A Multidisciplinary Lifestyle Intervention Program Decreases Cardiovascular Disease Risk Factors in Adults After 100 Days of Treatment

A thesis presented to
the faculty of
the College of Health Sciences and Professions of Ohio University

In partial fulfillment
of the requirements for the degree
Master of Science

Mallory A. Knight
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This thesis proposal titled
A Multidisciplinary Lifestyle Intervention Program Decreases Cardiovascular Disease Risk Factors in Adults After 100 Days of Treatment

by

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ABSTRACT

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Food and Nutrition

A Multidisciplinary Lifestyle Intervention Program Decreases Cardiovascular Disease Risk in Adults After 100 Days of Treatment

Director of Thesis: David H. Holben

Background. A multidisciplinary lifestyle intervention program was developed to decrease risk factors for cardiovascular disease in adult participants from a rural community in Ohio. This workplace intervention was largely funded by Human Resources, and included diet, exercise, stress management techniques (yoga), and behavior modification counseling by a registered dietitian. While many studies have examined the impact of diet or exercise program on risk, few have examined programs that are multidisciplinary in nature.

Methods. This study examined the impact of the program on weight, % body fat, lean mass, fat mass, body mass index (BMI), maximal oxygen consumption (VO₂ max), waist circumference, total, high density lipoprotein (HDL), and low density lipoprotein (LDL) cholesterol levels, triglycerides, glucose, and blood pressure during the first 100 days of treatment. Measurements were obtained using standardized methods, including air displacement plethysmography for body composition measures and a venipuncture for biochemical parameters (fasting).
Results. Seventy-two adults (53 females [73.6%]; 19 males [26.4%]) participated in the study. Paired t-tests were utilized to assess for changes from baseline to 100 days of participation. Weight (p < .001), % body fat (p < .001), fat mass (p < .001), BMI (p < .001), VO$_2$ max (p < .001), waist circumference (p < .001), total (p < .001), HDL (p = .026), and LDL (p < .001) cholesterol levels, triglycerides (p = .004), glucose (p = .013), and blood pressure (systolic, p = .001; diastolic, p < .001) significantly decreased. Lean body mass did not significantly change (p > .05).

Conclusion. This multidisciplinary lifestyle intervention program was effective in reducing the aforementioned cardiovascular disease risk factors among adult participants. Future studies should examine whether the changes seen after 100 days are sustained.

Approved: _____________________________________________________________

David H. Holben

Professor of Applied Health Sciences and Wellness
ACKNOWLEDGMENTS

I would like to thank my advisor, Dr. David Holben, for his support, guidance, mentorship, and most of all his patience over the last two years. I would also like to thank my committee members, Mrs. Deborah Murray, Dr. Cheryl Howe, and Mr. Thomas Murray for their support and guidance. I would especially like to express gratitude to Tom, the founder of the Risk Reduction Program, for making this study possible.

To my friends and family, thank you for your support and encouragement.

To Nate who has always been there, thank you for being supportive, understanding, and for always knowing what to say.
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CHAPTER 1: INTRODUCTION

Cardiovascular disease is the number one killer of men and women over the age of 35 in the United States and was responsible for 26% of the deaths in the United States in 2006 (Heron et al., 2009). Despite efforts to improve the rates, the 2007 mortality death rate data demonstrated that 2,200 Americans die of cardiovascular disease each day, equating to 1 death every 39 seconds from cardiovascular disease (Roger et al., 2010). It is estimated that in 2010, the cost of heart disease in the United States was $316.4 billion. This total includes health care services, medications, and lost productivity of those diagnosed with cardiovascular disease (Lloyd-Jones, Adams, et al., 2010).

Certain “risk” factors have been clinically proven to increase the chances of cardiovascular disease and heart attack (Lloyd-Jones et al., 2010). Some of these risk factors can be modified or treated to reduce the chances of developing cardiovascular complications. Treatable or modifiable risk factors include tobacco exposure, stress, high blood pressure, hypercholesterolemia, overweight and obesity, diabetes, and physical activity (Roger et al., 2010; Yusuf et al., 2004). There are also unmodifiable risk factors that increase the chances of developing cardiovascular disease such as age, and gender (Hoffman et al., 2011). Studies have shown that the simultaneous presence of multiple risk factors within an individual, and the extent to which an individual demonstrates a risk factor, both increase the risk of developing cardiovascular disease (Lloyd-Jones, Hong, et al., 2010). Cardiovascular disease risk factors and ideal cardiovascular health definitions as defined by the American Heart Association are summarized in Table 1.
Table 1

*American Heart Association Recommendations for Ideal Cardiovascular Health: Life’s Simple 7*

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Ideal cardiovascular health recommendations*</th>
</tr>
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<tbody>
<tr>
<td>Smoking</td>
<td>Never smoked or quit &gt;12 months ago</td>
</tr>
<tr>
<td>Body mass index</td>
<td>&lt; 25 kg/m²</td>
</tr>
<tr>
<td>Physical activity</td>
<td>≥ 150 min/week moderate intensity or ≥ 75 min/week vigorous intensity or combination</td>
</tr>
<tr>
<td>Total cholesterol</td>
<td>&lt; 200 mg/dl</td>
</tr>
<tr>
<td>Healthy diet</td>
<td>4-5 of the following:</td>
</tr>
<tr>
<td></td>
<td>• ≥ 3, 1-oz equivalent servings of fiber-rich whole grains/day</td>
</tr>
<tr>
<td></td>
<td>• ≥ 4.5 cups of fruits and vegetables/day</td>
</tr>
<tr>
<td></td>
<td>• &lt; 1500 mg sodium/day</td>
</tr>
<tr>
<td></td>
<td>• 2, 3.5-oz servings of oily fish/week</td>
</tr>
<tr>
<td></td>
<td>• ≤ 450 kcals of sugar sweetened beverages per week</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>&lt; 120/ &lt; 80 mm Hg</td>
</tr>
<tr>
<td>Fasting plasma glucose</td>
<td>&lt; 100 mg/dl</td>
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</table>

The most common type of cardiovascular disease in the United States is coronary heart disease (Heron et al., 2009). This condition can result in impaired blood flow in the coronary arteries, which can cause myocardial infarction, heart failure, arrhythmias, and sudden death. This impaired blood flow, or ischemia, is responsible for most clinical cardiovascular events, such as myocardial infarction and stroke (Lloyd-Jones, Adams, et al., 2010). Impaired blood flow in the coronary arteries is most often caused by a condition known as atherosclerosis, a disease characterized by thickening and narrowing of the arterial walls. A normal healthy arterial wall endothelium plays a key role in cardiovascular health by promoting proper vasodilatation and vasoconstriction of the artery. The endothelium also functions to promote anti-inflammatory responses that help maintain the integrity of the arterial wall. If the endothelium is damaged, its ability to carry out these functions is compromised (Davignon & Ganz, 2004). Risk factors for cardiovascular disease (see Table 1) can cause this damage to occur in the endothelium, which can result in impaired blood flow in the coronary arteries (Chambless et al., 1997).

Many approaches have been suggested for the treatment and prevention of cardiovascular disease. The most recent position paper published by the American Heart Association’s Council on Epidemiology and Prevention suggested that a multidisciplinary approach, combining diet, exercise, and behavior change, is more effective in reducing risk factors for cardiovascular disease than treatment options that promote only one of these variables alone (Kumanyika et al., 2008). The committee also stressed the strong correlation between cardiovascular disease and obesity, above many of the other modifiable risk factors. This is due to increased health problems associated
with obesity, which include many of the aforementioned risk factors for cardiovascular
disease, such as high blood pressure, elevated blood cholesterol, and diabetes
(Kumanyika et al., 2008).

A multidisciplinary approach to treating cardiovascular disease is recommended
because of the beneficial effect it can have on overall cardiovascular health. For people
with heart disease, studies have shown that lowering cholesterol and blood pressure
levels can reduce the risk of dying from heart disease, having a nonfatal myocardial
infraction, and needing heart bypass surgery or angioplasty. In individuals who
demonstrate no previous coronary heart disease (CHD) history, lowering cholesterol and
blood pressure levels can reduce the risk of developing heart disease. The American
Heart Association also recommends eating a healthy diet, maintaining a healthy body
weight or body mass index (BMI), and exercising regularly to reduce risk for heart
disease (Lloyd-Jones, Adams, et al., 2010).

**Study Objectives**

In the past 10 years there have been dramatic increases in the number of people with
cardiovascular risk factors, including obesity among adults and children in the United
States (Centers for Disease Control and Prevention [CDC], 2010). This has prompted
researchers and health care professionals to focus on finding new and improved
cardiovascular disease prevention methods. Despite the recommendation for developing
multidisciplinary treatment programs, most interventions have focused solely on one
lifestyle change (e.g., dietary intake, physical activity). Consequently, the American
Heart Association’s Strategic Impact Goal through 2020 and beyond is striving to define and implement new strategies for the improvement of cardiovascular health (Lloyd-Jones, Hong, et al., 2010). This present research will determine the effectiveness of a multidisciplinary treatment program which combines all treatment variables recommended by the American Heart Association (dietary intake and exercise), plus stress management techniques and behavior modification counseling to reduce the prevalence and mortality rates caused by cardiovascular disease. Specifically, the program combines a tailored exercise regimen, stress reduction via yoga classes, and individualized dietary counseling to reduce aforementioned risk factors.

The Risk Reduction Program (RRP) at Ohio University utilizes a multidisciplinary approach to cardiovascular disease treatment, including an individualized diet prescription and nutrition counseling, tailored exercise regimens, stress management techniques (yoga), and behavior modification counseling to decrease risk factors for cardiovascular disease. The program was designed to enhance the quality of life of individuals with: a) lifestyle diseases such as coronary artery disease, diabetes, hypertension, obesity; b) medical conditions that require structured clinical supervision; or c) stable cardiovascular disease who have not previously participated in a cardiac rehabilitation program.
Research Questions and Research Hypothesis

The purpose of the study will be to evaluate the efficacy of the RRP on risk factors for cardiovascular disease in an at-risk population after the first 100 days of treatment. Table 2 outlines the specific research questions and hypothesis for this study.

Table 2

<table>
<thead>
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<th>Research question</th>
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<tr>
<td>1. What is the effect of the RRP on body weight, percent body fat, lean weight,</td>
<td>1. The RRP will have a positive effect on body weight, percent body fat,</td>
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<td>fat weight, BMI, VO₂ max, and waist circumference from preprogram measures to</td>
<td>lean weight, fat weight, BMI, VO₂ max, and waist circumference from</td>
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<td>100 days of participation?</td>
<td>preprogram measures to 100 days of participation.</td>
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<tr>
<td>2. What is the effect of the RRP on total, HDL, and LDL cholesterol levels,</td>
<td>2. The RRP will have a positive effect on total, HDL, and LDL cholesterol</td>
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<tr>
<td>triglycerides, blood pressure, and glucose levels from preprogram measures to</td>
<td>levels, triglycerides, blood pressure, and glucose levels from preprogram</td>
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<tr>
<td>100 days of participation?</td>
<td>measures to 100 days of participation.</td>
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Limitations

This study has several limitations:

1. While dietary instruction and nutrition prescription was provided, specific dietary intake could not be controlled, and all dietary intake was self reported.

2. Due to the extreme time commitment of the program, participants were allowed to schedule exercise and nutrition counseling appointments at varying times throughout the week. Frequency and duration were controlled for, but the parameters for exercise and nutrition counseling were set for a weekly basis and exact days between sessions or appointments were not controlled.

3. Throughout this review, endothelial dysfunction is discussed as a major factor associated with cardiovascular disease pathology. However, there were no biological measures of endothelial dysfunction included in the study.

4. While stress management techniques (yoga) were incorporated in the RRP, this study did not include any psychological or psychosocial measures to assess the effectiveness of stress reduction.

5. The dietary, nutrition, and stress reduction interventions were consistent in all participants; however there was neither a control group nor a diet/exercise only intervention. This inhibited the comparison of the effectiveness of the RRP to no intervention, or diet/exercise alone.
Cardiovascular Disease: Brief Overview

Cardiovascular disease, also known as heart disease, is a term that refers to several different types of heart conditions. The most common type of heart condition in the United States is coronary heart disease (Lloyd-Jones, Adams, et al., 2010). This condition can result in impaired blood flow in the coronary arteries, which can cause myocardial infarction (MI), heart failure, arrhythmias, and sudden death. This impaired blood flow, or ischemia, is responsible for most deaths caused by cardiovascular disease. In particular, the leading cause of death from coronary heart disease is MI or ischemia in one or more of the coronary arteries that can result in necrosis, tissue damage, and death (Lloyd-Jones, Adams, et al., 2010).

The morbidity and mortality associated with cardiovascular disease makes it a major health care problem in the United States that affects both men and women of all ethnicities (Danaei et al., 2009). According to the latest report from the American Heart Association on heart disease and stroke statistics, an estimated 81,100,000 Americans are currently living with at least one form of cardiovascular disease (Lloyd-Jones, Adams, et al., 2010). It is estimated that 2,300 Americans die from cardiovascular disease each day (CDC, 2010). In fact, the estimated mortality rates associated with cardiovascular disease account for more deaths in adults over the age of 35 in the United States than all other major diseases. Generally, the mortality rate from cardiovascular disease increases with
age for men and women of all races. However, after the age of 65, Caucasian males have the highest rate of mortality (Heron et al., 2009).

Atherosclerosis and Cardiovascular Disease

Impaired blood flow in the coronary arteries is most often caused by a condition known as atherosclerosis. Atherosclerosis is a disease characterized by thickening and narrowing of the arterial walls caused by inflammation and the accumulation of oxidized cholesterol, smooth muscle cells, and fibroblasts (Davignon & Ganz, 2004). A normal healthy arterial wall endothelium plays a key role in cardiac health by promoting proper vasodilatation and vasoconstriction of the artery (Britten, Zeiher, & Schachinger, 1999). The endothelium also functions to promote anti-inflammatory responses that help maintain the integrity of the arterial wall. If the endothelium is damaged, its ability to carry out these functions is compromised (Endemann & Schiffrin, 2004). Damage can cause the endothelium to become dysfunctional which can lead to irregular regulation of vasoconstriction, vasodilatation, and arterial wall integrity. These events function to promote the development and progression of atherosclerosis (Endemann & Schiffrin, 2004).

In the presence of endothelium dysfunction, atherosclerosis promotes local inflammatory responses that cause damage to the arterial wall. The inflammatory responses cause damage by increasing endothelial permeability, which leads to platelet aggregation, leukocyte adhesion, and the generation of cytokines (Britten et al., 1999). This damage to the arterial wall can result in plaque formation on the inside of the artery
and eventual blockage. The blockage of arteries creates an environment capable of resulting in ischemia. Often times this blockage occurs in the coronary arteries and results in myocardial infarctions (Davignon & Ganz, 2004). For this reason, atherosclerosis is very closely associated with cardiovascular disease.

There is a causal relationship between cardiovascular disease risk factors and endothelium dysfunction. Cardiovascular disease risk factors play a role in promoting endothelial dysfunction, by exacerbating the development of atherosclerosis (Chambless et al., 1997). The Multi-Ethnic Studies of Atherosclerosis (MESA) evaluates various risk factors associated with cardiovascular disease and their relationship to atherosclerosis (Nettleton et al., 2007). These studies have shown that cardiovascular disease risk factors are associated with increased atherosclerotic incidence. These risk factors include obesity, high plasma cholesterol and lipid levels, and poor dietary intake (i.e., increased saturated fat, sodium, and sugar intake; decreased fruit, vegetable, whole grain, and unsaturated fatty acid consumption) (Nettleton et al., 2007). Other studies have also linked the development of atherosclerosis to smoking and hypertension (Talukder et al., 2010; Yusuf et al., 2004).

Cardiovascular Disease Risk Factors

Medical conditions and lifestyle choices can put people at a higher risk for heart disease. These factors are commonly referred to as cardiovascular disease risk factors (Yusuf et al., 2004). In order for a medical or lifestyle condition to be considered a risk factor by the American Heart Association, it must meet a number of criteria, including
having an independent statistical association based on studies that include large numbers of outcome events (Greenland et al., 2010). The American Heart Association recognizes a number of conditions, including high cholesterol, high blood pressure, diabetes, cigarette smoking, overweight and obesity, poor diet, and physical inactivity, as risk factors for cardiovascular disease (Lloyd-Jones, Hong, et al., 2010). Studies have shown that these conditions are associated with the development of cardiovascular disease in individuals that are asymptomatic for heart disease (Anderson, Odell, Wilson, & Kannel, 1991). A number of large population-based studies, such as The Framingham Heart study (2006), The INTERHEART study (2004), and the Atherosclerosis Risk In Communities study (1997), have demonstrated that risk factors can be used as predictive indicators to estimate the risk of cardiovascular disease (Chambless et al., 1997; Fox et al., 2006; Yusuf et al., 2004). These studies have provided the evidence to develop generally accepted methods of assessing cardiovascular risk.

