The Pennsylvania State University

The Graduate School

College of Health and Human Development

REDUCING CARDIOVASCULAR DISEASE RISK FACTORS WITH A PHYSICAL FITNESS PROGRAM

A Thesis in

Kinesiology

by

Justin L. Jones

Submitted in Partial Fulfillment
of the Requirements
for the Degree of

Master of Science

August 2012

The thesis of Justin L. Jones was reviewed and approved* by the following:

Jinger S. Gottschall
Assistant Professor of Kinesiology
Thesis Advisor

Shawna Doerksen
Assistant Professor of Recreation, Park and Tourism Management

Steriani Elavsky
Assistant Professor of Kinesiology

Nancy I. Williams
Professor of Kinesiology and Physiology
Head of Department, Kinesiology

*Signatures are on file in the Graduate School

ABSTRACT

Cardiovascular disease is the leading cause of death in the United States, as 32.8% of deaths are due to coronary heart disease, stroke, and heart failure. Developing cardiovascular disease is heightened with the onset of risk factors such as hypertension, high cholesterol, diabetes, and obesity. Unfortunately, the current health status of adult Americans details an alarming occurrence of risk factors as 30.0% of adults have high blood pressure, 26.7% have high blood cholesterol, 10.4% have type II diabetes, and 35.7% are obese. Fortunately, engaging in regular physical activity can reduce the risk of developing cardiovascular disease. The American College of Sports Medicine and the United States Department of Health and Human Services established the Physical Activity Guidelines for Fitness to provide a recipe for the time, frequency, and intensity of exercise. The current thesis will demonstrate the beneficial effects of meeting the guidelines as well as detailing methods to complete the standards. For the first study of the thesis, I implemented the Physical Activity Guidelines for Fitness into a 30-week multi-modal intervention to evaluate how a multi-modal program influences cardiovascular disease risk factors. I hypothesized that the group fitness program would produce beneficial effects on cardiovascular disease risk factors by decreasing body weight, fat body mass, total cholesterol concentration, triglycerides concentration, blood pressure, and also by increasing lean body mass and HDL-C concentration. In the second study, I investigated heart rate intensity in order to determine whether moderate- or vigorous-intensity activity has a greater effect on the reduction of body mass. I hypothesized that there would be a greater reduction in body mass when a higher percentage of time during the workout is spent in vigorous-intensity. For the third and final study, I evaluated how to incorporate moderate- and vigorous-intensity hill intervals into treadmill walking workouts in order to maximize metabolic cost. I hypothesized that continuous hill intervals and random hill intervals would result in the same metabolic cost in a 20-minute treadmill workout. This thesis will provide evidence about strategies to both meet the Physical Activity Guidelines for Fitness and reduce cardiovascular disease risk factors.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENTS

First of all, I would like to thank my thesis advisor, Dr. Jinger S. Gottschall. None of this would have been possible without her guidance, support, and mentoring during the past two years. She not only had a strong influence on my academic endeavors but also made me realize how much I value including physical activity in a healthy life. I am grateful for her positive outlook and determined work ethic.

Next, I would like to thank Dr. Shawna Doerksen and Dr. Steriani Elavsky for their contribution to this thesis. Their insightful comments and suggestions greatly improved the quality of the final product.

I would also like to thank my friends and family members who were always available to provide suggestions, proof read the document, and provide endless support during the process of writing my thesis.

Lastly, I would like to thank the members of the Neuromotion Laboratory in the Department of Kinesiology at The Pennsylvania State University for assisting with data collection and analysis.

Chapter 1

Introduction

1.1 BACKGROUND

Cardiovascular disease is the leading cause of death in the United States as 32.8% of deaths are caused due to coronary heart disease, stroke, and heart failure (12). Developing a cardiovascular disease is heightened with the onset of risk factors such as hypertension, high cholesterol, diabetes, obesity and physical inactivity (15). The current health status of adult Americans details an alarming occurrence of risk factors as 30.0% of adults have high blood pressure, 26.7% have high blood cholesterol, 10.4% have type II diabetes, 35.7% are obese, and 32.4% do not engage in leisure-time physical activity (10, 11). There is also an economic toll with cardiovascular disease as the estimated charge for total cost is $297.8 billion (12).

While cardiovascular disease takes the lives of hundreds of thousands of Americans each year it can be prevented with healthy decisions such as including physical activity and making healthy dietary choices (16). The American Heart Association proclaims a lifestyle shift towards healthy behavior- meeting the guidelines for physical activity and adhering to a healthy dietary plan- will lead to greater longevity and cardiovascular free survival with diminished mortality and morbidity (14). Regular physical activity has numerous benefits to reducing the risk of cardiovascular disease as it can reduce total body fat, triglycerides, resting systolic and diastolic blood pressures, and increases high density lipoprotein cholesterol (HDL-C) concentration and improves glucose tolerance (14).

The American College of Sports Medicine (ACSM) and the United States Department of Health and Human Services established the Physical Activity Guidelines for Fitness prescribes that adults engage in a minimum of 30 minutes of moderate-intensity cardiorespiratory exercise per day, 5 days per week (3, 17). The guidelines can also be accomplished with vigorous-intensity exercise for a minimum of 20 minutes of cardiorespiratory exercise, 3 days per week. In addition to cardiorespiratory exercise, the guideline advocates for strength training exercise for each of the major muscle groups on 2 to 3 days per week along with a set of brief flexibility exercises, 60 seconds per major joint, to maintain joint range of motion at least 2 days per week.

Incorporating moderate leisure-time physical activity results in 1.3 years more in life expectancy and 1.1 years more without cardiovascular disease, in comparison to not engaging in leisure-time physical activity, while including vigorous leisure-time physical activity results in greater increases- 3.7 years more in life expectancy and 3.3 years more without cardiovascular disease (2). Furthermore, meeting the moderate-intensity guidelines lowers the risk of coronary heart disease by 14% and the risk is further lowered, to 20%, by doubling the established guideline minutes (13).

Chapters 2 and 3 of the thesis utilize commercial group fitness classes to implement the Physical Activity Guidelines for Fitness. Chapter 2 investigates the beneficial changes of the 30-week program on cardiovascular disease risk factors while Chapter 3 investigates the heart rate data during a time period in the program in order to determine whether moderate- or vigorous- intensity has a greater reduction in body mass.

The program comprises Les Mills™ group fitness classes with four options of cardiorespiratory classes- BodyAttack™, BodyCombat™, BodyStep™, and RPM™- a strength training class- BodyPump™- and a flexibility class- BodyFlow™.

BodyAttack™ is a sports-inspired interval workout choreographed to popular music that combines athletic aerobic movements with strength and stabilization exercises. The 60-minute class is workout that focuses on improving speed, fitness, strength, and agility with the goal of raising overall fitness and stamina for high energy sports as well as improving coordination and agility. Each class begins with a warm-up of simple aerobic moves and then the range of movement gradually increases to ease into the workout routine. The workout consists of two periods of high intensity aerobic exercise, each with recovery and conditioning periods to focus on upper and then lower body to develop strength through core conditioning. The last component of each class is the recovery and stretching segment which is an active cool-down followed by a period of motions to increase flexibility (4).

BodyCombat™ is a 60-minute cardiovascular workout based on multiple martial art disciplines such as karate, boxing, taekwondo, tai chi, and muay thai. Each workout choreographs combinations of punches and kicks in order to improve coordination and agility. Each class begins with a warm-up period that features instruction on each of the martial arts moves to be incorporated in the work-out. The workout focuses on speed, power, and endurance with combinations of strikes, punches, kicks, and jumps. The workout segment features phases of raised intensity followed by short recovery periods between each intensity phase. The class ends with a strength training series of push-ups and core conditioning exercise followed by an active recovery as well as flexibility exercises (5).

BodyStep™ is a 60-minute aerobic workout using a height-adjustable platform and choreographed simple movements on, over, and around the platform. Each class starts with a warm-up where the instructor teaches the movements incorporated in the workout. The intensity and range of movement is gradually increased leading into the workout, which features three cardio-segments and a speed segment. The class concludes with conditioning for the upper body and abdominals and a cool down with stretching for flexibility (8).

RPM™ is a 60-minute indoor cycling class that uses music to provide the rhythm for a workout featuring simulated hill climbs, time trials, flat terrain riding, and racing by varying levels of resistance on the cycle. The class begins with a warm-up at an easy intensity and light resistance. The workout features increased speed and intensity in accordance with increased resistance to simulate the series of hill climbs, racing sections, and time trials as well as short periods of recovery in between. An easy, low resistance cool down concludes each class and is followed by a series of stretches to improve flexibility (9).

The resistance exercise class for muscular strength is BodyPump™ which utilizes a barbell with low weight loads and high repetition movements. The 60-minute class focuses on all of the major muscle groups with exercises such as squats, chest and triceps presses, dead lifts and biceps curls. The focused muscle group order remains the same for each class- warm-up, squats, chest, back, triceps, biceps, lunges, shoulders, abdominals, and cool-down- but there is variation in the exercise approach for each lifting exercise depending on the choreographed music selection. Participants are able to change the weight on the barbell (mass of barbell: 1.6 kg) for each of the exercise lifts ranging from 3.6 kg to 31.6 kg. There are 70 to 100 repetitions for each muscle group for a total of up to 800 repetitions in the duration of the class. The cool-down begins with conditioning for the abdominals and ends with stretches for all of the working muscle groups (7).

Finally, the flexibility class is BodyFlow™ which is a 60-minute class based on yoga, tai chi, and Pilates. The choreographed stretches, moves, and poses are developed to improve joint flexibility and range of motion as well as improving core strength. Each class concludes with a 10-minute period focused on relaxation and meditation (6).

The goal in Chapter 2 is to establish an effective fitness program that results in health benefits, meets the Physical Activity Guidelines for Fitness, and is applicable to a large number of people. I hypothesize that the group fitness program will produce beneficial effects on cardiovascular disease risk factors by decreasing body weight, body fat percentage, total cholesterol concentration, low-density cholesterol concentration (LDL), triglycerides concentration, systolic blood pressure, diastolic blood pressure, and by also increasing lean body mass percentage and HDL-cholesterol concentration. Chapter 3 investigates the heart rate data during a segment of the program in Chapter 2 to determine whether moderate- or vigorous-intensity results in a greater reduction in body mass. I hypothesize that there will be a greater reduction in body mass when a higher percentage of time during the workout is spent at moderate-intensity. With the goal of striving to include more moderate-intensity during workouts, Chapter 4 investigates how to incorporate moderate-intensity hill intervals into treadmill walking in order to maximize the metabolic cost of a 20-minute workout. I hypothesize that continuous hill intervals and random hill intervals will result in the same metabolic cost in a 20-minute treadmill workout. This thesis will provide results for a fitness program in recommendation for an effective approach to address the burden of cardiovascular disease along with fulfilling the Physical Activity Guidelines for Fitness.

1.2 REFERENCES

1. Center for Disease Control and Prevention. Pennsylvania: Burden of Chronic Diseases, 2008.

2. Franco OH, de Laet C, Peeters A, et al: Effects of physical activity on life expectancy with cardiovascular disease. *Arch Intern Med 165*(20): 2355-2360, 2005.

3. Garber CE, Blissmer B, Deschenes MR, et al: American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Med Sci Sports Exerc 43*(7): 1334-1359, 2011.

4. Les Mills™. About BodyAttack. http://www.lesmills.com/global/bodyattack/about-bodyattack.aspx. Viewed: Jan 3, 2012.

5. Les Mills™. About BodyCombat. http://www.lesmills.com/global/bodycombat/about-bodycombat.aspx. Viewed: Jan 3, 2012.

6. Les Mills™. About BodyFlow. http://www.lesmills.com/global/bodflow/about-bodyflow.aspx. Viewed: Jan 3, 2012.

7. Les Mills™. About BodyPump. http://www.lesmills.com/global/bodypump/about-bodypump.aspx. Viewed: Jan 3, 2012.

8. Les Mills™. About BodyStep. http://www.lesmills.com/global/bodystep/about-bodystep.aspx. Viewed: Jan 3, 2012.

9. Les Mills™. About RPM. http://www.lesmills.com/global/rpm/about-rpm.aspx. Viewed: Jan 3, 2012.

10. National Center for Health Statistics. Health, United States, 2011: With Special Features on Socioeconomic Status and Health. Hyattsville, MD. 2012.

11. National Health Interview Survey. Leisure-Time Physical Activity-None (Percent). http://www.healthindicators.gov/Indicators/Leisure-time-physical-activity-none-percent_1313/National_0/Profile/Data. Viewed: May 20, 2012.

12. National Heart, Lung, and Blood Institute. Morbidity & Mortality: 2012 Chart Book on Cardiovascular, Lung, and Blood Diseases. National Institutes of Health, 2012.

13. Sattelmair J, Pertman J, Ding EL, et al: Dose response between physical activity and risk of coronary heart disease: a meta-analysis. *Circulation 124*(7): 789-795, 2011.

14. Thompson WR, American College of Sports Medicine, Gordon NF, et al: in *ACSM's Guidelines for Exercise Testing and Prescription.* Lippincott Williams & Wilkins, 2009.

15. Ulmer, L., Berhane, Z., and Sindhi, H. The Burden of Cardiovascular Disease in Pennsylvania. Pennsylvania Department of Health: The Heart Disease and Stroke Program, 2010.

16. United States Department of Agriculture and United States Department of Health and Human Services. *Dietary Guidelines for Americans, 2010.* 7th Edition, Washington, DC: U.S. Government Printing Office, December 2010.

17. United States Department of Health and Human Services. 2008 Physical Activity Guidelines for Americans. Office of Disease Prevention and Health Promotion, Washington, DC, 2008.

Chapter 2

A Group Fitness Program is Effective in Reducing Cardiovascular Disease Risk Factors: A Pilot Study

2.1 BACKGROUND

Regular physical activity leads to numerous health benefits in regards to cardiovascular disease risk factors (14, 15). Past research has shown implementing an exercise program with both aerobic and strength training, without any dietary changes, decreases body fat percentage, total cholesterol, LDL-C concentration, fasting glucose, and increases HDL-C concentration in physically inactive adults. Park et al. (9) studied 10 overweight women (mean age: 43.4 yr, mean BMI: 25.8 $kg \cdot m^{-2}$) who participated in a 24-week fitness program of cardiorespiratory and strength training with a comparison to a group of only cardiorespiratory training and a control group. The participants in the combined program completed 3 days of step aerobics for 60 minutes on alternating days and 3 days of strength training for 60 minutes on the days in between each week while the aerobic-only group completed 6 days of 60 minutes of the step class each week. The heart rate range for the aerobic training was 60% to 70% of the maximum heart rate, defined as moderate intensity by ACSM (12), while the strength training was based on maximum repetition weight. The full body strength training program started with participants lifting 60% of their maximum repetition weight for the first 12 weeks and then increased to 70% of their maximum repetition weight for the final 12 weeks. After the 24-week combined training program the mean body weight had a difference of 9.5% and body fat percentage was reduced from 41.4% to 31.1% between the start and end of the study. The combined training program was more effective in improving body composition as the mean body weight decreased by 7.4% and body fat percentage lowered from 42.2% to 33.0%. Total cholesterol concentration was decreased by 25.4%, LDL-C concentration by 34.7%, and triglycerides concentrations decreased by 42.3% from baseline. HDL-C concentration increased by 23.1% and lean body mass increased from 58.6% to 68.9% (9).

