

COMPARISON OF HIGH INTENSITY INTERVAL TRAINING VERSUS
MODERATE INTENSITY CONTINUOUS TRAINING IN A PHASE II
CARDIAC REHABILITATION PROGRAM

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ABSTRACT

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Research has compared the effects of moderate intensity continuous training (MCT) versus high intensity interval training (HIIT) in phase II cardiac rehabilitation patients. However, the results from these studies have conflicting results. Therefore, there was a need for further research on the topic. The purpose of the current study is to evaluate if HIIT leads to greater improvements in peak volume of oxygen consumed (VO_2) when compared to MCT in a group of phase II cardiac rehab patients. Both exercise groups, MCT and HIIT, improved their peak VO_2 , 12MWT distance, resting systolic blood pressure, resting diastolic blood pressure, score of depression, score of anxiety, score of stress on the Depression Anxiety Stress Scale -21, and the Patient Health Questionnaire - 9 with no significant difference in improvements between the two exercise groups. There was a statistically significant difference in improvements between the two exercise groups resting heart rate with the HIIT group improving greater than the MCT group. The results of this study suggest that HIIT can be used as an effective alternative to MCT on improving functional capacity in a group of phase II cardiac rehabilitation patients.

I would like to dedicate this to my friends and family who have helped and supported me in everything I do.

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CHAPTER I. INTRODUCTION

Introduction

Many individuals experience cardiac events, procedures, or surgeries such as a heart attack, coronary angioplasty, coronary stents, coronary bypass graft surgery, or a heart transplant (“Don’t skip”, n.d.). Phase II cardiac rehab is a multidisciplinary medically monitored outpatient program that includes a combination of exercise therapy, patient education and counseling, dietary counseling, and psychosocial assessment and intervention. Cardiac rehab has been proven to be effective in improving recovery rates and reducing future cardiac complications (Piepoli, Davos, Francis, & Coats, 2004) in patients that have had a cardiac event. However, many are not referred to cardiac rehab. Researchers who analyzed a national registry found that between 2005 and 2014 only 10.4 percent of qualified heart failure patients were referred to cardiac rehab following discharge from the hospital (“Only one”, n.d.). It is of the utmost importance to increase the number of patients being referred to cardiac rehab in order to realize improved outcomes in this group of patients.

There is still debate regarding what the optimal intensity and type of exercise training is for patients who have experienced a cardiac event (Freyssin et al., 2012). Two types of training are currently used in phase II cardiac rehab programs. Moderate intensity continuous training (MCT) is routinely prescribed for cardiac patients in phase II cardiac rehab. MCT exercise is rated as “fairly light” to “somewhat hard” in terms of intensity level. Typically the upper limit of intensity that is prescribed during the early stages of phase II cardiac rehab is 60 – 70% of heart rate reserve (“Moderate levels”, n.d.). This intensity of exercise is then performed continuously for 10 – 30 minutes depending on endurance and as tolerated by the patient. High intensity interval training (HIIT) has been used as an effective type of training in healthy adults for many

years; however, routine implementation of HIIT into a phase II cardiac rehab programs for higher risk cardiac patients has yet to be established. Recent clinical studies have implemented HIIT into phase II cardiac rehab programs. The HIIT program allows patients to work at a higher intensity for duration of two to three minutes while alternating with recovery intervals at a moderate intensity. In these clinical studies work intervals ranged from an intensity of 80-95% of heart rate reserve and rest intervals ranged from 50-70% of heart rate reserve with a duration of 30 – 45 minutes per rehab session (Freyssin et al., 2012; Keteyian et al., 2014).

Several factors are effected by aerobic exercise, the most important being functional capacity. It is defined as the highest amount of oxygen consumed during maximal exercise in activities that require large muscle groups and is known to be a strong predictor of mortality (Sandstad et al., 2015). Multiple studies have been done to compare and evaluate the ability of interval training to improve overall functional capacity (Benda et al., 2015; Chrysohoou et al., 2015; Fisher et al., 2015; Freyssin et al., 2012; Haykowsky et al., 2013; Jung, Bourne, Beauchamp, Robinson, & Little, 2015; Sandstad et al., 2015; Weston, Wesloff, & Coombes, 2014). Some studies that have directly compared the effects of HIIT and MCT have found that HIIT produces greater improvements in functional capacity compared to MCT (Freyssin et al., 2012; Haykowsky et al., 2013; Weston et al., 2014). In contrast, some studies have found no significant difference between the improvements of VO_2 peak (Benda et al., 2015; Hidehiro, Shin-Ya, & Adayoshi, 2015). One reason there is a difference in these results could be due to differences in the duration of the training program, interval time, and work to rest ratios. Each of these factors plays a major role in the effectiveness of both HIIT and MCT.

Optimal interval intensity and duration play a main role in receiving maximum benefits from interval training. A recent meta-analysis by Weston, Wisloff, & Coombes found that

following 12-16 weeks of interval training VO_2 peak had improved twofold in the interval training group (IT = 19.4%, MICT = 10.3%) compared to moderate intensity continuous training (Weston et al., 2014). Previous studies suggest that the benefits of interval training increase at a rate similar to continuous training (Benda et al. 2015; 20). The findings of the Weston et al. (2014) review and meta-analysis suggest that there may be continued improvement in VO_2 peak following interval training while improvement in continuous training may plateau over time (Weston et al., 2014).

Studies have found that interval training is associated with improvements in reverse left ventricular remodeling, increased left ventricular end-diastolic and decreased end-systolic volume, increased left ventricular ejection fraction, improved diastolic dysfunction, increased endothelial function, and increased stroke volume (Angadi et al., 2015; Haykowsky et al., 2013; Holloway et al., 2015; Ramos, Dalleck, Tjonna, Beetham, & Coombes, 2015); all of which allow the heart to function more efficiently. By itself the improvements in left ventricular ejection fraction as a result of interval training would decrease the risk of adverse cardiovascular events.

Physiological changes are not the only benefit patients receive from undergoing therapy in a phase II cardiac rehab program. Clinical studies have evaluated the effectiveness of exercise to improve anxiety, depression and stress in those who have experienced a cardiac event (Benda et al., 2015; Milani & Lavie, 1998; Weston et al., 2014). The results of the studies were that anxiety, depression, and stress improved following both HIIT and MCT (Chrysohoou et al., 2015; Milani & Lavie, 1998), but when directly compared there was no significant difference between the two (Freyssin et al., 2012). However, one study reported that those who participated in HIIT found exercise to be more enjoyable and had higher quality of life scores (Wilson & Brookfield, 2009).

Despite the benefits provided through interval training in specific clinical populations, this form of training is not without risk. All who have had a cardiac event are at increased risk of reoccurring events (Haykowsky et al., 2013). However, a recent study suggested the risk of a cardiac event during both interval training and continuous training in a cardiac rehabilitation setting is low (Rognmo et al., 2012). It would seem that the benefits outweigh the risks in those performing interval training in a cardiac rehab setting.

Supplementing aerobic training with resistance training is important because it assists in improving functional capacity, productivity, and independence. Returning to daily occupational and recreational activity is also of the utmost importance (Spencer, 2007). Muscle strength can improve up to 25-30% when resistance training is included for cardiac patients (Sorace, Ronal, & Churilla, 2008). These improvements lead to increases in patient's strength, bone mass, and neuromuscular control, which results in reduced risk of sustaining debilitating or life-threatening injuries from falls (Merrill, 1997).

Purpose

The purpose of this study is to determine if high intensity interval training will lead to greater improvements in functional capacity, and/or the symptoms of anxiety, depression, and stress compared to moderate intensity continuous training in a group of phase II cardiac rehab patients.

Significance

The benefits of phase II cardiac rehab following a cardiac event are well known. It helps patients recover faster, acquire the strength and endurance they need to increase independence and resume activities of daily living, as well as decrease risk of future heart complications ("Cardiac rehab", n.d.). However, there is still discussion among cardiac rehab clinicians on what

type of exercise protocol, HIIT or MCT, provides the greatest benefit as it relates to functional capacity, and the symptoms of anxiety, depression, and stress. This study will examine whether HIIT or MCT is the most beneficial to effect these favorable changes in a group of phase II cardiac rehab patients.

Hypothesis

It is hypothesized that:

1. If HIIT is used rather than MCT in a phase II cardiac rehab program it will lead to greater improvements in functional capacity;
2. Symptoms of anxiety, depression, and stress will show greater signs of improvement following HIIT compared to MCT.

CHAPTER II. REVIEW OF LITERATURE

Phase II Cardiac Rehabilitation

Phase II cardiac rehab is a multidisciplinary medically monitored outpatient program that includes a combination of exercise therapy, patient education and counseling, dietary counseling, and psychosocial assessment and intervention. The health care professionals who make up the cardiac rehab staff typically include a physician, exercise physiologist, nurse, dietician, and psychologist. The individualized exercise program helps patients that have had a cardiac event, surgery, or procedure recover faster and acquire the strength and endurance they need to resume activities of daily living (“Cardiac rehab”, n.d.). The patient education program focuses on topics that help to inform patients of cardiovascular structure and function, well-balanced nutrition, strength and stretching, smoking, and high blood pressure, and how to keep their heart healthy (“Don’t skip”, n.d.). Patients receive counseling from a dietician to discuss current eating habits. The dietician will instruct patients on how their diet can be adapted to improve their weight, serum lipid profile, blood pressure, and blood sugars. Patients meet with a psychologist to assess symptoms of depression, anxiety, and stress. The psychologist will provide counseling on present issues and suggest methods to help cope with current stressors in order to minimize their effects. The patient’s individual treatment plan is tailored to each patient’s individual needs and goals are set to help them make lifestyle changes that will reduce their risk of future heart problems.

Patients are referred to phase II cardiac rehab for a variety of cardiac events, surgeries, or procedures such as a heart attack, coronary angioplasty, coronary stents, coronary bypass graft surgery, heart transplant, heart failure, and stable angina (“Don’t skip”, n.d.). Phase II cardiac

rehab programs usually consists of a total of 36 sessions, which is typically covered by the patient's health insurance, including Medicare.

Participation in phase II cardiac rehab following a cardiac event, surgery, or procedure is associated with decreases in all-cause mortality rates (Suaya, Stason, Ades, Normand, & Shepard 2009). Suaya, Stason, Ades, Normand, & Shepard (2009) found that the five year mortality rate in phase II cardiac rehab patients is 21% lower than those who did not participate in cardiac rehab (Suaya et al., 2009). In addition, a strong – dose response relationship exists between the number of phase II cardiac rehab sessions and long-term outcomes in Medicare beneficiaries. Attending all 36 phase II cardiac rehab sessions was found to be associated with lower risk of death and myocardial infarction at four years post event compared to those who attended fewer phase II cardiac rehab sessions (Hammill, Curtis, Schulman, & Whellan, 2010). In addition to reductions in all-cause mortality, phase II cardiac rehab therapy also leads to significant improvements in physiological and psychosocial parameters, which allows patients to complete activities of daily living and improve overall quality of life (Jaureguizar et al., 2016).

Types of Training

There is still debate regarding what is the optimal intensity and type of exercise training for patients who have experienced a cardiac event (Freyssin et al., 2012). Two types of training are currently used in phase II cardiac rehab programs, moderate intensity continuous training (MCT) and high intensity interval training (HIIT). Several studies have addressed the effects of MCT and HIIT in cardiac patients. Both are effective at improving cardiovascular function, pulmonary function, and functional capacity in phase II cardiac rehab patients. However, because these forms of exercise vary in duration and intensity they have shown to produce

varying effects on physiological parameters such as functional capacity, as well as psychological parameters such as the symptoms of anxiety, depression, and stress.

Moderate Intensity Continuous Training (MCT)

MCT is routinely prescribed for patients in a phase II cardiac rehab program. The American College of Sports Medicine states that in a standard phase II cardiac rehab program the prescribed exercise intensity for a cardiac patient should be above the minimal level required to produce a “training effect”, yet below the metabolic load that provokes abnormal clinical signs and symptoms (American College of Sports Medicine, 2014). Typically, exercise exertion rated as “fairly light” to “somewhat hard” (60 – 70% of heart rate reserve) is the upper limit of intensity that is prescribed during the early stages of phase II cardiac rehab (“Moderate levels”, n.d.). This intensity of exercise is then performed continuously for 10 – 30 minutes depending on endurance and as tolerated by the patient. This training protocol has proven to be effective in improving cardiac function, pulmonary function, functional capacity, and symptoms of anxiety, depression, and stress.