The most recent strategic impact goal for cardiovascular health promotion and disease reduction for 2020 set by the American Heart Association (2010) define risk factors by the level that is most widely associated with ideal cardiovascular health outcomes. The definition of ideal cardiovascular health is therefore defined by adhering to the recommended levels of seven health behaviors and factors. The identified behaviors include current smoking habits, body mass index, physical activity level, and dietary habits. The health factors include total cholesterol, blood pressure, and fasting plasma glucose (Lloyd-Jones, Hong, et al., 2010). Together, these seven health behaviors define risk factors for cardiovascular disease and are referred to by the American Heart
Association as Life’s Simple 7 (Sacco, 2011). The thresholds that define the ideal cardiovascular health behaviors were determined by combining current national guidelines with supporting information from the latest literature and research in cardiovascular disease (Lloyd-Jones, Hong, et al., 2010). The current research stipulates that following and maintaining these guidelines are closely associated with decreased development of cardiovascular disease, decreased morbidity from heart disease, decreased health care costs, and increased quality of life (Lloyd-Jones, Hong, et al., 2010). Table 3 below summarizes the recommendations for ideal cardiovascular health as defined by the American Heart Association.
Table 3

*Recommendations for Ideal Cardiovascular Health: Life’s Simple 7**

<table>
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</tr>
</tbody>
</table>

*Recommendations are for adults >20 years of age. **From “Defining and setting national goals for cardiovascular health promotion and disease reduction: The American Heart Association’s strategic impact goal through 2020 and beyond,” by D. M. Lloyd-Jones et. al., 2010, Circulation, 121(4), p. 591. Copyright 2010 by Lippincott Williams & Wilkins. Adapted with permission.
The definition of ideal cardiovascular health meets these health parameters and related behaviors (Lloyd-Jones, Hong, et al., 2010). A recent survey conducted by the Behavioral Risk Factor Surveillance System was used to estimate the prevalence of the 4 health behaviors. Specifically, the prevalence of nonsmoking, having a healthy BMI, being physically active, and having a healthful diet was examined among adults in the United States. The data revealed that only 3% of the surveyed population exhibited all of these health behaviors (Reeves & Rafferty, 2005). Another study, the INTERHEART study of 52 countries found that if all seven health definitions were met along with optimal alcohol consumption and psychosocial index, there would be a 90% reduction in the onset of the first cardiovascular event (Yusuf et al., 2004).

Smoking

The current literature on the harmful health effects of smoking is extensive and has linked smoking to many of the leading causes of death in the United States, including cancer and cardiovascular disease (CDC, 2008; Ockene & Miller, 1997). Every report on health from the U.S. Surgeon General since 1964 has concluded that smoking is the cause of many diseases and has adverse health effects. The most recent report from the Surgeon General found that the list of diseases caused by smoking is expanding. It is now known that smoking causes adverse effects to nearly every organ in the body. The latest report also found that there are no health benefits to smoking cigarettes manufactured with lower levels of nicotine and tar (Office of the Surgeon General, 2004; Office on Smoking and Health, 2006). The data are so definitive that smoking has been labeled as the single
most alterable risk factor for morbidity and mortality in the United States (Ockene & Miller, 1997).

An estimated 443,000 premature deaths a year from 2000 to 2004 were due to smoking-related illnesses. A total of 32.7% of these deaths (adults 35 years and older) were related to cardiovascular disease (CDC, 2008). The link between cardiovascular disease and smoking is largely due to the adverse effects incurred in the endothelium of arterial walls. Smoking leads to endothelial dysfunction by interfering with the normal biological functioning of the endothelium (Pittilo, 1990). One major function of the endothelium is to regulate vasoconstriction and dilation by secreting nitric oxide (Arnal, Dinh-Xuan, Pueyo, Darblade, & Rami, 1999). Studies have shown that smoking interferes with nitric oxide secretion, thereby limiting the endothelium’s ability to be an effective vasodilator and constrictor. This interference in regulatory endothelial function can negatively affect blood perfusion to tissues (Celermajer et al., 1993). Smoking also compromises the oxygen carrying ability of the blood due to the carbon monoxide in cigarette smoke. Carbon monoxide binds more competitively to hemoglobin than oxygen. This decreases the amount of oxygen carried throughout the body and can cause erythrocytosis (Leone, Mori, Bertanelli, Fabiano, & Filippelli, 1991; U. S. Department of Health and Human Services, 2004, 2006). This overall combination of malfunctioning endothelium and impaired oxygen capacity can lead to cardiovascular complications.

As is the case with many other combinations of risk factors, individuals that exhibit obesity and smoking have a compounded increased risk to cardiovascular health (Must et al., 1999). The National Heart, Lung, and Blood Institute (NHLBI) address this
in their clinical guidelines on the identification, evaluation, and treatment of
overweight and obesity in adults (1998). The institute recommends smoking cessation
especially for those individuals that are overweight and obese. This is primarily due to
the major increase in cardiovascular health risk associated with smoking and the
substantial decrease in cardiovascular disease mortality after smoking cessation (Novello,
1990).

Exposure to secondhand smoke causes adverse health effects including an
increased risk of cardiovascular disease morbidity and mortality (CDC, 2008).
Specifically studies indicate exposure to secondhand smoke increases risk for
cardiovascular disease by 25 to 30%. Similar to active smoking, it causes impaired
platelet and endothelial function, linking it to cardiovascular disease development.
Animal models demonstrate exposure to secondhand smoke produces atherosclerosis;
however, this relationship is only suggestive in human studies. The relationship between
secondhand smoke and cardiovascular disease is related to the intensity of exposure with
higher intensities correlating to increased risk. Evidence also supports that recent
exposure to second hand smoke may be more harmful than past exposure (U. S.
Department of Health and Human Services, 2006).

The U.S. Department of Health and Human Service’s report on the Health
Benefits of Smoking Cessation (1990) stated that the benefits of smoking cessation are
immediate for men and women of all ages, with or without diagnosed cardiovascular
disease. Specific health benefits include decreased risk of cardiovascular disease, cancer,
myocardial infraction, stroke, and lung disease. The evidence in this report also
concludes that former smokers demonstrate a substantial decrease in cardiovascular disease mortality and live longer than continuing smokers. Benefits of smoking cessation carry over to former smokers that reported years of heavy smoking and those that were diagnosed with smoking-related diseases (Novello, 1990).

Overweight and Obesity

In the United States, overweight and obesity can be attributed to nearly 1 in 10 deaths a year (Danaei et al., 2009). According to the CDC, an estimated 149.3 million Americans ages 20-74 (78 million men and 71.3 million women) were classified as overweight in 2008. Of these, an estimated 75 million (34.9 million men and 40.1 million women) were classified as obese (Flegal, Carroll, Ogden, & Curtin, 2010). These statistics classify obesity as a national health threat. All obese adults are considered at risk for developing cardiovascular disease because obesity alone is a risk factor, and it also increases the likelihood of having other risk factors for cardiovascular disease, including high blood pressure, type 2 diabetes mellitus, and high blood cholesterol (NHLBI, 1998).

Overweight and Obesity Characterization

Overweight and obesity are characterized by an excess amount of adipose tissue in the body (Salans, Cushman, & Weismann, 1973). It is important to note that the terms “obesity” and “overweight” are not mutually exclusive because individuals that are obese are also overweight (NHLBI, 1998). The NHLBI defines obesity as a chronic disease that is multifactorial in nature because it develops from a combination of genetic
predisposition and environmental factors (NHLBI, 1998). The multifactorial nature of obesity is important to note because it exemplifies the challenges to treating the condition. Studies have shown that body composition is somewhat genetic, and, therefore, individuals can have a predisposition to obesity. However, the extent to which this genetic trait is expressed is not certain and is influenced by exposure to environmental factors (O'Rahilly & Farooqi, 2006).

Obesity and overweight can be further defined as an imbalance of energy intake (kcals consumed) to energy output (kcals expended), with overweight and obesity resulting from a ratio of excessive intake to output (Gurevich-Panigrahi, Panigrahi, Wiechec, & Los, 2009). Energy imbalance has been attributed to many factors including increased availability of energy dense foods and decreased requirements for physical exertion during daily life (O'Rahilley & Farooqi, 2006). Improved palatability of food has been attributed to increased food intake during individual eating sessions and increased frequency of overall food intake (Mattes, 2008). The American Heart Association also reports that only 0.5% of adults over the age of 20 adhere to ideal healthy diet standards, while 76% of adults are classified as having poor dietary intake (Lloyd-Jones, Hong, et al., 2010). With this increase in energy intake, a corresponding increase in physical activity would be needed to provide balance. However, studies have found that the majority of the United States population falls below recommended levels of physical activity needed to prevent weight gain from excess caloric intake (Hill & Wyatt, 2005).

The imbalance of energy input to energy output can result in excess fat deposition and overtime, overweight and obesity (Gurevich-Panigrahi et al., 2009). Excess fat
deposits develop differently at various stages during anatomical development. When obesity presents early in life it is generally hyperplastic in nature and the result of an increase in adipose cell number. Studies show that an increase in adipose tissue quantity generally occurs twice during normal human development, within the first few years of life and during puberty. Obesity that presents later in life is generally hypertrophic, meaning an increase in adipose cell size (Salans et al., 1973). The size of adipose cells can vary considerably within an individual and between individuals; however, adipose cells are generally larger in obese individuals (Salans et al., 1973). The loss of fat in adults is the result of a decrease in the size of adipose cells, or a reduction of triglyceride content, not a decrease in the number of adipose cells (Knittle & Ginsberg-Fellner, 1972).

Traditionally, it was assumed that the role of adipose tissue was to function as a site for fat storage in the body. It is now known that adipose tissue functions more like an endocrine system and has many other functions including hormone secretion of peptides and pro-inflammatory cytokines (Gurevich-Panigrahi et al., 2009). Studies have shown that the size and location of adipocytes is a determinate of the type and amount of hormonal secretion that occurs (O'Rahilly & Farooqi, 2006). In particular, accumulation of adipose tissue around the abdominal region has a negative effect on metabolic function related to cardiovascular disease risk (Klein et al., 2004). Abdominal visceral adipose tissue is also associated with abnormal lipid metabolism, high blood pressure, and impaired insulin function (Krotkiewski et al., 1983). These metabolic issues, which result from overweight and obesity, can contribute to the development of type 2 diabetes mellitus, high blood cholesterol, and high blood pressure (Klein et al., 2004).
Central Obesity and Metabolic Syndrome

When overweight and obesity (particularly central adiposity) result in the presence of a specific cluster of metabolic risk factors for type 2 diabetes and cardiovascular disease, they are often diagnosed as a syndrome known as metabolic syndrome. These risk factors include, elevated fasting glucose, high triglyceride levels, high blood pressure, and elevated waist circumference (Alberti et al., 2009). This cluster of risk factors is commonly referred to as a “syndrome” because they occur together more often than they occur alone. There is some controversy regarding the exact definition and diagnosis of metabolic syndrome. However, numerous organizations—the Joint Scientific Statement from the International Diabetes Federation Task Force on Epidemiology, NHLBI, American Heart Association, World Heart Federation, International Atherosclerosis Society, and International Association for the Study of Obesity—state that the diagnosis of three of the five aforementioned risk factors qualify an individual for metabolic syndrome (Alberti et al., 2009).

Elevated levels of proinflammatory markers are often associated with metabolic syndrome and have been linked to the presence of cardiovascular disease. One such inflammatory marker, C-reactive protein, has been linked to many of the metabolic abnormalities associated with these conditions including elevated cholesterol, triglyceride, blood pressure, and BMI levels, as well as abnormal fasting glucose, and low HDL-cholesterol levels (Santos, Lopes, Guimaraes, & Barros, 2005). The liver produces C-reactive protein in response to cytokines produced by visceral adipose tissue. Atherosclerotic lesions also release C-reactive protein linking elevated levels to the
pathogenesis of atherosclerosis and cardiovascular disease (Festa et al., 2000).

Elevated C-reactive protein levels have been directly correlated with the presence of all five components of the metabolic syndrome. However, because these components generally occur in conjunction with one another, it is difficult to assess whether elevated C-reactive protein levels play a role in the pathogenesis of metabolic syndrome, or if it is simply a marker of abnormal metabolic functioning (Santos et al., 2005).

A common link among the conditions associated with C-reactive protein is the presence of chronic subclinical inflammation associated with excess body fat (Festa et al., 2000). Impaired insulin function and insulin resistance, which are related to the development of type 2 diabetes and cardiovascular disease, are extremely common metabolic conditions associated with central obesity and metabolic syndrome. Insulin resistance has also been linked to the presence of chronic inflammation, which may also be the underlying cause of type 2 diabetes (Festa et al., 2000). It should be noted that metabolic syndrome is not considered an independent risk factor for cardiovascular disease or type 2 diabetes because the diagnostic criteria used to define metabolic syndrome does not include many of the unmodifiable and modifiable risk factors that indicate risk (e.g. age, smoking; Alberti et al., 2009). However the NHLBI’s National Cholesterol Education Program Adult Treatment Panel III (ATP III) considers metabolic syndrome both a predictor of cardiovascular disease and type 2 diabetes as well as a contributor to disease progression (NHLBI, 2002).
Body Composition

Elevated waist circumference, a risk factor for metabolic syndrome, is directly correlated to the amount of abdominal visceral adipose tissue and therefore important when assessing risk for cardiovascular disease (Pouliot et al., 1994). Table 4 below lists high-risk waist circumference measurements that correlate to increased risk for developing cardiovascular disease, as well as other comorbidities associated with obesity (NHLBI, 1998).

Table 4

*Waist Circumferences That Correlate to Increased Disease Risk in Obese Individuals*

<table>
<thead>
<tr>
<th>Gender</th>
<th>Waist circumference</th>
<th>Risk status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td>&gt; 102 cm (&gt; 40 in)</td>
<td>High Risk</td>
</tr>
<tr>
<td>Women</td>
<td>&gt; 88 cm (&gt; 35 in)</td>
<td>High Risk</td>
</tr>
</tbody>
</table>

In order to accurately define overweight and obesity, a measurement of weight for height known as BMI is generally used. BMI is significantly correlated with total body fat content and is the most commonly used measurement for assessing and defining body composition (O’Rahilly & Farooqi, 2006). BMI can be calculated using metric units (weight [kg]/height squared [m²]) or using English units (weight [lbs]/height squared [in²] x 703). Overweight and obesity are therefore defined as a BMI of 25 to 29.9 kg/m² and a BMI of ≥ 30 kg/m² respectively (NHLBI, 1998). A complete list of BMI classifications as defined by the NHLBI (1998) can be found in Table 5. These classifications were used by the American Heart Association to define risk factors and ideal health behaviors for cardiovascular disease (Lloyd-Jones, Hong, et al., 2010).

Table 5

<table>
<thead>
<tr>
<th>Weight classification</th>
<th>Obesity class</th>
<th>BMI (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underweight</td>
<td></td>
<td>&lt; 18.5</td>
</tr>
<tr>
<td>Normal</td>
<td></td>
<td>18.5-24.9</td>
</tr>
<tr>
<td>Overweight</td>
<td></td>
<td>25.0-29.9</td>
</tr>
<tr>
<td>Obesity</td>
<td>I</td>
<td>30.0-34.9</td>
</tr>
<tr>
<td>Obesity</td>
<td>II</td>
<td>35.0-39.9</td>
</tr>
<tr>
<td>Extreme obesity</td>
<td>III</td>
<td>≥ 40</td>
</tr>
</tbody>
</table>

BMI is the most commonly used diagnostic measurement of weight status due to ease of use and the inexpensive nature of height and weight measurement collection (O'Rahilly & Farooqi, 2006). When assessing risk factors for cardiovascular disease, and treating overweight and obesity, BMI classification and waist circumference can be used to assess body composition and monitor changes in body weight (NHLBI, 1998). An increase in BMI status generally equates to an increase in body fat content, placing individuals with higher BMI classifications at increased risk for cardiovascular disease (Must et al., 1999). This is exemplified by the relationship of BMI to mortality rates from cardiovascular disease in both men and women. These population based measures reveal that an increase in BMI status equates to a higher incidence of mortality from cardiovascular disease (Flegal et al., 2010).