In a similar study with men, Libardi et al. (5) studied 11 physically inactive men (48.5 yr, 28.4 $kg{\cdot}m^{-2}$) who completed concurrent training of cardiorespiratory and strength training for 16 weeks while maintaining their previous dietary pattern along with three other study groups- resistance training only (n = 11), cardiorespiratory training only (n = 12), and a control group (n = 13). Participants completed both cardiorespiratory and strength training on the same day on 3 alternating days per week. Each training day consisted of 30 minutes of cardiorespiratory training, walking or running around an athletic track, and 30 minutes of full body strength training. The cardiorespiratory training intensity corresponded to 55-85% VO_{2peak}. For the first 8 weeks of the program the participants exercised at moderate intensity (12) and increased to vigorous intensity for the final 8 weeks. The participants completed 3 sets of 10-repetition maximum for each of the eight strength training exercises for the first 8 weeks and completed 3 sets of 8-repetition maximum for the final 8 weeks. Total cholesterol concentration was decreased by 27.8% and triglycerides concentrations decreased by 33.4% at the completion of the 16-week program (5).

McCarthy et al. (8) also studied the effects of a concurrent training program on sedentary men. Ten men (27.3 yr, 82.1 kg) completed a 10-week training program of cardiorespiratory and full body strength training while not changing their daily activity patterns, outside of the study, or their dietary habits for the duration of the program. The training program consisted of exercising 3 days per week, for 50 minutes each day, on alternating days. The cardiorespiratory and strength training performed on the same day. The participants exercised at 70% of their heart rate reserve, categorized by the ACSM as vigorous intensity (12), during the cardiorespiratory training of cycle ergometry and the strength training consisted on completing 3 sets of 6-repetition at maximum exertion for eight different lifts. Total body weight did not have a statistically significant decrease; however fat percentage decreased from 19.5% to 17.2% after the 10-week program (8).

These studies found statistically significant changes in cardiovascular disease risk factors by combining cardiorespiratory and strength training into one exercise program. This study augments the approach by establishing a multi-modal program to meet the Physical Activity Guidelines for Fitness and how the program affects cardiovascular disease risk factors such as systolic blood pressure, diastolic blood pressure, total cholesterol concentration, HDL-C concentration, LDL-C concentration, triglyceride concentration, glucose tolerance, and obesity/overweight. I hypothesize that a 30-week multi-modal group fitness class program will produce beneficial effects on cardiovascular disease risk factors by decreasing resting systolic and diastolic blood pressures, total cholesterol concentration, LDL-C concentration, triglyceride concentration, body mass, body fat percentage and by also increasing lean body mass percentage, improving glucose tolerance, and increasing HDL-C concentration.

2.2 METHODS

Twenty-nine healthy adults, 11 men and 18 women, started the program and 24 participants, 9 men and 15 women [men: 32.3(2.4) yr, 117.8(5.2) cm, 92.0(19.6) kg, 28.6(5.5) kg·m^{-2}; women: 30.4(4.5) yr, 163.0(6.4) cm, 79.8(15.6) kg, 30.2(5.5) kg·m^{-2}] completed the program. The weight classifications are shown in Table 2-1 and a flow-chart depicting the inclusion of participants is shown in Figure 2-1. All of the participants gave written informed consent that followed the guidelines of The Pennsylvania State University Human Research Committee. The participants were physically inactive, but otherwise healthy, and completed a health physical at the beginning of the study to determine if physical activity was appropriate. The initial criteria for inclusion in the study was the participant be between the age of 25 and 40, participate in less than 30 minutes of exercise per week, and be available from May to December without more than four days of travel in a single week. A participant would be excluded from the study, in accordance to the ACSM health screening for physical activity, if he or she had any of the following conditions: chest discomfort with exertion, unreasonable shortness of breath, symptoms of dizziness, fainting or blackouts, heart medication, asthma or other lung disease, burning or cramping sensations in lower legs with minimal physical activity, joint problems that limit physical activity, prescription medications, pregnant, diabetes, smoking, blood pressure greater than 140/90 mmHg, or blood cholesterol greater than 200 mg·dL^{-1}.

	Number of Overweight	Number of Obese
Men	1	4
Women	6	7

Table 2-1: Baseline Weight Classifications of Participants

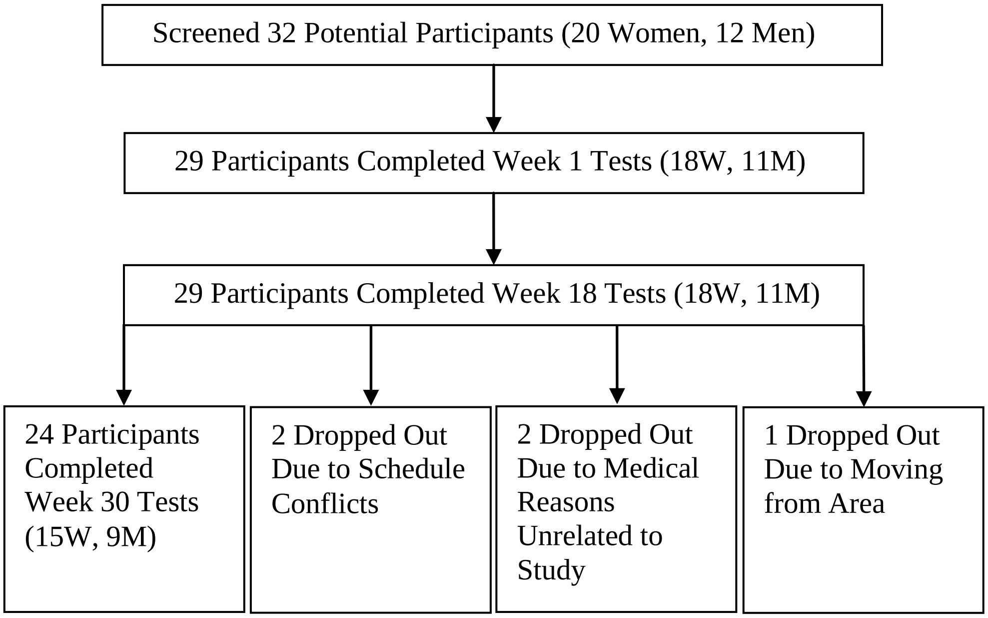

Figure 2-1: Included Participants

The musculoskeletal and physiological data were collected at the baseline (Week 3) and final week (Week 30) of the study. These musculoskeletal measurements- body mass, lean tissue mass, and fatty tissue mass- were collected in the Clinical Research Center using an iDXA scan. The physiological measurements were blood pressure and blood profile. Each participant had their blood pressure and blood profile taken and the blood profile, measured with Quest Diagnostics_Chem23, consisted of total cholesterol, HDL-C, LDL-C concentrations, and glucose tolerance.

The participants completed Les Mills™ instructed fitness classes, as described in Chapter 1, at The North Club in State College, Pennsylvania. Each class was offered every day of the week with classes beginning at 5:45 am until 6:45 pm allowing each participant to create an individual exercise schedule on a weekly basis. The prescribed fitness classes were the only form of physical activity, aside from daily activities, for the participants during the fitness class program.

The start of the fitness class program began with a 6-week introduction block, Table 2-2, where the participants were gradually introduced to the fitness classes and progressively increased their amount of exercise time in an effort to reduce injury. After the 6-week familiarization period the participants entered a 12-week block, Table 2-3, where they completed 3 cardiorespiratory classes per week, 2 muscular strength classes per week, and 1 flexibility class per week. The final 12-week block, Table 2-4, of the fitness class program consisted of 4 cardiorespiratory classes per week, 2 muscular strength classes per week, and 1 flexibility class per week.

Week Number	Cardiorespiratory (Time)	Muscular Strength (Time)	Flexibility (Time)
1	20 minutes (1 x 20 min)	20 minutes (1 x 20 min)	10 minutes (1 x 10 min)
2	40 minutes (2 x 20 min)	30 minutes (1 x 30 min)	20 minutes (1 x 20 min)
3	60 minutes (3 x 20 min)	45 minutes (1 x 30, 1 x 15 min)	30 minutes (1 x 30 min)
4	90 minutes (3 x 30 min)	60 minutes (1 x 60 min)	40 minutes (1 x 40 min)
5	120 minutes (3 x 40 min)	80 minutes (1 x 60, 1 x 20 min)	50 minutes (1 x 50 min)
6	150 minutes (3 x 50 min)	100 minutes (1 x 60, 1 x 40 min)	60 minutes (1 x 60 min)

Table 2-2: Familiarization Block of Fitness Classes

Week Number	Cardiorespiratory (Time)	Muscular Strength (Time)	Flexibility (Time)
7-18	180 minutes (3 x 60 min)	120 minutes (2 x 60 min)	60 minutes (1 x 60 min)

Table 2-3: First 12-Week Block of Fitness Classes

Week Number	Cardiorespiratory (Time)	Muscular Strength (Time)	Flexibility (Time)
19-30	40 minutes (4 x 60 min)	120 minutes (2 x 60 min)	60 minutes (1 x 60 min)

Table 2-4: Final 12-Week Block of Fitness Classes

All data were analyzed between baseline values and the final values using paired t-tests. A Bonferroni correction was applied to maintain the family-wise Type I error rate at 0.05 (1, 8). The p-value of 0.05 was divided by 10, in regards to the 10 paired t-tests, resulting with significance being defined as $p < 0.005$. Data analysis was conducted using Microsoft Excel 2007® and Minitab Student 14® and results were reported as mean (standard deviation) and the error bars in the graphs represent 1 standard error.

2.3 RESULTS

In support of the hypothesis, the 30-week group fitness class program resulted in statistically significant decreases in body mass, body fat percentage and an increase in lean body mass percentages in both men and women of the program. However, only two physiological variables resulted in a statistically significant difference for the men in the program. The mean values of the men’s HDL-C concentration ($p = 0.004$) increased and the triglyceride concentration ($p = 0.001$) decreased after the 30-week program.

The men’s mean body mass decreased by 5.3% from baseline body mass ($p = 0.001$), Table 2-5, and the mean Body Mass Index (BMI) was lowered from 28.6 $kg \cdot m^{-2}$

at baseline to 27.2 $kg \cdot m^{-2}$ at the final measurement. On the individual basis, six of the nine men had at least a 5.0% decrease in body mass. All of the men in the program increased lean body tissue percentage with the increases ranging from 2.7% to 11.5% from baseline measurements.

Variable	Baseline (Week 3)	Final (Week 30)
Body Weight (kg)	92.0(19.6)	87.1(17.9)*
Percent Lean (% BW)	68.3(5.9)	75.2(7.2)*
Percent Fat (% BW)	31.7(5.9)	24.8(7.2)*

Table 2-5: Men Body Composition
*: $p < 0.005$

The women's mean body mass decreased their body mass by 3.9% from baseline body mass ($p < 0.001$) with a 4.1% decrease in body fat percentage ($p < 0.001$), Table 2-6. The mean BMI lowered from 30.2 $kg \cdot m^{-2}$ to 28.9 $kg \cdot m^{-2}$. On the individual basis, five of the twelve women had at least a 5.0% decrease in body mass. All of the women in the program increased lean body tissue percentage with the increases ranging from 1.2% to 8.4% from baseline measurements.

Variable	Baseline (Week 3)	Final (Week 30)
Body Weight (kg)	79.8(15.6)	76.7(15.7)*
Percent Lean (% BW)	57.0(6.0)	61.1(6.8)*
Percent Fat (% BW)	43.0(6.0)	38.9(6.8)*

Table 2-6: Women Body Composition
*: $p < 0.005$

There were two statistically significant differences in the men's blood profile. The mean HDL-C concentration increased by 12.1% from baseline concentration, 45.1 mg·dL^{-1} to 50.6 mg·dL^{-1} ($p = 0.004$) and the mean triglyceride concentration decreased by 30.0% from baseline concentration, 107.8 mg·dL^{-1} to 75.6 mg·dL^{-1} ($p = 0.001$), Figure 2-2. The only other blood profile variable which was near the statistically significant p-value was LDL-C concentration, which decreased by 13.2%, 127.0 mg·dL^{-1} to 110.2 mg·dL^{-1} ($p = 0.007$). The remaining blood profile variables without statistically significant differences included total cholesterol concentration, baseline value of 193.4 mg·dL^{-1} to a final value of 178.0 mg·dL^{-1} ($p = 0.022$) and glucose tolerance, 89.2 mg·dL^{-1} to 87.2 mg·dL^{-1} ($p = 0.112$). The blood pressure measures, Figure 2-3, also did not have significant differences with the mean baseline systolic blood pressure of 125.5 mmHg and a final pressure of 122.0 mmHg ($p = 0.173$) and the mean diastolic blood pressure of 83.3 mmHg and a final pressure of 80.5 mmHg ($p = 0.116$).