High Intensity Interval Training (HIIT)

HIIT has been used as an effective type of training in healthy adults for many years; however, routine implementation of HIIT into a phase II cardiac rehab program for higher risk cardiac patients has yet to be established. Keteyian et al. (2014) recently implemented a HIIT exercise program into a standard phase II cardiac rehab program to assess if issues would arise in monitoring, adjusting, and progressing HIIT workloads (Keteyian et al., 2014). They found that it was successfully implemented and led to greater improvements in peak exercise capacity and submaximal endurance when compared to MCT (Keteyian et al., 2014). Other recent clinical studies have also implemented HIIT in phase II cardiac rehab programs. In these clinical studies

work intervals range from an intensity of 80-95% of heart rate reserve and rest intervals range from 50-70% of heart rate reserve with a duration of 30 – 45 minutes per rehab session (Freysin et al., 2012; Keteyian et al., 2014). The HIIT program allows patients to work at a higher intensity for a duration of two to three minutes while alternating with recovery intervals at a moderate intensity. This enables the patients to maximize oxygen intake during a phase II cardiac rehab session, which may lead to greater training adaptations and improvements in functional capacity following HIIT compared to MCT (Freysin et al., 2012).

Functional Capacity

Functional capacity is the highest amount of oxygen consumed during maximal exercise in activities that require large muscle groups. Functional capacity is known to be a strong predictor of mortality (Weston et al., 2014). Therefore, improving functional capacity is important because those with a diminished functional capacity are at greater risk for developing cardiovascular disease (Fisher et al., 2015).

Functional capacity can be measured through various exercise testing modalities such as cardiopulmonary exercise (CPX) testing and the 12-minute walk test (12MWT) (American College of Sports Medicine, 2014). CPX testing is the gold standard for determining functional capacity (Wilson & Brookfield, 2009). Burke (1976) evaluated the use of multiple laboratory and field tests. He reported that of the protocols evaluated the Modified Balke Treadmill Protocol was the most valid and reliable measure (Burke, 1976). There are multiple walk tests used to assess functional capacity in phase II cardiac rehab programs including the two minute walk test (2MWT), six minute walk test (6MWT), and 12MWT. Kosak & Smith (2005) evaluated the inter- and intra rater reliability and sensitivity to change between the three walk tests (Kosak & Smith, 2005). They found that all of the walk tests correlate well (> 0.0993) but the 2MWT

significantly overestimated the 6MWT and 12MWT distances due to inability to account for fatigue (Kosak & Smith, 2005). Of the three walk tests the 12MWT was the most sensitive to change over the course of the rehabilitation program. Bernstein et al. (1994) reiterates this concept with findings that the 12MWT correlates better with changes in a maximal exercise test than do changes in shorter walk tests such as the 2MWT and the 6MWT (Bernstein et al., 1994). The 12MWT was also reliable and valid when used with coronary heart disease patients (De Greef et al., 2005). Therefore, it could be implied that the use of the 12MWT is the most accurate of the three walk tests commonly used in phase II cardiac rehab to assess functional capacity.

Functional capacity can be improved through aerobic exercise (HIIT and MCT). Research has found that both HIIT and MCT improve functional capacity but vary in the rate in which they do so (Fisher et al., 2015). Multiple studies have been done to compare and evaluate the ability of interval training to improve functional capacity (Benda et al., 2015; Chrysohoou et al., 2015; Fisher et al., 2015; Freyssin et al., 2012, Haykowsky et al., 2013; Jung et al., 2015; Sandstad et al., 2015; Weston et al., 2014). Some studies that have directly compared the effects of HIIT and MCT have found that HIIT produces greater improvements in functional capacity compared to MCT. Freyssin et al. (2012) evaluated the differences in effects of eight weeks of HIIT or MCT exercise training in phase II cardiac rehab patients with chronic heart failure (Freyssin et al., 2012). They found that the HIIT group significantly increased both VO_2 peak and distance walked during the 6MWT when compared to the MCT exercise group (Freyssin et al., 2012). Keteyian et al. (2014) also evaluated the use of HIIT versus MCT in a phase II cardiac rehab program (Keteyian et al., 2014). They tested the hypothesis that HIIT could be employed in a standard phase II cardiac rehab program in patients with coronary heart disease and would result in a greater increase in cardiorespiratory fitness. They found that follow-up

cardiopulmonary exercise (CPX) testing anaerobic threshold and peak VO_2 increased more following HIIT when compared to MCT (Keteyian et al., 2014).

Although studies have found that HIIT may produce greater results in VO_2 peak than MCT (Freyssin et al., 2012; Haykowsky et al., 2013) some have found no significant difference between the improvements of VO_2 peak (Benda et al., 2015; Hidehiro et al., 2015). Benda et al. (2015) found that both HIIT and MCT revealed improvements in VO_2 peak, with no significant difference between the two exercise groups following 12 weeks of exercise training in heart failure patients (Benda et al., 2015). Jung et al. (2015) evaluated the use of HIIT and MCT in adults with pre-diabetes. They found that after four weeks of training cardiorespiratory fitness were equally improved following both exercise groups, with no difference between the two (Jung et al., 2015). However, this study was significantly shorter than the other studies, which may suggest that there was not enough time for a difference to be shown.

There are multiple reasons why there are differences in functional capacity following HIIT and MCT training protocols. One reason there may be a difference in effects may be due to differences in the duration of the training program, interval time, and work to rest ratios. Each of these factors plays a major role in the effectiveness of both HIIT and MCT.

Length of Interval and Duration of Training Program

Optimal intensity and duration play a significant role in receiving maximum benefits from interval training (Fisher et al., 2015). A study on interval training in women with rheumatic disease found a correlation between exercise intensity and improvement in VO_2 peak (Sandstad et al., 2015). They reported that participants who worked at intensities greater than 92% of their heart rate max had significantly greater improvements in VO_2 peak than those exercising between 85-92% of heart rate max (Sandstad et al., 2015). In addition, a recent study by Weston,

Wisloff, & Coombes (2014) found that following 12-16 weeks of interval training VO_2 peak had improved twofold (HIIT = 19.4%, MICT = 10.3%) in the HIIT group compared to the MCT group (Weston et al., 2014). These findings represent the potential increased benefits that can occur from participation in interval training.

All of the studies (with exclusion of Weston et al., 2014) evaluated in this literature review consist of training programs that lasted 12 weeks or less with some of them being completed in less than four weeks. As a result, some research studies have reported that interval training and continuous training provided similar results in changes of VO_2 peak. Weston, Wisloff, & Coombes (2014) state that although some research studies suggest that the benefits of interval training increase at a rate similar to continuous training (Benda et al., 2015; Jung et al., 2015; Weston et al., 2014), they report that there may be continued improvement in VO_2 peak following interval training while improvement following continuous training may plateau as exercise program duration increases (Weston et al., 2014). It is important to acknowledge that most phase II cardiac rehab programs last 36 sessions (3 sessions per week), allowing 12 weeks of exercise. Therefore, the studies that lasted 12 weeks more accurately depict the results that will occur following a phase II cardiac rehab program.

Cardiac Structure and Function

There is still disagreement over the level and intensity of exercise that should be performed in clinical settings and whether MCT or HIIT provides the greatest improvements (Wisloff et al., 2007). Despite this, research studies suggest that the wide variety of benefits that are obtained through completing HIIT is no longer only suitable and recommended for healthy individuals but for those who have respiratory and cardiovascular diseases as well (Hidehiro et al., 2015).

Wisløff et al. found that heart failure patients who completed interval training had reverse left ventricular remodeling, left ventricular end-diastolic increases, end-systolic volume decline, and increased left ventricular ejection fraction, which indicates that the risk of adverse cardiovascular events is less likely to reoccur post-interval training (Wisloff et al., 2007). In contrast, Haykowsky et al. (2013) reported no significant difference between continuous training and interval training in left ventricular ejection fraction, although there was a significant increase from baseline levels in both exercise groups. Therefore, more research is needed to determine if there are differences between MCT and HIIT on ventricular ejection fraction.

Brachial artery flow-mediated dilation is used to determine endothelial function. A recent meta-analysis reported that endothelial function is significantly improved in those who completed interval training compared to those who completed continuous training (Ramos et al., 2015). In contrast, Benda, et al. (2015) found no significant changes to the brachial artery flow-mediated dilation after completion of both continuous training and interval training, which suggests no change in endothelial function. However, there were different exercise training protocols used in the studies. The study by Ramos, et al. (2015) evaluated an exercise program that lasted for 12-16 weeks whereas the study by Benda et al. (2015) only had patients complete 12 weeks of training. The duration of the exercise program and the protocols followed may have caused the apparent conflicts in results.

Stroke volume is the amount of blood that is pumped out of the left ventricle to the rest of the body during each contraction (Kenney, Wilmore, & Costill, 2015). It is one of two determinants of cardiac output, which determines how efficiently the heart can pump blood, and it can be improved through aerobic training. Interval training has increased stroke volume by 17% in individuals with heart failure (Wisloff et al., 2007). Another study on heart failure

patients with reduced ejection fractions also found that stroke volume was significantly increased by 30% following interval training (Haykowsky et al., 2013). In both of these studies exercise training was completed for 12 weeks. Therefore, these findings suggest that stroke volume can be significantly increased through interval training when completed for a minimum of 12 weeks (Haykowsky et al., 2013; Wisloff et al., 2007).

Anxiety, Depression, and Stress

Studies have evaluated the effectiveness of exercise to improve the symptoms of anxiety, depression and stress in those who have experienced a cardiac event (Chrysohoou et al., 2015; Freyssin et al., 2012; Milano & Lavie, 1998; Wilson & Brookfield, 2009). Due to differing levels of intensity between HIIT and MCT, research on symptoms of anxiety, depression and stress have shown varying results following the two modes of aerobic exercise.

Milani & Lavie (1998) evaluated the effects of a 12-week cardiac rehab exercise program on depression, which utilized continuous aerobic exercise. They assessed depression using the Symptom Questionnaire and SF-36 and found that patients experienced less depressive symptoms following cardiac rehab regardless of clinical depression diagnosis (Milani & Lavie, 1998). In addition, those who were clinically depressed had dramatic increases in quality of life scores, energy, general health, and decreases in symptoms of anxiety (Milani & Lavie, 1998). Chrysohoou et al. (2015) evaluated patients with chronic heart failure and found similar results following 12 weeks of combined HIIT and strength training when compared to a control group. Their results show that symptoms of depression and quality of life scores are improved following HIIT.

Freyssin et al. (2012) directly compared the effects of an eight-week HIIT and MCT training program on symptoms of anxiety and depression in patients with heart failure. The

results of the study support other findings that symptoms of anxiety and depression can be improved following both HIIT and MCT, with no significant difference between the two training groups (Freyssin et al., 2012). This suggests that psychological parameters such as anxiety and depression can be improved by completing exercise, but performing one form of training (HIIT or MCT) will not provide greater benefits than the other. However, Wilson & Brookfield (2009) found that those who completed interval training found exercise to be more enjoyable and had higher increases in quality of life scores (45).

Aerobic Exercise Combined with Resistance Training

Phase II cardiac rehab programs are primarily focused on aerobic exercise because reconditioning the heart muscle is the primary concern following a cardiac event. However, research studies have demonstrated the importance of incorporating resistance training because it can be safe and beneficial for cardiac patients (Merrill, 1997). It is important to incorporate resistance training into the program because improving functional capacity, productivity, independence, and returning to daily occupational and recreational activity are also valuable to the well being of the patient (Spencer, 2007). A majority of phase II cardiac rehab patients have musculoskeletal weakness, which is associated with inactivity and old age (Spencer, 2007).

The greatest benefit to combining resistance training with aerobic training is increased muscular strength and endurance (Sorace et al., 2008). Studies have shown that overall muscle strength can improve up to 25-30% when resistance training is included for cardiac patients (Sorace et al., 2008). These improvements lead to increases in patient's strength, bone mass, and neuromuscular control, which results in reduced risk of sustaining debilitating or life-threatening injuries from falls (Merrill, 1997).

