, Hargens TA, Strath SJ, Kaminsky LA. Physical activity habits of cardiac patiens participating in an early outpatient rehabilitation program. *J Cardiopulm Rehabil*. 2009;In Press.

23. Ayabe M, Brubaker PH, Dobrosielski D, et al. The physical activity patterns of cardiac rehabilitation program participants. *J Cardiopulm Rehabil*. 2004;24(2):80-86.

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

25. Graser SV, Pangrazi RP, Vincent WJ. Effects of placement, attachment, and weight classification on pedometer accuracy. *J Phys Act Health*. 2007;4(4):359-369.

26. Bravata DM, Smith-Spangler C, Sundaram V, et al. Using pedometers to increase physical activity and improve health: a systematic review. *JAMA*. 2007;298(19):2296-2304.

27. Lauzon N, Chan CB, Myers AM, Tudor-Locke C. Participant experiences in a workplace pedometer-based physical activity program. *J Phys Act Health*. 2008;5(5):675-687.

28. Schofield L, Mummery WK, Schofield G. Effects of a controlled pedometer-intervention trial for low-active adolescent girls. *Med Sci Sports Exerc*. 2005;37(8):1414-1420.

29. Tudor-Locke C, Hatano Y, Pangrazi RP, Kang M. Revisiting "how many steps are enough?". *Med Sci Sports Exerc*. 2008;40(7 Suppl):S537-543.

30. Van Camp SF, Cantwell JD, Fletcher GF, Smith LK, Thomoson PD. American College of Sports Medicine position stand. Exercise for patients with coronary artery disease. *Med Sci Sports Exerc*. 1994;26(3):1-5.

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

32. Chan C, Ryan D, Tudor-Locke C. Relationship between objective measures of physical activity and weather: a longitudinal study. *Int J Behav Nutrition Phys Act*. 2006;3(1):21.

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

34. Baker G. Are pedometers useful motivation tools for increasing walking in sedentary adults? Available from http://www.walk21.com/conferences /conference_papers_detail.asp?Paper=143&Conference=Zurich; 2005.

35. Sherman SE, D'Agostino RB, Silbershatz H, Kannel WB. Comparison of past versus recent physical activity in the prevention of premature death and coronary artery disease. *Am Heart J*. 1999;138(5):900-907.

36. Thomas RJ, King M, Lui K, et al. AACVPR/ACC/AHA 2007 performance measures on cardiac rehabilitation for referral to and delivery of cardiac rehabilitation/secondary prevention services. *Circulation*. 2007;116(14):1611-1642.

37. Caspersen CJ, Powell KE, Christenson GM. Physical activity, exercise, and physical fitness: definitions and distinctions for health-related research. *Public Health Rep*. 1985;100(2):126-131.

38. Stokes J, 3rd, Kannel WB, Wolf PA, Cupples LA, D'Agostino RB. The relative importance of selected risk factors for various manifestations of cardiovascular disease among men and women from 35 to 64 years old: 30 years of follow-up in the Framingham Study. *Circulation*. 1987;75(6 Pt 2):V65-73.

39. Kannel WB. Contributions of the Framingham Study to the conquest of coronary artery disease. *Am J Cardiol*. 1988;62(16):1109-1112.

40. Balady GJ, Fletcher BJ, Froelicher ES, et al. Cardiac rehabilitation programs. A statement for healthcare professionals from the American Heart Association. *Circulation*. 1994;90(3):1602-1610.

41. Chiolero A, Paccaud F, Bovet P. Upward hypertension trends: changes in blood pressure or in antihypertensive treatment? *Hypertension*. 2009;53(3):e22-23.

42. Carr MC, Brunzell JD. Abdominal obesity and dyslipidemia in the metabolic syndrome: importance of type 2 diabetes and familial combined hyperlipidemia in coronary artery disease risk. *J Clin Endocrinol Metab*. 2004;89(6):2601-2607.

43. Ogden CL, Yanovski SZ, Carroll MD, Flegal KM. The epidemiology of obesity. *Gastroenterology*. 2007;132(6):2087-2102.

44. Ramsey F, Ussery-Hall A, Garcia D, et al. Prevalence of selected risk behaviors and chronic diseases--Behavioral Risk Factor Surveillance System (BRFSS), 39 steps communities, United States, 2005. *MMWR Surveill Summ*. 2008;57(11):1-20.