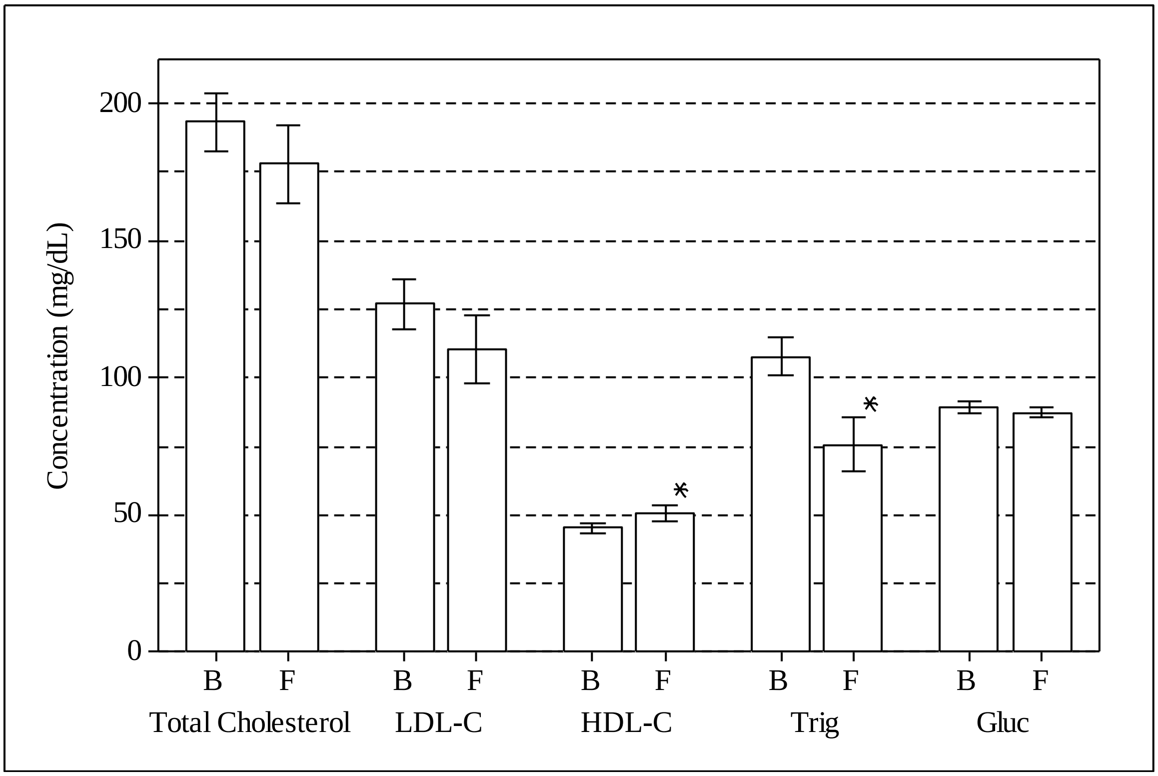

Figure 2-2: Changes in Blood Profile Variables for Men

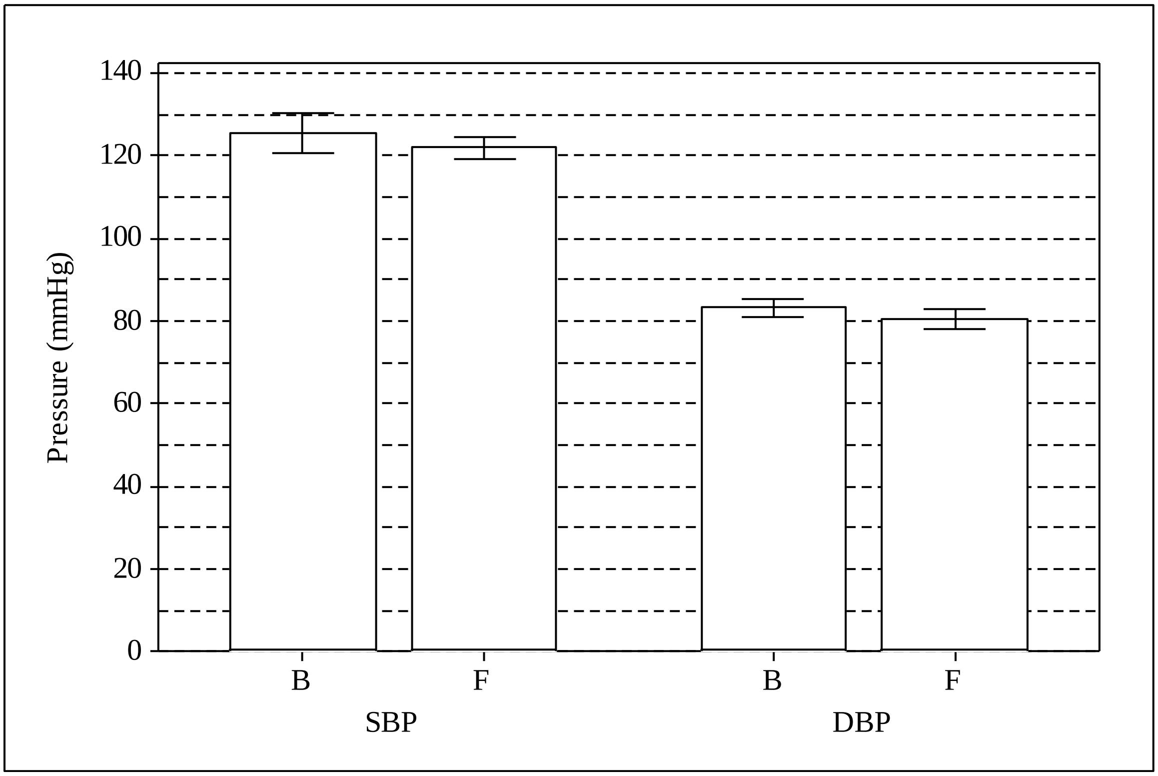

Figure 2-3: Changes in Blood Pressures for Men

There were not any statistically significant differences for the women's physiological variables. The lowest p-value resulted with the women's LDL-C concentration, with a baseline value of 103.7 mg·dL^{-1} and a final value of 96.3 mg·dL^{-1} ($p = 0.019$), Figure 2-4. On the individual basis, seven women reduced their LDL-C concentration by at least 10% from baseline value. The mean baseline value for HDL-C concentration was 54.5 mg·dL^{-1} and the final value was 55.7 mg·dL^{-1} ($p = 0.246$), triglyceride concentration was 106.1 mg·dL^{-1} at baseline and 99.1 mg·dL^{-1} ($p = 0.192$), and the total cholesterol concentration baseline value was 179.4 mg·dL^{-1} and the final value was 172.1 mg·dL^{-1} ($p = 0.026$). The final blood profile variable, glucose tolerance, did not have a difference in mean values between baseline and final values. The blood pressure measures, Figure 2-5, also did not have significant differences with the mean baseline systolic blood pressure of 124.4 mmHg and a final pressure of 118.4 mmHg (p = 0.176) and the mean diastolic blood pressure of 80.9 mmHg and a final pressure of 78.4 mmHg (p = 0.03).

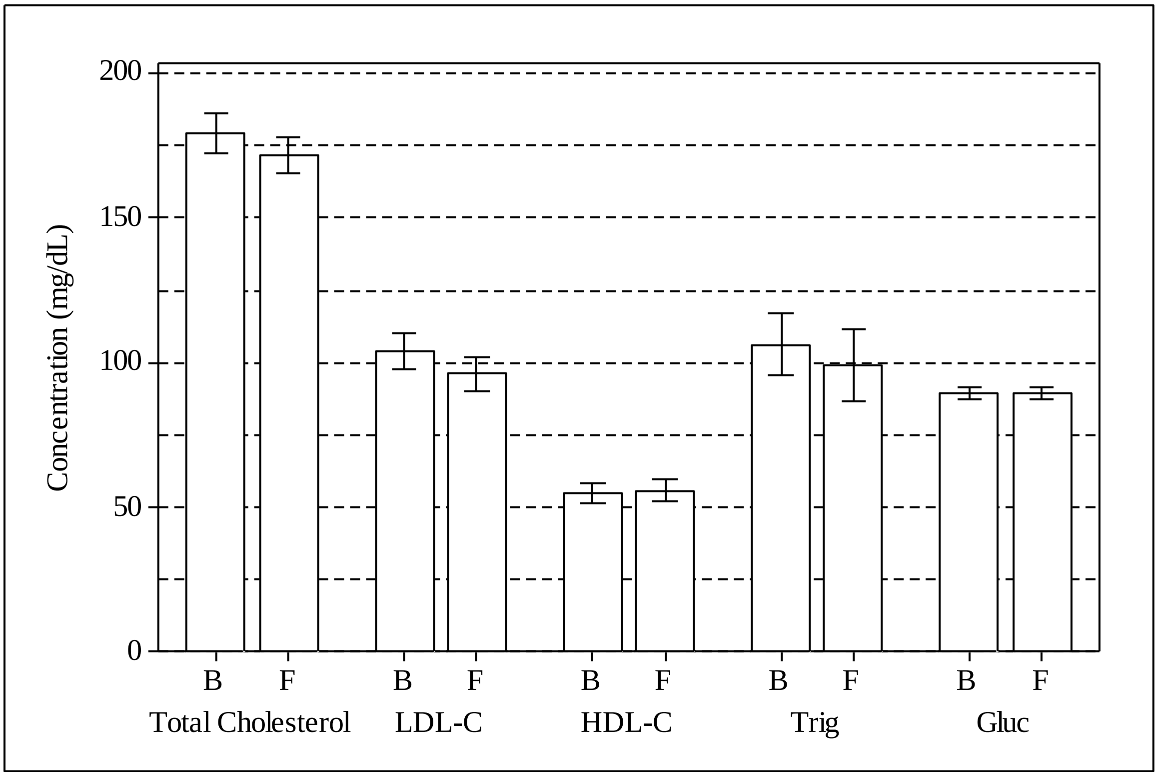

Figure 2-4: Changes in Blood Profile Variables for Women

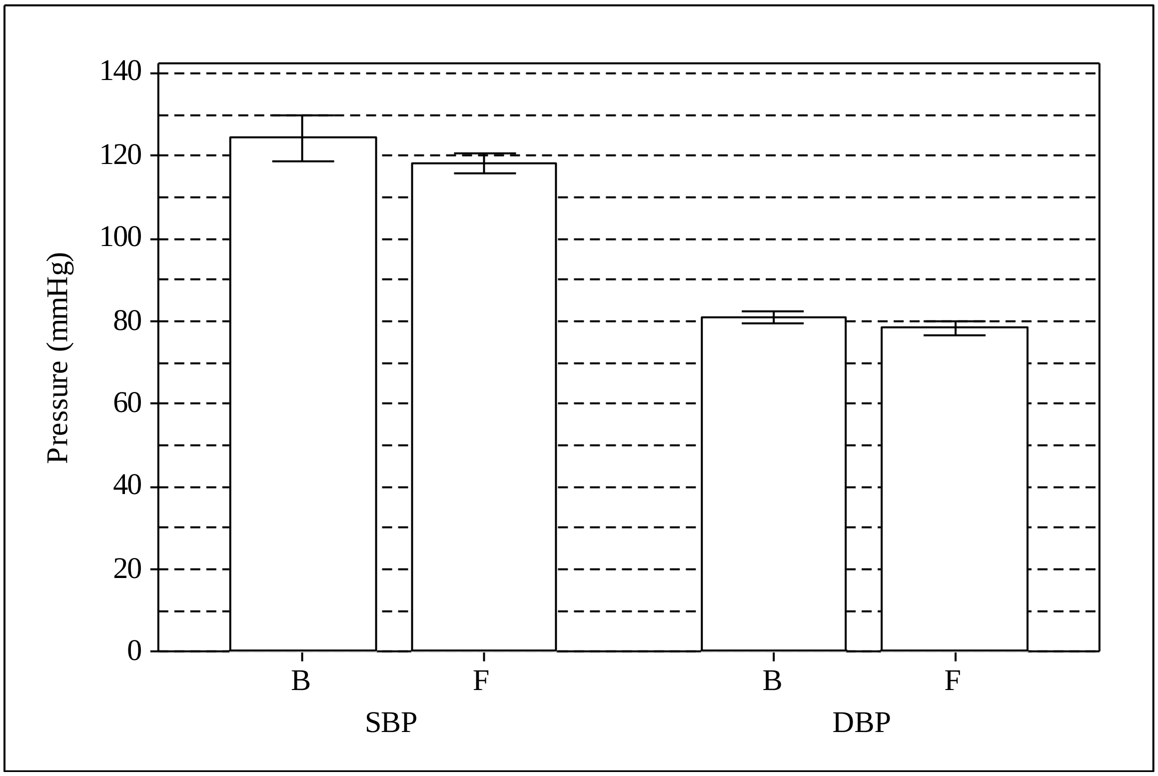

Figure 2-5: Changes in Blood Pressures for Women

2.4 DISCUSSION

The 30-week group fitness program was effective in reducing body mass and body fat percentage while increasing lean body tissue percentage. These beneficial changes can be applied to affecting the cardiovascular disease risk factor of overweight/obesity. ACSM states a 3% to 5% reduction in body mass can lead to reductions in health risks and add that clinically significant reduction in body mass is defined by having a 5% change in body mass as a minimum (2). Additionally, the Strategies To Overcome & Prevent (STOP) Obesity Alliance, a collaborative group of government, labor, business, health insurers, and quality-of-care organizations whose goal is to implement innovative and practical strategies to reduce obesity, recommend a

5% to 10% sustained reduction in body mass as the appropriate measure of success for effective interventions (11). The mean body mass for the men in the study was reduced by 5.3% from baseline and on an individual basis 6 men and 5 women had reductions of at least 5%.

The protocol of this study differed from previous research as participants in the program were able to choose the cardiorespiratory classes as well as structure the classes to fit their daily schedule. The participants in the previous studies were structured to a single cardiorespiratory exercise and a single strength training routine on specific days of the week for the duration of the respective study (5, 8, 9). Additionally, the participants in the previous studies completed their workouts in a laboratory setting and were continually monitored by a researcher. The participants in this study completed their workouts in the typical fitness class setting at The North Club which applies to another STOP Obesity Alliance goal of obtaining actionable research with methods that are applicable in actual practice found in everyday life (11).

The decrease in triglyceride concentration for the men in the group fitness class program was similar to the decrease reported for the men in the Libardi et al. study (5). The triglyceride concentration decreased by 30.0% in the multi-modal program while Libardi et al. reported a 33.4% decrease in the 16-week concurrent training of cardiorespiratory and strength training. The training protocol of Libardi et al. resulted in a greater decrease in total cholesterol, with a decrease of 27.8%, compared to the men in the group fitness class program. This greater decrease may be due to a larger mean baseline value, 244.8 $\text{mg}\cdot\text{dL}^{-1}$, compared to the 193.4 $\text{mg}\cdot\text{dL}^{-1}$ measured in this study. However, the decrease in body mass reported in the Libardi et al. study was less than the decrease found in this study. Perhaps the lower decrease in body mass for Libardi et al, 0.6% from baseline, is due to less cardiorespiratory training time. The men in the Libardi's 16-week training protocol completed 30 minutes of cardiorespiratory training on 3 days per week while the men in this study completed 60 minutes of cardiorespiratory training on 3 days per week. The men in the McCarthy et al. study completed in a similar amount of cardiorespiratory training time, 50 minutes on 3 days per week (8), to the program in this study but the McCarthy et al. training protocol did not result in a statistically significant decrease in mean body mass. The concurrent training protocol did result in a 2.3% decrease in body fat percentage which is less than the percent change compared to the 30-week program in this study. The smaller decrease in the McCarthy et al. study is most likely due to a shorter, 10 week, training protocol.