BMI is an effective measure of adiposity when considering population based guidelines and excess weight; however, the exact amount and distribution of fat are important when assessing health risks related to overweight and obesity (NHLBI, 1998). BMI is not a direct measure of body fat mass, nor does BMI indicate distribution of fat. For this reason, BMI is often used in conjunction with other measures that correlate more directly to fat distribution, such as waist circumference, to obtain a more accurate representation of health risk (Wellens et al., 1996). Therefore, when measuring body fat in an individual, BMI should be viewed as a general guideline for excess body fat/height$^2$, not a measure of body fat to body mass (Frankenfield, Rowe, Cooney, Smith, & Becker, 2001).
A recent study by Gomez-Ambrosi et al. (2011) of over 6,000 adults between the ages of 18-80 demonstrated that BMI underestimated obese levels of body fat percent by 29% in the lean category, and 80% in the overweight category. In other words, 29% of the participants that classified as lean, and 80% that classified as overweight by the BMI scale actually had obese levels of body fat percentages (Gomez-Ambrosi et al., 2011). These inaccuracies are due in part to the fact that BMI does not distinguish between lean mass and fat mass within an individual (Romero-Corral et al., 2008).

In order to accurately assess excess adipose tissue, a measure of percent body fat (%BF) should be determined by performing a body composition analysis. This is especially important when assessing weight loss and gain in overweight and obese individuals at risk for cardiovascular disease. Body composition analysis allows exact determination of percent body fat, as well as determination of percent lean mass, both of which can be used to determine cardiovascular health risk (Romero-Corral et al., 2008).

A few common laboratory based measures of body composition include: hydrostatic or underwater weighing, dual-energy X-ray absorptiometry, magnetic resonance imaging, and whole-body air-displacement plethysmography (Fields, Goran, & McCrory, 2002). While these methods are commonly used and considered accurate means of body composition determination, each has limitations. For example, few methods can accurately assess the body composition of severely obese (BMI ≥ 35 kg/m²) individuals (Ginde et al., 2005).

Of the previously mentioned body composition measurements, hydrostatic weighing and air-displacement plethysmography are two methods considered capable of
accurately measuring the body composition of individuals with BMI $\geq 35$ kg/m$^2$.

However, the hydrostatic weighing procedure, which requires an individual to be submerged in a large tank of water, is somewhat physically demanding. Individuals that are unable to meet the physical demands of the testing procedure are therefore unable to employ this method of body composition analysis (Ginde et al., 2005). Conversely, air displacement plethysmography, known commercially as the BOD POD (Life Measurement Inc., Concord, CA, USA), requires very little physical demand, making it useful across a wide array of subjects. Studies have shown the BOD POD (Life Measurement Inc., Concord, CA, USA) is reliable, valid, and a preferred method of body composition determination (Fields et al., 2002; Ginde et al., 2005). Once BMI and body composition (body fat %, lean mass, and fat mass) are established, measurement of body weight can serve as an intermediate indicator of improved body composition (NHLBI, 1998).

It is important to understand and define measures of excess body fat because overweight and obesity can be directly linked to higher prevalence of health conditions, such as high blood pressure, type 2 diabetes mellitus, and high blood cholesterol (Must et al., 1999), all of which are risk factors for cardiovascular disease (Lloyd-Jones, Hong, et al., 2010). Studies have also shown that as weight status increases, the prevalence of health conditions and the prevalence of multiple health conditions in an individual also increase (Must et al., 1999). This makes overweight and obesity especially pertinent to cardiovascular disease because the simultaneous presence of multiple risk factors within
an individual, and the extent to which an individual demonstrates a risk factor, both increase the risk of developing cardiovascular disease (Lloyd-Jones, Hong, et al., 2010).

_Treatment of Overweight and Obesity_

Due to the synergistic nature of the presence of multiple risk factors for cardiovascular disease, it is important to treat overweight and obesity (Lloyd-Jones, Hong, et al., 2010). In individuals that exhibit overweight and other risk factors for cardiovascular disease, equal emphasis is placed on treatment of all cardiovascular disease risk factors exhibited, not just weight loss. This is because reduction of risk factors will reduce the risk of cardiovascular disease whether or not weight loss is achieved (NHLBI, 1998). However, it has been proven that weight loss in obese patients can improve or prevent multiple risk factors for cardiovascular disease. In particular, weight loss reduces blood pressure in overweight hypertensive individuals, reduces serum triglycerides, increases high-density HDL cholesterol, and reduces total serum cholesterol and LDL-cholesterol (Klein et al., 2004). Weight loss also leads to a decrease in insulin resistance and may be the most beneficial method of treating type 2 diabetes in individuals with adequate insulin secretion (Albright et al., 2000).

According to the NHLBI (1998), the initial goal of weight loss therapy should be 1 to 2 pounds per week to reduce body weight by approximately 10% from baseline. A reasonable timeline for this initial weight loss is 6 months of therapy. After 6 months of therapy, weight loss generally plateaus and an updated treatment plan should be considered that takes into account the reduced body weight (NHLBI, 1998). The NHLBI along with other organizations, such as the American Heart Association, recommend a
multidisciplinary weight loss approach that combines dietary therapy, physical activity, and behavior modification therapy to treat overweight and obesity. This is especially important to prevent weight regain after loss (Klein, Fontana et al., 2004; NHLBI, 1998). The specific dietary and physical activity interventions to treat overweight and obesity are detailed below in Table 6. These weight loss guidelines are aimed at achieving the aforementioned goals of preventing further weight gain, reducing total body weight, and maintaining a lower body weight.

Table 6

<table>
<thead>
<tr>
<th>Weight loss intervention</th>
<th>Initial goal</th>
<th>Long term goal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary therapy</td>
<td>Weight loss of 1 to 2bs/week; 10% reduction</td>
<td>Weight loss maintenance, or continued weight loss</td>
</tr>
<tr>
<td>Physical activity</td>
<td>30-45 min, 3 to 5 days/week</td>
<td>30 min or more 4 to 7 days/week</td>
</tr>
<tr>
<td>Behavior modification</td>
<td>Identifying and modifying eating habits that increase body weight</td>
<td>Weight loss maintenance through sustained behavior modification</td>
</tr>
</tbody>
</table>

A multidisciplinary approach to the treatment of overweight and obesity is especially important when considering the reduction of risk factors for cardiovascular disease. When dietary weight loss therapy is combined with physical activity, an increased amount of abdominal fat is reduced, and cardiorespiratory fitness is improved (NHLBI, 1998). Studies have shown that decreases in abdominal fat have important metabolic implications on cardiovascular disease risk factors associated with obesity (Klein et al., 2004). Specifically weight reduction results in improved insulin function, reduced blood pressure, and improved cholesterol levels in individuals diagnosed with corresponding co-morbidities; type 2 diabetes mellitus, hypertension, and hyperlipidemia (Goldstein, 1992). These beneficial metabolic changes are observed after only modest weight reduction and continue to improve as weight loss continues (Klein et al., 2004). It is important to note that simply reducing the amount of abdominal fat does not produce the same metabolic improvements in cardiovascular disease risk factors. Studies of abdominal fat removal through surgical procedures such as liposuction, demonstrate no change in insulin function, blood pressure, and lipid cholesterol levels even though a long term reduction of body fat was achieved (Mohammed, Cohen, Reeds, Young, & Klein, 2008).

Physical Activity

The American Heart Association defines physical activity as any bodily movement produced by skeletal muscles that results in energy expenditure beyond resting expenditure (Thompson et al., 2003). When physical activity is planned, structured, and
performed with the purpose of improving cardiovascular health or physical fitness it is defined as exercise (Marwick et al., 2009; Thompson et al., 2003). Regular physical activity, or exercise, has been proven to reduce the risk of developing cardiovascular disease by effectively improving or reducing many of the aforementioned risk factors (Thompson et al., 2003). Specifically, studies have shown that physical activity results in improvements in endothelial function, body composition, blood lipid and glucose profiles, and blood pressure (Marwick et al., 2009). Regular physical activity also prevents the development of coronary artery disease, the most common type of cardiovascular disease in the United States (Heron et al., 2009; Thompson et al., 2003).

*Frequency, Intensity, and Duration of Physical Activity*

The frequency, duration, and intensity of physical activity are important factors when considering reduction of cardiovascular risk and disease prevention (Albright et al., 2000). Frequency refers to how often a physical activity is performed, or how many times a week an individual exercises. Intensity of physical activity refers to the rate of energy expended during a particular activity, or the percent of aerobic power used. The duration refers to the length of time spent performing an activity. The relationship between frequency, duration, intensity and health benefits of physical activity can be further explained by the total amount of energy expended during a particular period of physical activity, or the dose (Thompson et al., 2003). The dose, intensity, and frequency are important to note when defining how much physical activity is needed for optimal health benefits.
Frequency and duration are used to determine the amount of Intensity at which an individual should exercise. Intensity is expressed as a measure of maximal heart rate, or percent of maximal oxygen uptake (%VO₂ max) (Thompson et al., 2003). VO₂ max is a measure of the maximal aerobic power of the cardiovascular system. Energy for exercise lasting longer than 10 minutes, primarily comes from aerobic (oxygen requiring) metabolism in the muscles. As the intensity of exercise increases, oxygen uptake by the cardiovascular system must also increase to accommodate the higher work rate and deliver more oxygenated blood to the muscles (Powers & Howley, 2009). The relationship of oxygen uptake (VO₂) to work rate and power output is linear, representing a complementary increase in oxygen uptake with an increase in power output. However, as work rate continues to increase, oxygen uptake will eventually plateau, meaning a complimentary increase in oxygen uptake to accommodate the increased power output will not occur. VO₂ max is the point at which oxygen uptake plateaus, biologically representing the maximal capacity of the cardiorespiratory system (Powers & Howley, 2009).

Generally, the more physically fit an individual is, the higher the VO₂ max value. Elite distance runners can demonstrate VO₂ max values (ml/kg/min) in the upper 80’s-90’s while sedentary individuals can fall in the 20-30’s. Because VO₂ max reflects the relationship between cardiac output, and arteriovenous oxygen difference (oxygen exchange and uptake by the muscles) improvements in VO₂ max are due to increases in one or both of these variables (Powers & Howley, 2009). Therefore, improvements to VO₂ max are generally the result of exercise training. Deconditioned patients, and those
with very low pre-training VO₂ max values, generally demonstrate the largest increases in VO₂ max in response to exercise training programs. The type of exercise training also has an effect on VO₂ max. Studies have shown that endurance (aerobic) training results in the largest improvements in VO₂ max (Valkeinen, Aaltonen, & Kujala, 2010). While VO₂ max can be improved with exercise training, it is also largely influenced by genetics. The HERITAGE Family Study, a study of the role of genotype in response to aerobic exercise training, showed that among sedentary adults, VO₂ max is up to 50% genetically influenced (Bouchard et al., 1998). Results of the HERITAGE Family Study also demonstrate that changes in VO₂ max, in response to exercise training, are up to 47% genetically influenced (Bouchard et al., 1999).

After a determination of VO₂ max has been made, an individualized exercise prescription based upon intensity can be applied. Moderate intensity refers to expending energy at 40% to 60% of VO₂ max and would be the equivalent of a fast paced walk or light jog that noticeably elevates the heart rate. Vigorous intensity physical activity refers to expending energy at greater than 60% of VO₂ max and would be the equivalent to a jog or light run with a respective increase in heart rate and labored breathing (Haskell et al., 2007; Thompson et al., 2003). The latest Physical Activity and Public Health Recommendations for adults from the American College of Sports Medicine, and the American Heart Association (2009) define exercise recommendations based on prevention of weight gain, physical activity for weight loss, and prevention of regain after loss (Donnelly et al., 2009). In general, adults can prevent weight gain, or achieve modest weight loss, by performing 150-250 minutes of moderate-intensity aerobic activity each
week (at least 30 minutes daily, 5 days weekly) (Donnelly et al., 2009; Haskell et al., 2007; Lloyd-Jones, Hong, et al., 2010).

In addition to aerobic activity, two days of resistance training are also recommended. Resistance training involves performing weight bearing physical activities that increase or maintain muscle mass. Increased muscle mass equates to an improved ratio of fat free mass to fat mass therefore, reducing risk for cardiovascular disease (Donnelly et al., 2009; Haskell et al., 2007). Increased muscle tissue has also been linked to improved metabolic functions associated with cardiovascular disease. Specifically, decreased insulin resistance, improved serum cholesterol levels, and decreased systolic and diastolic blood pressure (Albright et al., 2000).

Resistance activities should be 8-10 repetitions per set of different weight bearing exercises that target large muscle groups (Haskell et al., 2007). Aerobic physical activity, activities that increase cardio-respiratory fitness, includes activities such as swimming, running, and walking. These should be performed between days of resistance activities to avoid consecutive days of resistance training. There is a relationship between frequency, intensity, and dose that allows individuals to gain similar benefits from decreased frequency at higher intensities such as 75 minutes of vigorous-intensity exercise 2 times a week, or 3 separate 10 minute doses of moderate-intensity physical activity a day, 5 days a week (Haskell et al., 2007; Marwick et al., 2009).

Physical Inactivity

Although regular physical activity is beneficial to health, physical inactivity is more common for the majority of Americans (Pleis, Lucas, & Ward, 2009). Physical
inactivity, or the absence of physical activity, is responsible for 1 in 10 cardiovascular disease-related deaths each year (Danaei et al., 2009). According to the most recent National Health Interview Survey, 33% of adults in the United States do not engage in at least 10 minutes of any type of leisure-time physical activity daily (Pleis et al., 2009). It was also reported that inactivity is higher among women than men and that inactivity increases with age (Pleis et al., 2009). National data obtained from the Behavioral Risk Factor Surveillance System, which surveyed over 150,000 adults, showed that only 22% of adults reported being regularly physically active (Reeves & Rafferty, 2005). The decrease in physical activity can be attributed to technological advances that decrease the need for physical exertion, as well as generally higher-paying wages for sedentary jobs. However, statistics show that individuals with college degrees are more likely to meet the physical activity recommendations than those of any other lesser education status (Haskell et al., 2007).

**Role of Physical Activity in Cardiovascular Disease Risk Reduction**

An important role of physical activity in cardiovascular health status is a positive impact on endothelial dysfunction, one of the leading causes of atherosclerosis and coronary artery disease. Because of this, physical activity is used to both reduce the incidence of, and improve symptoms of atherosclerosis (Thompson et al., 2003). During moderate and vigorous doses of physical activity there is an increased need for oxygen throughout the body that results in an increase in blood flow. The increase in blood flow through the arteries places stress on the endothelium and leads to increased vasodilatation, or opening of the coronary arteries. This exercise-induced response is
generally acute, but after periods of habitual physical activity, the vasodilatory
function of the endothelium improves chronically (Britten et al., 1999). This effect has
been observed in many animal models, and recent studies human of patients have
produced similar results. In particular, studies of physical training interventions of
patients with cardiovascular disease have shown that physical activity leads to improved
endothelial function (via the aforementioned mechanism) and, therefore, improved
overall cardiovascular health (Hornig, Maier, & Drexler, 1996).

Physical activity also produces favorable endothelial effects by improving serum
lipid and cholesterol content and slowing the progression of coronary artery disease
(Thompson et al., 2003). This was exemplified by (Schuler et al., 1992) in a study of 113
subjects diagnosed with coronary artery disease. This study found that incorporating
regular physical activity and a low fat diet with standard medical care, resulted in
reduction and regression of coronary lesion size and formation respectively. Additionally,
total serum cholesterol and triglyceride levels were reduced, and serum HDL-cholesterol
levels increased (Schuler et al., 1992). The improvement in serum cholesterol levels
achieved through physical activity is especially pertinent to individuals diagnosed with
high blood cholesterol levels, a risk factor for cardiovascular disease and atherosclerosis
(Thompson et al., 2003). A recent study by (Couillard et al., 2001) of 200 men enrolled in
the Health, Risk Factors, Exercise Training and Genetics (HERITAGE) family study
(2001) compared the results of a 20-week long endurance exercise training program on
blood HDL-cholesterol and triglyceride levels. The results of the study showed that
regular aerobic, or endurance, exercise has a favorable effect on cholesterol levels. Men
with elevated plasma triglycerides also demonstrated a 15% reduction and about a 5% increase in HDL-cholesterol levels (Couillard et al., 2001).

The American Heart Association supports the implementation of regular physical activity to reduce the risk of developing type 2 diabetes mellitus. Physical activity is also recommended for those diagnosed with type 2 diabetes due to positive metabolic effects and improved glycemic control (Marwick et al., 2009). Both aerobic and resistance exercise play an equally beneficial role in improving metabolic functions. A combination of both has been shown to be twice as effective in improving glycemic control (Sigal et al., 2007). The favorable effects of aerobic exercise, which include improvements in glucose tolerance and insulin sensitivity, are acute effects; meaning they typically deteriorate within 48 to 72 hours after an exercise session (King et al., 1995). Engaging in regular resistance training can result in improvements in body composition which also promote beneficial metabolic changes in individuals with type 2 diabetes mellitus via body fat reduction (Albright et al., 2000). Therefore, in order to sustain beneficial effects over longer periods of time, individuals with type 2 diabetes should strive to exercise at least every 3 days and incorporate both resistance and aerobic physical activity (Albright et al., 2000; King et al., 1995).