45. Chobanian AV, Bakris GL, Black HR, et al. The seventh report of the joint national committee on prevention, detection, evaluation, and treatment of high blood pressure: the JNC 7 report. *JAMA*. 2003:289.219.2560.

46. O'Gorman DJ, Karlsson HK, McQuaid S, et al. Exercise training increases insulin-stimulated glucose disposal and GLUT4 (SLC2A4) protein content in patients with type 2 diabetes. *Diabetologia*. 2006;49(12):2983-2992.

47. Tonnesen P. How to reduce smoking among teenagers. *Eur Respir J*. 2002;19(1):1-3.

48. Myers J. Cardiology patient pages. Exercise and cardiovascular health. *Circulation*. 2003;107(1):e2-5.

49. Pate RR, Pratt M, Blair SN, et al. Physical activity and public health. A recommendation from the Centers for Disease Control and Prevention and the American College of Sports Medicine. *JAMA*. 1995;273(5):402-407.

50. Haskell WL, Lee IM, Pate RR, et al. Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Circulation*. 2007;116(9):1081-1093.

51. Fletcher GF, Balady GJ, Amsterdam EA, et al. Exercise standards for testing and training: a statement for healthcare professionals from the American Heart Association. *Circulation*. 2001;104(14):1694-1740.

52. Balady GJ, Williams MA, Ades PA, et al. Core components of cardiac rehabilitation/secondary prevention programs: 2007 update: a scientific statement from the American Heart Association Exercise, Cardiac Rehabilitation, and Prevention Committee, the Council on Clinical Cardiology; the Councils on Cardiovascular Nursing, Epidemiology and Prevention, and Nutrition, Physical Activity, and Metabolism; and the American Association of Cardiovascular and Pulmonary Rehabilitation. *Circulation*. 2007;115(20):2675-2682.

53. Fletcher GF, Balady G, Froelicher VF, Hartley LH, Haskell WL, Pollock ML. Exercise standards: a statement for healthcare professionals from the American Heart Association. *Circulation*. 1995;91(2):580-615.

54. Pollock ML, Gaesser GA, Butcher JD, et al. American College of Sports Medicine position stand. The recommended quantity and quality of exercise for developing and maintaining cardiorespiratory and muscular fitness, and flexibility in healthy adults. *Med Sci Sports Exerc*. 1998;30(6):975-991.

55. Nelson ME, Rejeski WJ, Blair SN, et al. Physical activity and public health in older adults: recommendation from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc*. 2007;39(8):1435-1445.

56. Mazzeo RS, Cavanagh P, Evans WJ, et al. American College of Sports Medicine position stand. Exercise and physical activity for older adults. *Med Sci Sports Exerc*. 1998;30(6):992-1008.

57. Belardinelli R, Georgiou D, Cianci G, Purcaro A. Randomized, controlled trial of long-term moderate exercise training in chronic heart failure: effects on functional capacity, quality of life, and clinical outcome. *Circulation*. 1999;99(9):1173-1182.

58. Balady GJ, Ades PA, Comoss P, et al. Core components of cardiac rehabilitation/secondary prevention programs: a statement for healthcare professionals from the American Heart Association and the American Association of Cardiovascular and Pulmonary Rehabilitation writing group. *Circulation*. 2000;102(9):1069-1073.

59. Borg G. *Borg's perceived exertion and pain scales*. Champlaign, IL: Human Kinetics; 1998.

60. Vanhees L, Lefevre J, Philippaerts R, et al. How to assess physical activity? How to assess physical fitness? *Eur J Cardiovasc Prev Rehabil*. 2005;12(2):102-114.

61. Sirard J, Pate R. Physical Activity Assessment in Children and Adolescents. *Sports Medicine*. 2001;31(6):439-454.

62. Schoeller DA, Ravussin E, Schutz Y, Acheson KJ, Baertschi P, Jequier E. Energy expenditure by doubly labeled water: validation in humans and proposed calculation. *Am J Physiol*. 1986;250(5 Pt 2):R823-830.