The 24-week combined training protocol completed by the women in the Park et al. (9) study resulted in greater decreases in the shared measured cardiovascular disease risk factors of the women in this study. The women in the Park et al. study decreased mean body mass by 9.5%, total cholesterol concentration by 25.0%, and triglyceride concentration by 42.3% compared to the decreases of 3.9%, 4.1%, and 6.5% for the respective values for the women in this study. The women that completed the Park et al. training protocol included an additional strength training session each week and also had higher baseline values compared to the women in this study. The mean baseline total cholesterol concentration for the women in this study was 179.4 $mg \cdot dL^{-1}$ and baseline triglyceride concentration of 106.0 $mg \cdot dL^{-1}$ while the women in the Park et al. study started the training protocol with a mean baseline total cholesterol concentration of 247.5

$mg \cdot dL^{-1}$, a triglyceride concentration of 148.8 $mg \cdot dL^{-1}$, and a mean body fat percentage of 41.4%.

AHA, in a meta-analysis reviewing exercise interventions, reported exercise training programs of 12 weeks or more in duration increase HDL-C concentration by an average of 4.6% from baseline values (13). The men in the group fitness class program had a statistically significant increase in HDL-C concentration of 12.1% from the baseline value. The reported average decrease for triglyceride concentration is 3.7% (13) while the program in this study resulted in a statistically significant decrease of 30.0% for the men. The greater differences from the report AHA values may be due to the weekly amount of cardiorespiratory training and strength training in comparison to the other studies. Also, the length of the program, 30 weeks of training, is more than double the minimum requirement of the included AHA studies. On an individual basis, perhaps the participants involved in the program exercised at a greater intensity than the other AHA exercise intervention studies. Chapter 3 will investigate the heart rate data collected during a sub-set of this study to determine the workout intensity for the participants.

A limitation of this study was not including a control group for comparison. The previous studies all included control groups (5, 8, 9) and the participants completed the same workout routines for each respective study. While this study was established to provide freedom of choice to the participants to build a workout routine, future studies could assign participants to a specific class to determine if a certain cardiorespiratory class results in a greater decrease in cardiovascular disease risk factors. Future studies should also include dietary journals to track the calorie consumption for the duration of the program. Participants were not required to alter their daily diet habits but there is no way of knowing if they increased calorie intake with the increase in exercise. Perhaps the changes in cardiovascular disease risk factors were less for the women in the study because they were responding to the increase in exercise by increasing their caloric intake, as theorized by some researchers (3), or perhaps it could be due to hormonal differences (7, 10). Lastly, future studies should also include more participants as the results of this pilot study were most likely hampered by the small participant number where the mean can be strongly affected by one outlier as well as collect psychological data to determine if the high retention rate of this program, 94%, is due to the group atmosphere.

The 30-week multi-modal group fitness class program is a viable option for further development in order to provide effective programs to increase physical activity and prevent cardiovascular disease. Given the results from the pilot study, more research needs to be done on how to implement an effective full scale physical activity program that works towards quieting the nation’s leading killer.

2.5 REFERENCES

1. Cabral, HJ. Multiple Comparisons Procedures. *Circulation*. 117(5): 698-701, 2008.

2. Donnelly JE, Blair SN, Jakicic JM, et al: Appropriate Physical Activity Intervention Strategies for Weight Loss and Prevention of Weight Regain for Adults. Medicine & Science in Sports & Exercise 41(2): 459-471 10.1249/MSS.0b013e3181949333, 2009.

3. Harris GK and Baer DJ. Gender differences in body fat utilization during weight gain, loss, or maintenance. In: Preuss, HG, Bagchi D, editors. *Phytopharmaceuticals for Obesity Treatment.* Boca Raton, FL: CRC Press: 239-244, 2007.

4. Johnson, CB. Cardiovascular Health: Pennsylvania's Blueprint for Action. Pennsylvania Department of Health, 2004.

5. Libardi CA, De Souza GV, Cavaglieri CR, et al: Effect of resistance, endurance, and concurrent training on TNF-alpha, IL-6, and CRP. *Med Sci Sports Exerc 44*(1): 50-56, 2012.

6. Lloyd-Jones DM, Hong Y, Labarthe D, et al: Defining and Setting National Goals for Cardiovascular Health Promotion and Disease Reduction. *Circulation 121*(4): 586-613, 2010.

7. Maric C. Sex differences in cardiovascular disease and hypertension. *Hypertension.* 46(3): 475-476, 2005.

8. McCarthy JP, Agre JC, Graf BK, et al: Compatibility of adaptive responses with combining strength and endurance training. *Med Sci Sports Exerc 27*(3): 429-436, 1995.

9. Park SK, Park JH, Kwon YC, et al: The effect of combined aerobic and resistance exercise training on abdominal fat in obese middle-aged women. *J Physiol Anthropol Appl Human Sci 22*(3): 129-135, 2003.

10. Pérez-Lópes FR, Larrad-Mur L, Kallen A, et al. Review: Gender differences in cardiovascular disease: hormonal and biochemical influences. *Reproductive Sciences.* 17(6): 511-531, 2010.

11. Strategies to Overcome and Prevent Obesity Alliance. Policy Recommendations. Department of Health Policy of The George Washington University School of Public Health and Health Services, Washington, DC, 2012.

12. Thompson WR, American College of Sports Medicine, Gordon NF, et al: in *ACSM's Guidelines for Exercise Testing and Prescription.* Lippincott Williams & Wilkins, 2009.

13. Thompson PD, Buchner D, Piña IL, et al: Exercise and Physical Activity in the Prevention and Treatment of Atherosclerotic Cardiovascular Disease. *Circulation 107*(24): 3109-3116, 2003.

14. Ulmer, L., Berhane, Z., and Sindhi, H. The Burden of Cardiovascular Disease in Pennsylvania. Pennsylvania Department of Health: The Heart Disease and Stroke Program, 2010.

15. United States Department of Health and Human Services- Physical Activity Guidelines Advisory Committee. *Physical activity Guidelines Adivsory Committee Report, 2008*. Washington DC.

Chapter 3

A Higher Percentage of Time in Vigorous-Intensity Results in a Greater Reduction of Body Mass

3.1 BACKGROUND

This chapter investigates the heart rate data for two separate months of the previous chapter to determine if moderate- or vigorous-intensity results in a greater reduction in body mass. Numerous health agencies- United States Department of Health and Human Services, American Heart Association, American College of Sports Medicine, and the Center of Disease Control- recommend adults participate in aerobic physical activity for a minimum of 150 minutes of moderate-intensity per week or 75 minutes of vigorous-intensity per week along with muscle-strengthening activities of moderate or high intensity involving all major muscle groups twice per week for health benefits (15, 16). Moderate- and vigorous-intensity cardiorespiratory exercise can be combined within a week as long as the energy expenditure is 500–1000 metabolic equivalent·minutues·week^{-1} (approximately 1000 kcal·week^{-1}) (5). Moderate-intensity is defined in absolute terms as 3.0 to 6.0 metabolic equivalents (METs) and vigorous-intensity is defined as anything greater than 6.0 METs. In relative terms, moderate-intensity is 64% to 76% of maximal heart rate while vigorous-intensity is 77% to 93% maximal heart rate (15). Exercise intensity can also be expressed in terms of percent heart rate reserve, percent VO_{2max}, and percent VO_{2max} reserve but benefits follow a dose-response relationship regardless of the exercise intensity measurement used and exercise training can be tailored within defined zones of these measurements (7).

The effect of exercise intensity on fat mass is an on-going debate of health professionals and research scientists with no clear answer as to what the dose-response curve is for intensity but there are few studies investigating the relation of exercise intensity and reduction in fat mass (13). Haskell et al. state that physical activity of longer duration or higher intensity is associated with increased health benefits but the shape of the dose-response curve is unknown and most likely varies on the measured health outcome, such as lowering of cardiovascular disease or premature mortality, and the baseline physical activity level of the study population (6). Gaining a better understanding of the dose-response relies on studies that evaluate the effects of physical activity variables- intensity, frequency, and duration- at fixed volumes (9). While energy expenditure is linked to the amount of weight loss during exercise, the effects of exercise intensity is unclear (8, 11, 14).

Dalleck et al. (2) concluded that a moderate-intensity exercise program resulted in a 1.6% decrease in percent body fat for 15 physically inactive premenopausal women [37.4(6.3) yr, 166.2(6.2) cm, 72.1(11.2) kg] during a 10-week exercise program. The exercise program consisted of walking at a moderate-intensity, 50% $VO_{2reserve}$, 3 to 4 days per week for 10 weeks designed to meet ACSM's guideline for energy expenditure of 1000 $kcal \cdot wk^{-1}$.

Mougious et al. (8) studied a participant group similar to the Dalleck et al. (2) protocol, healthy premenopausal untrained women, but compared the effects of exercise intensity on body composition. The women in the Mougious et al. study exercised on a treadmill four times per week for three months while seven women exercised at 45% VO_{2max} and seven women exercised at 72% VO_{2max} for the duration of the program and the energy expenditure was set at 370 kcal for both intensity programs. The 45% VO_{2max} group had a greater decrease in body mass, 4.8% compared to the 72% VO_{2max} group, 3.0% (8).

ACSM notes that there is no clear additional health benefit associated with including vigorous-intensity exercise since most studies do not have equal volume of energy expended in the comparison (6). It is unclear if any greater health benefit is due to the vigorous-intensity or if the results reflect the higher volume of energy expended. Very few studies have investigated the effect of different intensity levels while holding the frequency and duration of the physical activity constant.

Since this study examines two separate months of the program study described in Chapter 3 the frequency and duration are already established, with the frequency set at three 60-minute cardiorespiratory classes, two 60-minute strength training classes, and one 60-minute flexibility class each week for a duration of 30 weeks. This leaves the one physical activity variable, intensity, to be measured utilizing heart rate monitor technology. The goal of this study is to determine whether moderate- or vigorous-intensity exercise results in a greater reduction in body mass. I hypothesize that there will be a greater reduction in body mass when participants spend more time exercising at a vigorous-intensity.

3.2 METHODS

Twenty-two healthy adults, 8 men and 14 women [men: 32.2(2.5) yr, 28.8(6.1) $kg \cdot m^{-2}$; women: 30.8(4.4) yr, 30.6(5.0) $kg \cdot m^{-2}$] were selected for this protocol. While this is a segment of the study described in Chapter 2, the heart rate data for two participants- one man and one woman- could not be analyzed because the data could not be extracted by individual workouts. The protocol investigates the middle third of the group fitness class program.

The participants wore a Polar® RS400 heart rate monitor during every workout and heart rate was measured every 5 seconds. The heart rate data was downloaded every week using Polar® IrDA USB Adapter and Polar® Pro Trainer 5™ software.

Each heart rate transmitter had a unique Polar® OwnCode® (5 kHz) that ensured each computer in the watch registered its own individual transmitter and there was no chance of interference from other transmitters (10). The measurement of the heart rate is within ±1% or ±1 $beat \cdot min^{-1}$, depending on which one was larger, during steady state conditions.

The recording time of heart data for each individual class were determined by the participant starting and stopping the recording function on the heart rate monitor. The heart rate monitor computer would distribute the record heart rates into one of six defined heart rate zones, Sport Zones®, determined by percentage ranges of estimated maximum heart rate. The default estimation of maximum heart rate on the computer was $HR_{max} = 220 - age$ (10).

Zone	Polar® Intensity	Percentage Range	ACSM Intensity
0	Very very light	Less than 50% HR$_{max}$	Light 57-63% HR$_{max}$
1	Very light	50-60% HR$_{max}$	
2	Light	60-70% HR$_{max}$	Moderate 64-76% HR$_{max}$
3	Moderate	70-80% HR$_{max}$	
4	Hard	80-90% HR$_{max}$	Vigorous 77-95% HR$_{max}$
5	Maximum	90-100% HR$_{max}$	

Table 3-1: Sport Zones® and Corresponding Heart Rates

The Sport Zones® were stored on the computer and were downloaded with the Polar® Pro Trainer 5™ software and organized using Microsoft Excel 2007®. The data were stored as the percentage of time spent in a certain Sport Zone® during an individual workout. The percentages were then compiled in Excel to organize by each participant. In order to establish moderate- and vigorous-intensity Sport Zones® 2 and 3 were determined to estimate ACSM's moderate-intensity while Sport Zones® 4 and 5 were determined to estimate ACSM's vigorous-intensity.

The body mass loss data was divided into two categories- Above Mean and Below Mean- for each participant's body mass change. The mean body loss was 1.6% and if a participant lost more than 1.6% they were categorized in Above Mean and if they lost less than 1.6% than they were categorized in Below Mean. The distribution of men and women in each categorized group can be seen in Table 3.2.

Group	Total	Men	Women
Above	12	6	6
Below	10	2	8

Table 3-2: Distribution of Men and Women in the Categorized Groups

The percentages of time spent in moderate- and vigorous-intensity were compared using a 2-sample t-test with an applied Bonferroni correction to maintain the family-wise Type I error rate at 0.05 (1). The p-value of 0.05 was divided by 12, in regards to the 12 comparisons, resulting with significance being defined as $p < 0.0042$. Data comparisons were conducted with Minitab Student 14® and results were reported as mean (standard deviation) and the error bars in the graphs represent 1 standard error.

3.3 RESULTS

In support of the hypothesis, there was a larger decrease in body mass with more time spent in vigorous-intensity. The Above Mean categorized group spent 52.9% of total cardiorespiratory workout time in vigorous-intensity while the Below Mean group spent statistically significant less time in vigorous-intensity, 37.7% ($p < 0.001$). The Above Mean group spent 39.7% of total cardiorespiratory workout time in moderate-intensity which was significantly less than the Below Mean group, 52.5% ($p < 0.001$), Figure 3-1. The corresponding change in body mass and lean body tissue percentage is presented in Table 3-3 and the distribution of number of completed cardiorespiratory classes and corresponding percentage of time spent in each intensity-level for the participants can be seen in Table 3-4.