The improvements in metabolic control observed in individuals with type 2 diabetes are often the result of improvements in body composition. Specifically, physical activity in overweight and obese individuals can reduce waist circumference by reducing the amount of abdominal visceral fat. This results in an improvement in body composition, as well as a reduction in body weight and, ultimately, a reduction in
cardiovascular disease risk (Goldstein, 1992). The National Heart Lung and Blood Institute (1998) also recommends combining physical activity with dietary therapy (NHLBI, 1998). Weight loss from dieting alone results in a loss of about 75% fat mass and 25% fat-free mass. When an exercise training program is incorporated, the amount of fat-free mass lost can be reduced by almost half (Ballor & Poehlman, 1994). Body composition changes associated with the combination of physical activity and diet therapy have greater long-term effects including greater mobilization and loss of visceral adipose tissue, which leads to weight loss and improved metabolic functioning (Albright et al., 2000). Physical activity along with diet is important to the maintenance of weight loss due to the lower energy input and increased energy output needed to prevent weight re-gain (Klein et al., 2004).

While physical activity plays a key role in preventing and reducing the aforementioned risk factors for cardiovascular disease, it plays an especially important role in reducing elevated blood pressure levels (Pescatello et al., 2004). Studies of physical activity interventions to reduce blood pressure demonstrate 30-60 minutes of moderate physical activity most days of the week is effective in reducing systolic and diastolic blood pressure (Fagard, 2001). The decrease in blood pressure after physical activity is seen in both non-hypertensive individuals as well as hypertensive individuals. However, those with hypertension see the greatest decreases in blood pressure after exercise with the average being 1.8-2.6 mm Hg and 5.8-7.4mm Hg respectively. Furthermore, the decrease in blood pressure observed after physical activity can continue for almost a full day after exercise cessation (Pescatello et al., 2004; Thompson et al.,
While hypertension is a risk factor for cardiovascular disease, slightly elevated blood pressure levels still increase risk for cardiovascular disease (R. S. Vasan et al., 2001). This makes the reduction of blood pressure as a result of physical activity especially important for individuals with borderline hypertension and could serve as an effective treatment option (Thompson et al., 2003).

Nutrition and Cardiovascular Disease

The NHLBI’s Third Report of the National Cholesterol Education Program (NCEP) Expert Panel recommends the use of the Therapeutic Lifestyle Change Program (TLC) to reduce cholesterol. This program was designed to decrease LDL cholesterol levels and reduce risk for cardiovascular disease. The main goal of cholesterol-lowering dietary therapy is to decrease levels of LDL cholesterol. Elevated LDL cholesterol levels have been linked to dietary cholesterol, saturated fat, and trans fat intake (NHLBI Adult Treatment Panel III, 2002). Dietary intake patterns that replace saturated fats and cholesterol with unsaturated fats, and intake high levels of fruits, vegetables, and grains have been shown to decrease LDL cholesterol levels therefore decreasing cardiovascular risk (Mensink & Katan, 1992).

The intake of dietary cholesterol via animal sources (eggs, meat, dairy products, fish, and poultry) results in an overall increase in total serum cholesterol. In general, 100mg of dietary cholesterol results in a 2 to 3 mg/dL increase in total serum cholesterol. Because LDL cholesterol makes up the majority of serum cholesterol (60-80%), this equates to an overall increase in LDL (Food and Nutrition Board, Institute of Medicine,
2006a). It should be noted that the intake of dietary cholesterol is not essential because all cells in the body have the ability to adequately produce sufficient amounts of endogenous cholesterol. However, avoiding all dietary cholesterol sources would require adhering to a strict vegan diet and ingesting only plant protein sources. Monitoring cholesterol intake is a solution that can aid in decreasing total serum cholesterol while allowing dietary intake of animal protein sources (Food and Nutrition Board, Institute of Medicine, 2006a).

Like cholesterol, saturated fat (a type of fatty acid) can be synthesized in the body and intake is not essential. Within the body, fatty acids are a source of energy, function in fat-soluble vitamin absorption, form triglycerides, and are a structural component of cell membranes. However, Saturated fatty acids increase LDL cholesterol levels by suppressing the expression of LDL receptors (Food and Nutrition Board, Institute of Medicine, 2006a). Because of the relationship between LDL cholesterol and saturated fat, it is recommended that saturated fat consumption be extremely low. Sources of saturated fats are generally animal based products like cheese, while milk, butter, and fatty meats. However, plant based oils including coconut oil, and palm oil are also high in saturated fats (Food and Nutrition Board, Institute of Medicine, 2006a).

Saturated fats are often found in prepackaged, and convenience foods alongside another type of fat, trans fat. Like saturated fat, trans fat increases LDL cholesterol levels, however, unlike saturated fat, trans fat is not manufactured in the body and plays no beneficial health role what so ever. Although trans fats are classified as unsaturated fatty acids, they behave similarly to saturated fatty acids and result in an increase in LDL
cholesterol. Sources of trans fats include partially hydrogenated products like vegetable shortenings, pre packaged bakery items, and foods fried in partially hydrogenated oils. Because there are no health benefits associated with trans fats, it is recommended that the lowest amount possible be consumed (< 1% of total kcals) (Food and Nutrition Board, Institute of Medicine, 2006a).

When assessing the intake of saturated fats and cholesterol, nutrition professionals (registered dietitians) can perform a dietary assessment based on food records and reported intake. In order to facilitate this process, the Dietary CAGE questionnaire was developed by the ATP III panel. CAGE is an acronym for Cheese (and other sources of dairy fats), Animal fats (meats and fried foods), Got it away from home (high fat meals from restaurants or take out), and Extra (high fat commercial products; candy doughnuts) (NHLBI Adult Treatment Panel III, 2002). It is important to accurately assess the amount of saturated fat intake because a 1% increase in calories from saturated fat, can result in a 2% increase in LDL cholesterol (NHLBI Adult Treatment Panel III, 2002). The Dietary CAGE method can be used to ensure a more accurate intake of saturated fat and cholesterol, as well as educate clients on sources of foods that increase LDL cholesterol levels and increase risk for cardiovascular disease.

Mono and polyunsaturated fatty acids, oleic acid and linoleic acid respectively, have been shown to decrease levels of LDL cholesterol (Mensink & Katan, 1992). Polyunsaturated fatty acids are most commonly found in liquid vegetable oils like (soybean and safflower oil), margarines, walnuts, and sunflower seeds. Fatty fish such as salmon, trout, herring and mackerel are also good sources of polyunsaturated fats. While
Polyunsaturated fats have beneficial effects on LDL cholesterol, too much polyunsaturated fatty acid intake has been shown to decrease HDL levels and increase triglycerides (NHLBI Adult Treatment Panel III, 2002). Monounsaturated fatty acids, commonly found in olive oil, also produce a decrease in LDL cholesterol. Unlike polyunsaturated fatty acid, it does not produce a decrease in HDL cholesterol (Mensink & Katan, 1992). Therefore the TLC daily recommendations for polyunsaturated fatty acids is up to 10% of total kcals from fat, and up to 20% of kcals from monounsaturated fats (NHBLI Adult Treatment Panel III, 2002).

The ATP III therapeutic lifestyle changes also recommend consuming a diet rich in fruits, vegetables, and grain products. Dietary fiber, a compound found primarily in fruits, vegetables, legumes, and whole grains lowers serum cholesterol by blocking absorption of dietary fat and by facilitating the excretion of cholesterol containing bile acids via binding in the gut. (Food and Nutrition Board, Institute of Medicine, 2006a). Specifically, the binding of soluble fiber to bile acids inhibits micelle formation and causes bile acids to be excreted in the feces, rather than absorbed by the small intestine. This depletion of bile acid stores requires the body to use cholesterol for the synthesis of new bile acids instead of lipoproteins. While this process is nonspecific and all forms of cholesterol are lowered, soluble fiber has the greatest impact on LDL cholesterol with minimal impact to HDL cholesterol (Anderson & Hanna, 1999). An increase of 5-10 g of soluble fiber (beans, oats, skin of fruits and vegetables, psyllium) per day can decrease LDL cholesterol by as much as 5% (NHLBI Adult Treatment Panel III, 2002). The American Heart Association recommends consuming 25-30g per day of dietary fiber, due
to the LDL lowering effects of soluble fiber and the digestive effects associated with insoluble fiber seen in type 2 diabetes (Van Horn, 1997).

Vegetables, fruits, grains, and legumes also contain phytochemicals, antioxidants, vitamins, and omega-3 fatty acids. Phytochemicals are biologically active non-nutrient compounds that have beneficial health effects. Specifically, plant foods contain sterols, cholesterol like compounds, that decrease cholesterol absorption in the body (Anderson & Hanna, 1999). The overall dietary pattern recommended to decrease total cholesterol and reduce cardiovascular disease risk is consistent with recommendations from the Dietary Guidelines for Americans outlined in Table 7 (NHLBI Adult Treatment Panel III, 2002).
Table 7

Percent of Total Daily Calorie Intake Recommended by the Therapeutic Lifestyle Changes to Reduce LDL Cholesterol

<table>
<thead>
<tr>
<th>Dietary component</th>
<th>Therapeutic lifestyle changes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Fat</td>
<td>25-35%</td>
</tr>
<tr>
<td>Saturated</td>
<td>&lt; 7%</td>
</tr>
<tr>
<td>Polyunsaturated</td>
<td>10% max</td>
</tr>
<tr>
<td>Monounsaturated</td>
<td>20% max</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>&lt; 200 mg/dL</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>50-60%</td>
</tr>
<tr>
<td>Protein</td>
<td>15%</td>
</tr>
<tr>
<td>Dietary fiber</td>
<td>20-30 g</td>
</tr>
<tr>
<td>Soluble fiber</td>
<td>10-25 g</td>
</tr>
<tr>
<td>Plant stanols/sterols</td>
<td>2 g</td>
</tr>
</tbody>
</table>

Adapted from “Third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III) final report,” by National Heart Lung, and Blood Institute Adult Treatment Panel III, 2002, Circulation, 106(25), p. 3143. Copyright 2002 by Lippincott Williams & Wilkins. Adapted with permission.

Therapeutic Lifestyle Changes incorporates recommendations from the American Heart Association, U.S. Dietary Guidelines Committee, as well as other recommendations from reputable health care organizations like the National Heart Lung and Blood Institute. This is seen in the similarities between the Therapeutic Lifestyle Changes and the American Heart Association’s general recommendations to reduce cholesterol, which suggest a total daily caloric intake of < 7% saturated fat, < 1% trans fat, and < 300 mg of cholesterol (Lichtenstein et al., 2006). The relationship between overweight and obesity, metabolic syndrome and dyslipidemia is also recognized by ATP.
III, which recommends increased physical activity (at least 200 kcals/day) and decreased energy intake in addition to LDL lowering to achieve healthy BMI. The general recommendations for the therapeutic lifestyle changes (TLC) to lower cholesterol include: reduced dietary intake of saturated fats and cholesterol, increased dietary options that lower LDL cholesterol (soluble fiber), reduced weight, and increased physical activity. (NHLBI Adult Treatment Panel III, 2002).

The Lyon Heart Diet Study, a randomized cardiovascular disease prevention trial of 605 subjects from 1988-1992, studied the effects of a Mediterranean type diet on cardiovascular disease. The diet consisted of high fruit, vegetable, bread, cereals, potatoes, beans, nuts and seed intake. It also included olive oil and rapeseed oil as the exclusive dressing for salads, moderate wine consumption, low amounts of dairy, fish, and poultry products, and very little intake of eggs, and red meat. Butter and cream were replaced by margarine (supplied by the researchers) with a similar consistency to olive oil, but a higher alpha-linolenic acid (a form of polyunsaturated fatty acid) content. The study, which was stopped early due to the overwhelmingly positive results from the experimental group, found that the Mediterranean diet had a 50-70% cardiovascular risk lowering effect (de Lorgeril et al., 1999).

Subjects in the control group averaged a dietary intake of 30% fat (8% saturated, 13% mono 5%, poly) and 200 mg/dL of total cholesterol a day. They also consumed a greater amount of oleic, alpha-linolenic acid, and dietary fiber than the control group. A four-year follow up of this study revealed the significant reduction in cardiovascular events was sustained (de Lorgeril et al., 1999). Though many aspects of the therapeutic
lifestyle dietary recommendations are similar to the Mediterranean diet, the results of the study were not correlated with improved cholesterol levels (McKeown, Logan, McKinley, Young, & Woodside, 2010). Research stipulates that the beneficial effects of the Lyon Heart Study (Mediterranean diet) were therefore due to low consumption of meat and meat products, high vegetable, fruit, legume, and nut consumption, replacing saturated fatty acids with monounsaturated fatty acids, and moderate alcohol consumption (ethanol) (Trichopoulou, Bamia, & Trichopoulou, 2009).

Another aspect of the Lyon Heart study’s Mediterranean-like diet was the increased amounts of omega-3 fatty acid, a polyunsaturated fatty acid found in fatty fish, flaxseed, and canola oil that was consumed. Specifically, the Lyon Heart Study demonstrated the benefit Omega-3 fatty acid has on cardiovascular health (Kris-Etherton et al., 2001). Since the Lyon Heart Study, research has shown that Omega-3 acids lower triglyceride levels. Preliminary studies demonstrated that Omega-3 inhibited the production of VLDL (a precursor molecule to LDL) resulting in a decrease in LDL cholesterol (Leaf & Weber, 1988). The omega 3 fatty acids found in animal sources such as fatty fish demonstrate a greater lipid lowering effect than vegetable sources of Omega 3 such as flax seed, rapeseed oil, and nuts (Lavie, Milani, Mehra, & Ventura, 2009). This is due to the different types of omega-3’s found in animal sources of (eicosapentaenoic acid, EPA and docosahexaenoic acid, DHA) verses plant sources (alpha linolenic acid, ALA). While the exact mechanism is not fully understood, DHA and EPA decrease synthesis of triglycerides and increase fat metabolism within the body. Studies have
shown that 4 g/day can reduce triglyceride content by up to 40% while increase in HDL levels by 10% (Harris, 1997; Lavie et al., 2009).

Dietary intake patterns high in fruits, vegetables, low-fat dairy products, and low in saturated and total fat have also demonstrated beneficial effects on blood pressure (Appel et al., 1997). The Dietary Approaches to Stop Hypertension (DASH) trial tested the effects of combined dietary patterns on blood pressure, rather than just one nutrient alone. This study tested the effects 3 dietary interventions on 459 adults with systolic blood pressure less than 160 mm Hg and diastolic blood pressure between 80-95 mm Hg. The participants were randomly assigned to a control diet that mimicked the “typical American diet” (potassium magnesium and calcium levels 25%, average macronutrient and fiber intake), fruit and vegetable diet (potassium magnesium and calcium levels 75%, high fiber intake), or the combination diet (potassium magnesium and calcium levels 75%, high fiber, high protein intake. The sodium contents of the diets were similar at about 3 g/day. After 8 weeks of treatment, the combination diet (dietary intake patterns high in fruits, vegetables, low-fat dairy products, and low in saturated and total fat) demonstrated a 5.5 mm Hg decrease in systolic and 3 mm Hg decrease in diastolic blood pressure levels. The fruit and vegetable diet decreased blood pressure, but to a much lesser extent (Appel et al., 1997).

This trial was followed by another DASH diet study that included the addition of reduced sodium intake (Sacks et al., 2001). Specifically this study tested 3 control groups, and 3 DASH groups, at 3 levels of sodium intake, high (150 mmol/day), intermediate (100 mmol/day), and low (50 mmol/day). 412 adults with blood pressure
greater than 120/80 mm Hg, underwent treatment for 30 days. The results of the study demonstrated that while the reduced sodium lowered blood pressure levels in the control group, the DASH diet resulted in significantly lower systolic blood pressure at every sodium level and significantly lower diastolic blood pressure at the high and intermediate sodium levels (Sacks et al., 2001).