63. Ferrannini E. The theoretical bases of indirect calorimetry: a review. *Metabolism*. 1988;37(3):287-301.

64. Matarese LE. Indirect calorimetry: technical aspects. *J Am Diet Assoc*. 1997;97(10 Suppl 2):S154-160.

65. Schoeller DA. Making indirect calorimetry a gold standard for predicting energy requirements for institutionalized patients. *J Am Diet Assoc*. 2007;107(3):390-392.

66. Craig CL, Marshall AL, Sjostrom M, et al. International physical activity questionnaire: 12-country reliability and validity. *Med Sci Sports Exerc*. 2003;35(8):1381-1395.

67. Harada ND, Chiu V, King AC, Stewart AL. An evaluation of three self-report physical activity instruments for older adults. *Med Sci Sports Exerc*. 2001;33(6):962-970.

68. Klesges RC, Eck LH, Mellon MW, Fulliton W, Somes GW, Hanson CL. The accuracy of self-reports of physical activity. *Med Sci Sports Exerc*. 1990;22(5):690-697.

69. Durante R, Ainsworth BE. The recall of physical activity: using a cognitive model of the question-answering process. *Med Sci Sports Exerc*. 1996;28(10):1282-1291.

70. Chen KY, Bassett DR, Jr. The technology of accelerometry-based activity monitors: current and future. *Med Sci Sports Exerc*. 2005;37(11):S490-500.

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

72. Shepherd E, Toloza E, McClung C, Schmalzried T. Step activity monitor: Increased accuracy in quantifying ambulatory activity. *J Orthop Research*. 1999;17(5):703-708.

73. Freedson PS, Melanson E, Sirard J. Calibration of the computer science and applications, inc. accelerometer. *Med Sci Sports Exerc*. 1998;30(5):777-781.

74. Hultquist CN, Albright C, Thompson DL. Comparison of walking recommendations in previously inactive women. *Med Sci Sports Exerc*. 2005;37(4):676-683.

75. Marshall S, Levy S, Tudor-Locke C, Kolkhorst F, Wooten K. Translating physical activity recommendations into a pedometer-based step goal: 3000 steps in 30 minutes. *Am J Prev Med*. 2009;36(5).

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

77. Tudor-Locke C, Burkett L, Reis JP, Ainsworth BE, Macera CA, K. WD. How many days of pedometer monitoring predict weekly physical activity in adults? *Prev Med*. 2005;40(3):293-298.

78. Ozboda R, Corbin C, Masurier GL. Does reactivity exist in children when measuring activity with unsealed pedometers? *Ped Exerc Sci*. 2004;16:158-166.

79. Matevey C, Rogers LQ, Dawson E, Tudor-Locke C. Lack of reactivity during pedometer self-monitoring in adults. *Measure Phys Ed Exerc Sci*. 2006;10(1):1-11.

80. Croteau KA. A preliminary study on the impact of a pedometer-based intervention on daily steps. *Am J Health Promot*. 2004;18(3):217-220.

81. Williams BR, Bezner J, Chesbro SR, Leavitt R. The effect of a behavioral contract on adherence to a walking program in postmenopausal African American women. *Top Geriatric Rehab*. 2005;21(4):332-342.

82. Wenger N, Froelicher E, Smith L. Cardiac Rehabilitation. Clinical Practice Guidelines No. 17. In: US Department of Health and Human Services PH, Agency for Health Care Policy and Research National Heart, Lung, and Blood Institute, ed. Rockville, MD; 1995.

83. Daly J, Sindone AP, Thompson DR, Hancock K, Chang E, Davidson P. Barriers to participation in and adherence to cardiac rehabilitation programs: a critical literature review. *Prog Cardiovasc Nurs*. 2002;17(1):8-17.

84. Hellman EA. Use of the stages of change in exercise adherence model among older adults with a cardiac diagnosis. *J Cardiopulm Rehabil*. 1997;17(3):145-155.

85. Marcus BH, Simkin LR. The stages of exercise behavior. *J Sports Med Phys Fitness*. 1993;33(1):83-88.

86. Lichtman JH, Bigger JT, Jr, Blumenthal JA, et al. Depression and coronary heart disease: recommendations for screening, referral, and treatment: a science advisory from the American Heart Association prevention committee of the Council on Cardiovascular Nursing, Council on Clinical Cardiology, Council on Epidemiology and Prevention, and interdisciplinary Council on Quality of Care and Outcomes Research: endorsed by the American Psychiatric Association. *Circulation*. 2008;118(17):1768-1775.