There are many variables to consider for the patients that are able to complete resistance training as part of their phase II cardiac rehab program, which includes technique, intensity, and safety (Merrill, 1997). Merrill (1997) states that each aspect of resistance training is equally important in order to perform the exercises efficiently and safely. Each patient should be instructed on proper technique. It is important they perform slow, controlled movements and focus on moving through a full range of motion (Merrill, 1997). Patients should be taught to recognize how hard they are working and recognize symptoms that warrant discontinuation of the exercise such as chest pain, dizziness, shortness of breath, or excessive muscular fatigue. Patients should be working at a rating of perceived exertion of no more than 15 or “somewhat hard” (Merrill, 1997). Cardiac rehab staff should monitor patients via electrocardiogram and blood pressure should be measured once per session to ensure it is staying within a safe range (Merrill, 1997). If all aspects of the resistance-training program are followed then patients will be able to participating in a safe program that is beneficial for their self – efficacy, ability to perform activities of daily living, and overall quality of life (Spencer, 2007).

Exercise Adherence

A majority of the population does not participate in the recommended 150 minutes of moderate intensity physical activity per week (Huberty et al., 2008). There are many reasons why people do not complete the recommended amount of physical activity each week. These factors include: self-consciousness, fear of falling, lack of energy, and lack of time (Seguin et al., 2012), which can lead to lack of adherence to an exercise program. Research has found that there is a lack of adherence in long-term exercise training programs for middle-aged and older adults (Shizue et al., 2015). It suggests that 50% of the people that begin an exercise program will drop out within the first six month of participation (Wilson & Brookfield, 2009). Therefore, it is

important to determine the factors that increase probability of dropping out and create exercise programs that the people are most likely to adhere to.

Many people lack the time and motivation (Kravitz, 2011) to complete the American College of Sports Medicine recommended 150 minutes of moderate intensity continuous training each week, which promotes optimal cardiovascular benefits (American College of Sports Medicine, 2014). Unrealistic expectations, such as losing weight quickly, are another factor that contributes to decreased adherence and increased dropout rates from exercise programs in older adults (Huberty et al., 2008). Interval training is an attractive alternative to continuous training because it is time efficient and may allow the population to achieve desired results in considerably less time than traditional exercise guidelines (Jung et al., 2015).

Exercise adherence is important for overall health and well being. Aerobic exercise improves pulmonary function, cardiovascular function, and functional capacity. It can also assist in the decreased likelihood of developing age and lifestyle related disorders diseases (Shizue et al., 2015). Therefore, creating programs that encourage exercise adherence will promote longevity; decrease risk of cardiovascular disease, improve overall quality of life, and prolong functional ability.

Safety and Risk

Despite the advances made and benefits provided through interval training in special populations, this form of training is not without risk. Those who have experienced cardiac events, surgeries, and procedures such as coronary angioplasty, coronary stents, coronary bypass graft surgery, and heart transplant are at increased risk of reoccurring events (Haykowsky et al., 2013). Rognmo et al. (2012) recently assessed the safety of interval training compared to continuous training. They found that the risk of having a cardiac event in both interval training

and continuous training in a cardiovascular rehabilitation setting is low (Rognmo et al., 2012). They also found that there are greater cardio-protective benefits to interval training compared to continuous training (Rognmo et al., 2012). Therefore, the benefits outweigh the risks in those performing interval training in a cardiovascular rehabilitation setting.

Conclusion

Research clinicians continue to discuss which type of training, MCT or HIIT, should be the primary exercise training protocol prescribed in phase II cardiac rehab programs to ensure the greatest improvements in cardiovascular function, pulmonary function, functional capacity, and symptoms of anxiety, depression, and stress. Recent research suggests that interval training does not only benefit healthy populations but also those who have had cardiac events as well (Hidehiro et al., 2015). Interval training is associated with improvements in reverse left ventricular remodeling, increased left ventricular end-diastolic and decreased end-systolic volume, increased left ventricular ejection fraction, decreased diastolic dysfunction, increased endothelial function, and increased stroke volume (Angadi et al., 2015; Haykowsky et al., 2013; Holloway et al., 2015; Ramos et al., 2015; Wilson & Brookfield, 2009); these allow the heart to function more efficiently. Functional capacity can be significantly improved through aerobic exercise, which leads to decreases in cardiovascular disease risk factors and mortality. Multiple studies have found that HIIT produces greater improvements in VO_2 peak than MCT (Freyssin et al., 2012; Keteyian et al., 2014; Weston et al., 2014); whereas some research studies have found no significant difference between the two (Benda et al., 2015; Jung et al., 2015).

Previous initial research has evaluated the effects of MCT versus HIIT in phase II cardiac rehab patients pointing to many potential positive health benefits. However, there is need for

further research on the effects of HIIT when combined with resistance training, patient education and nutrition counseling, and psychosocial assessment and intervention.

CHAPTER III. METHODS

Participants

Patients undergoing therapy in a phase II cardiac rehabilitation program were recruited for this study. A total of eighteen (N=18) men and women were included in the study. The inclusion criterion required that the subjects be at least 45 years old, have a left ventricular ejection fraction $\geq 40\%$, be more than three weeks post myocardial infarction or percutaneous intervention (PCI) and be at least four weeks post coronary artery bypass graft (CABG) surgery. Patients must have attended four of the first six cardiac rehab sessions, which is classified as the run-in period, and be free of any co-morbidity that would limit them from undergoing treadmill exercise.

Measures

Cardiopulmonary Exercise (CPX) Testing. Pulmonary function, cardiac function, and functional capacity were evaluated using a CPX test via the Modified-Balke Treadmill Protocol (Heyward, 2010). The CPX test included three components: static pulmonary function tests (PFT's), treadmill stress test electrocardiogram (ECG), and measurement of gas exchange.

The PFTs were completed first and assessed the patient's static lung function by spirometry by measuring forced vital capacity (FVC), forced expiratory volume during the first second (FEV1), FVC/FEV1, and maximum voluntary ventilation (MVV). These breathing tests were performed while standing. During the first test the patient took a slow deep breath in as big as they can and then blow the air out until all of it is expelled. The second test had them take a deep breath in then breathe the air out as quickly as they can until all air is expelled. During the final test the patient was requested to take quick deep breaths in and out as fast as they can for 12 seconds. A clinical exercise physiologist read and interpreted the results of the PFTs.

Next the patient completed the treadmill stress ECG and gas exchange portion of the CPX test. The patient was prepped with ten electrodes using the Mason-Likar Modified lead placement and was hooked up to an ECG machine, which evaluated the electrical conductivity of the heart during rest, exercise, and recovery. A cardiologist read and interpreted the results of the patient's stress ECG to determine if there are any ECG arrhythmias or ischemic changes during the stress test. Measurement of gas exchange was used to evaluate the patient's functional capacity. During the treadmill stress test the patient was attached to the metabolic cart (MedGraphics), which measures volume of oxygen consumed (VO_2), volume of CO_2 produced (VCO_2), minute ventilation (V_E) ventilatory threshold (V_T), and minute ventilation – carbon dioxide product relationship (V_E/VCO_2) and respiratory rate. A nose clip was worn to ensure that all air breathed in and out is through the mouthpiece that is connected to the metabolic cart. Blood pressure was measured during rest, every two minutes during the exercise test, and every two minutes during the ten minutes of recovery. Heart rate was measured continuously via the ECG from rest until 10 minutes post exercise test. Rating of Perceived Exertion (RPE) (Borg, 1982) was recorded every two minutes during the exercise test. A Modified Balke Treadmill Protocol was used for the exercise test. This allowed patients to walk at a speed of their choice while percent incline (grade) increases by two and a half percent every two minutes for the duration of the test. The CPX test should last between six to twelve minutes (American College of Sports Medicine, 2014). The gas exchange portion of the CPX test was read and interpreted by a clinical exercise physiologist to determine peak VO_2 , V_T , and V_E/VCO_2 slope.

The CPX test is the gold standard when determining functional capacity (Wilson et al., 2009). Burke (1976) evaluated the use of multiple laboratory and field tests. The results of the

study found that of the protocols evaluated, the Modified-Balke Treadmill Protocol was the most valid and reliable measure of functional capacity.

12-Minute Walk Test. Functional capacity was also evaluated through the use of a 12 – Minute Walk Test (12MWT) (McGavin, Gupta, & McHardy, 1976). The greater the distance walked in 12 minutes the higher the participant’s functional capacity. McGavin, Gupta & McHardy (1976) introduced the 12MWT, which can be used in individuals with disabilities, by modifying the 12-minute run protocol (Cooper, 1968). Mathieu et al. (2005) evaluated the use of the 12MWT in individuals with coronary heart disease. They found that the 12MWT is both reliable and valid when used to predict VO₂ peak (Manthieu et al., 2005).

Depression Anxiety Stress Scale - 21. Symptoms of depression, anxiety, and stress was evaluated through the Depression Anxiety Stress Scale (DASS-21) (Osman et al., 2012). There are 21 items on the questionnaire and it takes less than 10 minutes to complete. The items are based on a four-point (0-3) severity scale. Because the DASS-21 is the short version of the DASS the final scores for each item groups will need to be multiplied by two. Those numbers were then used to assess the patient’s symptoms of depression, anxiety, and stress. Ng et al. (2007) evaluated the validity of the DASS-21. They found that the DASS-21 was significantly correlated with all MHQ-14 subscales and HoNOS scores, and was significantly related to CGI scale categories, supporting the validity of the DASS-21 (Ng et al., 2007).

Patient Health Questionnaire - 9. Symptoms of depression was further evaluated through the use of the Patient Health Questionnaire – 9 (PHQ-9) (Kocalevent, Hinz, & Brahler, 2013). There are 9 items on the questionnaire and it takes less than five minutes to complete. To score the test each of the columns was added separately then add the totals for each of the columns together to find the total score, the severity score. Kocalevent et al. (2013) evaluated the

use of the PHQ-9 in the general population. They found that the PHQ-9 is a reliable and valid of measure of symptoms of depression in the general population (Kocalevent et al., 2013).

Procedures/Treatment

Participants were recruited from patients being admitted into the Phase II cardiac rehabilitation program at the University of Toledo Medical Center. During their initial clinic visit appropriate patients will be given information regarding the study and given the opportunity to accept or decline participation. If they choose to accept participation in the study an informed consent document will be signed and dated by the patient and returned to the researcher. Each patient will receive a paper copy of the signed and dated informed consent for his or her records. The DASS-21 and PHQ-9 questionnaires will be completed during their initial clinic visit.

Each patient was expected to participate in the study for 12 weeks. The first two weeks was the run-in period, which consisted of standard phase II cardiac rehab therapy, 12MWT, and a CPX test. Patients will completed a 12MWT during their first cardiac rehab session. Heart rate and blood pressure was measured pre- and post-12MWT and distance walked around a small indoor track was recorded to the nearest 50 feet.