The results of the DASH trials demonstrate that there are specific dietary factors that play a predominant role in the prevention and reduction of elevated blood pressure levels (Appel et al., 1997; Sacks et al., 2001). Decreased sodium intake, increased potassium, magnesium, and calcium intake, moderation of alcohol consumption, and reduced caloric intake to induce weight loss are all factors that help to reduce blood pressure (Appel & American Society of Hypertension Writing Group, 2009). The specific recommendations for low sodium is to decrease sodium intake to less than 2400 mg/day for the general population, and less than 1500 mg/day for adults over 51, African Americans, and individuals with hypertension, diabetes, or chronic kidney disease (NHLBI Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure, 2004). This goal can be accomplished by adhering to the DASH diet, which emphasizes increased consumption of whole grains, nuts, seeds, legumes, vegetables, fruit, and low-fat dairy products, and decreased fat intake (27% of total kcals).

In order to accommodate all risk factors for cardiovascular disease, the American Heart Association’s Dietary Recommendations for Ideal Cardiovascular Health (2010), recommends a DASH-like eating plan that includes methods for achieving desirable
cholesterol levels (Lloyd-Jones, Hong, et al., 2010). The type of dietary fat ingested affects LDL, HDL, and triglyceride levels. Increasing intake of heart healthy unsaturated fatty acids (nuts, fish, flaxseed) and decreasing intake of trans and saturated fatty acids (whole milk, cream, butter, cheese, and fatty meats) helps to decrease LDL and triglyceride levels while increasing HDL (Fletcher et al., 2005; Food and Nutrition Board, Institute of Medicine, 2006a). The American Heart Association recommends eating 4 oz servings of fish twice a week. Dietary fiber, found primarily in fruits, vegetables, legumes, and whole grains lowers serum cholesterol by blocking absorption of dietary fat and increasing excretion of bile acids (Food and Nutrition Board, Institute of Medicine, 2006a). The TLC, DASH, and Mediterranean diets are summarized below in Table 8 for comparison of recommendations.
Table 8

*Dietary Recommendations to Decrease Risk Factors for Cardiovascular Disease, DASH, TLC, and Mediterranean*

<table>
<thead>
<tr>
<th>Food type</th>
<th>DASH*</th>
<th>TLC**</th>
<th>Mediterranean</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grains</td>
<td>7-8</td>
<td>≥ 6</td>
<td>2-3</td>
</tr>
<tr>
<td>Fruits</td>
<td>4-5</td>
<td>2-4</td>
<td>4-6</td>
</tr>
<tr>
<td>Vegetables</td>
<td>4-5</td>
<td>3-5</td>
<td>2-3</td>
</tr>
<tr>
<td>Fat free or low fat milk and milk products</td>
<td>2-3</td>
<td>2-3</td>
<td>1-2</td>
</tr>
<tr>
<td>Lean meats, poultry, fish</td>
<td>2 or less</td>
<td>≤ 5 oz</td>
<td>Fish: 4-5/week</td>
</tr>
<tr>
<td>Nuts, seeds, and legumes</td>
<td>4-5/week</td>
<td>Counted vegetables</td>
<td>&lt;4 weekly</td>
</tr>
<tr>
<td>Fats and oils</td>
<td>Limited</td>
<td>Depends on kcals/day</td>
<td>1-2 (Olive oil)</td>
</tr>
<tr>
<td>Sweets and added Sugars</td>
<td>Limited</td>
<td>Limited</td>
<td>1-3/week</td>
</tr>
</tbody>
</table>

*From Dietary Approaches to Stop Hypertension

The American Heart Association defines overweight and obesity as independent risk factors for cardiovascular disease (Lloyd-Jones, Hong, et al., 2010). However, overweight and obesity can be directly linked to the pathology of other cardiovascular disease risk factors, including high blood pressure, type 2 diabetes mellitus, and high blood cholesterol (Must et al., 1999). It is important to note that there is a progressive relationship between weight status and the presence of these conditions. Specifically, as weight status increases, the likelihood of an individual having multiple risk factors for cardiovascular disease increases concurrently (Must et al., 1999). Therefore, the dietary treatment options for overweight and obesity should focus on reduction of weight. In general, this goal is accomplished by a calorie-restricted diet that is individually modified to meet specific weight loss needs. The NHLBI’s clinical guidelines on the identification, evaluation, and treatment of overweight and obesity in adults, recommend a caloric deficit of 500 to 1000 kcal/day to produce weight loss of 1 to 2 pounds per week, with a goal of a 10% total body weight reduction in 6 months. These guidelines also recommend incorporating physical activity and behavior modification therapy to increase efficacy of weight loss (NHLBI, 1998).

Caloric restriction is also a vital component to the treatment and prevention of type 2 diabetes and reduction of cardiovascular disease risk. The American Heart Association recommends a fasting blood glucose of \( \leq 100 \text{ mg/dl} \) for optimal cardiovascular health. Hyperglycemia, or high blood sugar levels, are associated with increased risk for cardiovascular disease as well as increased risk for complications associated with diabetes such as insulin resistance and peripheral vascular disease.
(Lloyd-Jones, Hong, et al., 2010). Weight loss, especially when achieved through diet and exercise, has been proven to decrease the prevalence of metabolic complications associated with diabetes and central obesity (Lichtenstein et al., 2006).

Behavior Modification

Successfully achieving the ideal health behaviors recommended by the American Heart Association often requires individuals to make major lifestyle changes (Lloyd-Jones, Hong, et al., 2010). Many individuals have difficulty implementing new health behaviors simply because this requires changing one’s current behaviors. In order to facilitate change, a form of therapy known as behavior modification is often incorporated to increase the adherence to, and effectiveness of, overweight and obesity related risk reduction treatment programs (NHLBI, 1998). The goal of behavior modification therapy is to identify current behaviors that contribute to increased health risk and modify these behaviors to decrease risk. Behavior modification strategies generally target behaviors related to energy intake and physical activity (Wing, 1992). The role of a behavior modification counselor is to establish rapport with the patient, and gain an understanding of barriers to adherence. The knowledge of barriers to change allows the behavior modification counselor to provide the patient with support and strategies regarding how to successfully apply changes (Foreyt & Poston, 1998).

Before behavior modification therapy can be successful, a collaborative relationship between counselor and patient must be formed. This relationship is the cornerstone to effectively engaging clients in treatment. During this process it is
important for the counselor to express understanding of the patient’s condition and allow the patient to feel in control of the treatment process (Foreyt & Poston, 1998). A valuable approach for this is the use of motivational interviewing, a patient centered counseling technique. Using this technique the patient elicits self-motivation for change, and plays a role in directing the therapy (Miller & Rollnick, 2002). Studies have demonstrated that motivational interviewing is effective in treating obese and overweight patients, as well as those unsure about making change. For this reason, behavior modification therapy is often used in conjunction with motivational interviewing (Armstrong et al., 2011).

Once a collaborative relationship between patient and counselor has been established, specific behavioral strategies, designed to change behaviors associated with energy intake and physical activity, are utilized (Foreyt & Poston, 1998). Table 9 lists and describes common behavioral modification strategies that are utilized in the reduction of cardiovascular disease risk factors (Klein et al., 2004).
Table 9

*Behavior Modification Strategies Description and Purpose*

<table>
<thead>
<tr>
<th>Behavior strategy</th>
<th>Description</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>Self-monitoring</td>
<td>Keep detailed self-reported records of food intake and physical activity</td>
<td>Bring awareness to behaviors and factors that affect behavior</td>
</tr>
<tr>
<td>Stimulus control</td>
<td>Identify personal and environmental stimuli that cause excess intake and</td>
<td>Learn how to identify, avoid, and control stimuli that lead to</td>
</tr>
<tr>
<td></td>
<td>physical inactivity</td>
<td>unhealthy behaviors</td>
</tr>
<tr>
<td>Goal setting</td>
<td>Set short term, specific, attainable goals for food intake and physical</td>
<td>Accomplish frequent, incremental increases in healthy behaviors until</td>
</tr>
<tr>
<td></td>
<td>activity</td>
<td>target behaviors are achieved</td>
</tr>
<tr>
<td>Cognitive restructuring</td>
<td>Identify and challenge beliefs and attitudes undermining healthy behaviors</td>
<td>Change negative or unrealistic internal feelings and beliefs about health</td>
</tr>
<tr>
<td>Stress management</td>
<td>Learning methods to reduce stress and tension</td>
<td>Decrease stress to avoid stress-response behaviors</td>
</tr>
<tr>
<td>Problem solving</td>
<td>Identify solutions to problems that prevent healthy behaviors</td>
<td>Solve and prevent problems that hamper healthy behaviors</td>
</tr>
<tr>
<td>Social support</td>
<td>Include family members and peers in the treatment process</td>
<td>Improve healthy behaviors by gaining support from peers and family</td>
</tr>
<tr>
<td>Relapse prevention</td>
<td>Develop coping strategies for social and emotional situations that might</td>
<td>Prevent relapse by recognizing and planning for situations that cause</td>
</tr>
<tr>
<td></td>
<td>result in lapse or relapse from treatment</td>
<td>lapse</td>
</tr>
</tbody>
</table>

While there are many different strategies, certain principles should be held universal and employed throughout the behavior modification process. Therapy should always be goal-oriented, process-oriented, and involve small changes. Goals that are easily attainable, measurable, realistic, and time-bound should be set throughout the program (Foreyt & Poston, 1998; Wing, 1992). Often, the achievement of goals is dependent upon how a goal is formulized. For this reason, health care practitioners employ the use of SMART goal setting, i.e., setting goals that are specific, measurable, achievable, realistic, and time-bound (Bovend'Eerdt, Botell, & Wade, 2009). This method ensures patient involvement, and allows the counselor to engage the patient in open dialogue about the expectations of treatment.

The process of actually making a behavior change is extremely complex and involves a person’s readiness to take action. The “stages of change” model describes behavior change in the context of a process that occurs over time and in stages. This transtheoretical approach stipulates that there are five stages, each representing a period of time and a task. In order to reach the next stage, a period of time must be spent completing the task via a specific process. The stages as outlined by Norcross, Krebs, and Prochaska (2011) are listed and described in Table 10 below.
Table 10

*Transtheoretocal Model of the Stages of Change*

<table>
<thead>
<tr>
<th>Stage</th>
<th>Readiness to change</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precontemplation</td>
<td>No intention to change</td>
<td>Patient unaware of, or underestimates problem</td>
</tr>
<tr>
<td>Contemplation</td>
<td>Contemplating change</td>
<td>Patient aware that problem exists but uncommitted to taking action</td>
</tr>
<tr>
<td>Preparation</td>
<td>Planned change</td>
<td>Patient has a definite time set to take action and might be making small changes</td>
</tr>
<tr>
<td>Action</td>
<td>Change has been made to behavior and/or environment</td>
<td>Patient has successfully altered behavior for a period of time (1 day to 6 months)</td>
</tr>
<tr>
<td>Maintenance</td>
<td>New behavior is maintained and relapse has not occurred</td>
<td>Patient consistently engages in new behavior and works to prevent relapse (&gt; 6 months from initial change)</td>
</tr>
</tbody>
</table>


Another theory utilized by health care practitioners to understand a patient’s current behaviors and ability to apply changes is social cognitive theory. This theory
states that behaviors are simultaneously influenced by an individual’s characteristics, current behavior patterns, and environment (Byrd-Bredbenner, Abbot, & Cussler, 2011). Social cognitive theory postulates that in order for a person to successfully make a behavior change they must possess motivation and the ability to create an environment conducive to the desired behavior. In order to do this, a person must demonstrate a high level of self-efficacy, i.e., belief in one’s ability to achieve a behavior. Within this theory, there are fundamental concepts that affect a person’s ability to change. In addition to self-efficacy, these concepts include outcome expectations, self-regulation, and observational learning (Bandura, 2004). Social cognitive theory also emphasizes that a person’s ability to deal with environmental stressors is a vital component to their ability to make successful health behavior changes (Byrd-Bredbenner et al., 2011). Many of the concepts in social cognitive theory are addressed in the behavior change model, thereby making both techniques useful to health practitioners.

The use of behavioral modification therapy, social cognitive theory, transtheoretical stages of change, and motivational interviewing in health interventions can create an individualized patient-centered approach to reducing risk factors. Generally, members of the multidisciplinary team apply these techniques in groups or individually throughout the intervention (Wing, 1992). Studies have shown that the inclusion of behavioral therapy, in addition to dietary and physical activity interventions, results in better success achieving the initial weight loss goal (9% reduction from baseline), as well as maintenance of that weight loss (5% after 1 year; Wadden, Sarwer, & Berkowitz, 1999). Therefore in order to achieve the most reduction in cardiovascular disease risk,
treatment of modifiable cardiovascular risk factors should involve dietary therapy, physical activity, and behavior therapy.

Cholesterol

The reduction of serum cholesterol levels is a critical step in the prevention of atherosclerosis and cardiovascular risk factors (NHLBI Adult Treatment Panel III, 2002). The American Heart Association recommends total cholesterol levels of $< 200 \text{ mg/dL}$ for ideal cardiovascular health (Lloyd-Jones, Hong, et al., 2010). Currently 98.8 million adults in the United States are classified as at risk for cardiovascular disease due to high cholesterol levels (CDC, 2010). Many risk factors for cardiovascular disease also adversely affect cholesterol levels, including overweight and obesity, type 2 diabetes, smoking, physical inactivity, and poor dietary intake (NHLBI Adult Treatment Panel III, 2002). Therefore many of the recommendations to reduce these risk factors also apply to treating hypercholesterolemia. In order to adequately grasp the impact of cholesterol on cardiovascular health, it is important to examine the biological function and role of cholesterol in the body.

Cholesterol is a sterol (a type of lipid) that is a necessary component of cell membranes and a precursor molecule in the production of steroid hormones and bile acids. Cholesterol is manufactured in the body and ingested in the diet through animal substances; plants do not produce cholesterol (Food and Nutrition Board, Institute of Medicine, 2006a). Due to the hydrophobic nature of lipids, cholesterol is transported through the blood stream in the form of a lipoprotein, a compound composed of a lipid
core surrounded by a shell made of protein, phospholipids, and cholesterol. There are four main types of lipoproteins that function in various ways depending upon where they are manufactured in the body (NHLBI Adult Treatment Panel III, 2002).

Chylomicrons, lipoproteins manufactured by intestinal cells after ingestion of dietary fat, consist of approximately 90% triglycerides, 3% cholesterol, 5% phospholipid, 2% protein and apolipoproteins including Apo B-48 (NHLBI Adult Treatment Panel III, 2002). Once in the blood stream, the triglycerides within chylomicrons are broken down into fatty acids by the enzyme lipoprotein lipase and absorbed by body cells. This process takes a total of 2 to 10 hours depending upon fat content ingested, with total clearing of chylomicrons after 12 to 14 hours of fasting (Cox & Garcia-Palmieri, 1990).

Very low-density lipoproteins (VLDL) are manufactured in the liver and consist of about 70% triglycerides, 10% cholesterol, 10% phospholipid, and 10% protein and apolipoproteins (Cox & Garcia-Palmieri, 1990). Upon entering the blood stream, triglycerides are broken down by lipoprotein lipase, are absorbed by body cells. As VLDL loses triglycerides, which are less dense than water, it becomes denser and eventually forms a new lipoprotein molecule made mostly of cholesterol (Cox & Garcia-Palmieri, 1990).

This new molecule, low-density lipoprotein (LDL), consists of about 26% cholesterol, 10% triglyceride, 15% phospholipid, 25% protein and a single apolipoprotein (Apo B-100) LDL cholesterol functions to transport cholesterol to cells, or is taken up by the liver for repackaging (Cox & Garcia-Palmieri, 1990; NHLBI, Adult Treatment Panel III, 2002;). Certain types of white blood cells embedded within arterial walls called
scavenger cells can absorb LDL cholesterol, especially oxidized LDL cholesterol. Over time LDL cholesterol begins to build up inside these cells leading to foam cell formation and eventual plaque formation. This process occurs when LDL levels are elevated and begins the process of atherosclerosis (Shashkin, Dragulev, & Ley, 2005). In order to reduce risk for atherosclerosis, serum LDL levels should be <100 mg/dl (NHLBI Adult Treatment Panel III, 2002).

Another type of lipoprotein, high-density lipoprotein (HDL), produced by liver and intestinal cells, is composed of about 5% triglyceride, 20% cholesterol, 25% phospholipid, and 50% protein and apolipoproteins. HDL cholesterol has multiple apolipoproteins including, Apo A-I and Apo A-II, which make up the majority of circulating HDL, about 70% and 20% respectively (Cox & Garcia-Palmieri, 1990; NHLBI, Adult Treatment Panel III, 2002). The other 10% of HDL apolipoproteins include ApoE, ApoA-IV, ApoJ, ApoC-I, ApoC-II, and ApoC-III (Kontush & Chapman, 2006). The unique composition of HDL cholesterol allows it to function differently than the other lipoproteins. HDL cholesterol functions to uptake excess cholesterol from the blood stream and transport it back to the liver for excretion (Cox & Garcia-Palmieri, 1990). In addition, HDL molecules can remove cholesterol from the membranes of peripheral cells attached to the endothelial wall including macrophages and foam cells. While this process is complex and multifaceted, Apo A-I and Apo A-II proteins associated with HDL cholesterol are thought to be the major components that facilitate this uptake. Another apolipoprotein associated with HDL, ApoE, which makes up a small percentage of the circulating HDL, is also thought to aid in cholesterol uptake from
macrophage cells (Kontush & Chapman, 2006). A serum HDL cholesterol level of greater than \( \geq 60 \text{ mg/dl} \) is recommended for optimal health benefit. Further more, > 60 mg/dl HDL cholesterol is referred to as a negative risk factor (NHLBI Adult Treatment Panel III, 2002).