87. Dunn SL, Stommel M, Corser WD, Holmes-Rovner M. Hopelessness and its effect on cardiac rehabilitation exercise participation following hospitatlization for acute coronary syndrome. *J Cardiopulm Rehabil*. 2009;29:32-39.

88. Engright PL. The Six-Minute Walk Test. *Respir Care*. 2003;48(8):783-785.

89. Crapo R, Engright P, Zeballos JR. ATS Statement: guidelines for the six-minute walk test. *Am J Resp Critical Care Med*. 2002;166(1):111-117.

APPENDIX A

INDIVIDUAL SUBJECT DATA

Definition of Abbreviations

Sub:	Subject study number
PF:	Pedometer Feedback subjects
UC:	Usual Care subjects
WK:	Study week
Steps:	Average daily stepcounts
Min:	Average moderate to vigorous activity minutes
$Steps_R$:	Average daily stepcounts for days attending rehab
$Steps_{NR}$:	Average daily stepcounts for days not attending rehab
Min_R:	Average moderate to vigorous activity minutes for days attending rehab
Min_{NR}:	Average moderate to vigorous activity minutes for days not attending rehab
BMI:	Body composition index, defined by mass over height (kg/m^2)
6MWT:	6-minute walk test distance (feet)
SE_S:	Sum of scores for self-efficacy questionnaire
SS_{FA}:	Sum of scores for social support from family questionnaire
SS_{FR}:	Sum of scores for social support from friends questionnaire
DB_P:	Average of pro- scores for decision balance questionnaire
DB_C:	Average of con- scores for decision balance questionnaire
DB_D:	Difference of pro- and con- scores for decision balance questionnaire
MI:	Myocardial infarction
PCI:	Percutaneous coronary intervention
CABG:	Coronary artery bypass graft
AVR:	Aortic valve replacement/repair
MVR:	Mitral valve replacement/repair
Transplant:	Heart transplant

Group	Sub	Wk	Steps	Min	$Steps_R$	$Steps_{NR}$	Min_R	Min_{NR}	6MWT	BMI
PF	**2**	1	5672	1.3	7864	4796	2.9	0.6	1658	27.7
		4	5662	3.0	8280	4615	7.3	1.3	.	.
		8	5332	1.9	7560	4440	4.0	1.0	1682	26.5
UC	**6**	1	4787	1.0	6209	4418	1.1	1.0	1341	28.9
		4	5881	2.1	10485	4960	2.5	2.0	.	.
		8	8866	2.6	8470	9025	3.3	2.3	1414	29.2
PF	**10**	1	4488	4.3	6010	3346	6.3	2.8	1487	23.7
		4	3675	2.8	4864	3081	4.5	1.9	.	.
		8	5835	19.5	8411	2400	31.8	3.2	1609	25.1
PF	**11**	1	4991	13.7	8559	3564	34.0	5.6	1901	30.5
		4	6098	19.7	7781	4836	31.9	10.6	.	.
		8	7503	30.1	9795	4448	49.8	3.9	1950	29.3
PF	**12**	1	6692	32.3	8850	4534	46.6	18.0	1414	34.5
		4	8558	26.1	10249	8276	26.6	26.0	.	.
		8	9351	32.2	.	9351	.	32.2	1463	35.3
UC	**15**	1	3619	0.9	1788	4535	0.1	1.3	1316	23.8
		4	3270	0.1	4376	1845	0.2	0.1	.	.
		8	2073	0.6	4139	1384	1.9	0.1	1365	24.8
UC	**18**	1	4908	4.3	5544	3321	4.7	3.2	1316	26.7
		4	4801	4.4	6248	2871	5.7	2.7	.	.
		8	4689	5.0	5890	3089	6.8	2.6	1511	26.3
UC	**19**	1	3430	4.3	7200	2802	5.4	4.1	1316	43.1
		4	3617	1.8	5064	3375	1.7	1.8	.	.
		8	3517	2.1	3620	3525	2.5	1.7	1316	43.6
UC	**21**	1	5503	17.2	8367	4358	31.5	11.5	1901	33.3
		4	7073	20.9	10306	4648	39.5	6.9	.	.
		8	6485	17.6	8392	5723	31.5	12.1	1999	33.7
UC	**22**	1	5454	4.6	5531	5397	3.8	5.3	1268	41.0
		4	7307	7.9	.	7307	.	7.9	.	.
		8	7921	5.5	8821	5671	6.5	3.1	1463	41.0
UC	**23**	1	6734	7.2	6864	6605	4.9	22.6	1170	31.9
		4	5392	7.0	6443	4691	7.6	6.6	.	.
		8	4351	2.7	5847	2356	2.3	3.2	1268	33.3
PF	**24**	1	6638	4.9	9926	4173	6.6	3.6	1706	26.6
		4	7046	6.2	8341	6075	6.2	6.3	.	.
		8	10161	11.4	12189	8641	12.2	10.8	1706	27.7
PF	**25**	1	6472	18.4	5887	6911	19.0	17.9	1755	39.6
		4	7214	15.6	10013	6654	47.0	9.3	.	.
		8	7703	13.4	12883	6840	23.1	11.8	1950	39.7
PF	**26**	1	6089	15.6	7759	4836	25.9	7.9	1950	23.9
		4	9807	46.7	9464	10265	47.5	45.7	.	.
		8	9023	31.4	9459	8696	45.2	21.1	2048	22.2