Variable	Percent Change
Total Group Mean Body Mass	-1.6
Above-Mean Group Body Mass	-3.0
Below-Mean Group Body Mass	-0.04
Total Group Mean Lean Tissue	+5.3
Above-Mean Lean Tissue	+6.4
Below-Mean Lean Tissue	+4.0

Table 3-3: Percent Change of Mean Body Mass and Lean Tissue Percentage

Class	# of Workouts	Moderate (%)	Vigorous (%)
Cardiorespiratory: Total	394	45.5(23.1)	46.0(27.5)
Cardio: Above	212	39.7(21.0)	52.9(25.1)
Cardio: Below	182	52.5(23.6)	37.7(28.1)
BodyAttack™: Total	68	43.2(16.0)	49.9(18.4)
Attack: Above	40	46.5(14.10	46.3(16.8)
Attack: Below	28	38.4(17.7)	55.1(19.8)
BodyCombat™: Total	132	42.6(24.8)	52.2(27.3)
Combat: Above	86	39.4(24.6)	55.9(26.5)
Combat: Below	46	48.4(24.3)	45.3(27.8)
RPM™: Total	154	49.4(23.7)	38.9(29.3)
RPM™: Above	70	37.0(19.4)	53.2(26.8)
RPM™: Below	84	59.9(21.9)	26.9(25.8)
BodyStep™: Total	40	46.4(23.3)	46.8(28.0)
Step: Above	16	39.9(18.6)	54.8(22.4)
Step: Below	24	50.7(25.4)	41.4(30.5)

Table 3-4: Distribution and Percentage of Time Spent in Intensity Levels for the Cardiorespiratory Classes

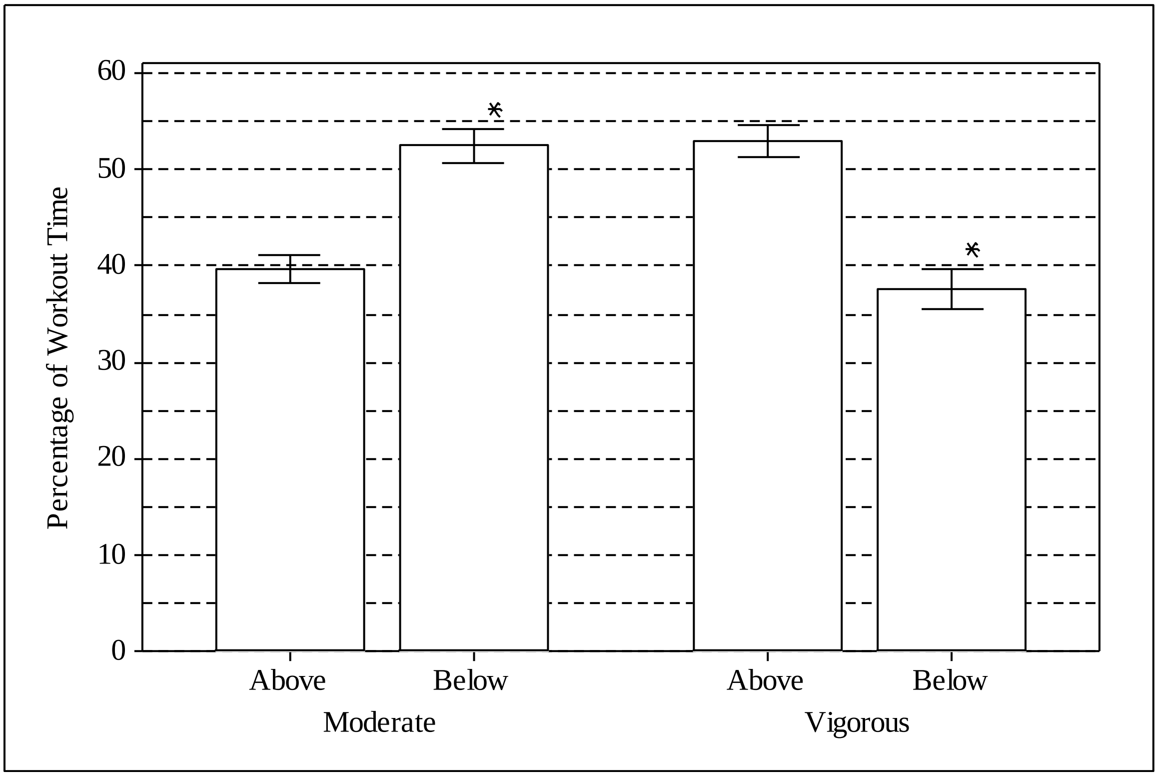

Figure 3-1: Differences of Above and Below Mean Groups for the Cardiorespiratory Classes
*: $p < 0.001$

There were no statistically significant differences between the Above and Below Mean groups for either moderate- or vigorous-intensity for the strength training class, BodyPump™. The Above Mean group spent 55.5% of the workout time for BodyPump™ classes and the Below Mean group spent 53.8% in moderate-intensity ($p = 0.21$). The Above Mean group spent 7.1% of the workout time for BodyPump™ classes while the Below Mean group spent 6.4% in vigorous-intensity ($p = 0.28$), Figure 3-2.

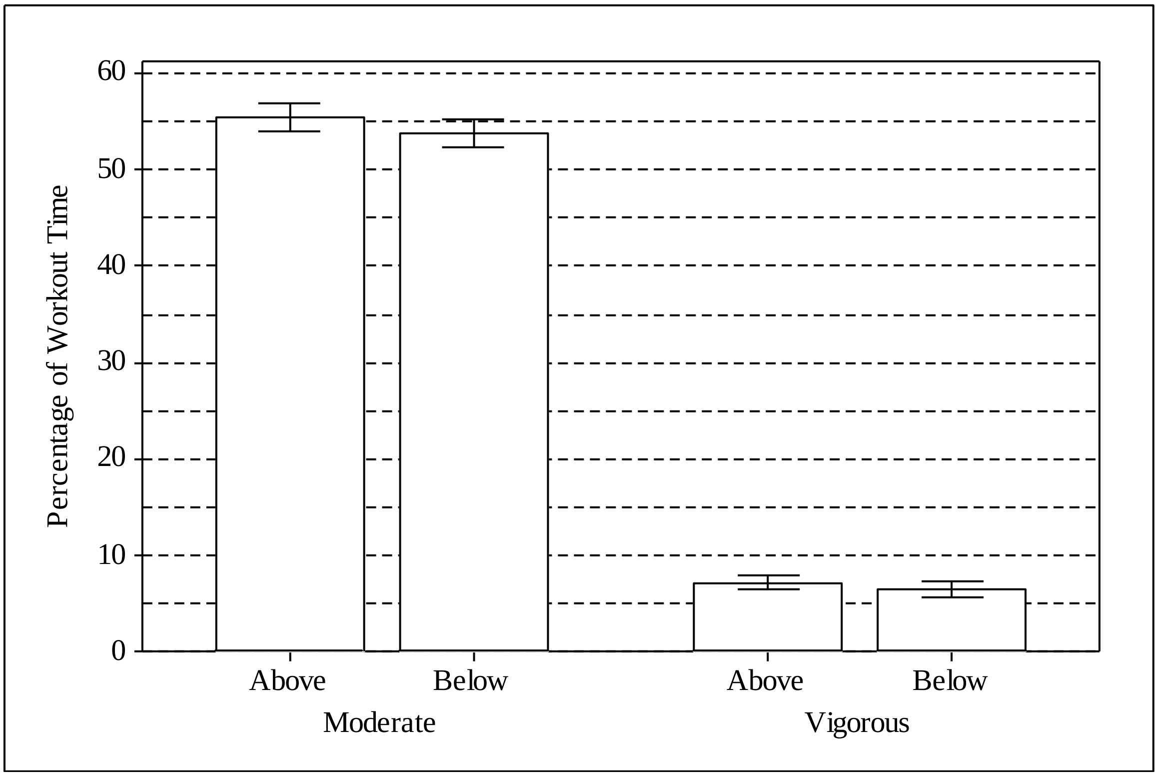

Figure 3-2: Differences of Above and Below Mean Groups for BodyPump™

There was a statistically significant differences between the Above and Below Mean for the flexibility class, BodyFlow™, in vigorous-intensity. The Above Mean group spent 0.1% of the workout time for BodyFlow™ classes and the Below Mean group spent 2.5% in vigorous-intensity ($p = 0.004$). The Above Mean group spent 31.2% of workout time and the Below Mean group spent 39.6% of workout time in moderate-intensity ($p = 0.02$), Figure 3-3.

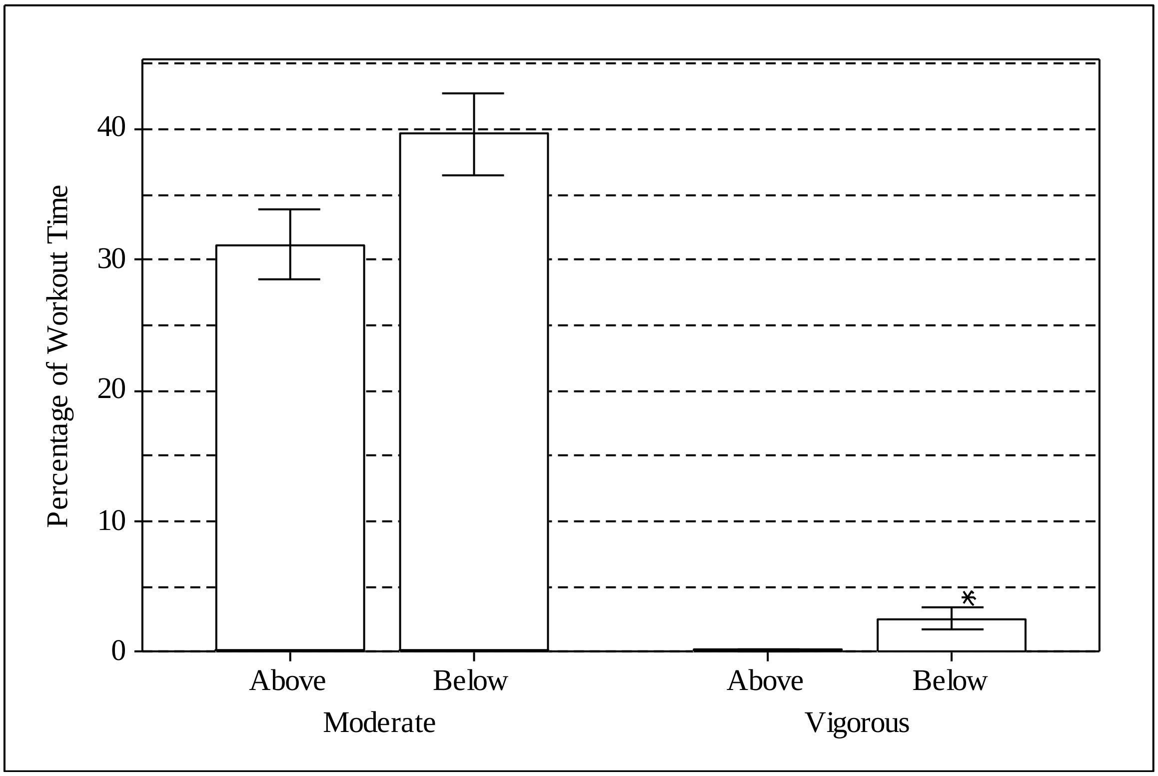

Figure 3-3: Differences of Above and Below Mean Groups for BodyFlow™

3.4 DISCUSSION

There was a greater reduction in body mass with a higher percentage of workout time in vigorous-intensity. This result provides evidence for a dose-response effect with a higher intensity resulting in a greater effect on body mass reduction. Few studies have compared moderate- and vigorous-intensity and this protocol offers support for further investigating the effects of vigorous-intensity.

The Mougios et al. (8) study resulted in reductions in body mass while participants engaged in both moderate- and vigorous-intensity. While both intensities resulted in a reduction in body mass, the participants who exercised in the moderate-intensity level had a greater reduction in body mass. Unfortunately, Mougios et al. did not include any men in their study for a comparison of the groups that resulted in a greater reduction of body mass with a higher percentage of workout time spent in the moderate-intensity level. However, the women who were grouped into the classification of Above Mean had a 3.1% reduction in body mass during this segment which is a similar reduction seen with the women who exercised in the vigorous-intensity group in the Mougios et al. study.

Observing the class distribution tables shows that there was not an even distribution of completed workouts for each class for either group. Future studies should compare the effect of specific classes on the reduction of body mass. A study could either equally distribute participants to each class or establish a program that rotates participants through each of the classes with equal numbers of workouts in each class to determine if exercising in a particular class has a greater effect on reducing body mass. In addition to the equal class distribution, future studies can prescribe participants to exercise at either the moderate- or vigorous-intensity level.

The protocols of previous studies were structured in a manner to ensure participants exercised at the specified intensity for the entire duration of the workout (2, 8). Researchers constantly monitored a participant’s heart rate or oxygen consumption to verify the participant’s effort matched the required intensity level. In contrast, this protocol did not set a specific exercise intensity that the participants needed to adhere to during their workout. Each workout was led by a trained fitness instructor but the participants exercised a self-selected intensity.

Prescribed intensity workouts result in lower rates of adherence especially in overweight and obese adults (4). If a participant views a workout as being too rigorous and less pleasant than what they prefer their enjoyment and motivation to exercise will diminish thus reducing adherence to the exercise program (4). While workout programs featuring self-selected intensities increase adherence and are more enjoyable do participants select intensities that are beneficial in terms of decreasing body mass and body fat percentage and meet the Physical Activity recommendations (3)?

Estimating the $\text{MET}\cdot\text{min}\cdot\text{wk}^{-1}$ (5) can be done by utilizing the moderate- and vigorous-intensity graphs for the cardiorespiratory classes, which total 180 minutes each week, and establishing estimates for the METs of moderate- and vigorous-intensity levels. The approximate weekly MET·min for each categorized group are 784 MET·min for the men in the Above Mean group and 931 MET·min for the men in the Below Mean group. The approximate weekly MET·min for the women in Above Mean group is 1043 MET·min and 911 MET·min for the women in the Below Mean group. All of these approximate $\text{MET}\cdot\text{min}\cdot\text{wk}^{-1}$ values fall within the ACSM physical activity recommendation of 500 to 1000 $\text{MET}\cdot\text{min}\cdot\text{wk}^{-1}$ (15).

A limitation to these values is the Sport Zones® do not exactly match the corresponding $\%\text{HR}_{\text{max}}$ values to moderate- and vigorous-intensity levels established by ACSM (15). Moderate-intensity is classified with a relative intensity of 64-76% which falls within Sport Zones® 2 and 3, 60-80% and vigorous-intensity is classified with a relative intensity of 77-95% which falls within Sport Zones® 4 and 5, 80-100%.