The measure of hypercholesterolemia is determined by a multivariate analysis of the total serum cholesterol present, which includes HDL, LDL, and intermediate forms of cholesterol (NHLBI, Adult Treatment Panel III, 2002). Table 11 lists the definitions of cholesterol levels as defined by the NHLBI’s National Cholesterol Education Program’s (NCEP) Adult Treatment Panel III.

Table 11

*Adult Treatment Panel III Classification of Serum Cholesterol Levels*

<table>
<thead>
<tr>
<th>Cholesterol type (mg/dL)</th>
<th>Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total cholesterol</td>
<td>Desirable &lt; 200</td>
</tr>
<tr>
<td></td>
<td>Borderline High 200-239</td>
</tr>
<tr>
<td></td>
<td>High ( \geq 240 )</td>
</tr>
<tr>
<td>HDL cholesterol</td>
<td>Desirable ( \geq 60^* )</td>
</tr>
<tr>
<td></td>
<td>Low &lt; 40</td>
</tr>
<tr>
<td>LDL cholesterol</td>
<td>CHD/CHD RE</td>
</tr>
<tr>
<td></td>
<td>(2+) RF</td>
</tr>
<tr>
<td></td>
<td>(0-1) RF</td>
</tr>
<tr>
<td></td>
<td>&lt; 100</td>
</tr>
<tr>
<td></td>
<td>&lt; 130</td>
</tr>
<tr>
<td></td>
<td>&lt; 160</td>
</tr>
</tbody>
</table>

HDL >60mg/dL=Negative risk factor; CHD=Cardiovascular disease; RE= Risk Equivalents; RF=Risk Factors. *From “Third report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III) final report,” by National Heart, Lung, and Blood Institute Adult Treatment Panel III, 2002, Circulation, 106(25) p. 3143. Copyright 2002 by Lippincott Williams & Wilkins. Adapted with permission.
Due to the adverse health implications of increased LDL cholesterol levels, the desirable levels of LDL cholesterol are defined by three categories of risk for cardiovascular disease; a) established and coronary heart disease (CHD) risk equivalents, b) multiple risk factors (2+), and, c) 0-1 risk factors. Diagnosed CHD or other cardiovascular disease, type 2 diabetes, and Framingham 10-year risk score > 20% classify as the greatest risk. The remaining two categories are based on the assessment of cigarette smoking, age, hypertension, low HDL cholesterol, and family history of premature CHD. However, if an individual has an HDL level 60 mg/dL, a risk factor is subtracted from the count (NHLBI Adult Treatment Panel III, 2002).

Many studies have linked hypercholesterolemia to the development of endothelial dysfunction, which is a critical factor in the progression to atherosclerosis (Britten et al., 1999). When cholesterol levels are high, the ability of the endothelium to regulate blood flow to the coronary arteries is impaired. Specifically, the endothelium is unable to properly dilate in response to the normal hormonal stimulus that signals the need for increased blood flow to the coronary arteries (Zeiher, Drexler, Saurbier, & Just, 1993). The amount of endothelial dysfunction, or the amount to which the endothelium is unable to dilate, is directly proportional to total serum cholesterol levels. Individuals already diagnosed with atherosclerosis that continue to present with hypercholesterolemia have an even higher incidence of impaired blood flow than those with atherosclerosis alone (Zeiher et al., 1993).

Of the four types of lipoproteins, LDL cholesterol makes up the majority of serum cholesterol (60-80%) and plays a key role in atherogenic development (NHLBI, Adult
Large scale studies, including INTERHEART and The Framingham Heart Study, have linked LDL cholesterol, and ApoB-100, to increased risk for cardiovascular disease, due to the direct causal relationship of cholesterol to atherosclerosis (Wilson, Abbott, & Castelli, 1988; Yusuf et al., 2004). The NHLBI’s Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (2002) directly links hypercholesterolemia, specifically elevations in LDL, to atherosclerosis, stating that it is a prerequisite for the development of the condition (NHLBI Adult Treatment Panel III, 2002).

Serum triglycerides levels have also been directly linked to increased risk for cardiovascular disease. Triglycerides do not contribute to atherosclerotic plaque formation in the same manner as LDL cholesterol (Havel, 1990). However, recent research has linked remnant lipoproteins rich in triglycerides (triglyceride rich lipoproteins) to the progression of atherosclerosis (Hodis et al., 1994). The recommended serum triglyceride level is < 150 mg/dL (NHLBI, Adult Treatment Panel III, 2002). Elevated triglycerides are generally the result of other risk factors for cardiovascular disease including overweight and obesity, physical inactivity, poor dietary intake, and smoking. Elevated triglyceride levels can serve as an indication of these risk factors and is linked to low levels of HDL-cholesterol (NHLBI, Adult Treatment Panel III, 2002).

Adverse health effects are attributable to increased levels of LDL, triglycerides, and total cholesterol, in contrast, increased HDL cholesterol is associated with decreased cardiovascular risk (NHLBI, Adult Treatment Panel III, 2002; Wilson et al., 1988). HDL
cholesterol facilitates the removal of cholesterol from arterial cell walls via a pathway known as reverse cholesterol transport. This process reduces the amount of cholesterol build up in arteries and helps prevent the progression of atherosclerosis (Sviridov & Nestel, 2002). HDL cholesterol and its apolipoproteins (Apo A-1, A-II, E, J) have antioxidant properties that protect LDL cholesterol from oxidation. Specifically, these apolipoproteins are thought to maintain the structure of LDL cell walls via binding activities, and absorb lipid derived free-radical oxidizing agents. This prevents the oxidation and uptake of the LDL by scavenger cells in the arterial wall, therefore preventing plaque formation (Navab et al., 2000).

In order for cholesterol to accumulate in arterial walls, leukocytes have to adhere themselves to the endothelial wall. This is part of the inflammatory response caused by oxidative stress (chronic inflammation) and by the pro-oxidative environment it creates, which increased levels of C-reactive protein often indicate (Kontush & Chapman, 2006). High concentrations of HDL (ApoA-1, Apo-A-II, and Apo-A-IV) inhibit the adhesion process, as well as the cytokine-induced production of adhesion molecules (Cockerill, Rye, Gamble, Vadas, & Barter, 1995; Kontush & Chapman, 2006). HDL cholesterol has also been associated with antithrombic effects by its ability to stimulate nitric oxide release resulting in increased vasodilatation (ApoA-I; Nofer et al., 2004).

When HDL levels are low, many of these antiatherogenic effects are inhibited. For this reason, low HDL levels are an indication of cardiovascular disease risk. Several risk factors for cardiovascular disease can contribute to low HDL levels including, overweight and obesity, physical inactivity, uncontrolled type 2 diabetes, smoking, and poor dietary
intake (NHLBI, Adult Treatment Panel III, 2002). In order to benefit from the antiathrogenic effects of HDL cholesterol, it is important to reduce total cholesterol levels to < 150 mg/dL, and it is recommended that serum HDL cholesterol not be less than 60 mg/dL (NHLBI, Adult Treatment Panel III, 2002).

The recommendations for lowering cholesterol are targeted at eliminating the underlying causes of high cholesterol including overweight and obesity, physical inactivity, uncontrolled type 2 diabetes, smoking, and poor dietary intake. Lowering LDL cholesterol in particular has been proven to slow the progression of atherosclerosis and reduce the risk of cardiovascular disease (Hodis et al., 1994). Excess fat associated with overweight and obesity, and type 2 diabetes is directly linked to high triglyceride and low HDL cholesterol levels. Weight loss via dietary therapy and physical activity is recommended to improve body composition and cholesterol levels (Fletcher et al., 2005). Engaging in regular physical activity has a positive effect on lipid and lipoprotein levels resulting in decreased LDL and increased HDL levels (Schubert et al., 2006). The combination of high cholesterol and saturated fat intake with low poly- and monounsaturated fat intake has been linked to high cholesterol levels (de Lorgeril, Salen, Monjaud, & Delaye, 1997). Interventions that encourage intake of heart healthy foods like fruits, vegetables, nuts whole grains, wine in moderation, mono- and polyunsaturated fats, total fat intake of less than 30% (8% to 10% saturated), and less than 200 mg/d cholesterol and can play a pivotal role in reducing total cholesterol, LDL cholesterol, and triglycerides, as well as increasing HDL cholesterol levels (Fletcher et al., 2005; Kris-Etherton et al., 2001). Smoking is correlated with low HDL and high triglyceride levels
and when combined with other risk factors has a synergistic effect on endothelial dysfunction. Smoking cessation has been linked improved endothelial function and normalization of cholesterol levels (Celermajer et al., 1993; Novello, 1990).

The management of cholesterol levels to achieve optimal cardiovascular health is an important component of risk reduction. The overlap between risk for cardiovascular disease and hypercholesterolemia allows for simultaneous treatment and reduction of risk. Incorporating regular physical activity, healthy diet, healthy body composition, non-smoking, and controlled type 2 diabetes, can greatly reduce risk for cardiovascular disease and improve cholesterol levels (Fletcher et al., 2005; Lloyd-Jones, Hong, et al., 2010).

Blood Pressure

The term “blood pressure” refers to the amount of force produced when blood, pumped through the body by the heart, pushes against arterial walls (NHLBI, 2011). Two different pressure measurements, systolic and diastolic, make up total blood pressure, which is measured in millimeters of mercury (mm Hg). Systolic refers to pressure exerted when the heart is expelling blood, and diastolic refers to pressure exerted when the heart is at rest or filling. Fluctuations in blood pressure are normal; however, when blood pressure is too high for long periods of time, it can be detrimental to health (NHLBI, 2011). Hypertension, or extremely elevated blood pressure, is one of the most common medical conditions associated with increased risk for cardiovascular disease and has been attributed to the largest number cardiovascular disease related deaths of deaths (Danaei et
Elevated resting blood pressure, central obesity, presence of family history, and physical inactivity all serve as predictors for hypertension (Chobanian et al., 2003). Table 12 lists the classifications for blood pressure levels as defined by the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure, 2004.

Table 12

**Joint National Committee 7 Classification of Blood Pressure Levels for Adults**

<table>
<thead>
<tr>
<th>Blood Pressure</th>
<th>Systolic (mm Hg)</th>
<th>Diastolic (mm Hg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Normal</td>
<td>&lt; 120</td>
<td>and &lt; 80</td>
</tr>
<tr>
<td>Prehypertension</td>
<td>120-139</td>
<td>Or 80-89</td>
</tr>
<tr>
<td>Stage 1 hypertension</td>
<td>140-159</td>
<td>Or 90-99</td>
</tr>
<tr>
<td>Stage 2 hypertension</td>
<td>≥ 160</td>
<td>Or ≥ 100</td>
</tr>
</tbody>
</table>


These classifications are based on the highest measure of either systolic or diastolic blood pressures; meaning that the highest reading in either category serves as the indicator for classification. The categories are also based on the average of two or more measurements of resting blood pressures (Chobanian et al., 2003). Unlike other risk factors for cardiovascular disease, high blood pressure can be asymptomatic and is sometimes referred to as the “silent killer.” A global study of the impact of high blood
pressure showed that blood pressure increases with age and if, left untreated, will continue to rise (NHLBI, 2011).

Blood pressure levels have a progressive relationship to cardiovascular disease, which means, the risk for cardiovascular disease becomes greater as blood pressure levels increase (Chobanian et al., 2003). However, it is important to note that prehypertension, or slight elevations in blood pressure (≥120/80 mm Hg), has a progressive correlation to increased risk as well. The Framingham Heart Study exemplified this correlation by showing that individuals with just slightly higher than normal systolic (130-139 mm Hg) or diastolic (85-89 mmHg) blood pressure are at greater increased risk for cardiovascular disease than individuals with normal blood pressure (Vasan et al., 2001). Worldwide, elevated blood pressure can be attributed to about 47% of cardiovascular events; however, hypertension can only account for about half of those events. This makes prehypertension attributable to the remaining percentage, demonstrating the impact of only slightly elevated blood pressure on health (Lawes, Vander Hoorn, & Rodgers, 2008). In the United States, approximately 50 million people classify as hypertensive and another 25 million classify as prehypertensive (Vasan et al., 2002). The extreme number of people affected by elevated blood pressure, can be attributed to a number of modifiable and unmodifiable risk factors such as age, sodium intake, physical activity, and obesity (Rosendorff et al., 2007).

Age, an unmodifiable risk factor for elevated systolic blood pressure levels, produces an average increase of 1.7 mmHg per year from ages 1-18, and a 0.6 mm/Hg increase every year after that (Burt et al., 1995). Because of the strong correlation
between increased blood pressure and age, it is estimated that 90% of adults will become hypertensive within their lifetime (Vasan et al., 2002). Excessive sodium intake, a modifiable risk factor, has been linked to elevated blood pressure, endothelium dysfunction, and left ventricular hypertrophy (Rosendorff et al., 2007).

Sodium, normally ingested in the form of sodium chloride, is an essential mineral that plays a key role in maintaining fluid volume and osmolarity within the body (Food and Nutrition Board, Institute of Medicine, 2006b). Sodium induces a dose-dependent rise in blood pressure, and when consumed in excess, contributes significantly to hypertension (Appel et al., 2011). Some subsets of the population are more susceptible to sodium-induced rises in blood pressure than others. Individuals that are older, diagnosed with hypertension, diabetes, chronic kidney disease, and African Americans exhibit a greater sensitivity to sodium (Food and Nutrition Board, Institute of Medicine, 2006b). Studies have shown that the increase in blood pressure caused by sodium intake is a factor in endothelial dysfunction, the precursor to atherosclerosis.

This process is exacerbated by the presence of dyslipidemia (elevated triglycerides and LDL cholesterol as well as low HDL cholesterol), and oxidative stress, and smoking (Rosendorff et al., 2007). Over time, atherosclerosis results in flow impedance via blockage of arterials, altered vasodilatory capacity, and increased strain on cardiac muscles, which further exacerbates elevated blood pressure (Endemann & Schiffrin, 2004). Central obesity, diabetes and physical inactivity have also been linked to elevated blood pressure levels due to association with adverse effects on endothelial and metabolic function. Although the mechanism is not entirely clear, central obesity and
physical inactivity have been associated with the development of insulin resistance, which has adverse metabolic and cardiovascular disease effects (Grundy et al., 1999). The simultaneous presence of multiple risk factors can produce a synergistic increase in risk for cardiovascular disease, which is often the seen in individuals with high blood pressure (Lawes et al., 2008).

Treatment options for hypertension focus primarily on lifestyle interventions such as the implementation of a low-sodium DASH dietary therapy and increased physical activity (Rosendorff et al., 2007). Weight reduction, adherence to the low sodium DASH eating plan, and regular physical activity have all proven to independently decrease blood pressure and reduce risk for cardiovascular disease (Chobanian et al., 2003). Pharmaceutical therapy is also a major treatment option for individuals with severe hypertension. The efficacy of antihypertensive pharmaceutical therapy has been shown to improve when combined with diet and physical activity. This synergistic effect contributes to a greater decrease in cardiovascular disease risk; therefore, the Joint National Committee of Prevention, Detection, Evaluation, and Treatment of High Blood Pressure recommends combining two or more lifestyle modifications (Chobanian et al., 2003). The overall treatment goal for hypertension should focus on reducing blood pressure to < 140/90 mm Hg, and < 130/80 mm Hg for hypertensive individuals with diabetes and chronic kidney disease (Chobanian et al., 2003).

Because excessive sodium intake is directly associated with increased blood pressure, decreasing dietary sodium can be an effective therapy (Chobanian et al., 2003). The recommendation for low sodium intake is less than 2300 mg/day for the general
population, and less than 1500 mg/day for adults 51 and older, African Americans, and individuals with hypertension, diabetes, or chronic kidney disease (Lichtenstein et al., 2006; U.S. Department of Agriculture & U.S. Department of Health and Human Services, 2010). A recent study of nonmedicated stage 1 and 2 hypertensive individuals showed that adhering to these guidelines alone produced approximately a 12 mmHg decrease in systolic and 6 mmHg decrease in diastolic blood pressures (Kojuri & Rahimi, 2007). It is important to note that decreasing dietary sodium intake can reduce blood pressure levels in the presence or absence of weight loss (The Trials of Hypertension Prevention Collaborative Research Group, 1997). Therefore, overweight and obese hypertensive individuals should also adhere to a low-sodium, modified calorie, DASH-like eating plan to achieve the most cardiovascular risk reduction (Lichtenstein et al., 2006).