Group	Sub	Wk	Steps	Min	$Steps_R$	$Steps_{NR}$	Min_R	Min_{NR}	6MWT	BMI
PF	**27**	1	5799	20.5	8515	3762	39.4	6.3	1243	26.4
		4	6630	25.5	9061	4807	47.7	8.9	.	.
		8	10681	46.9	12479	6185	59.0	16.6	1609	26.0
PF	**29**	1	3843	13.0	5001	2105	17.5	6.1	1511	37.5
		4	5710	.	10231	4677	.	.	.	.
		8	7312	21.9	8429	5823	16.6	28.8	1706	37.2
UC	**31**	1	4767	5.4	5222	3629	6.2	3.2	1316	27.1
		4	5673	12.2	6843	3874	14.2	9.4	.	.
		8	5320	7.1	6290	4932	13.5	4.6	1658	27.5
UC	**32**	1	4453	9.3	9051	2614	25.8	2.7	1853	27.7
		4	4739	8.8	7616	3301	21.4	2.5	.	.
		8	6169	11.9	8422	4427	24.7	2.3	1901	28.6

Group	Sub	Wk	SE_S	SS_{FA}	SS_{FR}	DB_P	DB_C	DB_D
PF	**2**	1	19.0	39.0	27.0	4.1	1.5	2.6
		4	22.0	35.0	25.0	4.4	1.8	2.6
		8	19.0	28.0	21.0	4.0	2.3	1.7
UC	**6**	1	14.0	35.0	0.0	3.9	3.0	0.9
		4	12.0	26.0	21.0	3.3	1.2	2.1
		8	17.0	4.0	0.0	4.3	1.3	3.0
PF	**10**	1	11.0	27.0	0.0	2.8	2.5	0.3
		4	10.0	27.0	21.0	3.0	2.3	0.7
		8	11.0	27.0	0.0	2.8	2.7	0.1
PF	**11**	1	17.0	47.0	32.0	3.3	2.7	0.6
		4	21.0	47.0	34.0	3.9	3.0	0.9
		8	21.0	47.0	32.0	3.9	2.7	1.2
PF	**12**	1	14.0	34.0	44.0	4.5	1.2	3.3
		4	11.0	32.0	56.0	4.5	1.3	3.2
		8	13.0	32.0	38.0	4.3	2.5	1.8
UC	**15**	1	21.0	49.0	29.0	4.3	1.7	2.6
		4	20.0	57.0	40.0	3.6	1.8	1.8
		8	20.0	49.0	47.0	4.0	1.5	2.5
UC	**18**	1	15.0	10.0	0.0	4.3	2.2	2.1
		4	18.0	30.0	26.0	3.7	1.5	2.2
		8	20.0	22.0	35.0	5.0	5.0	0.0
UC	**19**	1	12.0	21.0	21.0	4.9	4.8	0.1
		4	13.0	23.0	21.0	4.8	3.2	1.6
		8	15.0	23.0	21.0	4.5	4.0	0.5
UC	**21**	1	12.0	21.0	30.0	3.9	2.2	1.7
		4	12.0	26.0	29.0	3.8	2.3	1.5
		8	16.0	24.0	29.0	3.8	2.3	1.5
UC	**22**	1	17.0	40.0	24.0	4.8	2.0	2.8
		4	17.0	23.0	23.0	4.6	2.5	2.1
		8	15.0	38.0	27.0	3.7	2.7	1.0
UC	**23**	1	14.0	35.0	28.0	3.9	3.3	0.6
		4	11.0	45.0	35.0	3.5	2.8	0.7
		8	10.0	33.0	22.0	3.2	3.0	0.2
PF	**24**	1	12.0	40.0	28.0	3.1	2.3	0.8
		4	11.0	19.0	19.0	3.1	2.2	0.9
		8	10.0	30.0	21.0	2.9	2.2	0.7
PF	**25**	1	22.0	39.0	29.0	5.0	2.0	3.0
		4	20.0	33.0	28.0	4.8	2.0	2.8
		8	20.0	37.0	21.0	4.9	2.2	2.7
PF	**26**	1	14.0	39.0	29.0	4.0	2.3	1.7
		4	18.0	42.0	30.0	4.3	2.2	2.1
		8	19.0	34.0	23.0	4.1	2.3	1.8