Modern heart rate technology makes it possible to monitor fitness programs to ensure the participant is exercising at a specific intensity. For instance, Polar heart rate monitors have two features- ZonePointer® and ZoneLock®- which notify the user when they are in a certain heart rate zone (10). The Zones® can be set to define the moderate- and vigorous-intensity heart rate zones. This heart rate zone notification is not limited to Polar® monitors as other manufacturers, such as Acentas®, Activio®, and Suunto®, have similar features (12).

The results of this study do not only offer new ideas for heart rate monitor training but also determine the intensities of the group fitness class program described in Chapter 2. Participants exercised at self-selected intensities that fulfilled the Physical Activity Guidelines for Fitness. Furthermore, the greater reduction in body mass with a higher percentage of time spent in vigorous-intensity provides data for the higher end of the dose-response effect which has not been investigated.

3.5 REFERENCES

1. Cabral, HJ. Multiple Comparisons Procedures. *Circulation*. 117(5): 698-701, 2008.

2. Dalleck LC, Borresen EC, Wallenta JT et al. A moderate-intensity exercise program fulfilling the American College of Sports Medicine net energy expenditure recommendations improves health outcomes in premenopausal women. *J Strength Cond Res 22*(1): 256-262, 2008.

3. Ekkekakis P: Let them roam free? Physiological and psychological evidence for the potential of self-selected intensity in public health. *Sports Med (New Zealand) 39*(10): 857-888, 2009.

4. Ekkekakis P, Lind E: Exercise does not feel the same when you are overweight: the impact of self-selected and imposed intensity on affect and exertion. *Int J Obes (Lond) 30*(4): 652-660, 2006.

5. Garber CE, Blissmer B, Deschenes MR, et al: American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Med Sci Sports Exerc 43*(7): 1334-1359, 2011.

6. Haskell WL, Lee IM, Pate RR, et al: Physical activity and public health: updated recommendation for adults from the American College of Sports Medicine and the American Heart Association. *Med Sci Sports Exerc 39*(8): 1423-1434, 2007.

7. Harris GK and Baer DJ. Gender differences in body fat utilization during weight gain, loss, or maintenance. In: Preuss, HG, Bagchi D, editors. *Phytopharmaceuticals for Obesity Treatment*. Boca Raton, FL: CRC Press: 239-244, 2007.

8. Hofmann P, Tschakert G: Special needs to prescribe exercise intensity for scientific studies. *Cardiol Res Pract 2010*: 209302, 2011.

9. Mougios V, Kazaki M, Christoulas K, et al: Does the intensity of an exercise programme modulate body composition changes? *Int J Sports Med 27*(3): 178-181, 2006.

10. National Cancer Institute. 2008 Physical Activity Guidelines for Americans. United States National Institutes of Health- Applied Research, http://appliedresearch.cancer.gov/funding/pa_guidelines.html. Viewed: July 13, 2012.

11. Pennsylvania Department of Health. Pennsylvania Nutrition and Physical Activity Plan to Prevent Obesity Related Chronic Diseases. Pennsylvania Advocates for Nutrition and Activity, 2003.

12. Polar®, Polar RS400 User Manual, Copyright 2006 Polar Electro Oy, FIN-90440 Kempele, Finland.

13. Ross, R and Janssen, I. Physical activity, total and regional obesity: dose-response considerations. *Med Sci Sports Exerc.* 33(6 Suppl): S521-527, 2001.

14. Schönfelder M, Hinterseher G, Peter P, et al: Scientific comparison of different online heart rate monitoring systems. *Int.J.Telemedicine Appl. 2011*: 6:1-6:6, 2011.

15. Slentz CA., Duscha BD, Johnson JL, et al. Effects of the amount of exercise on body weight body composition, the measures of central obesity: STRRIDE- a randomized controlled study. *Arch Intern Med 164*(1): 31-39, 2004.

16. Swain DP and Franklin BA. Comparison of cardioprotective benefits of vigorous versus moderate intensity aerobic exercise. *Am J Cardiol.* 97(1): 141-147, 2006.

17. Thompson WR, American College of Sports Medicine, Gordon NF, et al: in *ACSM's Guidelines for Exercise Testing and Prescription.* Lippincott Williams \& Wilkins, 2009.

18. United States Department of Health and Human Services- Physical Activity Guidelines Advisory Committee. *Physical activity Guidelines Adivsory Committee Report, 2008*. Washington DC.

Chapter 4

The Continuous Hill Interval Workout is the Optimal Hill Training Method

4.1 BACKGROUND

The results from Chapter 3 reveal the need to include vigorous-intensity in workouts for a greater reduction in body mass. While a direct linear dose-response relation was not established in the previous results, it is evident that the Physical Activity Guidelines for Fitness have an effect on maintaining and reducing body mass. Effective physical activity programs need to apply a variable of dose-repose, whether it is intensity, frequency, or duration.

The most popular form of physical activity for adults is walking (4) as 34.4% of Americans walk during their leisure time (3). Walking programs are established to encourage routine physical activity yet walking is not the most effective in terms of meeting the Physical Activity Guidelines for Fitness. Less than 7% of the people whose primary form of exercise is walking exercise frequently enough, long enough in time, or at a high enough intensity to meet the guidelines (3).

One possible improvement to the predicament of this popular activity not adhering to recommended levels is to increase the intensity of the activity by incorporating hills during a walking bout. Hill intervals vary the intensity throughout the workout and the intensity is varied at fixed intervals which can increase the average exercise intensity overall for the workout (4). Hill workouts can be performed on a treadmill and are a typical treadmill preset program. A workout can feature continuous or random hill intervals. A continuous hill interval workout consists of longer hill intervals with few changes in hill grade while a random hill interval workout consists of shorter hill intervals with more changes in hill grade. For instance, the Precor 966i™ treadmill offers three different hill interval workouts- 1:1 Interval, 1:2 Interval, and 1:3 Interval. The 1:1 Interval workout has equal time of level walking and hill walking- 1 minute at level and 1 minute of hill walking, for example. The 1:2 Interval has 2-minute hill intervals while the 1:3 Interval has 3-minute hill intervals each with 1-minute level intervals. Another preset program is the Aerobic-1 Weight Loss workout. The workout involves 1-minute intervals starting at level and then 1-minute each at 4%, 5%, 6%, 5%, 4%, returns to level and repeats this pattern for the duration of the workout. The goal of this study is to provide a recommendation for the optimal hill workout that maximizes metabolic cost while increasing the level of intensity of the exercise regimen.

The metabolic cost of walking up an incline at constant speed is a linear equation defined: $\dot{V}O_2$ ($mL \cdot kg^{-1} \cdot min^{-1}$) = [0.1 $mL \cdot kg^{-1} \cdot m^{-1}$(S)] + [1.8 $mL \cdot kg^{-1} \cdot m^{-1}$(S)(G)] + 3.5 $mL \cdot kg^{-1} \cdot min^{-1}$where S is the speed measured in $m \cdot min^{-1}$ and G is the percent grade expressed as a decimal. The 0.1 $mL \cdot kg^{-1} \cdot m^{-1}$ coefficient is the oxygen cost of moving one kilogram of body weight one meter. The first component of the equation defines the horizontal cost of walking and the second component defines the vertical cost of walking. The 1.8 $mL \cdot kg^{-1} \cdot m^{-1}$ coefficient is the approximate value for the oxygen cost of moving vertically against gravity for every meter walking and the additional 3.5 $mL \cdot kg^{-1} \cdot min^{-1}$ is the oxygen cost at rest, 1 metabolic equivalent (1 MET) (8).

The increase in oxygen consumption while walking up an incline is due to an increase in muscle activity in order to raise the body's center of mass to a higher position

(1). The first step up an incline requires extra concentric contraction in the hip flexor muscles, such as the rectus femoris, to raise the leg to a higher position (1). Once the lead-foot has landed on the incline additional work is needed from the hip and knee extensors, such as the biceps femoris and rectus femoris, to raise the body's center of mass up the incline (1). The ankle flexors and extensors also require more muscle activity while walking up an incline. The tibialis anterior and gastrocnemius will have more activity due to the increase in angular movement required by the ankle to propel up the incline. The rectus femoris and bicep femoris have increased muscle activity going from level walking to an incline during the first half of the stance phase of the gait cycle. The soleus has increased muscle activity during the second half of the stance phase (1). Lay et al. analyzed the effects of walking on an incline by utilizing a ramp at five different grades (- 39%, -15%, level, 15%, and 39%). The need to raise the leg for toe clearance and heel strike results in a kinematic postural change and also increases the hip extensor moment (5). And analyzing the electromyography data resulted in an increase of the mean activity, burst durations, and power productions for the rectus femoris, vastus medialis, biceps femoris, soleus, and gastrocnemius during incline walking (6).

In order to increase the level of intensity of an individual's workout regimen we need to know the optimal way to implement hill intervals to maximize the metabolic cost. The purpose of this study is to determine whether exercisers have a greater metabolic cost while walking with continuous hill intervals- longer hill intervals with few changes in hill grade- or random hill intervals- shorter hill intervals with more changes in hill grade. Based on the metabolic cost equation, I hypothesize that the two hill training methods will result in the same metabolic cost if the mechanics are identical and the time spent at each hill grade is the same.

4.2 METHODS

To test the hypothesis ten health college students [5 men and 5 women, age: 20.90(0.99) yr, mass: 69.57 (16.23) kg, height: 1.72 (0.11) m, mean (standard deviation)] completed the protocol. We included any subject that could complete both of the methods and did not screen for fitness level or activity background. We excluded any participant with any bone or muscular joint injuries or lower body operations within the last two years. All participants gave written, informed consent according to The Pennsylvania State University Human Research Committee and the study was approved by an International Review Board committee.

Each participant completed two 20-minute hill interval training workouts- one continuous hill workout and one random hill workout. The workouts were performed on a treadmill at a speed of 2.0 miles·hour^{-1} and featured 5 different hill grades- level, 6%, 12%, 18%, and 24%. Each workout had equal time at each hill grade with equal total transition time between each interval. The order of the hill intervals was different for each subject.

The continuous hill interval workout consisted of five 192-second (total of 960 seconds) hill intervals with four 60-second (total of 240 seconds) transition intervals between each hill interval. The random hill interval workout consisted of twenty 48-second (total of 960 seconds) hill intervals with twenty 12-second (total of 240 seconds) transition intervals between each hill interval. An example for each workout is illustrated in Figure 3-1. An example of the continuous hill interval workout is represented by the figure on the left while the random hill interval workout is represented by the figure on the right. The continuous method example consists of 192 seconds at 18%, a 60 second transition, 192 seconds at 6%, a 60 second transition, 192 seconds at 24%, a 60 second transition, 192 seconds at level, a 60 second transition, and 192 seconds at 12%. The first 288 seconds of the random method example consists of 48 seconds at 18%, a 12 second transition, 48 seconds at 6%, a 12 second transition, 48 seconds at 12%, a 12 second transition, 48 seconds at level, a 12 second transition, and 48 seconds at 24%.

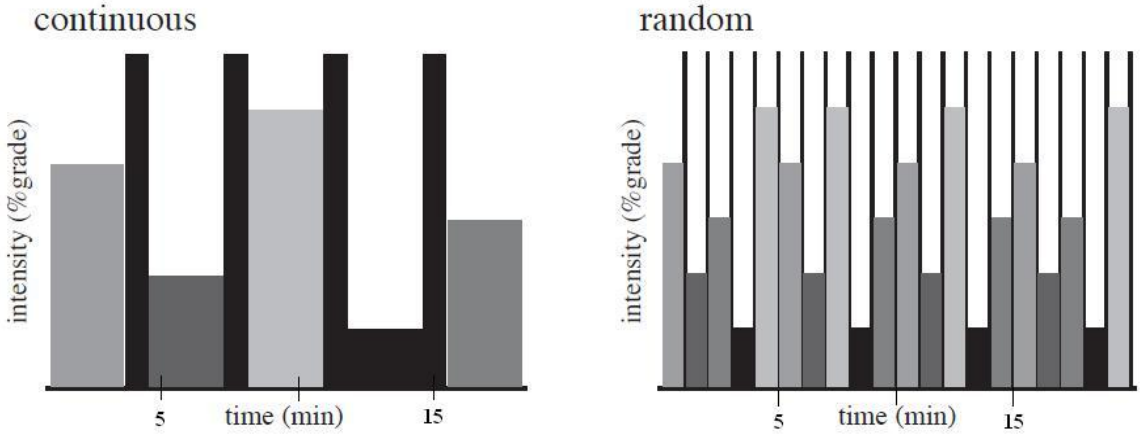

Figure 4-1: An Example of a Continuous and Random Hill Interval Workout

The metabolic cost of each workout was measured using an open-circuit respirometry system (ParvoMedics, Sandy, UT, USA) and measure the rates of oxygen consumption, $\dot{V}O_{2,}$ and carbon dioxide production, $\dot{V}CO_2$.

To assure the mechanical work was identical we measured the base of support, joint angles, and muscle activity in each of the two hill interval workouts. We collected kinematic data with a six-camera, passive market 3D photogrametry system (Motion Analysis Corporation, Santa Rosa, CA). The calibration for the system was less than 0.5 mm in a capture volume of approximately 2m x 2m x 2m. Prior to data collection, we placed retro reflective markers on the seventh cervical vertebrae, sacral crest, and bilaterally on the iliac crest, lateral head of the fibula, patella, lateral malleolus, calcaneus, and fifth metatarsal. The marker set data was collected at 100 Hz and post-processed with EVaRT software (Version 3.21, Motion Analysis Corporation). The data was then processed using a purpose-written Matlab program (Version R2006b, The Mathworks, Natick, MA) with a low-pass filter for the marker trajectories at 7 Hz, fourth-order, dual-pass, Butterworth.

The electromyography (EMG) signal was collected at 1000 Hz using a wired amplifier system (Bortec Octopus AMT-8, Calgary, AB, Canada) with a bandpass filter setting of 5 to 500 Hz. We prepared each participant's skin with fine sandpaper and rubbing alcohol before placing the electrode on the skin. 1 x 1.5 cm^2 bipolar, silver-silver chloride, surface electrodes (Vermed, A10041, Bellows Falls, VT, USA) were placed over 6 muscles of the left leg- rectus femoris (RF), vastus lateralis (VL), biceps femoris (BF), anterior tibialis (AT), lateral gastrocnemius (LG), and soleus (SL)- in accordance to Cram et al. (2). The interelectrode distance was 2 cm. The position of the electrodes was verified with a functional test consisting of a series of flexion and extension exercises recommended by Winter et al. (10) and Cram et al. (2) along with verifying the crosstalk between the muscles was negligible.