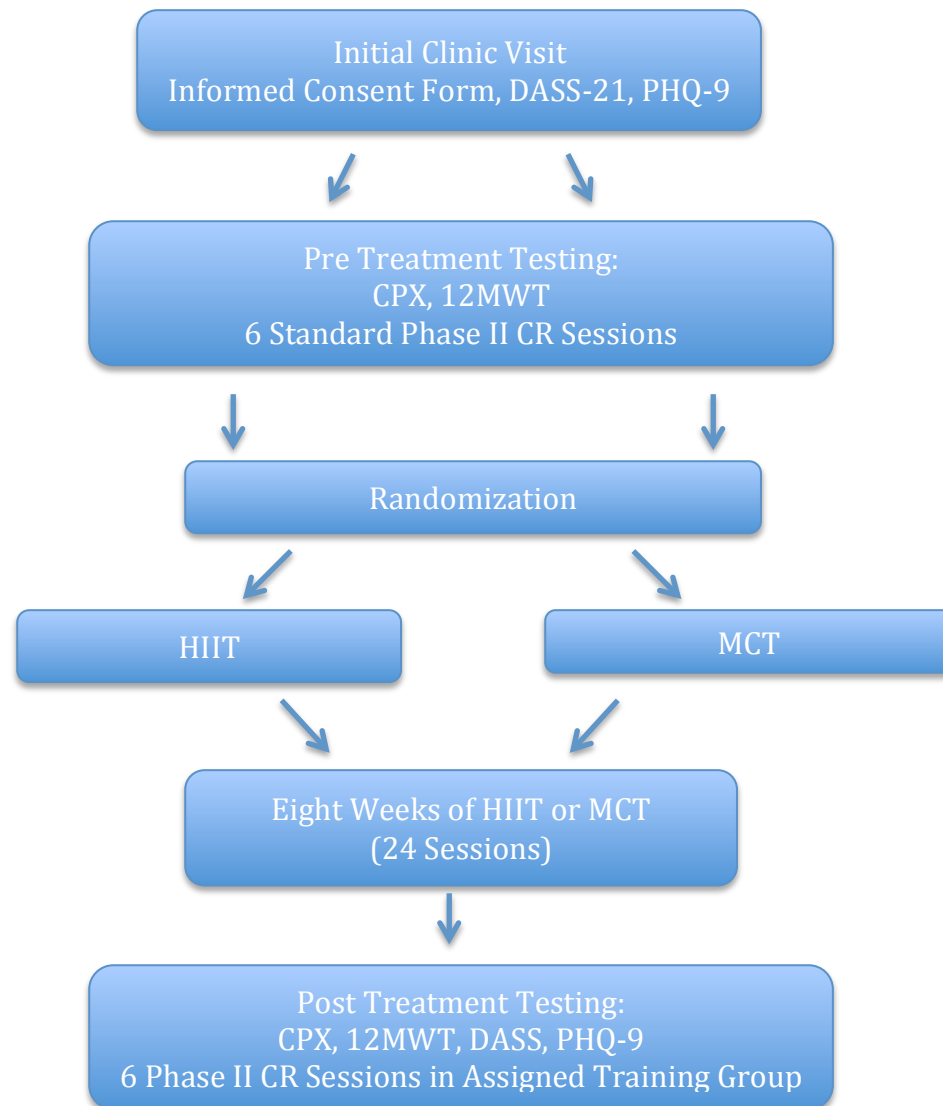
A cardiologist read and interpreted the stress ECG to assess cardiac performance. If the patient has class II-IV angina, significant arrhythmia, or greater than one millimeter of horizontal or down sloping ST-segment depression during the CPX test their cardiologist will be notified and they will decide whether their exercise should be limited. Eligible patients were then randomized, using a random number generator, into either high intensity interval training (HIIT) or moderate intensity continuous training (MCT) exercise groups. Participants then completed eight weeks of the assigned MCT or HIIT exercise training under supervision of a clinical exercise physiologist. MCT patients completed a five-minute period of active warm up, 35

minutes of cardiorespiratory training at 60% to 80% of heart rate reserve (HRR), and five minutes of active cool down. HIIT patients completed a five-minute period of active warm up, 36 minutes of cardiorespiratory training, and five minutes of active cool down. The cardiorespiratory training for the HIIT exercise group included six intervals, which consist of a three-minute period of higher intensity work intervals at an intensity of 80% to 90% of HRR followed by a three-minute active recovery period at an intensity of 60% to 70% of HRR. Following the final active recovery period patients completed five minutes of active cool down. The MCT and HIIT exercise group completed a total of 45 and 46 minutes of cardiovascular training during each exercise session, including warm up and cool down, respectively. All patients ended each cardiac rehab session by participating in 15 minutes of weights and stretching, for a combined total of 60 and 61 minute long cardiac rehab session in the MCT and HIIT exercise groups, respectively.

Following eight weeks of either MCT or HIIT training, follow up testing was completed by participating in a second 12MWT, CPX test, filling out the DASS-21 and PHQ-9 questionnaires, and completing six additional phase II cardiac rehab sessions in the patient's designated HIIT or MCT training group. All participants attended group education sessions, and received individual counseling from a dietician, clinical exercise physiologist, and a registered nurse.

Design

Figure 1. Flow of Participants From Recruitment to Post Program Assessment



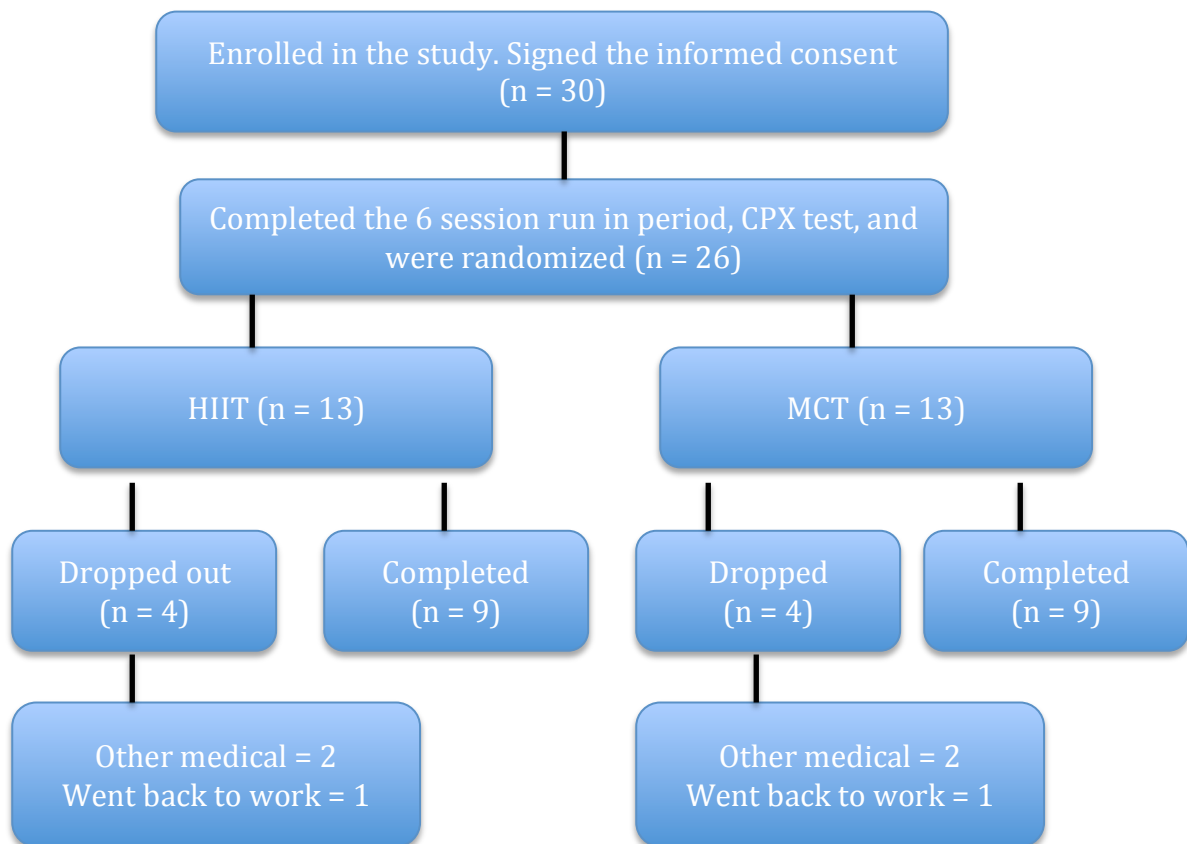
Analysis

Patient baseline characteristics were compared using an independent t test. Changes from baseline to follow up were analyzed using an independent t test. For all the analyses a $P < .05$ was accepted as significant.

CHAPTER IV. RESULTS

Each patient seen in the cardiac rehab clinic was screened for participation in the study. Due to the inclusion/exclusion criteria many of these patients were excluded from the study. The total number of patients who were enrolled in the study was thirty (N=30). The results of the randomization placed a total of nine participants into the MCT (N=9) exercise group and a total of nine in the HIIT (N=9) exercise group. Figure 1 shows the flow of participants from recruitment to study completion. Unfortunately, a total of 10 patients ended up dropping out of the study. Reasons for dropping out included going back to work, non-adherence, non-cardiac related medical complications, and deciding to no longer participate.

Figure 2. Flow of Participants Through the Trial



Patients were randomized into either the HIIT or MCT exercise group using a random number generator. There was equal distribution of cardiac diagnosis in the HIIT and MCT groups (see Table 1).

Table 1. Number of Diagnoses in Each Exercise Training Group

Diagnosis	MCT (n = 9)	HIIT (n = 9)
Myocardial Infarction	2	1
Stent/PTCA	3	5
Stable Angina	1	1
Coronary Artery Bypass Graft	2	2
Valve Surgery	1	0

Baseline Measures

At the beginning of phase II cardiac rehabilitation, patient characteristics including age, height, weight, body mass index, and ejection fraction were used to evaluate if the two exercise groups were similar. Current medication usage of Beta-blockers, calcium channel blockers, and digoxin were also compared. Both were compared using an independent samples *t*-test to assess potential differences between exercise intervention groups at baseline (Table 2). The only significant difference in patient characteristics between the two exercise groups was height ($p = 0.001$). There was no significant difference in medication usage at baseline between the two exercise groups.

Table 2. Comparison of HIIT and MCT Baseline Patient Characteristics and Medication Usage

Characteristic/Medication	MCT Group (n = 9)	HIIT Group (n = 9)	<i>P</i>
Age (years)	63.67 ± 9.02	66.00 ± 5.12	0.510
Height (in.)	66.89 ± 2.89	71.89 ± 1.96	0.001*
Weight (lbs.)	180.89 ± 42.11	200.89 ± 59.91	0.425
BMI	27.59 ± 5.01	27.31 ± 6.35	0.918
Ejection Fraction (%)	51.67 ± 9.68	55.22 ± 11.25	0.483
Beta Blocker	1.11 ± 0.333	1.22 ± 0.441	0.555
Calcium Channel Blocker	1.78 ± 0.441	1.67 ± 0.500	0.624
Digoxin	2.00 ± 0	2.00 ± 0	---

NOTE. Values are mean +/- SD

Abbreviation: BMI, body mass index; EF, ejection fraction

*: Significance at $p < 0.05$

--- Cannot be computed because both SDs are 0.

The outcome variables that were evaluated in this study were also compared between the two exercise groups at baseline to evaluate if they were similar (Table 3). They were compared using an independent samples *t* test. At baseline all outcome variables, including peak VO₂, 12MWT distance, 12MWT resting heart rate, 12MWT resting systolic blood pressure (SBP), 12MWT resting diastolic blood pressure (DBP), DASS-21 score of depression, DASS-21 score of anxiety, DASS-21 score of stress, and PHQ-9 score were not significantly different between the two exercise groups.

Table 3. Comparison of HIIT and MCT Testing Variables at Baseline

Variable	MCT Group	HIIT Group	<i>P</i>
Peak VO ₂ (ml/kg/min)	18.52 ± 4.95	21.22 ± 6.40	0.315
12MWT Distance (ft.)	2855.56 ± 565.93	3004.55 ± 585.86	0.573
12MWT RHR (bpm)	75.22 ± 10.75	71.64 ± 11.72	0.573
12MWT Resting SBP (mmHg)	130.00 ± 21.05	128.00 ± 17.25	0.818
12MWT Resting DBP (mmHg)	72.44 ± 11.74	75.09 ± 10.60	0.603
DASS-21 Depression	1.67 ± 1.12	1.00 ± 0.00	0.111
DASS-21 Anxiety	1.89 ± 1.17	1.27 ± 0.91	0.200
DASS-21 Stress	1.44 ± 0.88	1.00 ± 0.00	0.169
PHQ-9	1.56 ± 0.88	1.18 ± 0.41	0.266

NOTE. Values are mean +/- SD

Abbreviation: VO₂, volume of oxygen consumed; 12MWT, 12 minute walk test; RHR, resting heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure; DASS-21, Depression Anxiety Stress Scale-21; PHQ-9, Patient Health Questionnaire-9

Changes in Weight

Participants in both the HIIT and MCT exercise groups increased their weight following eight weeks of training. Patients' weight from their first and last phase II cardiac rehab session was used to compare changes in weight. The HIIT exercise group had an average increase in weight of 1.36 pounds. The MCT exercise group had an average increase in weight of 2.33 pounds.

Changes in Medications

A majority of the patients in this study did not have a change in medications throughout the duration of the study. There was only one patient who had a decrease in his beta-blocker due to his low resting heart rate.

Changes in Peak VO₂

Participants in both the HIIT and MCT exercise groups improved their peak VO₂ following eight weeks of training. Results of the post CPX test indicate that the MCT and HIIT exercise groups improved their functional capacity by an average of 2.25 ml/kg/min and 2.94 ml/kg/min, respectively. Statistical analysis confirmed that there was no significant difference in the improvement of peak VO₂ between the two groups ($p = 0.173$).

Changes in 12MWT Distance

Participants in both the HIIT and MCT exercise groups improved their 12MWT distance following eight weeks of training. Results of the post 12MWT indicate that the MCT and HIIT exercise groups improved their 12MWT distance by 259 feet and 562 feet, respectively. Statistical analysis confirmed there was no significant difference in the change in the distance walked during the 12MWT between the two exercise groups after exercise training ($p = 0.096$).