Group	Sub	Wk	SE_S	SS_{FA}	SS_{FR}	DB_P	DB_C	DB_D
PF	**27**	1	15.0	37.0	28.0	4.5	2.8	1.7
		4	20.0	41.0	28.0	5.0	2.8	2.2
		8	20.0	50.0	33.0	4.8	2.3	2.5
PF	**29**	1	18.0	48.0	23.0	3.7	2.5	1.2
		4	16.0	49.0	28.0	4.1	1.3	2.8
		8	20.0	45.0	0.0	4.6	2.7	1.9
UC	**31**	1	20.0	37.0	0.0	3.1	2.2	0.9
		4	15.0	37.0	21.0	3.0	2.2	0.8
		8	21.0	30.0	0.0	2.7	2.7	0.0
UC	**32**	1	14.0	34.0	0.0	3.4	1.5	1.9
		4	9.0	34.0	0.0	3.1	2.5	0.6
		8	12.0	22.0	0.0	3.4	2.7	0.7

Group	Sub	Gender	Age	BMI	Diagnosis	Employed
PF	2	M	45	27.7	MI	Y
	10	M	55	23.7	PCI	N
	11	M	53	30.5	MI	Y
	12	F	52	34.5	MI	Y
	24	M	58	26.6	MI	Y
	25	M	40	39.6	MI	Y
	26	M	54	23.9	PCI	Y
	27	F	68	26.4	CABG	N
	29	F	58	37.5	AVR	Y
UC	6	F	54	28.9	Transplant	N
	15	M	67	23.8	CABG	N
	18	F	72	26.7	MVR	N
	19	M	53	43.1	MI	N
	21	M	50	33.3	PCI	Y
	22	F	49	40.1	MI	Y
	23	M	63	31.9	CABG	N
	31	M	75	27.1	CABG	N
	32	M	59	27.7	Stable Angina	N

APPENDIX B

BEHAVIORAL CHANGE QUESTIONNAIRE PACKET

Dear ______________________, ________________

Subject's name *Today's Date*

You will find a total of three questionnaires within this packet. Please feel free to take this home with you to complete at your earliest convenience. You will find simple, easy to follow instructions for each questionnaire, and it is estimated to take no longer than thirty (30) minutes to complete all three. If you have any questions regarding your participation in the study or this packet of questionnaires, please do not hesitate to contact me at (765) 285-3577 or by email at jljones14@bsu.edu.

Please return this packet during your next visit to Phase III Cardiac Rehabilitation on _________ at Ball Memorial Hospital.