The muscle activity analysis was conducted using a linear envelope (10) obtained by low pass filtering (dual-pass, fourth order, Butterworth) the rectified EMG data at 10

Hz. The amplitude analysis consisted of full-wave rectifying the band-pass filtered signals and then calculating the mean EMG amplitude for 5% segments of the walking stride and then averaged 5 strides for each workout and finally normalized to EMG of normal level walking.

The metabolic cost of the two hill interval workouts were compared using a paired t-test. The kinematics and EMG measures of the two workouts were compared with repeated measures ANOVA with post-hoc tests. Significance was defined as $p < 0.05$ and results were reported as mean (standard deviation).

4.3 RESULTS

Contrary to the hypothesis, the metabolic cost was greater during the continuous hill interval workout, with a mean metabolic cost of 6.51 $W \cdot kg^{-1}$ (0.43 $W \cdot kg^{-1}$). The random hill interval workout resulted in a mean metabolic cost of 5.32 $W \cdot kg^{-1}$ (0.41 $W \cdot kg^{-1}$) ($p = 0.007$).

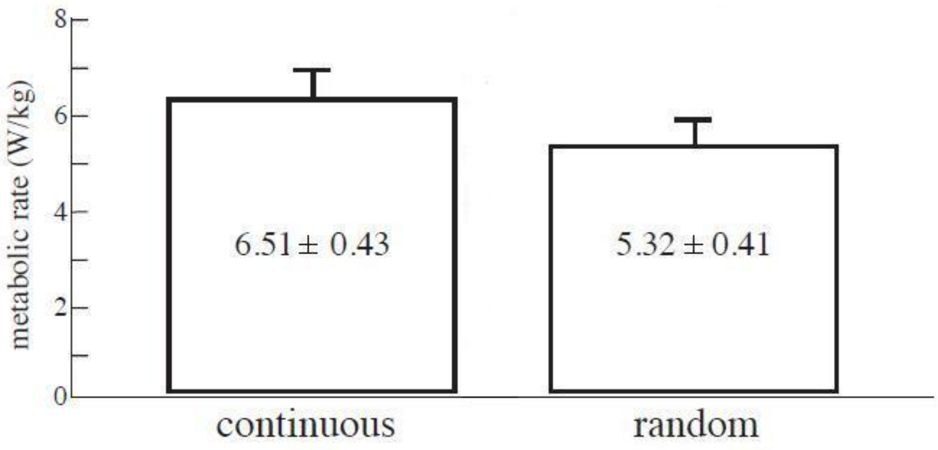

Figure 4-2: The Metabolic Cost of Continuous and Random Hill Interval Workouts

Next, we compared the ankle angle during the gait cycle for the two workouts. The ankle angles were nearly identical between the continuous and random hill interval workouts with no statistically significant differences between the two curves. The ankle angle was measured for each of the hill grades- level, 6%, 12%, 18%, and 24% for both of the workouts. Both the continuous and random hill interval workouts increased ankle angle during the stance phase of the gait cycle. For example, at approximately 32% of the gait cycle the ankle angle is 0° during normal level walking. The ankle angle during the 6% hill grade increased to 50° flexion, 100° flexion during the 12% hill grade, 145° flexion during the 18% hill grade, and 170° flexion during the 24% hill grade.

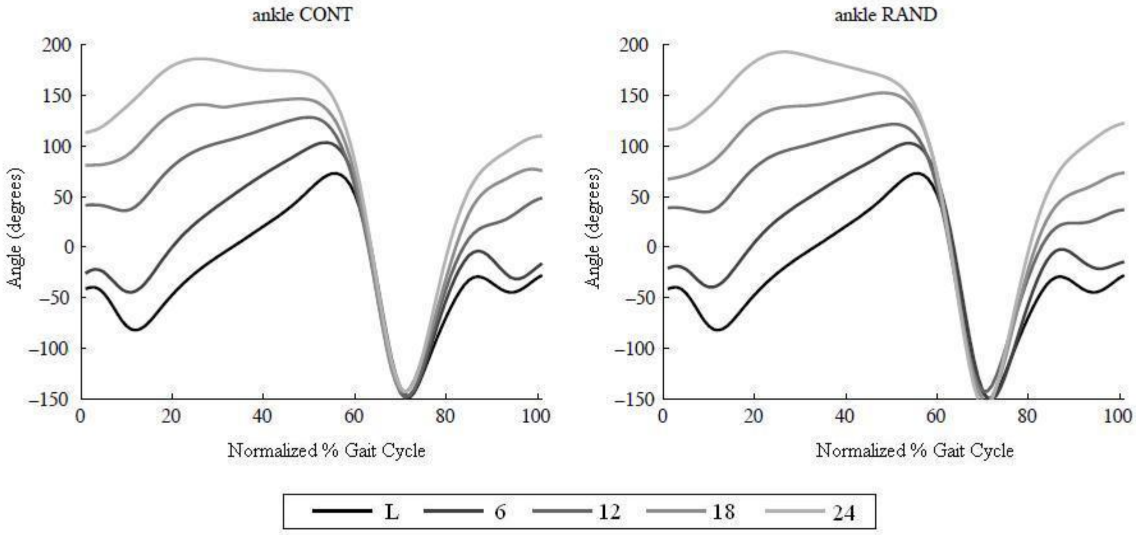

Figure 4-3: Ankle Angle during Gait Cycle for Continuous and Random Hill Interval Workouts

The knee angle curves are also similar between the two hill interval workouts with no statistically significant differences between the two curves. During the early portion of stance phase, at approximately 12% of the gait cycle, the knee angle increased during the first major flexion burst and was increased for each hill grade. Knee flexion angle during normal level walking is 8°, the knee flexion angle during the 6% hill grade increased to 9°, 22° during the 12% hill grade, 28° during the 18% hill grade, and 35° during the 24% hill grade. These results held for both of the hill interval workouts.

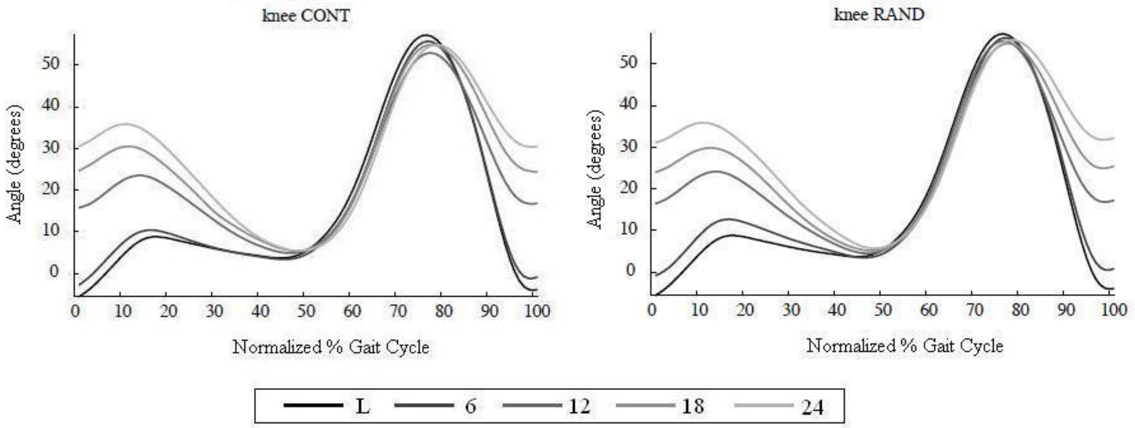

Figure 4-4: Knee Angle during Gait Cycle for Continuous and Random Hill Interval Workouts

Next, we compared the EMG data for the vastus lateralis. The EMG curves were similar between the continuous hill interval workout and the random hill interval workout with no statistically significant differences between the two curves. The muscle activity at approximately 15% of the gait cycle during the 24% continuous interval hill grade was more than 2.5 times the muscle activity of level walking. The muscle activity was 2.0 times that of normal level walking during the 18% hill grade and 1.5 times normal level walking during 12% hill grade. These results were the same for the random interval hill grades.

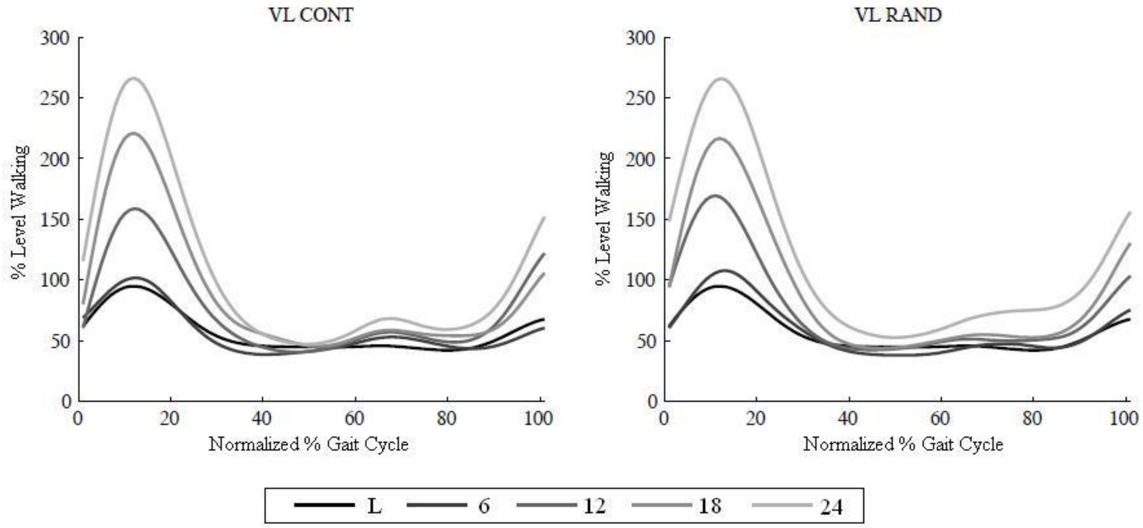

Figure 4-5: Vastus Lateralis EMG Curves for Continuous and Random Hill Interval Workouts

The EMG data trends were similar for the rectus femoris with no statistically significant differences. Muscle activity increased during both hill interval workouts at the same portions of the gait cycle, at 15% of the gait cycle for example. Muscle activity during the 24% hill grade for both workouts was 2.3 times more than normal level walking while it increased 2.1 times during the 18% hill grade.

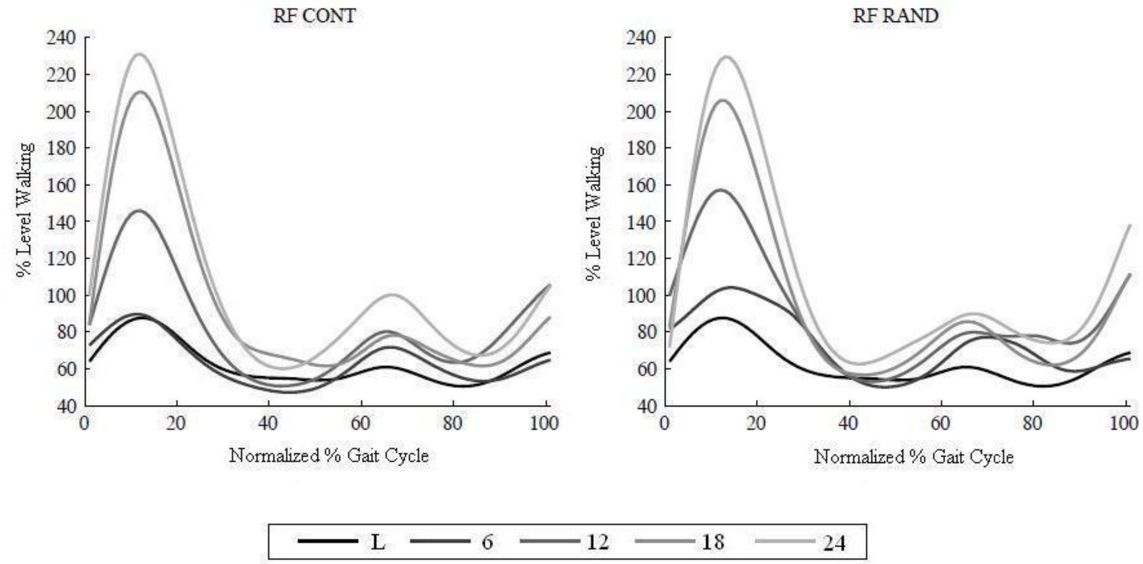

Figure 4-6: Rectus Femoris EMG Curves for Continuous and Random Hill Interval Workouts

The lateral gastrocnemius and soleus had a similar major muscle activity peak at approximately 45% of the gait cycle with no statistically significant difference between the inclines for each muscle. The increased hill grades resulted in increased muscle activity at this portion of the gait cycle. For instance, the muscle activity for the lateral gastrocnemius was increased by more than 2.5 times normal level walking during the 24% hill grade.