Changes in 12MWT Resting Heart Rate

Following eight weeks of training, the MCT exercise group did not have an improvement in resting heart rate. They had a slight increase in resting heart rate of 1.1 beats per minute. However, the HIIT exercise group did show improvements in their resting heart rate by having a decrease in resting heart rate of 5.9 beats per minute. Statistical analysis confirmed there was a significant difference in the change in resting heart rate between the two exercise groups ($p = 0.033$).

Changes in 12MWT Resting Systolic Blood Pressure

Participants in both the HIIT and MCT exercise groups improved their resting systolic blood pressure following eight weeks of training. The MCT and HIIT exercise groups improved their systolic blood pressure by 4 millimeters of mercury (mmHg) and 6 mmHg, respectively.

Statistical analysis confirmed there was no significant difference in improvement in resting systolic blood pressure between the two exercise groups ($p = 0.719$).

Changes in 12MWT Resting Diastolic Blood Pressure

Following eight weeks of training the MCT group did not improve their diastolic blood pressure while the HIIT group did improve. The MCT exercise group had an increase in diastolic blood pressure of 1.6 mmHg and the HIIT exercise group decreased their diastolic blood pressure by 3.1 mmHg. Statistical analysis confirmed there was no significant difference in improvements in resting diastolic blood pressure between the two exercise groups after eight weeks of training ($p = 0.715$).

Changes in Depression, Anxiety, and Stress Scale – 21

Following training the MCT exercise group improved their depression and stress score by 0.34 and 0.22, respectively. Their average anxiety score remained unchanged after post-testing. The HIIT group's depression and stress scores remained unchanged after post-testing and the anxiety score increased slightly by 0.03. Statistical analysis confirmed that there was no significant difference in the changes in depression ($p = 0.347$), anxiety ($p = 0.357$), and stress ($p = 0.347$) scores on the DASS-21 scale between the two exercise groups following eight weeks of training.

Changes in Patient Health Questionnaire – 9

Following eight weeks of training the MCT and HIIT exercise group's PHQ-9 scores improved by 0.23 and 0.18, respectively. There was no significant difference in the changes in the PHQ-9 scores between the two exercise groups ($p = 0.081$).

Table 4. Changes in Outcome Variables

Variable	MCT			HIIT			
	Pre	Post	Change	Pre	Post	Change	<i>p</i>
Peak VO ₂ (ml/kg/min)	18.52 ± 4.95	20.75 ± 3.93	+ 2.23	21.22 ± 6.40	24.14 ± 5.95	+ 2.92	0.173
12MWT Distance (ft.)	2855.56 ± 565.93	3144.44 ± 328.30	+ 288.94	3004.55 ± 585.86	3566.67 ± 636.89	+ 562.12	0.096
12MWT RHR (bpm)	75.22 ± 10.75	76.33 ± 10.80	+ 1.11	71.64 ± 11.72	65.67 ± 8.43	- 5.9	0.033*
12MWT RSBP (mmHg)	130.00 ± 21.05	126.00 ± 18.76	- 4.00	128.00 ± 17.25	122.89 ± 17.30	- 5.11	0.719
12MWT RDBP (mmHg)	72.44 ± 11.74	74.00 ± 9.90	+ 1.56	75.09 ± 10.60	72.00 ± 12.74	- 3.09	0.715
DASS-21 Depression	1.67 ± 1.12	1.33 ± 1.00	- 0.34	1.00 ± 0.00	1.00 ± 0.00	0.00	0.347
DASS-21 Anxiety	1.89 ± 1.17	1.89 ± 1.76	0.00	1.27 ± 0.91	1.30 ± 0.483	+ 0.03	0.357
DASS-21 Stress	1.44 ± 0.88	1.22 ± 0.667	- 0.22	1.00 ± 0.00	1.00 ± 0.00	0.00	0.347
PHQ-9	1.56 ± 0.88	1.33 ± 0.500	- 0.23	1.18 ± 0.41	1.00 ± 0.00	- 0.18	0.081

NOTE. Values are mean +/- SD; *: significance at $p < 0.05$

CHAPTER V. Discussion

The purpose of this study was to determine if high intensity interval training would lead to greater improvements in functional capacity and the symptoms of depression, anxiety, and stress compared to moderate intensity continuous training in a group of phase II cardiac rehab patients. The results of the study suggest that there was no significant difference in improvements in functional capacity and the symptoms of depression, anxiety, and stress between the two training protocols.

Population

The study had a dropout rate of 33%, leaving a smaller sample size than originally expected to compare the MCT and HIIT training protocols. There were five participants that dropped out from the MCT group, five participants that dropped out from the HIIT group, and two that dropped out prior to being randomized into an exercise group. The reasons for dropping out included going back to work, non-adherence, non-cardiac related health complications, and deciding to no longer participate.

Changes in Peak VO₂

Peak VO₂ is known to be a strong predictor of overall mortality (Weston et al., 2014). It is of the utmost importance to improve peak VO₂ in those who have had a cardiovascular event. Peak VO₂ can be improved through cardiovascular conditioning such as MCT and HIIT. Optimal training intensity and duration to improve peak VO₂ is yet to be determined in those that have experienced a cardiovascular event. Previous published research has suggested that the use of HIIT with phase II cardiac rehab patients will lead to greater improvements in peak VO₂ when compared to MCT (Freyssin et al., 2012; Haykowsky et al., 2013; Keteyian et al., 2014; Jaureguizar et al., 2016). This study also evaluated whether different types of training, MCT and

HIIT, in a group of phase II cardiac rehab patients would lead to significant differences in improvements in peak VO_2 . The findings from this study would suggest that both MCT and HIIT exercise training protocols increase peak VO_2 following eight weeks of training. However, it also showed that there was no significant difference in the effects between the two training groups.

Even though the results showed that there was no statistical significant difference in effect between the two training groups, clinical significance was still present. Due to the small sample size it was less likely to achieve statistical significance. Although there was no statistical significant difference between the two training protocols in peak VO_2 the results showed greater absolute improvements following HIIT when compared to MCT. In the HIIT group, peak VO_2 was improved by approximately 1 Metabolic Equivalent (MET). An increase of 1 MET is associated with a 13% decrement in risk of all mortality and coronary heart disease (Freyssin et al., 2012). These results suggest that although there was no statistical significance differentiating the two groups it can be observed that the HIIT group had greater improvements in peak VO_2 .

Improvements in peak VO_2 in the HIIT groups from the Freyssin et al. (2012) and Keteyian et al. (2014) studies are very similar to those of the present study. In all three studies the HIIT exercise groups improved their peak VO_2 by approximately 3 ml/kg/min. However, improvements in peak VO_2 in the MCT group were not similar across all three studies. In the Freyssin et al. and Keteyian et al. studies the MCT group only improved their peak VO_2 by 0.2 ml/kg/min and 0.7 ml/kg/min, respectively. This is lower than the present study whose MCT group improved by 2.25 ml/kg/min. Therefore, the difference in results from previous studies to the current study may be attributed to a more effective intensity and duration while completing MCT, as discussed below.

There are many factors that affect the rate in which functional capacity improves with exercise. This includes the frequency, intensity, duration, and exercise modality used for training purposes. The current study is very similar to the study done by Keteyian et al. (2014) that found that HIIT led to greater improvements in peak VO_2 when compared to MCT. There are a few differences between the two studies, including differences in exercise duration, exercise to recovery ratio, type of exercise modality utilized, and number of participants, which could have led to the differences in results. The current study had patients in the HIIT group complete three - minute exercise and rest intervals for a total of 36 minutes whereas the Keteyian et al. (2014) study had patients complete four - minute intervals of exercise and three – minute intervals of exercise at a lower intensity for a total of 31 minutes. The additional minute in the high intensity exercise interval that Keteyian et al. (2014) had their HIIT group complete could have led to the greater improvements in peak VO_2 . In addition, the current study's MCT group completed 35 minutes of training but the Keteyian et al. (2014) study only had the MCT group complete 30 minutes of training per session. Because the current study had the MCT group complete 35 minutes rather than 30 minutes of continuous exercise that could have increased their peak VO_2 as well. These differences could have closed the gap that resulted in HIIT having greater increases in peak VO_2 compared to MCT in the Keteyian et al. (2014) study.

Other studies have used much shorter intervals than the one used in this study (Freyssin et al., 2012; Jaureguizar et al., 2016). These studies used high intensity work intervals that lasted approximately 20-30 seconds with 40-60 seconds of recovery in-between each interval. Both of these studies resulted in a greater improvement in peak VO_2 following HIIT when compared to MCT. These results suggest that those with cardiovascular diseases may need more time to recover with a work to rest ratio of 1:2, compared to the 1:1 ratio that the current study used. If

HIIT patients in the current study applied the 1:2 ratio, spending more time recovering from the high intensity interval then their peak VO_2 may have been affected.

In addition, previous studies that have evaluated the effects of HIIT and MCT on peak VO_2 have limited their patients to specific exercise modalities (cycle or treadmill) for the duration of the study, to match the modality they completed their exercise test on. However, this study tried to make the patients feel as if they were the typical phase II cardiac rehab patients. Due to this, patients were free to choose which type of exercise they wanted to complete each day, not being limited to one piece of equipment for the duration of the study. This could have decreased the training sensitivity of the exercise since each of the patients in the current study were required to complete their CPX test on a treadmill. This suggests that if a patient chose to undergo exercise training on equipment other than the treadmill for a majority of the study then the improvement in their peak VO_2 may have been reduced.

Another difference between the present study and previous studies done comparing the effects of peak VO_2 between MCT and HIIT is that the patients in this study were required to complete resistance training as part of their phase II cardiac rehabilitation program. Previous research studies did not allow the patients to complete resistance training for the duration of the exercise-training program. A recent review and meta-analysis compared the effects of progressive resistance training on functional capacity and strength in adults with coronary heart disease (Hollings, Mavros, Freeston, & Fiatarone Singh, 2017). They compared progressive resistance training versus aerobic training and combined training versus aerobic training. They found that in combined training, when progressive resistance training was added to aerobic training, there were greater improvements seen in functional capacity and strength compared to aerobic training alone (Hollings et al., 2017). The findings from the Hollings, et al. study may

support why in the current study the patients in the MCT exercise group improved their functional capacity much greater than those in previous published research.

After comparing the current study to previous research evaluating the effects of MCT and HIIT on peak VO_2 it is clear that exercise intensity, duration, and type of exercise plays a significant role in how effective the training is. Although this study did not find a statistical significant difference in improvements following eight weeks of MCT and HIIT, both of the exercise group's peak VO_2 did show improvements. It should be noted that the MCT group's peak VO_2 improved much greater than in previous studies, which may be why a difference in effect was not statistically significant. Therefore, it can be implied that MCT as well as HIIT can be used in phase II cardiac rehab patients to improve their peak VO_2 and contribute to a decrease in their overall mortality.

Changes in 12MWT Distance

The distance walked on a 12MWT is an objective measure of functional capacity. Previous studies have determined that the 12MWT is a valid and reliable test to measure functional capacity in those with coronary heart disease (Manthieu et al., 2005). No previous studies have been done comparing the change in 12MWT distance following eight weeks of MCT and HIIT. However, Freyssin et al. (2012) used the 6MWT in a similar study comparing the effects of MCT versus HIIT. Previous research by Freyssin et al. (2012) found that following eight weeks of training using MCT and HIIT both groups improved their distance walked in the 6MWT with no significant difference between the two exercise groups. The results from the current study support the findings by Freyssin et al. (2012). The current study, similarly to Freyssin et al. (2012), showed improvements in the 12MWT distance walked with no significant difference between the two exercise groups after eight weeks of training.

Since the 12MWT is an objective measure of functional capacity it can be assumed that since there were improvements in walk test distance following both MCT and HIIT there should also be similar improvement in functional capacity between the two training groups. The current study supported this theory with no significant differences ($p = 0.173$) in improvements following eight weeks of training. However, the Freyssin et al. (2012) study found that their HIIT group's peak VO_2 significantly increased while the MCT group did not. As previously discussed, this difference in functional capacity improvements could possibly be due to variances in exercise training protocols.