Date

Sincerely,

Jason Jones
Research Assistant
Clinical Exercise Physiology Program
Ball State University

DECISIONAL BALANCE

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

Please rate how important each of these statements are in your decision of whether to be physically active. In each case, think about how you feel **right now**, not how you felt in the past or how you would like to feel.

Scale

1. = not at all important
2. = slightly important
3. = moderately important
4. = very important
5. = extremely important

1. I would have more energy for my family and friends if I were regularly physically active.	1	2	3	4	5
2. Regular physical activity would help me relieve tension.	1	2	3	4	5
3. I think I would be too tired to do my daily work after being physically active.	1	2	3	4	5
4. I would feel more confident if I were regularly physically active.	1	2	3	4	5
5. I would sleep more soundly if I were regularly physically active.	1	2	3	4	5
6. I would feel good about myself if I kept my commitment to be regularly physically active.	1	2	3	4	5
7. I would find it difficult to find a physical activity that I enjoy and that is not affected by bad weather.	1	2	3	4	5
8. I would like my body better if I were regularly physically active.	1	2	3	4	5
9. It would be easier for me to perform routine physical tasks if I were regularly physically active.	1	2	3	4	5
10. I would feel less stressed if I were regularly physically active.	1	2	3	4	5
11. I feel uncomfortable when I am physically active because I get out of breath and my heart beats very fast.	1	2	3	4	5
12. I would feel more comfortable with my body if I were regularly physically active.	1	2	3	4	5
13. Regular physical activity would take too much of my time.	1	2	3	4	5
14. Regular physical activity would help me have a more positive outlook on life.	1	2	3	4	5
15. I would have less time for my family and friends if I were regularly physically active.	1	2	3	4	5
16. At the end of the day, I am too exhausted to be physically active.	1	2	3	4	5

Confidence (Self-efficacy)

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.

Circle the number that indicates how confident you are that you could be physically active in each of the following situations:

Scale

1= not at all confident
2= slightly confident
3 = moderately confident
4 = very confident
5 = extremely confident

1. When I am tired 1 2 3 4 5
2. When I am in a bad mood 1 2 3 4 5
3. When I feel I don’t have time 1 2 3 4 5
4. When I am on vacation 1 2 3 4 5
5. When it is raining or snowing 1 2 3 4 5

SOCIAL SUPPORT FOR PHYSICAL ACTIVITY SCALE

The following questions refer to social support for your physical activity.

The following is a list of things people might do or say to someone who is trying to do physical activity regularly. Please read and answer every question. If you are not physically active, then some of these questions may not apply to you.

Please rate each question *two times*. Under "Family", rate how often anyone living in your household has said or done what is described during the past three months. Under "Friends", rate how often your friends, acquaintances, or co-workers have said or done what is described during the past three months.

Please write one number from the following rating scale in each space:

1 = none
2 = rarely
3 = a few times
4 = often
5 = very often
0 = does not apply

		Family	Friends
1.	Did physical activities with me.	_______	________
2.	Offered to do physical activities with me.	_______	________
3.	Gave me helpful reminders to be physically active (i.e., "Are you going to do your activity tonight?")	_______	________
4.	Gave me encouragement to stick with my activity program.	_______	________
5.	Changed their schedule so we could do physical activities together.	_______	________
6.	Discussed physical activity with me.	_______	________
7.	Complained about the time I spend doing physical activity.	_______	________
8.	Criticized me or made fun of me doing physical activities.	_______	________
9.	Gave me rewards for being physically active (i.e., gave me something I liked).	_______	________
10.	Planned for physical activities on recreational outings.	_______	________
11.	Helped plan events around my physical activities.	_______	________
12.	Asked me for ideas on how they can be more physically active.	_______	________
13.	Talked about how much they like to do physical activity.	_______	________

APPENDIX C

USUAL CARE & BASELINE ACTIVITY LOG

PEDOMETER INTERVENTION TO INCREASE PHYSICAL ACTIVITY OF PATIENTS ENTERING A MAINTENANCE CARDIAC REHABILITATION PROGRAM

- As soon as you wake up each morning, put the pedometer on your belt or waistband at the midline of the thigh (clip the pedometer to a belt if you wear one, otherwise just clip it to your waistband). If you do not usually wear a belt or thick waist band, an elastic band can be provided for the pedometer.
- The pedometer should be worn at all times except when swimming, showering, or sleeping.
- We ask that you wear the pedometer for 7 consecutive days prior to returning it (note: it is important that you wear it for the last 7 days prior to returning it; i.e. do not wear it for 7 days and then not wear it for 2 days prior to returning it).
- Return the pedometer to the Cardiopulmonary Rehabilitation program on the specified date.
- If you have any questions please call Jason Jones at (765) 285-3577 or email at jljones14@bsu.edu
- Thank you for participating in this research study.