Weight reduction in obese and overweight individuals is directly associated with decreased blood pressure levels. While the goal of weight loss therapy should be to obtain a healthy BMI (18.4 -24.9 m$^2$), reductions in blood pressure can be obtained with only modest weight loss (Appel & American Society of Hypertension Writing Group, 2009). Studies have shown that weight loss of about 4.5 pounds (10 kg) can result in a 5-20 mm Hg reduction in systolic blood pressure (Miller et al., 2002; The Trials of Hypertension Prevention Collaborative Research Group, 1997). Weight reduction, specifically decreases in central obesity, also result in improved metabolic functioning, and improved blood lipid profiles. The decrease in these risk factors, which are both
independently associated with hypertension and cardiovascular disease, has synergistic effect on the overall improvement of cardiovascular disease health (Klein et al., 2004).

Engaging in regular physical activity has been proven to effectively reduce blood pressure in individuals with and without hypertension (Fagard, 2001). This reduction in nonhypertensive individuals suggests that regular physical activity may be the only therapy necessary to reduce blood pressure in individuals that are prehypertensive (Thompson et al., 2003). The American College of Sports Medicine (2004) specifically recommends a minimum of 30 minutes or more of aerobic exercise, 3-5 days weekly due to proven acute and chronic blood pressure lowering effects (Pescatello et al., 2004).

Diabetes and Blood Glucose

The increased prevalence of overweight and obesity in the United States has coincided with a complementary increase in diagnosed cases of type 2 diabetes mellitus (Fox et al., 2006). In 2010, the U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, reported that 18.8 million people in the United States were diagnosed with type 2 diabetes (CDC, 2011). Chronic hyperglycemia, or elevated blood glucose levels, associated with both type 1 and 2 diabetes, has a negative impact on cardiovascular health. This, along with other complications associated with diabetes, makes diabetes a risk factor for cardiovascular disease (Grundy et al., 1999). The increased risk associated with diabetes is so severe that adults with type 2 diabetes are two to four times more likely to die of cardiovascular disease than adults without diabetes (CDC, 2011).
The American Diabetes Association (2011) defines diabetes mellitus as a group of metabolic diseases characterized by hyperglycemia (high blood sugar) resulting in defects in insulin secretion, insulin action, or both (American Diabetes Association, 2011). In general, two main types of diabetes, type 1 and type 2, encompass the majority of diabetes cases in the United States. Type 1 diabetes is characterized by a total lack of pancreatic insulin production and is the result of a genetic autoimmune process that attacks the insulin producing β-cells of the pancreas. This type of diabetes, also referred to as juvenile-onset diabetes or insulin-dependent diabetes, accounts for a very small proportion (5-10%) of the total cases of diabetes. Type 2 diabetes, which accounts for 90-95% of diabetes cases, is caused by the simultaneous presence of resistance to insulin and dysfunctional secretion of insulin by pancreatic β-cells (American Diabetes Association, 2011).

Hyperglycemia serves as the prevalent diagnostic marker for type 2 diabetes; however, hyperglycemia increases gradually and can be asymptomatic until severely high levels are reached (Grundy et al., 1999). Physical symptoms of hyperglycemia and type 2 diabetes include frequent urination, extreme thirst, tingling or numbness in the extremities, weight loss, increased healing time of cuts and bruises, recurring infections, and blurred vision (American Diabetes Association, 2011). The American Diabetes Association (2011) accepts the following four methods for the diagnosis of diabetes; measure of hemoglobin A1C, fasting plasma glucose (FPG), 2-hour plasma glucose during an oral glucose tolerance test (OGTT), and a random plasma glucose reading in patients exhibiting signs of hyperglycemia.
Hemoglobin A1C is a reflection of blood glucose levels over a 2- to 3-month period. An A1C ≥ 6.5% equates to chronic high blood sugar and is a validating indicator for the presence of diabetes. This measure also serves as a method for tracking treatment progress, because it accurately reflects blood sugar levels over a period of time. A fasting plasma glucose measure ≥ 126 mg/dl and a 2-hour plasma glucose measure ≥ 200 mg/dl during an OGTT both indicate the presence of diabetes (American Diabetes Association, 2011). When individuals present with classic symptoms of hyperglycemia, a reading of ≥ 200 mm/dl from a random plasma glucose test can confirm the presence of diabetes quickly and effectively.

Most individuals diagnosed with type 2 diabetes are obese and/or have abdominal obesity, which may be the underlying cause of impaired insulin function and sensitivity (American Diabetes Association, 2011). Individuals with type 2 diabetes mellitus commonly exhibit the simultaneous presence of other cardiovascular disease risk factors including hypertension, and dyslipidemia (CDC, 2011). These conditions are also common in individuals with prediabetes, which is characterized by impaired fasting glucose (fasting plasma glucose of 100 mg/dl to 125 mg/dl), or impaired glucose tolerance (2-hour values in the oral glucose tolerance test of 140 mg/dl to 199 mg/dl; American Diabetes Association, 2011). Because the pancreatic β-cells are still able to produce insulin in type 2 diabetes, the presence of insulin resistance can remain undetected for a long time. Usually IFG is the first indication of insulin resistance which generally precedes the onset of diabetes (Grundy et al., 1999). This grouping of insulin
resistance, hypertension, central obesity, and dyslipidemia is commonly referred to as metabolic syndrome and extremely common in type 2 diabetics (Grundy et al., 1999).

Physical inactivity has also been linked to increased insulin resistance and metabolic syndrome (Albright et al., 2000). The American Heart Association (2010) recognizes that many of the health behaviors outlined for the reduction of cardiovascular risk, have also been independently proven to lower risk for developing type 2 diabetes. Of the seven health behaviors outlined by the American Heart Association (see Table 1), meeting the definition of just 3 of these behaviors (i.e., healthy BMI, healthy diet, and regular physical activity) can lower risk for developing type 2 diabetes by 88%. The addition of nonsmoking and moderate alcohol use can increase this to a 91% chance of not developing type 2 diabetes (Lloyd-Jones, Hong, et al., 2010).

Treatment of type 2 diabetes focuses largely on reduction of risk factors with the most emphasis placed on obesity and physical inactivity. Many risk factors for diabetes are independent risk factors for cardiovascular disease, and frequently appear simultaneously with type 2 diabetes. These include obesity, dyslipidemia, hypertension, physical inactivity, smoking, and glucose tolerance. This results in overlap in treatment recommendations for cardiovascular disease risk reduction and type 2 diabetes (Grundy et al., 1999). Therefore, the main treatment recommendation is to decrease weight and reach a healthy body composition through improved dietary intake and increased physical activity. This treatment plan targets the health factors that influence diabetes and cardiovascular disease both (dyslipidemia, hypertension, and glucose tolerance) allowing for simultaneous treatment of both conditions.
Moderate-intensity physical activity is recommended for individuals with type 2 diabetes mellitus because it is the most effective at lowering blood glucose during exercise and in the postexercise period (Albright et al., 2000). Studies have also demonstrated that moderate intensity physical activity is effective at reducing abdominal fat (Irving et al., 2008). Reduction in central obesity via diet and exercise is correlated with improved metabolic functioning and improved blood sugar control.

Stress

The American Heart Association and the National Heart Lung and Blood Institute recognize stress as a risk factor for cardiovascular disease. Stress can decrease adherence to cardiovascular intervention programs and is thought to be a predictor of relapse, especially to dietary therapy. For this reason behavior modification therapy focuses on ways to deal with stress, especially in relapse prevention (Byrd-Bredbenner et al., 2011). Yoga, a form of exercise that is based on mind and body relaxation, can be used to decrease stress. Yoga involves breathing techniques and meditation to relax muscles of the body, and to reduce stress. Stretching and diaphragmatic breathing has been implicated in the relaxation of muscles and sense of overall well being (Jayasinghe, 2004). Slow breathing, a practice common to yoga, has been linked to better cardiac rhythms and enhanced heart rate variability. These techniques are sometimes referred to as mindfulness-based stress reduction (MBSR). It has been suggested that the practice of yoga may contribute to reduced cardiac risk, especially in individuals with overweight and obesity. This may be due to the reduction in relapse as a result of stress. While there
are studies that report significant reductions in cardiovascular risk associated with yoga, the causal data is limited and therefore somewhat inconclusive (Jayasinghe, 2004).

Treatment Options

The cost for cardiovascular disease in 2010 was estimated at $177.1 billion dollars (Lloyd-Jones, Hong, et al., 2010). Reduction of risk factors for cardiovascular disease could have a substantial effect on the overall cost and mortality rates associated with cardiovascular disease. Individuals who maintain ideal cardiovascular health behaviors into middle age have much lower health care costs than those that do not. Specifically the average annual charges for men and women who maintained ideal cardiovascular health behaviors into middle age verses those that did not, were reduced by two thirds ($1,615) and one half ($1,885) respectively (Daviglus et al., 1998).

According to the National Heart Lung and Blood Institute and the American Heart Association, eliminating all major forms of cardiovascular disease, by effectively treating risk factors, could increase life expectancy by 7 years (Anderson et al., 1991; Lloyd-Jones, Adams, et al., 2010). In order to accomplish this, treatment approaches that target all risk factors should be employed. Specially, interventions that focus on achieving the lifestyle recommendations outlined by the American Heart Association should be the primary goal of therapy. These types of treatment programs are generally referred to as “lifestyle ” treatments because it is important to recognize that there are multiple components necessary to achieving ideal cardiovascular health (Lichtenstein et al., 2006).
In general, maintaining a healthy diet and being physically active are key components to achieving, reducing, and preventing almost all cardiovascular risk factors (Lichtenstein et al., 2006). The NHLBI (1998) recommends combining physical activity, dietary therapy, and behavior modification because these treatment options are the most effective means of achieving weight loss, which is a leading contributor to almost all risk factors associated with cardiovascular disease (NHLBI, 1998). Studies have also found that the combination of diet and physical activity increases the ratio of lean mass to fat mass. Specifically, incorporating an exercise training program with dietary therapy can reduce the amount of fat-free mass lost by almost 50% (Ballor & Poehlman, 1994). The combination of physical activity and diet therapy also has greater effects on mobilization and loss of visceral adipose tissue, a key risk factor in cardiovascular disease and metabolic dysfunction (Albright et al., 2000). Table 13 outlines the results of recent studies that have implemented multidisciplinary lifestyle interventions that combine diet and exercise to achieve reduction of risk factors for cardiovascular disease.
Table 13

Results of Multidisciplinary Interventions to Treat Risk Factors for Cardiovascular Disease

<table>
<thead>
<tr>
<th>Author</th>
<th>Participants/ health status</th>
<th>Exercise</th>
<th>Nutrition</th>
<th>Behavior modification</th>
<th>Timeline</th>
<th>Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aizawa, Shoemaker, Overend, &amp; Petrella, 2009</td>
<td>• n=63 • 53.9±8.7 yoa • Metabolic syndrome* • Pre hypertension • Pre-diabetes</td>
<td>• 30 minutes • ≥4days/week • Mod Int</td>
<td>• Mediterranean-style diet • Kcal/day prescription by physician</td>
<td>• Stages of change** • SNAC intervention</td>
<td>• 24 Weeks • Ontario, CA • 2008</td>
<td>• Significant ↓ in: waist circumference, blood pressure, fasting glucose</td>
</tr>
<tr>
<td>Arrebola et al., 2011</td>
<td>• n= 27 • 18-50 yoa • Grade II overweight • Grade I-II nonmorbid obese</td>
<td>• 30 Minutes • ≥3days/week • Mod Int</td>
<td>• ↓500-1000 kcal/day • 50-55% C • 15-20% P • &lt;30-35% F</td>
<td>• 11 sessions • 2 per month • Nut &amp; phys act Edu • Psych supp</td>
<td>• 6 months • Madrid, ES • 6-12/2008</td>
<td>• Significant ↓ in: weight, BMI, waist circumference, body fat %</td>
</tr>
<tr>
<td>Blumenthal et al., 2010</td>
<td>• n=49 • 52 mean yoa • Overweight • Obese • High BP</td>
<td>• 45 minutes • 3 days/week • 70-85% max HR</td>
<td>• ↓500 kcal/day • DASH</td>
<td>• Weekly • Cognitive-Behavioral Weight Loss</td>
<td>• 4 months • 10/29/03-7/28/2008</td>
<td>• Significant ↓ in: blood pressure, weight</td>
</tr>
<tr>
<td>Author</td>
<td>Participants/health status</td>
<td>Exercise</td>
<td>Nutrition</td>
<td>Behavior modification</td>
<td>Timeline</td>
<td>Results</td>
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</tr>
</tbody>
</table>
| Chen et al., 2009 | • n=29  
   • 44±10.5 yoa  
   • Obese  
   • Overweight | • 60 minutes  
   • 2  
   days/week  
   • Jogging  
   • 10,000  
   steps/day | • 1200  
   Kcal/day | • Diet Edu | • 3 months  
   • 4-11/2006  
   • Taiwan | • Significant ↓: weight, BMI, waist circumference, hip cir, TC, LDL-C, triglycerides, blood pressure, fasting insulin,  
   • No significant inc in HDL-C |
| Cocco & Pandolfi, 2011 | • n=44  
   • 59±4 yoa  
   • Hypertensive | • 20 mins x  
   2/day  
   • 5  
   days/week  
   • 80%  
   VO2max | • 1500  
   kcal/day | • Nut Edu | • 6 months | • Significant ↓: weight, blood pressure, |
| Eriksson, Westborg, & Eliasson, 2006 | • n=75  
   • 55.3±6.9 yoa  
   • Hypertension  
   • Dyslipidemia  
   • TIID  
   • Obesity | • 40-60mins  
   • 3  
   days/week | • 5 group  
   sessions/dietitian | • 3 monthly  
   physiotherapist  
   meetings | • 12 months  
   • Boden, SE | • Significant ↓ in: weight, blood pressure, waist circumference, hip circumference, LDL-cholesterol, triglycerides,  
   • Significant inc ↑ in VO2 max |
(Table 13, continued)

<table>
<thead>
<tr>
<th>Author</th>
<th>Participants/health status</th>
<th>Exercise</th>
<th>Nutrition</th>
<th>Behavior modification</th>
<th>Timeline</th>
<th>Results</th>
</tr>
</thead>
</table>
| Goodpaster et al., 2010 | • n=130  
• 46.1±6.5 yoa  
• Hypertension  
• Dyslipidemia  
• TIID  
• Obesity | • 60 mins/day  
• 5 days/week  
• 10,000 steps/day  
• Mod Int | • 1200-2100kcal  
• 50-55% C  
• 20-25% P  
• 20-30% F | • 1st 6 mos-3 group meetings, 1 ind/month  
• 2nd 6 mos-2 group sessions, 1 ind/month | • 12 months  
Pittsburgh, PA | • Significant ↓ in: weight, waist circumference, abdominal fat, blood pressure, insulin resistance |
| Jordan et al., 2008 | • n=60  
• 27.5 avg. yoa  
• Overweight  
• Obese | • Supervised 30min; 1 day/week  
• Encouraged: 45 mins, ≥3/week | • 1200-1500kcal/day | • Social cognitive theory*** | • 6 months  
Austin, TX | • Significant ↓ in: weight, body fat%, waist circumference |
| Lutes et al., 2008  | • n=59  
• 39.8 avg yoa  
• Overweight  
• Obese  
• Sedentary lifestyle | • Supervised: 40-45 mins; 2 days/week  
• Encouraged: 30 mins ≥4/week | • 1600-2000kcal/day | • Didactic behavioral counseling – 20 mins/weekly | • 16 weeks  
2002  
Virginia, USA | • Significant ↓ in: weight, waist circumference, abdominal fat |
(Table 13, continued)

<table>
<thead>
<tr>
<th>Author</th>
<th>Participants/health status</th>
<th>Exercise</th>
<th>Nutrition</th>
<th>Behavior modification</th>
<th>Timeline</th>
<th>Results</th>
</tr>
</thead>
</table>
| Oh et al., 2010     | • n=31  
• 49-70  
• Metabolic syndrome | • 1st 3 months: 40 mins; 3 days/week  
• 2nd 3 months: 40 mins; 2 days/week | • 1500 kcal/day  
• 55-60% C | • TLM  
• 1st 3 months 3 meetings/month  
• 2nd 3 months 2 meetings/month | • 6 mos  
• Korea | • Significant ↓ in: weight, waist circumference, BMI |
| Kim et al., 2006    | • n=32  
• 55.0±8.1 yoa  
• T2D | • 150 min/week  
• 40-60% VO2max | • Dietitian mediated | • Nut Edu  
• PA Edu  
• Health coach | • 6mos  
• Seol, Korea | • Significant ↓ in: weight, BMI, blood pressure, plasma glucose, HbA1c |