Changes in Resting Heart Rate and Blood Pressure Response

Typically, with aerobic exercise training the parasympathetic nerve is affected, leading to a decrease in resting heart rate (RHR), with an associated reduction in the risk for cardiovascular disease (Riebe et al., 2015). The results of this study showed a significant difference between the two exercise groups in RHR following eight weeks of training ($p = 0.033$). The MCT group's RHR increased by 1.1 bpm, which is the opposite of what was expected. In contrast, the HIIT group decreased their resting heart rate by 5.9 bpm. Even though these results suggest that MCT does not improve RHR previous studies have found that eight weeks of MCT reduced RHR by 2-4 bpm (Jaureguizar et al., 2016; Keteyian et al., 2014). There are many factors that affect resting heart rate such as medications and psychological aspects, such as being nervous or stressed. These factors could have contributed to the unexpected increase in RHR from the MCT group.

Resting blood pressure is also reduced with aerobic training. This is primarily due to decreased activity of the sympathetic nervous system and the improvement in peripheral vessel resistance (Oh, Hong, & Lee, 2016). Both systolic blood pressure and diastolic blood pressure were evaluated in the study. There was no significant difference in the changes in systolic and

diastolic blood pressure between the two exercise groups following eight weeks of training. Both MCT and HIIT showed improvements in resting systolic blood pressure by 4 mmHg and 6 mmHg, respectively. In addition, the HIIT groups showed improvements in resting diastolic blood pressure with a decrease of 3.1 mmHg. In contrast, the MCT groups' diastolic blood pressure actually increased by 1.6 mmHg. In previous studies MCT improved systolic and diastolic blood pressure equally if not more than the HIIT exercise groups (Jaureguizar et al., 2016; Keteyian et al., 2014). Oh et al. (2016) states that with aerobic exercise there is a hypotensive effect, which typically decreases blood pressure by 4-9 mmHg. Similarly to heart rate, blood pressure response is sensitive to medications (e.g. beta blockers), environmental factors (e.g. temperature), physiology (e.g. state of hydration), and psychological issues (e.g. anxiety and stress). It is unclear in this case why the MCT group's diastolic blood pressure responded abnormally to the training protocol.

Psychosocial Response to Training

Many of those that have had a cardiovascular event also experience symptoms of depression, anxiety, and stress. These can be exacerbated by an inability to perform activities of daily living and maintaining their independence. At the beginning and end of the study the DASS-21 was used to assess depression, anxiety, and stress and the PHQ-9 was also used to assess depression. There was no significant difference between the two exercise groups in any of the psychosocial questionnaires. Using the DASS-21, the MCT group's anxiety remained unchanged and the HIIT group's depression and stress remained unchanged after training. This is surprising because previous research on cardiac patients and exercise expresses that psychological factors such as depression and anxiety are usually improved following both MCT and HIIT with no significant difference between the two types of exercise training (Freyssin et

al., 2012). However, both training groups improved their PHQ-9 scores, which also assessed depression. At the beginning of phase II cardiac rehab only two of the eighteen patients presented with symptoms of depression, anxiety, and stress. Therefore, an improvement in their DASS-21 and PHQ-9 scores was not expected. However, it is important to note that both HIIT and MCT did see improvements in at least one aspect of the questionnaires.

These questionnaires do not take into account substantial life changes such as a death in the family or unforeseen money problems that may cause psychological issues to arise suddenly. If the patients in this study suffered from a major life change that has affected their psychological health following the start of the cardiac rehab program then it may have skewed the results of the study. A majority of the patients in phase II cardiac rehab experience psychological stressors outside of cardiac rehab. Many cardiac rehab programs have introduced psychological assessments into their program with the use of a psychologist. This allows patients to get the help they need with managing and minimizing the stressors that affect their psychological well-being.

These results can be particularly helpful to cardiac rehab staff in helping to acknowledge that some patients are suffering from psychological stressors that may not be noticeable with normal day conversation. It is important that cardiac rehab staff continue to look for signs of increased depression, anxiety, and stress and suggest avenues to deal with those stressors such as meeting with the staff psychologist to discuss their issues. Acknowledging change in patient psychological well-being will help decrease the prevalence of depression, anxiety, and stress in phase II cardiac rehab patients.

Limitations and Future Research

This study demonstrates that HIIT can be prescribed instead of MCT in phase II cardiac rehab patients to improve functional capacity and psychosocial parameters. However, the

number of patients in the study is much smaller than anticipated due to a high dropout rate. Patients did not complete the program because of numerous reasons including going back to work, non-adherence, non-cardiac related health complications, and deciding to no longer participate. It is very common, as seen in the present study, for phase II cardiac rehab patients to be non-adherent to the exercise program. In return, this leads to a large percentage of phase II cardiac rehab patients failing to complete the exercise program. Psychological factors such as exercise enjoyment may lead to increases in patient exercise adherence.

A majority of research studies on the effects of MCT and HIIT have predominantly male participants. The patients in this study are also predominately males. This could be attributed to the fact that males are at greater risk of developing cardiovascular disease, which is why there are a greater percentage of males in phase II cardiac rehab compared to females. Unfortunately, this has led to fewer research studies being done that include females. Lack of female presence in the current research study could have impacted the results. There are many physiological similarities between men and women following exercise training. This includes general improvements in resting heart rate and blood pressure, functional capacity, pulmonary and cardiovascular function. However, there are potential sex-based differences, which could alter the degree to which they improve. Sheel (2016) discussed the potential physiological sex differences between men and women during exercise. These factors included: smaller conducting airways, hypertension, sex hormones, fuel utilization, and muscle fatigue rate (Sheel, 2016). Each of these factors affects the female ability to exercise to the same degree as a male. Future research should focus on recruiting female patients to participate in the study so that sex differences can be assessed and ensure that females are receiving the appropriate exercise prescription in phase II cardiac rehabilitation.

Exercise duration was equal between the two exercise groups, MCT and HIIT. However, energy expenditure was probably not. The HIIT group exercised at a much higher intensity during their work interval (80-90% of HRR) compared to the MCT group (60-80% of HRR). During the HIIT groups recovery interval they were working within the intensity range that the MCT group was given to exercise at for the duration of the study. Due to the HIIT group being required to work at a higher intensity they, most likely, expended more energy compared to the MCT group. Future research should evaluate whether there is a difference in functional capacity improvement when energy expenditure between the two exercise groups is similar.

In addition to exercise time during phase II cardiac rehab, physical activity performed outside of rehab was not controlled for. This could have led to a wide variety in the amount of physical activity completed between the two exercise groups, which affect the physiological parameters that were measured in this study. Future research should track physical activity outside of phase II cardiac rehab to ensure there is no difference between the two exercise groups. This can be done by using a fitness tracker or by having patients keep a log of when they exercise outside of rehab.

Future research should address exercise enjoyment in HIIT for phase II cardiac rehab. Currently, there has been no research done assessing whether phase II cardiac rehab patients find MCT and/or HIIT equally or more enjoyable. Administering a questionnaire such as the Physical Activity Enjoyment Scale (PACES) following training can assess exercise enjoyment. It is apparent from this study that many patients drop out of cardiac rehab before completing the program. Higher functioning patients may find the challenge of HIIT to be more enjoyable than the standard MCT. The increase in exercise enjoyment may lead to increased exercise adherence and participation in phase II cardiac rehab.

Conclusions

The purpose of this study was to determine if high intensity interval training will lead to greater improvements in functional capacity, cardiovascular function, and the symptoms of anxiety, depression, and stress compared to moderate intensity continuous training in a group of phase II cardiac rehab patients. The results of the study suggest that there was no significant difference in improvements between the two training protocols, MCT and HIIT, following eight weeks of training. These results indicate that regardless of whether phase II cardiac rehab patients participate in traditional continuous training or HIIT they can expect to see improvements in their functional capacity and psychosocial parameters of depression, anxiety, and stress. In addition, it should be pointed out that patients undergoing treatment in the HIIT arm of the protocol did not experience any cardiac arrhythmias or excessive heart rate responses, such as ventricular tachycardia, during their cardiac rehab sessions. This further verifies that HIIT exercise protocols are safe for patients with a variety of cardiac diagnoses when undergoing treatment in a medically supervised Phase II cardiac rehab program.

REFERENCES

- American College of Sports Medicine. (2014). *ACSM's Guidelines for Exercise Testing and Prescription*. Philadelphia, PA: Lippincott, Williams & Wilkins.
- Angadi, S. S., Mookadam, F., Lee, D. D., Tucker, W. J., Haykowsky, M. J., & Gaesser, G. A. (2015). High-intensity interval training vs. moderate-intensity continuous exercise training in heart failure with preserved ejection fraction: a pilot study. *Journal of Applied Physiology*, *119* (6), 753-758.
- Benda, N. M., Seeger, J. H., Stevens, G. F., Hijmans-Kersten, B. P., van Dijk, A. J., Bellersen, L., & Thijssen, D. J. (2015) Effects of high-intensity interval training versus continuous training on physical fitness, cardiovascular function, and quality of life in heart failure patients. *Plos ONE*, *10*(10), 1-16.
- Bernstein, M. L., Despars, J. A., Singh, N. P., Avalos, K., Stansbury, D. W., & Light, R. W. (1994). Reanalysis of the 12-minute walk in patients with chronic obstructive pulmonary disease. *Chest*, *105*(1), 163-167.
- Borg G. A. (1982). Psychophysical bases of perceived exertion. *Medicine and Science in Sports and Exercise*, *14* (5), 377-381.
- Burke, E. J. (1976). Validity of selected laboratory and field tests of physical working capacity. *Research Quarterly. American Alliance for Health, Physical Education and Recreation*, *47*(1), 95-104.
- Cardiac Rehab: Restoring Health and Well-Being. (2016). *Westchester County Business Journal*, 4.
- Chrysohoou, C., Angelis, A., Tsitsinakis, G., Spetsioti, S., Nasis, I., Tsiachris, D. & Tousoulis, D. (2015). Cardiovascular effects of high-intensity interval aerobic training combined

- with strength exercise in patients with chronic heart failure: a randomized phase III clinical trial. *International Journal of Cardiology*, 179, 269–274.
- Cooper, H. H. A. (1968). Means of assessing maximal oxygen uptake. Correlation between field testing and treadmill testing. *Journal of the American Medical Association*, 203(3), 201-204.
- De Greef, M. H. G., Sprenger, S. R., Elzenga, C. T. A., Popkema, D. Y., Bennekens, J. H., Niemeijer, M. G., Middel, B., & Mook, G. A. (2005). Reliability and validity of a twelve-minute walking test for coronary heart disease patients. *Perceptual and Motor Skills*. 100 (2), 567-575.
- Don't skip cardiac rehab after a heart event. Cardiac rehab cuts death risk and improves lives. (2013). *Harvard Heart Letter: From Harvard Medical School*, 24 (3), 3.
- Fisher, G., Brown, A., Bohan Brown, M. M., Alcorn, A., Noles, C., Winwood, L., Resuehr, H., George, B., Jeansonne, M. M., & Allison, D. B. (2015). High intensity interval vs. moderate intensity training for improving cardiometabolic health in overweight or obese males: a randomized controlled trial. *Plos ONE*, 10 (10), 1-15.
- Freyssin, C., Verkindt, C., Prieur, F., Benaich, P., Maunier, S., & Blanc, P. (2012). Cardiac rehabilitation in chronic heart failure: effect of an 8-week, high-intensity interval training versus continuous training. *Archives Physiology Medical Rehabilitation*, 93 (a8), 1359-1364.
- Hammill, B. G., Curtis, L. H., Schulman, K. A., & Whellan, D. J. (2010). Relationship between cardiac rehabilitation and long-term risks of death and myocardial infarction among elderly Medicare beneficiaries. *Circulation*, 121 (1), 63-70.