Monday **Date:** ________	**Tuesday** **Date:** ________	**Wednesday** **Date:** ________	**Thursday** **Date:** ________	**Friday** **Date:** ________	**Saturday** **Date:** ________	**Sunday** **Date:** ________
Time on: ________	**Time on:** ________	**Time on:** ________	**Time on:** ________	**Time on:** ________	**Time on:** ________	**Time on:** ________
Time off: ________	**Time off:** ________	**Time off:** ________	**Time off:** ________	**Time off:** ________	**Time off:** ________	**Time off:** ________

Please report if you did not have the Pedometer on for the whole day (list day, reason, and how long it was not on). If none, check here_.

Please report any days you performed a planned bout of exercise ***outside Maintenance Cardiac Rehabilitation*** (list day, type of exercise, and how long you performed the activity).
If none, check here____.

Please report any days you performed activities that did not require a lot of moving around, but rather more arm activities (list day, type of activity, and how long you performed the activity).
If none, check here_____.

Comment on any unusual or atypical physical activities (activities that you do not usually participate in on a regular basis) you performed during the past week.
If none, check here_____.

APPENDIX D

PEDOMETER FEEDBACK ACTIVITY LOG

PEDOMETER INTERVENTION TO INCREASE PHYSICAL ACTIVITY OF PATIENTS ENTERING A MAINTENANCE CARDIAC REHABILITATION PROGRAM

- **DAILY STEP GOAL:** ≥ _____________ steps/**day** **For week** ________

- As soon as you wake up each morning, put the pedometer on your belt or waistband at the midline of the thigh (clip the pedometer to a belt if you wear one, otherwise just clip it to your waistband). If you do not usually wear a belt or thick waist band, an elastic band can be provided for the pedometer.
- The pedometer should be worn at all times except when swimming, showering, or sleeping.
- We ask that you wear the pedometer for the duration of this study, eight weeks.
- Return the pedometer on the day of your final scheduled CR Phase III program visit.
- If you have any questions please call Jason Jones at (765) 285-3577 or email at jljones14@bsu.
- Thank you for participating in this research study.

Monday Date:	**Tuesday Date:**	**Wednesday Date:**	**Thursday Date:**	**Friday Date:**	**Saturday Date:**	**Sunday Date:**
Time on:	**Time on:**	**Time on:**	**Time on:**	**Time on:**	**Time on:**	**Time on:**
Steps: (noon)	**Steps:** (noon)	**Steps:** (noon)	**Steps:** (noon)	**Steps:** (noon)	**Steps:** (noon)	**Steps:** (noon)
Steps: (dinner)	**Steps:** (dinner)	**Steps:** (dinner)	**Steps:** (dinner)	**Steps:** (dinner)	**Steps:** (dinner)	**Steps:** (dinner)
Steps: (Bedtime)	**Steps:** (Bedtime)	**Steps:** (Bedtime)	**Steps:** (Bedtime)	**Steps:** (Bedtime)	**Steps:** (Bedtime)	**Steps:** (Bedtime)
Time off:	**Time off:**	**Time off:**	**Time off:**	**Time off:**	**Time off:**	**Time off:**

Please See Reverse for Questions Regarding Physical Activity

Please report if you did not have the Pedometer on for the whole day (list day, reason, and how long it was not on). If none, check here____.

Please report any days you performed a planned bout of exercise ***outside Maintenance Cardiac Rehabilitation*** (list day, type of exercise, and how long you performed the activity).
If none, check here____.

Please report any days you performed activities that did not require a lot of moving around, but rather more arm activities (list day, type of activity, and how long you performed the activity).
If none, check here____.

Comment on any unusual or atypical physical activities (activities that you do not usually participate in on a regular basis) you performed during the past week. If none, check here____.