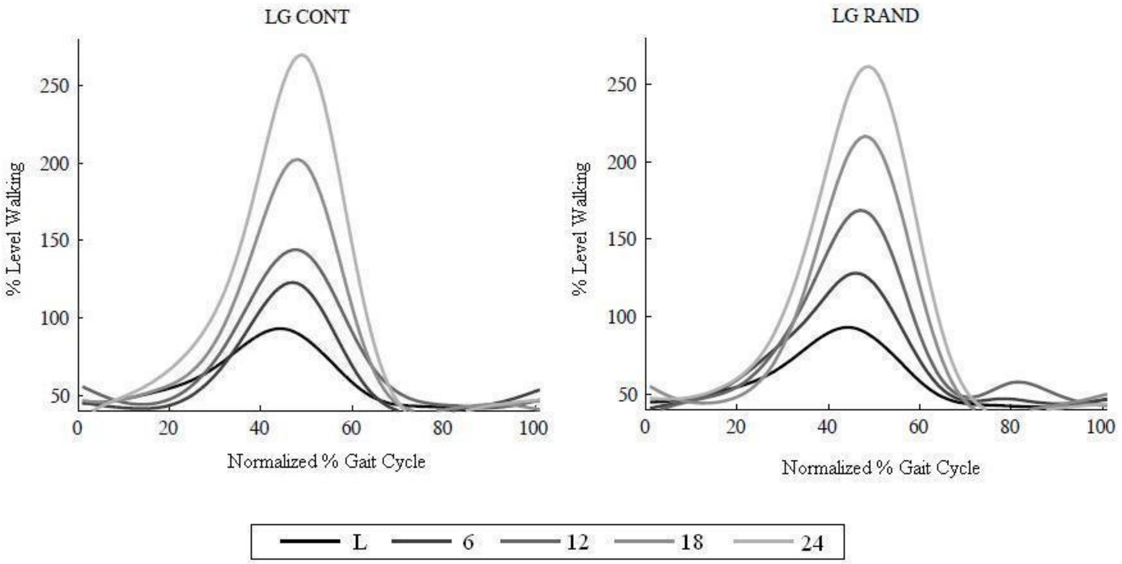

Figure 4-7: Lateral Gastrocnemius EMG Curves for Continuous and Random Hill Interval Workouts

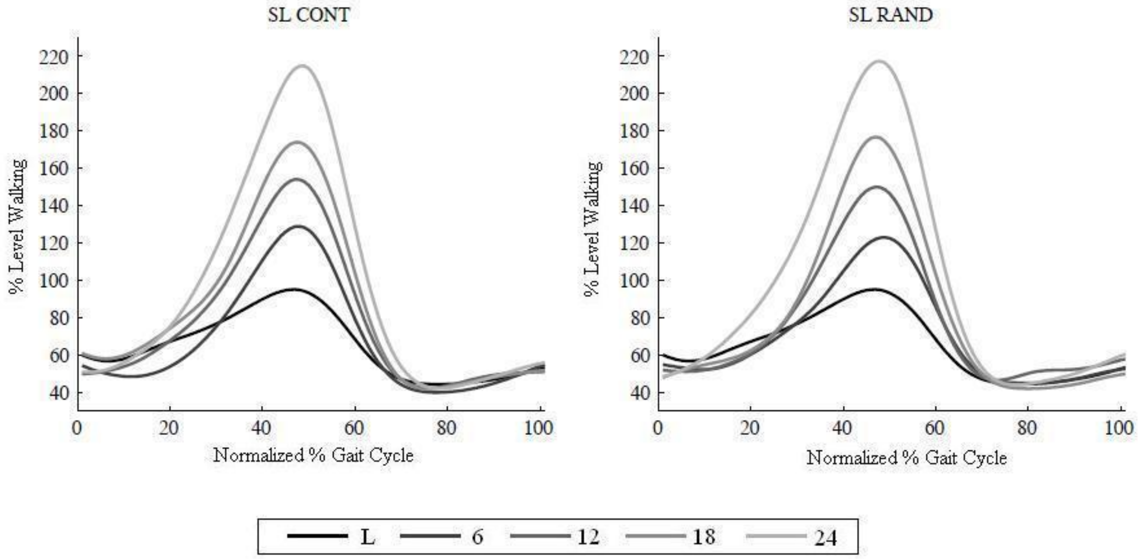

Figure 4-8: Soleus EMG Curves for Continuous and Random Hill Interval Workouts

4.4 DISCUSSION

The continuous hill interval workout resulted in a greater metabolic cost than the random hill interval workout. Exercisers can maximize their metabolic cost in a 20-mintue workout by using the continuous hill interval method. This workout can be implemented on a treadmill by choosing a program with longer hill intervals with few changes in hill intervals. Many commercial treadmills will not have the hill profile used in this protocol as the inclines featured the extremes of the treadmill to expose any potential differences and the speed was set slower than typical walking speed in accordance with the extreme range of hill grades. While the exact hill profile will not be applicable the level of intensity of the workout regimen can be increased by selecting the workout with longer hill intervals.

We hypothesized that the two hill interval training methods would result in the same metabolic cost since the metabolic equation predicted equal values since the speed and hill grades would be the same for both training methods. Each training method had the same hill grades and equal time at each hill grade so the vertical cost of walking should be the same between the two methods and the horizontal component of the equation is equal since the speed is constant for both methods. In contrast to what the equation predicted, there was a difference in metabolic cost between the two hill training methods.

We can only theorize as to why there was a difference in metabolic cost as our biomechanical data showed no difference between the two training methods and there was no statistically significant difference in joint angles. Our EMG data was similar to that of Lay et al. as muscle activity increased with an increasing incline (6). The increased muscle activity occurred at the same stages of the gait cycle. Also, the bicep femoris and rectus femoris had increased muscle activity during the first half of stance while the soleus had increased muscle activity during the second half of stance. There were no statistically significant differences between EMG data in the two training methods. Thus, the difference in metabolic costs is not due to EMG data of the muscles measured in this study. The greater metabolic cost of the continuous hill interval training method may have been due to a cardiovascular difference due to fatigue (7) or cardiovascular drift (9) that occurs during the longer duration at each hill interval. Perhaps individuals became more fatigued as they spent more time at each interval during the continuous hill method.

Another possibility is the difference in metabolic cost is due to higher muscle activity in a stabilizing muscle, such as the tensor fascia latae. The tensor fascia latae may become more involved in the longer hill intervals for extra stability during longer bouts of high propulsion. As we did not gather muscle activity data for stabilizing muscles, such as the tensor fascia latae or the adductor longus, we would suggest collecting these additional muscle EMG activities in future studies.

A limitation in this study was the transition intervals. The longer transition intervals in the continuous method were too long to simply transition from one hill grade to the next. We had to fluctuate between the two hill grades at the transition in order to complete the 60 second time period. The transition intervals in the random method did not have the same problem. The shorter, 12-second transition intervals were short enough to smoothly transition from one grade to the next. Future studies should ensure that the transitions are one continuous, smooth transition from one hill grade to the next instead of a fluctuation between hill grades. Future studies can also investigate if continuous hill intervals are more effective when biking on a stationary bicycle or exercising on an elliptical machine.

The concept of increasing intensity by incorporating hill intervals of longer duration can be applied outside of a fitness center. For instance, the intensity of a walk outdoors can be increased if you can find a hill to include on your route. The concept of continuous hill intervals can be applied by walking up the entire hill and returning to the bottom of the hill for one interval rather than doing shorter hill intervals by going up half way and returning to the bottom. Continuous intervals can also be performed on long stairways if hills are not an option in the area. For example, continuous stair intervals would be going from the ground floor and all the way to the top of the building rather than doing a single stairway for one floor over and over.

The intensity of a workout can be increased by lengthening the duration of the hill intervals. This concept can improve the quality of fitness programs, whether the workouts are performed at a fitness center, outdoors, or around a neighborhood.

4.5 REFERENCES

1. Chapman AE: *Biomechanical Analysis of Fundamental Human Movements.* Human Kinetics, 2008.

2. Cram, J. and Kasman, G. *Electrode Placement. Introduction to Surface Electromyography*. Cram, J., Kasman, G., and Holz, J., eds. Gaithersburg, MD: Aspen, 1998. pp. 371-375.

3. Fitzhugh EC, Thompson DL: Leisure-time walking and compliance with ACSM/AHA aerobic-related physical activity recommendations: 1999-2004 NHANES. *J Phys Act Health 6*(4): 393-402, 2009.

4. Garber CE, Blissmer B, Deschenes MR, et al: American College of Sports Medicine position stand. Quantity and quality of exercise for developing and maintaining cardiorespiratory, musculoskeletal, and neuromotor fitness in apparently healthy adults: guidance for prescribing exercise. *Med Sci Sports Exerc 43*(7): 1334-1359, 2011.

5. Lay, A., Hass, C., and Gregor, R. The effects of sloped surfaces on locomotion: a kinematic and kinetic analysis. *J Biomech* 39(9): 1621-1628, 2006.

6. Lay AN, Hass CJ, Richard Nichols T, et al: The effects of sloped surfaces on locomotion: an electromyographic analysis. *J Biomech 40*(6): 1276-1285, 2007.

7. Mizrahi J, Verbitsky O, Isakov E, et al: Effect of fatigue on leg kinematics and impact acceleration in long distance running. *Human Movement Science 19*(2): 139-151, 2000.

8. Thompson WR, American College of Sports Medicine, Gordon NF, et al: in *ACSM's Guidelines for Exercise Testing and Prescription.* Lippincott Williams \& Wilkins, 2009.

9. Wingo JE, Lafrenz AJ, Ganio MS, et al: Cardiovascular drift is related to reduced maximal oxygen uptake during heat stress. *Medicine & Science in Sports & Exercise 37*(2): 248-255, 2005.

10. Winter, DA, Fuglevand, AJ, and Archer, SE. Crosstalk in surface electromyography: Theoretical and practical estimates. *J Electromyogr Kinesiol* 4: 15-26, 1994.

Chapter 5

5.1 Conclusion

The results of this thesis provide a viable framework for a fitness program that meets the Physical Activity Guidelines for Fitness and decreases cardiovascular disease risk factors. The goal of Chapter 2 was to establish an effective fitness program that produces health benefits, meets the Physical Activity Guidelines for Fitness, and is applicable to a large number of people. Both the men and women who completed the group fitness class program decreased body mass, body fat percentage, and increased lean body mass tissue. Not only does the fitness program address the physical inactivity risk factor but also is an effective applicable weight loss option in addressing the obesity risk factor as well as showing the potential to beneficially affect blood profile variables. The STOP Obesity Alliance aims to establish successful fitness interventions with methods that are applicable in actual practice in everyday life and are effective in reducing body mass by at least 5% (3). The program applies to the STOP goal by decreasing the mean body mass of the men by 5.3% and 5 women had at least a decrease of 5%. The 30-week program could be extended in duration to determine if there would be a greater decrease in body mass to fully meet the goal of the STOP Obesity Alliance. The group fitness class program fully meets the other component of the goal as the classes used in the program are offered in health and fitness clubs across the country (1). While the program is an effective practice in everyday life it needs to be expanded to other areas of the community as only a small percentage of the population has a membership to a health and fitness club.

The group fitness class program can be utilized in the National Physical Activity Plan (2) as a resource to increase physical activity. The National Physical Activity Plan strives to promote physical activity opportunities for all Americans. One strategy developed in the Plan is to increase opportunities by utilizing existing infrastructures in the community. A potential application would be a joint-use agreement (4) between Les Mills™ and local schools which would allow the class to be held in school gymnasiums during non-school hours. Three of the classes- BodyAttack™, BodyCombat™, and BodyFlow™- require minimal equipment and could be easily implemented in a gymnasium. An adapted program could further be extended if, perhaps, Les Mills™ was able to re-use any older adjustable-height steps and barbell sets in the joint-use agreement. The recycled equipment could add BodyStep™ and BodyPump™ to offer three choices of cardiorespiratory classes along with the strength training and flexibility classes to establish a program to meet the Physical Activity Guidelines for Fitness.

The results of Chapter 3 show that the classes of the program are performed at intensity levels to fulfill the Physical Activity Guidelines of Fitness, as well as present a further need to investigate the dose-response effect of exercise intensity, especially in terms of differences between men and women. The women who lost a greater amount of body mass exercised for a higher percentage of time in vigorous-intensity and the men who lost a greater amount of body mass exercised for a higher percentage of time in moderate-intensity. As I was not investigating the difference in dose-response to exercise between men and women I can only speculate on why there was a different response to each intensity level. More research is needed on the responses to intensity-level in terms of weight loss and the difference between men and women. Future studies can control the intensity level by using the Sport Zone® data to develop moderate- and vigorous-intensity choreographed class routines. Additionally, heart rate technology can be utilized to better implement moderate- and vigorous-intensity physical activity. The zones can be set to have ranges established by ACSM to define the corresponding zones and the time in each intensity-level can be effectively measured. This could make the Physical Activity Guidelines for Fitness easier to understand for participants as they could monitor each workout and know when they are exercising in a certain intensity-level.

The goal of Chapter 4 was to incorporate moderate- and vigorous-intensity intervals into a treadmill workout and to determine the most effective implementation of the intervals for the greatest metabolic cost. The workout with a longer duration of time at each interval with few changes between intervals resulted in a greater metabolic cost. While the study was conducted on a treadmill the concept of the results can be applied to walking on inclines. The intensity of a walk on an outside trail can be increased by adding a few hills of longer length as opposed to walking up many shorter length hills. While walking is the most popular form of leisure-time physical activity most people who choose to walk as their form of exercise do not meet the Physical Activity Guidelines for Fitness. The results show that the intensity added with the hill intervals can fulfill the moderate- and vigorous-intensity levels.

The results of the three chapters in the thesis provide effective options for workouts in order to implement the Physical Activity Guidelines for Fitness and also can be used as a program to decrease the risk of cardiovascular disease. In Chapter 2, I detailed how the group fitness class program was effective in improving body composition and two blood profile variables and may be able to result in more beneficial effects if the program were extended for a longer period of time. The group classes show strong promise as being able to be implemented at a larger scale with an adherence rate of 94% and future studies need to investigate the social and psychological effects of the group atmosphere to determine if there is a unique motivating factor to group fitness classes. In Chapter 3, I reported that the participants were able to exercise at moderate- and vigorous-intensity levels on their own, without monitoring from researchers, during the cardiorespiratory classes showing that the choreographed routines are effective in eliciting intensity-levels to fulfill the Physical Activity Guidelines for Fitness. In addition, further research is needed to examine the dose-response effect of exercise intensity as Chapter 3 shows there is a possible difference between the effect on men and women. Finally, in Chapter 4, I demonstrated how to best implement hill intervals for a greater metabolic cost. The interval workout with longer duration in hill intervals with fewer changes resulted in a higher metabolic cost and a workout featuring few, longer hills as opposed to multiple, shorter hills.

For exercisers, these combined results offer effective physical activity options to fulfill the Physical Guidelines for Fitness along with a program that has results of improving body composition as well as the possibility of resulting in beneficial changes in blood profile variables. For researchers, these results offer areas of further investigation, such as the beneficial effects on cardiovascular disease risk factors with a longer duration group fitness program and the dose-response effect of intensity difference between men and women, as well as exploring the possibility of a joint partnership between fitness industry classes and local communities to increase the applicability of the program. This thesis presents an effective fitness program that results in beneficial changes to cardiovascular disease risk factors, fulfills the Physical Activity Guidelines for Fitness, and can reach hundreds of people.

5.2 REFERENCES

1. Les Mills™. Health Clubs. http://www.lesmills.com/global/facilities-we-partner-with/health-clubs.aspx. Viewed: Feb 21, 2012.

2. National Physical Activity Plan. Parks, Recreation, Fitness and Sports. Make the Move: 2010-11 National Implementation of the U.S. Physical Activity Plan. http://www.nxtbook.com/nxtbooks/ncppa/make_the_move/index.php#/1. Viewed: July 11, 2012.

3. Strategies to Overcome and Prevent Obesity Alliance. Policy Recommendations. Department of Health Policy of The George Washington University School of Public Health and Health Services, Washington, DC, 2012.

4. Vincent, JM. Partnerships for joint use: expanding the use of public school infrastructure to benefit students and communities. Center for Cities & Schools: University of California, Berkeley, 2010.