- Haykowsky, M. J., Timmons, M. P., Kruger, C., McNeely, M., Taylor, D. A., & Clark, A. M. (2013). Meta-analysis of aerobic interval training on exercise capacity and systolic function in patients with heart failure and reduced ejection fractions. *The American Journal of Cardiology*, *111* (10), 1466-1469.
- Heyward, V. H. (2010). *Advanced fitness assessment and exercise prescription* (6th edition) Champaign, IL: Human Kinetics.
- Hidehiro, N., Shin-Ya, U., Adayoshi, M. (2015). Low-frequency severe-intensity interval training improves cardiorespiratory functions. *Medicine & Science In Sports & Exercise*, *47* (4), 789-798.
- Hollings, M., Mavros, Y., Freeston, J., & Fiatarone Singh, M. (2017). The effect of progressive resistance training on aerobic fitness and strength in adults with coronary heart disease: A systematic review and meta-analysis of randomized controlled trials. *European Journal of Preventative Cardiology*, doi 10.1177/2047487317713329.
- Holloway, T. M., Bloemberg, D., da Silva, M., Simpson, J. A., Quadriatero, J., & Spriet, L. L. (2015). High intensity interval and endurance training have opposing effects on markers of heart failure in and cardiac remodeling in hypertensive rats. *PlosONE*, *10* (3), 1-16.
- Huberty, J. L., Ransdell, L. B., Sidman, C., Flohr, J. A., Shultz, B., Grosshans, O., & Durrant, L. (2008). Explaining long-term exercise adherence in women who complete a structured exercise program. *Research Quarterly For Exercise And Sport*, *79*(3), 374-384.
- Jaureguizar, K. V., Vincente-Campos, D., Bautista, L. R., Pena, C. H., Gomez, M. J. A., Rueda, M. J. C., & Ignacio, M. F. (2016). Effect of high-intensity interval versus continuous exercise training on functional capacity and quality of life in patients with coronary artery disease. *Journal of Cardiopulmonary Rehabilitation and Prevention*. *36*, 96-105.

- Jung, M. E., Bourne, J. E., Beauchamp, M. R., Robinson, E., & Little, J. P. (2015). High intensity interval training as an efficacious alternative to moderate-intensity continuous training for adults with prediabetes. *Journal of Diabetes Research*, 1-9.
- Kenny, W. L., Wilmore, J. H., & Costil, D. L. (2015). *Physiology of Sport and Exercise*. (6th edition) Human Kinetics Publishers, Champaign, IL.
- Keteyian, S. J., Hibner, B. A., Bronsteen, K., Kerrigan, D., Aldred, H. A., Reasons, L. M., Saval, M. A., Brawner, C. A., Schairer, J. R., Thompson, T., Hill, J., McCulloch, D., & Ehrman, J. K. (2014). Greater improvements in cardiorespiratory fitness using higher-intensity interval training in the standard cardiac rehabilitation setting. *Journal of Cardiopulmonary Rehabilitation and Prevention*, 34 (2), 98-105.
- Kocalevent, R., Hinz, A., & Brähler, E. (2013). Standardization of the depression screener Patient Health Questionnaire (PHQ-9) in the general population. *General Hospital Psychiatry*, 35(5), 551-555.
- Kosak, M., & Smith, T. (2005). Comparison of the 2-, 6-, and 12 minute walk tests in patients with stroke. *Journal of Rehabilitation Research & Development*. 42 (1), 103-108.
- Kravitz, L. (2011). What motivates people to exercise? Reasons and strategies for exercise adherence. *IDEA Fitness Journal*, 8(1) 25-27.
- Mathieu, H. G., Greef, Sprenger, S. R., Elzenga, C. A., Popkema, D. Y., Bennekens, J. H., Niemeijer, M. G., Middel, B., & Mook, G. (2005). Reliability and validity of a twelve-minute walking test for coronary heart disease patients. *Perceptual and Motor Skills*, 100, 567-575.
- McGavin, C. R., Gupta, S. P., & McHardy, G. J. (1976). Twelve-minute walking test for assessing disability in chronic bronchitis. *Britain Medical Journal*, 1, 822-828.

- Merrill, J. (1997). Resistance training in cardiac rehabilitation: a trend toward resistance training in the programs of cardiac rehab patients may speed their return to productive work and recreation. *Fitness Management, 13*(9), 35-37.
- Milani, R. V., & Lavie, C. J. (1998). Prevalence and effects of cardiac rehabilitation on depression in the elderly with coronary heart disease. *American Journal of Cardiology, 81* (10), 1233-1236.
- Moderate levels of exercise are often prescribed for people recovering from a heart attack or heart surgery, but a new study finds that pumping up workouts to high intensity levels might be a safe option too (2012). *MondayMorning*. p. 1.
- Ng, F., Trauer, T., Dodd, S., Callaly, T., Campbell, S., & Berk, M. (2007). The validity of the 21-item version of the Depression Anxiety Stress Scales as a routine clinical outcome measure. *Acta Neuropsychiatrica, 19* (5), 304-310.
- Oh, D., Hong, H., & Lee, B. (2016). The effects of strenuous exercises on resting heart rate, blood pressure, and maximal oxygen uptake. *Journal of Exercise Rehabilitation. 12* (1), 42-46.
- Only one in 10 heart failure patients referred for cardiac rehab. (2015). *Cleveland Clinics's Heart Advisor, 17* (12), 2.
- Osman, A., Wong, J., Bagge, C., Freedenthal, S., Gutierrez, P., & Lozano, G. (2012). The Depression Anxiety Stress Scales - 21 (DASS-21): Further examination of dimensions, scale reliability, and correlates. *Journal Of Clinical Psychology, 68* (12), 1322-1338.
- Piepoli, M. F., Davos, C., Francis, D. P., Coats, A. J. (2004). Exercise training meta-analysis of trials in patients with chronic heart failure. *British Medical Journal, 328*, 189.

- Ramos, J., Dalleck, L., Tjonna, A., Beetham, K., & Coombes, J. (2015). The impact of high-intensity interval training versus moderate-intensity continuous training on vascular function: a systematic review and meta-analysis. *Sports Medicine*, *45*(5), 679-692.
- Riebe, D., Franklin, B. A., Thompson, P. D., Garber, C. E., Whitfield, G. P., Magal, M., Pescatello, L. S. (2015). Updating ACSM's recommendations for exercise pre-participation health screening. *Medical Science Sports Exercise*. *47*, 2473-2479.
- Rognmo, Ø., Moholdt, T., Bakken, H., Hole, T., Mølsted, P., Myhr, N. E., Grimsmo, J., & Wisløff, U. (2012). Cardiovascular risk of high- versus moderate-intensity aerobic exercise in coronary heart disease patients. *Circulation*, *126* (12), 1436-1440.
- Sandstad, J., Stensvold, D., Hoff, M., Nes, B.M., Arbo, I., & Bye, A. (2015). The effects of high intensity interval training in women with rheumatic disease: a pilot study. *European Journal of Applied Physiology*, *115* (10), 2081-2089.
- Scott, J. M., Hornsby, W. E., Lane, A., Kenjale, A. A., Eves, N. D., & Jones, L. W. (2015). Reliability of maximal cardiopulmonary exercise testing in men with prostate cancer. *Medicine & Science In Sports & Exercise*, *47* (1), 27-32.
- Seguin, R. A., Economos, C. D., Palombo, R., Hyatt, R., Kuder, J., & Nelson, M. E. (2010). Strength training and older women: A cross-sectional study examining factors related to exercise adherence. *Journal Of Aging & Physical Activity*, *18*(2), 201-218.
- Sheel, A. W. (2016). Sex differences in the physiology of exercise: An integrative perspective. *Experimental Physiology*. *101* (2), 211-212.
- Shizue, M., Masayuki, M., Yasuharu, T., Akihiro, S., Shigenari, H., Mayuko, M., & Hiroshi, N. (2015). The factors affecting adherence to a long-term interval walking training

- program in middle-aged and older people. *Journal Of Applied Physiology*, 118(5), 595-603.
- Sorace, P., Ronal, P., & Churilla, J. B. (2008). Resistance training for cardiac patients: Maximizing rehabilitation. *ACSM's Health & Fitness Journal*, 12(6), 22-28.
- Spencer, J. L. (2007). Resistance training in outpatient cardiac rehabilitation. *Strength & Conditioning Journal (Allen Press)*, 29(1), 18-23.
- Suaya, J. A., Stason, W. B., Ades, P. A., Normand, S. L., & Shepard, D. S. (2009). Cardiac rehabilitation and survival in older coronary patients. *Journal of the American College of Cardiology*, 54 (1), 25-33.
- Weston, K.S., Wesloff, U., & Coombes, J. S. (2014). High-intensity interval training in patients with lifestyle-induced cardiometabolic disease: a systematic review and meta-analysis. *British Journal of Sports Medicine*, 48 (16), 1227-1234.
- Wilson, K., & Brookfield, D. (2009). Effect of goal setting on motivation and adherence in a six-week exercise program. *International Journal Of Sport & Exercise Psychology*, 7(1), 89-100.
- Wisløff, U., Støylen, A., Loennechen, J., Bruvold, M., Rognum, Ø., Haram, P., & Skjaerpe, T. (2007). Superior cardiovascular effect of aerobic interval training versus moderate continuous training in heart failure patients: a randomized study. *Circulation*, 115(24), 3086-3094.

APPENDIX A. INFORMED CONSENT

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Department of Cardiology
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Phone #419-383-3697

**ADULT RESEARCH SUBJECT INFORMATION AND CONSENT FORM and
AUTHORIZATION FOR USE AND DISCLOSURE OF PROTECTED HEALTH
INFORMATION**

RESEARCH PROJECT TITLE

**Comparison of High-Intensity Interval Training versus Moderate-Intensity Continuous Training in
a Phase II Cardiac Rehabilitation Program**

Principal Investigator: Dalynn T. Badenhop, Ph.D

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What you should know about this research study:

- We give you this consent/authorization form so that you may read about the purpose, risks, and benefits of this research study. All information in this form will be communicated to you verbally by the research staff as well.
- Routine clinical care is based upon the best-known treatment and is provided with the main goal of helping the individual patient. The main goal of research studies is to gain knowledge that may help future patients.
- We cannot promise that this research will benefit you. Just like routine care, this research can have side effects that can be serious or minor.
- You have the right to refuse to take part in this research, or agree to take part now and change your mind later.
- If you decide to take part in this research or not, or if you decide to take part now but change your mind later, your decision will not affect your routine care.
- Please review this form carefully. Ask any questions before you make a decision about whether or not you want to take part in this research. If you decide to take part in this research, you may ask any additional questions at any time.
- Your participation in this research is voluntary.



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Introduction: You are being invited to participate in a research study to compare the effectiveness of high-intensity interval exercise and moderate-intensity continuous exercise in cardiac rehabilitation. Your exercise capacity, feelings of anxiety, depression and stress will also be measured.

Your participation in this study will last about twelve weeks. If at any time you wish to stop participation in this study, you may do so. You are not required to complete the study.

If you have a lower extremity injury or are in need of a wheelchair, are unable to walk without using a cane or walker, or have a severe mental illness, you will not be allowed to participate in this study.

In addition to The University of Toledo Medical Center staff some of the Investigators are located at Bowling Green State University.

Purpose: The purpose of this study is to determine the effects of high intensity versus moderate intensity exercise and whether one form of exercise provides greater benefits for patients with heart problems than the other.

Procedure: Your participation in this study will last about twelve weeks. Only participants in the study will be placed in a high-intensity interval training group or moderate-intensity continuous training group. The study includes a minimum of four (4) testing sessions, which is standard for all phase II patients. At two of the testing sessions a cardiopulmonary exercise (CPX) test will be completed at The University of Toledo Heart and Vascular Center. At the other two testing sessions, you will complete a twelve-minute walk test and answer questions about stress, anxiety, and depression. After the first CPX test, your designated exercise-training program will be implemented in the University of Toledo Medical Center Cardiac Rehabilitation Program.

You will be “randomized” into one of the study groups described below. Randomization means that you are put into a group by chance. A computer program will place you in one of the groups. Neither you nor your doctor can choose the group you will be in. You will have an equal chance of being placed in either group.

You will volunteer your time for 4 testing sessions, which will last an hour each for a total of four (4) hours of your time. You will also complete 36 ninety-minute cardiac rehab sessions over the course of 12 weeks.

During these testing sessions, you will be asked to complete the following tasks:

1. During your first session, you will read and voluntarily sign an informed consent form.
2. During the first and last session, you will answer questions about stress, anxiety and depression. Your resting heart rate and resting blood pressure will be measured. You will be asked to complete a 12-minute walk test. The purpose of the 12-minute walk test is to determine how far you can walk in 12 minutes around a small indoor track. After completing the 12 minute walk test, your heart rate and blood pressure will be measured again.
3. During the second and fourth testing sessions you will complete a CPX test. The test will have two parts, a breathing test (pulmonary function test) and a treadmill stress test, which will include



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measuring how much oxygen you use during the stress test. The pulmonary function test will consist of three simple breathing tests. The first test you will be asked to take slow deep breaths in and out. The second test you will be asked to take a deep breath in then breath the air out as quickly as you can. During the final test you will be asked to take quick deep breaths in and out as quickly as you can. The treadmill stress test will consist of walking on a treadmill at a speed of your choice and the incline (hill) will increase every two minutes until you can't walk any more. The test usually lasts around six to twelve minutes. During the test the amount of air you move in and out of your lungs and the amount of oxygen you use will be measured through a mouthpiece. You will wear a nose clip to make sure all the air goes through the mouthpiece. In addition, your electrocardiogram (ECG) and blood pressure will be measured during the test.

4. After the first two sessions are complete you will begin exercise sessions in phase II cardiac rehab program. You will be asked to complete 36 (three (3) per week) of these 90-minute sessions, six (6) sessions during the run in period, 24 sessions of the assigned training program, and six (6) sessions at the end of the program.

The run in period consists of the first six (6) sessions of the Phase II cardiac rehab program. Participants in the study are required to attend four (4) of the first six (6) sessions to continue in the study.

Standard Visit in Phase II Cardiac Rehab	
HIIT	MCT
5 Minute Warm Up	
46 Minutes of Exercise	45 Minutes of Exercise
5 Minute Cool Down	
15 Minutes of Weights and Stretching	

Once enrolled in the phase II cardiac rehab program the exercise physiologists and nursing staff will closely monitor you during each exercise session. You will be asked to follow their instructions and participate in the exercise, weight training, stretching, and educational and counseling programs they have to offer.

After the CPX test your results will be evaluated and an individualized exercise prescription will be created based off the results of your test. You will be given specific instructions to follow on the duration and intensity of exercise you should complete during each of your cardiac rehab sessions.

MCT Exercise Group: MCT patients will complete a five-minute period of active warm up, 35 minutes of cardiorespiratory training at 60% to 80% of heart rate reserve (HRR), and five minutes of active cool down.

HIIT Exercise Group: HIIT patients will complete a five-minute period of active warm up, 36 minutes of cardiorespiratory training, and five minutes of active cool down. The cardiorespiratory training for the HIIT exercise group will include six intervals, which consist of a three - minute period of higher intensity work intervals at an intensity of 80% to 90% of HRR followed by a three - minute active recovery period



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where you will be asked to walk at an intensity of 60% to 70% of HRR. Following the final active recovery period patients will complete five minutes of active cool down.

Risks: As in all research, there may be unforeseen risks to you as a participant. During the CPX test and cardiac rehab sessions you should understand that there is the possibility of unfavorable changes or responses from exercise may occur. These may include fatigue, muscular soreness, slips or falls, and sudden death. The level of exercise in this study will be more intense than usual daily activities, but will be used to improve your heart health.

There is also the possibility of breach in confidentiality. The University of Toledo Medical Center will take all precautions to prevent this risk by using password protected files and only allowing research personnel and cardiac rehab staff access to the research data.

Risks to Pregnant Women: If you are a woman of childbearing potential, we will ask if you are pregnant. If you are pregnant you may not participate in The University of Toledo Cardiac Rehabilitation Program.

In the Event of a Research-Related Injury: In the event that you should be injured as a result of this study, you will be provided with the necessary care. This care does not imply negligence on the part of The University of Toledo Medical Center or any of the health care professionals involved. Where applicable, The University of Toledo Medical Center reserves the right to bill third-party payers for the services rendered. The University of Toledo Medical Center does not provide you with any additional compensation as the result of such injuries. In the event of injury, contact Dalynn T. Badenhop, Ph.D. at 419-383-3697.

Benefits: The benefits obtained from participation in this study are that you will likely be improving your overall health, heart strength, fitness level, functional ability, and will receive information about how you can improve your heart health. Participation in this study will also help future patients in cardiac rehabilitation by providing information about high-intensity interval training and moderate-intensity continuous training in cardiac rehabilitation.

Confidentiality: By agreeing to participate in this research study, you give The University of Toledo Medical Center, the Principal Investigator and all other personnel associated with this research study your permission to use or disclose health information that can be identified with you that we obtain in connection with this study. We will use this information for the purpose of conducting the research study as described in the research consent form.

The information that we will use or disclose includes your past and present medical history and physical information, laboratory testing results, diagnostic and interventional testing information, and outcomes data. Under some instances the Institutional Review Board of The University of Toledo Medical Center will review your information for compliance audits. The results of this study may be published for scientific purposes but your identity will not be revealed. Bowling Green State University may have access to data for research purposes.

The University of Toledo is required by law to protect the privacy of your health information, and to use or disclose the information we obtain about you in connection with this research study only as authorized



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by you in this form. There is a possibility that the information we disclose may be re-disclosed by the persons we give it to, and no longer protected. However, we will encourage any person who receives your information from us to continue to protect and not re-disclose the information.

Your permission for us to use or disclose your personal health information as described in this section is voluntary. However, you will not be allowed to participate in the research study unless you give us your permission to use or disclose your personal health information by signing this document.

Your access to your own personal health information may be denied during the term of the research study, but you can access your information once the research study is completed.

You have the right to revoke (cancel) the permission you have given to us to use or disclose your personal health information at any time by giving written notice to Dalynn T. Badenhop, Ph.D., The University of Toledo, 3000 Arlington Avenue, MS 1118, Toledo, OH 43614-2598. However, a cancellation will not apply if we have acted with your permission, for example, information that already has been used or disclosed prior to the cancellation. Also, a cancellation will not prevent us from continuing to use and disclose information that was obtained prior to the cancellation as necessary to maintain the integrity of the research study.

Except as noted in the above paragraph, your permission for us to use and disclose personal health information has no expiration date.

A more complete statement of The University of Toledo's Privacy Practices are set forth in its Joint Notice of Privacy Practice. If you have not already received this Notice, a member of the research team will provide this to you. If you have any further questions concerning privacy, you may contact the University of Toledo's Privacy Officer at 419-383-6933.

Voluntary Participation: Your participation in this study is completely voluntary, and you are not required to answer any questions that you do not feel comfortable answering or do any of the tasks involved in the study. You are free to withdrawal consent, and can stop participating in this study at any time. Whether or not you choose to participate in this study, it will not impact any relationship you may have with Bowling Green State University or The University of Toledo Medical Center.

Additional Cost: If you choose to participate in this study, you will not be billed for any research cost. All routine clinical care will be charged to you or your insurance company.

YOU WILL BE GIVEN A COPY OF THIS SIGNED FORM TO KEEP.

OFFER TO ANSWER QUESTIONS

Before you sign this form, please ask any questions on any aspect of this study that is unclear to you. You may take as much time as necessary to think it over. If you have any questions or comments about this study, you may contact Dr. Dalynn Badenhop at (419)-383-3697 or dalynn.badenhop@utoledo.edu, Meghan Long at (419)-350-6895 or mmlong@bgsu.edu, or Dr. Todd Keylock at (419)-372-6912 or tkeyloc@bgsu.edu. If you have questions about the conduct of this study or your rights as a research participant, you may contact the Chair, Human Subjects Review Board, Bowling Green State University,



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(419)-372-7716 or hsrb@bgsu.edu or the Chair, Institutional Review Board, The University of Toledo Medical Center, (419)-383-6796 or IRB.biomed@utoledo.edu.

If you have questions beyond those answered by the research team or your rights as a research subject or research-related injuries, please feel free to contact the Chairperson of the University of Toledo Biomedical Institutional Review Board at 419-383-6796.



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EXPIRATION DATE: 07/20/2017

IRB # 201487ICF Version Date: 08/26/2016**SIGNATURE SECTION (Please read carefully)**

YOU ARE MAKING A DECISION WHETHER OR NOT TO PARTICIPATE IN THIS RESEARCH STUDY. YOUR SIGNATURE INDICATES THAT YOU HAVE READ THE INFORMATION PROVIDED ABOVE, YOU HAVE HAD ALL YOUR QUESTIONS ANSWERED, AND YOU HAVE DECIDED TO TAKE PART IN THIS RESEARCH.

BY SIGNING THIS DOCUMENT YOU AUTHORIZE US TO USE OR DISCLOSE YOUR PROTECTED HEALTH INFORMATION AS DESCRIBED IN THIS FORM.

The date you sign this document to enroll in this study, that is, today's date, MUST fall between the dates indicated on the approval stamp affixed to the bottom of each page. These dates indicate that this form is valid when you enroll in the study but do not reflect how long you may participate in the study. Each page of this Consent/Authorization Form is stamped to indicate the form's validity as approved by the UT Biomedical Institutional Review Board (IRB).

_____ Name of Subject (please print)	_____ Signature of Subject or Person Authorized to Consent	_____ Date
_____ Relationship to the Subject (Healthcare Power of Attorney authority or Legal Guardian)		_____ Time a.m. p.m.
_____ Name of Person Obtaining Consent (please print)	_____ Signature of Person Obtaining Consent	_____ Date
_____ Name of Witness to Consent Process (when required by ICH Guidelines) (please print)	_____ Signature of Witness to Consent Process (when required by ICH Guidelines)	_____ Date

YOU WILL BE GIVEN A SIGNED COPY OF THIS FORM TO KEEP.



RR050

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**UNIVERSITY OF TOLEDO IRB
APPROVAL DATE: 09/07/2016
EXPIRATION DATE: 07/20/2017**

APPENDIX B. HSRB APPROVAL FORM



February 7, 2017

Meghan M. Long
School of Human Movement, Sport, and Leisure

BGSU ID: 0020167007

Dear Ms. Long:

You will be pleased to know that your thesis topic and committee have been approved as listed for 3-6 semester hours of credit:

Thesis Title: **Comparison of High-Intensity Interval Training Versus Moderate-Intensity Continuous Training in a Phase II Cardiac Rehabilitation Program**

Thesis Committee: Todd Keylock, Chair
 Charles Laurent
 Dalynn Badenhop

Students should begin registering for thesis research (6990) at the time when they begin planning their thesis project. Students who register for thesis research are required to maintain continuous registration in thesis research from one semester to another, excluding summer term, regardless of whether they are in residence at the University until the research is completed and the thesis is accepted by the Graduate College. However, students who plan to graduate summer term must be enrolled for at least one hour of thesis credit that term. The minimum continuous registration for a thesis student is one hour per semester.

To assist master's candidates in making maximum and efficient use of the library, students may schedule an individual research appointment by calling 419-372-6943. Please refer to the library web site at http://libguides.bgsu.edu/individual_research_appointments for information on this valuable service.

You should consult the Graduate College web site (<http://www.bgsu.edu/graduate.html>) for the deadline for submitting the electronic version of your thesis to the Graduate College during the term you plan to graduate. This is a firm deadline that cannot be extended. Your final examination should be scheduled to allow you to make any last minute corrections required by your committee, convert the manuscript to a PDF document, and then electronically submit the final document to the Graduate College via OhioLINK prior to the deadline. Individual copies of the final draft of your manuscript must be submitted to your committee well in advance of the date of your final examination in order to give them

sufficient time to read the manuscript and prepare for the exam. It is important to keep committee members abreast of your progress by providing them with drafts of the manuscript in accordance with their desires. Please consult program guidelines and check with your committee members to determine the appropriate time frame.

All theses must be submitted electronically via OhioLINK. Please consult the Graduate College ETD web site for specific directions on the conversion and submission process.

Once approved by the Graduate College, your manuscript is available on the web via OhioLINK. Your thesis will also be cataloged by the BGSU Library. Because of its public nature, the manuscript must reflect the highest scholarly standards. You will need to follow the directions in the Thesis and Dissertation Handbook (available on the Graduate College web site at: <http://www.bgsu.edu/graduate/thesis-and-dissertations/thesis-dissertation-handbook.html>) as well as the directions of your program in preparing and writing your manuscript. Familiarizing yourself with these requirements at the outset will save countless hours later in the process.

Your manuscript must be in error-free form ready for electronic submission. If errors in format or grammar are found in the manuscript, you will be required to correct them. This could result in a delay in your graduation. Therefore, attention to format requirements, and a careful proofing of the final draft of your manuscript (preferably by someone other than yourself) are imperative.

If you have any questions regarding these matters, please contact Dr. Alex Goberman at goberma@bgsu.edu. Best wishes with your research and writing.

Sincerely yours,



Margaret Z. Booth
Interim Dean of the Graduate College

pc: Committee
Student file
Vikki Krane, Graduate Coordinator
(School of Human Movement, Sport, and Leisure)