*Note.* Yoa, years of age; Mod Int, moderate intensity; C, carbohydrates; P, Protein; F, Fat; Mos, months; Edu, education; Nut, nutrition; PA, physical activity, SNAC=Staged Nutrition and Activity Counseling; VO2max, maximal oxygen capacity; ↓, reduction; TC, total cholesterol; *Metabolic syndrome is defined by the NHLBI by the presence of three or more of the following: waist circumference ≥ 102cm in men and ≥ 88 cm in women; triglyceride levels ≥ 1.69 mmol/L; HDL cholesterol levels <1.04mmol/L in men and 1.29 mmol/L in women; fasting plasma glucose levels ≥ 5.60 mmol/L; and Systolic blood pressure ≥130 and/or diastolic blood pressure ≥85mmHg (S. Grundy et al., 2005)**Stages of change (Prochaska & DiClemente, 1983)**Social cognitive theory (Bandura, 2004).
The studies outlined in Table 13 above are significant because they represent the application of cardiovascular treatment options being applied in wellness and clinical settings today. All of these studies target risk factors for cardiovascular disease including overweight and obesity, metabolic syndrome, hypertension, high cholesterol levels, type 2 diabetes, smoking, and physical inactivity. These studies demonstrate the application of recommended dietary interventions such as reduced caloric intake to reduce body weight (NHLBI, 1998), Therapeutic Lifestyle Changes (NHLBI, Adult Treatment Panel III, 2002), DASH diet (Sacks et al., 2001), Mediterranean-style diet (de Lorgeril et al., 1999) in clinical rather than population-based settings. Many of the studies employed behavior modification techniques including the stages of change (Prochaska & DiClemente, 1983) and social cognitive theory (Bandura, 2004).
CHAPTER 3: METHODS

The purpose of the study was to evaluate the efficacy of the RRP on risk factors for cardiovascular disease in an at-risk population after the first 100 days of treatment. Table 2 outlines the specific research questions and hypothesis for this study. Prior to the collection of any data, approval was obtained from the Institutional Review Board of Ohio University, Athens, Ohio. This study utilized a subset of data pooled from nine cohorts of individuals participating between 2006 and 2010 in the RRP.

Participants

Qualifying subjects for this study comprised a convenience sample of Ohio University faculty, staff, and their dependents that were classified as being at risk for cardiovascular disease and participating in the RRP. Individuals in RRP must have presented with lifestyle diseases or behaviors that were classified as risk factors for cardiovascular disease, such as coronary artery disease, diabetes, high blood pressure, cigarette smoking, dyslipidemia, stress, sedentary behavior, or obesity. Participants were identified by a referring physician or recruited by material sent out by WellWorks, Ohio Universities staff and faculty health and wellness center. The participants were required to partake in all scheduled exercise, dietary instruction, yoga, and group support classes scheduled by the interdisciplinary team in order to remain eligible for treatment.
Structure of the RRP Program

Throughout the RRP an interdisciplinary team of experts including an Exercise Physiologist, Physician, Registered Dietitian, Certified Physical Trainer, Certified Yoga instructor, and Health Coordinator oversaw the participants. Subjects were treated using a multidisciplinary approach that incorporated a tailored exercise regimen, stress reduction via yoga classes, and individualized dietary education to reduce aforementioned risk factors. These thesis data are from the portion of the RRP that lasted for 100 days (≈15 weeks). Week 1 included completion of a written medical history form, blood work for lipid and glucose levels, a physical assessment including lung function and body composition (utilizing waist circumference and BOD POD [Life Measurement Inc., Concord, CA, USA]), and an exercise stress test that determined VO₂ max. A number of instruments were used in the study to collect personal and objective information. These included the Risk Reduction Program Demographic Information Form, medical history form, and 3-day food recall.

Body composition (body weight, percent body fat, lean weight, fat weight, and BMI) was measured via air displacement plethysmography (ADP) using The BodPod Gold Standard (Life Measurement Inc., Concord, CA, USA) according to standard methods (Dempster & Aitkens, 1995). In summary, the machine was first calibrated using a two-point calibration system by taking a measurement at baseline (chamber empty) and then placing a 50-liter calibration cylinder in the chamber. Each participant wore a tightly fitting swimsuit, swim cap, and nose clip during the procedure. The
participant was first weighed on a calibrated scale and then asked to enter the chamber where they were required to sit upright. The door was then closed so an initial measurement could be obtained. During the first measurement the subject relaxed and breathed normally in the chamber for 50 seconds. This measurement was repeated at least twice and accepted if the body volume measurements agreed within 150 ml. After the base volume measurement was obtained, the door was opened, and the participant was attached to the system’s breathing circuit, and the door was reclosed. The second measurement was then performed to assess 1/3 of the functional residual capacity (FRC), the amount of air that remains in the lungs after normal respiration. This measurement completed the testing procedure and allowed the determination of body composition (percent fat, fat mass, and fat-free mass).

A certified exercise physiologist measured waist circumferences using a calibrated self-retractable no-stretch measuring tape (The Gulick II, model 67020; Gays Mills, WI) equipped with a 4-oz tension indicator. Participants were asked to wear tight fitting clothing and to stand with feet slightly apart, arms hanging loosely, for the midriff measurement. Waist circumference (in), which is in different locations for men and women, was measured at the narrowest point between the iliac crest and the lowest rib. The measuring tape was placed horizontally around the participant’s waist, perpendicular to the long axis of the body, and the measurement was taken after exhalation. The tension indicator was utilized to ensure conformation of the measuring tape to the participant’s skin surface.
Maximal oxygen uptake, VO$_2$ max (mL/kg/min) was predicted from a maximum treadmill stress test using the Bruce protocol (Bruce, Kusumi, & Hosmer, 1973). This protocol begins at 1.7 mph and 10% grade (4 METs) and increases the speed and grade of the treadmill at 3-minute intervals (a 3 metabolic equivalent, MET, increase per stage) until the participant reaches fatigue. The participants were permitted to place one or two fingers on the handrails for balancing purposes, however using the handrails for body weight support was not. The study physician used a standard 12-lead electrocardiogram (ECG) to monitor cardiac function throughout the protocol. Each participant was asked to exercise to maximum volitional exhaustion, during which time heart rate and rating of perceived exertion (RPE) were measured. A regression equation was then used to predict VO$_2$ max (mL/kg/min), which took into account the time exercised and maximum RPE.

Blood pressure measurements were recorded in millimeters of mercury (mm Hg) and obtained using a Welch Allyn sphygmomanometer (part number 5098-02; Skaneateles Falls, NY) and Welch Allyn stethoscope (part number 5079-73; Skaneateles Falls, NY). Certified physical trainers and exercise physiologists performed resting blood pressure measurements. Participants were asked to sit and the blood pressure cuff was placed approximately 1 inch above the bend of the elbow. After inflation of the cuff, both systolic and diastolic blood pressure measurements were obtained using standard methods outlined by the American Heart Association (Bordley, Connor, Hamilton, Kerr, & Wiggers, 1951).
Lipid and glucose levels were measured after 12-hour overnight fast by intravenous blood sample. Blood samples were drawn via venipuncture by a certified phlebotomist using the approved method outlined by the Clinical and Laboratory Standards Institute (CLSI; Ernst & Clinical and Laboratory Standards Institute, 2007). This procedure involves application of a tourniquet to determine location, size, depth and direction of vein via palpation and sterilization of the injection site. A BD-Vacutainer® Eclipse™ Blood Collection Needle with Pre-Attached Holder consisting of a 1½ inch 21 gage safety needle was used to collect 5mL of blood into a serum separator tube (Garvin, 2000). A certified testing facility, the Athens Medical Lab, Athens OH, analyzed the blood samples using a Johnson and Johnson Ortho-Clinical Diagnostic Vitros® 350 Chemistry System. This system employs a dry-slide method for determining glucose (Ortho-Clinical Diagnostics, 2009b), total cholesterol (Ortho-Clinical Diagnostics, 2009a) HDL cholesterol (Ortho-Clinical Diagnostics, 2009c), and triglyceride (Ortho-Clinical Diagnostics, 2009d) content of centrifuged serum samples, the chemistry of which is outlined in Allain et al. (1974) and Crume et al. (1978). LDL cholesterol levels are determined mathematically by using the results of the total cholesterol, HDL cholesterol, and triglyceride Vitros® DT slides. First the VLDL concentration must be determined by dividing total triglycerides by 5 to get mg/dL of VLDL (VLDL = TRIG/5). Once the VLDL cholesterol content is determined, HDL cholesterol and VLDL cholesterol are subtracted from total cholesterol to yield LDL cholesterol (LDL = TC-HDL-VLDL; Ortho-Clinical Diagnostics, 2009c).
Weeks 2-15 involved a review of baseline medical tests, and establishment of initial physical activity goals. Participants set SMART (specific measurable action-oriented realistic and time-bound) goals with a case manager to review needs and design an appropriate exercise program. Each plan was individualized to meet the participant’s goals. Participants continued to engage in assisted exercise with a certified personal trainer 2-3 times weekly for 1 to 1.5 hours of endurance (aerobic) and resistance training. Furthermore, participants were required to attend an hour of facilitated group support each week, 2 hours of yoga/stress management each week with a certified instructor, and an hour of group nutritional counseling with a registered dietitian 3 times during the first 100 days. Table 14 summarizes the content of the three group nutritional counseling sessions.
Table 14

**RRP Group Nutrition Counseling Session Content**

<table>
<thead>
<tr>
<th>Session</th>
<th>Theme</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Session 1</td>
<td>• Introduction to DASH-like diet</td>
<td>• Whole grains, fruits, vegetables, legumes, nuts, low-fat dairy,</td>
</tr>
<tr>
<td></td>
<td>• Identifying and choosing fats wisely</td>
<td>• Ca+, Mg, K+, Fiber,</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Types/sources of fat</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• low fat alternatives</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• How to decrease discretionary kcals</td>
</tr>
<tr>
<td>Session 2</td>
<td>• Mediterranean meal planning for Heart</td>
<td>• Omega-3 fatty acid sources</td>
</tr>
<tr>
<td></td>
<td>Health</td>
<td>• Nutrition label reading</td>
</tr>
<tr>
<td></td>
<td>• Increase Protein, Decrease Fat</td>
<td>• Decreasing sodium</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Plant based protein sources</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Meal planning techniques</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Vegetarian meal options</td>
</tr>
<tr>
<td>Session 3</td>
<td>• Portion Control</td>
<td>• Eating out techniques</td>
</tr>
<tr>
<td></td>
<td>• Holiday/Special Occasion Eating</td>
<td>• Identifying high risk situations</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Relapse prevention</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Portion management</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Staying active</td>
</tr>
</tbody>
</table>

The group nutritional counseling sessions focused on heart healthy DASH like and Mediterranean-like dietary recommendations. Behavioral modification therapy techniques were used including motivational interviewing, the stages of change, and cognitive behavioral therapy throughout group and individual sessions. A registered
dietitian provided participants with dietary intake goals based on individual need with a focus on decreased calories (-500 to -1000 kcals) for weight loss and specific macro- and micronutrient intake goals based on DASH, Mediterranean diet recommendations, and age-specific RDA’s. Participants were asked, but not required, to keep 24-hour food records for 3 days (2 week days and 1 weekend day) after each group and individual meeting to assess intake. All food records were reviewed by the registered dietitian and entered into Nutritionist Pro™ (First Data Bank, San Bruno, CA, USA) for analysis. Participants also made SMART goals based on nutrient intake after each session. General dietary guidelines were as follows: incorporate a) at least 4-5 servings of vegetable, b) 2-4 servings of fruit, and c) 3 servings of low fat dairy; d) make at least half of your grains whole grains, e) decrease saturated and transfat intake, f) increase poly- and monounsaturated fat intake, and g) increase vegetarian meals made with beans, nuts and seeds.

Additional nutritional counseling was provided on an individual basis during the first 100 days. This consisted of an initial 1-hour intake session to determine individual goals and eating plans which was followed up 7 to 14 days later with a ½ hour session to determine progress. The registered dietitian then determined how often additional half-hour sessions were needed and scheduled individual sessions on a weekly or biweekly basis. Weight was used to track progress. Dietary intake patterns were analyzed using Nutritionist Pro™ (First Data Bank, San Bruno, CA, USA). Behavior modification therapy, motivational interviewing, the stages of change, and cognitive behavioral therapy were also applied in individual nutrition counseling sessions. The final week,
week 15, involved retesting of previously performed tests from week 1. These samples were collected and analyzed in the same manner as week 1.

Data Collection

The measurements obtained at week 1 were compared with the measurements obtained at week 15 to determine the effect of the program after 100 days of treatment. Specifically, the data from nine cohorts, which completed the program during 2007 through 2010, were pooled. The study consisted of 72 adults (53 females and 19 males) that completed the study. The median age of participants was $49.1 \pm 8.6$ with no participant under the age of 28 or over the age of 70. Paired t-tests were utilized to assess for changes from baseline to 100 days of participation. Table 15 summarizes the research questions posed in Chapter 1. Table 16 summarizes the variables measured during the study.
Table 15

*Statistical Methods Used to Answer Research Questions*

<table>
<thead>
<tr>
<th>Research question</th>
<th>Statistical method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. What is the effect of the RRP on body weight, percent body fat, lean weight, fat weight, BMI, VO₂ max, and waist circumference from pre-program measures to 100 days of participation?</td>
<td>Paired t-test</td>
</tr>
<tr>
<td>2. What is the effect of the RRP on total, HDL, and LDL cholesterol levels, triglycerides, blood pressure, and glucose levels from pre-program measures to 100 days of participation?</td>
<td>Paired t-test</td>
</tr>
</tbody>
</table>
CHAPTER 4: RESULTS

In the United States, cardiovascular disease accounts for more deaths in adults over the age of 35 than all other major diseases (Lloyd-Jones, Hong, et al., 2010). It is estimated that 2,300 Americans die from cardiovascular disease each day (CDC, 2010), and another 81,100,000 Americans currently live with at least one form of cardiovascular disease (Lloyd-Jones, Adams, et al., 2010). The American Heart Association’s Strategic Impact Goal Through 2020 and Beyond is striving to address this major health care problem by defining and implementing new strategies for the improvement of cardiovascular health ((Lloyd-Jones, Hong, et al., 2010). The present research for this thesis was designed to determine the effectiveness of a multidisciplinary treatment program that combined all treatment variables recommended by the American Heart Association (dietary intake and exercise), plus stress management techniques and behavior modification counseling, to reduce the prevalence and mortality rates caused by cardiovascular disease. Specifically, the RRP in the present research study combined a tailored exercise regimen, stress reduction via yoga classes, and individualized dietary education. The purpose of this study was to evaluate the efficacy of the RRP on risk factors for cardiovascular disease in an at-risk population after the first 100 days of treatment.

Participant Demographics

A pooled convenience sample of 72 adults who participated in the RRP from 2006 through 2010 were participants in this study. The mean age of participants was
49.1±8.6 years with no participant under the age of 28 or over the age of 70. Figures 1 and 2 summarize the demographics of the study participants. A total of 53 females (73.6%) and 19 males (26.4%) enrolled in this study. Figure 1 illustrates the gender and number of participants from each of the nine cohorts utilized in this study. Figure 2 illustrates the age ranges and gender of the aforementioned pooled convince sample.

![Figure 1. Gender and number of participants in RRP from 2006-1010 grouped by cohort.](image-url)
Table 16 summarizes the variables measured during the study. As Table 16 demonstrates, the following measurements significantly decreased from baseline to 100 days of treatment: weight (p < .001), % body fat (p < .001), fat mass (p < .001), BMI (p < .001), waist circumference (p < .001), total (p < .001), HDL (p = .026), and LDL (p < .001) cholesterol levels, triglycerides (p = .004), glucose (p = .013), relative VO$_2$ max (p < .001), and blood pressure (systolic, p = .001; diastolic, p < .001). Lean body mass was the only measurement that did not significantly change (p > .05) during the study period (100 days).
Table 16

*Results of Multidisciplinary Intervention Program on Body Composition Parameters From Baseline to 100 Days of Treatment*

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>n</th>
<th>Baseline</th>
<th>100 Days</th>
<th>Absolute change</th>
<th>% Change</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>72</td>
<td>49.1 ± 8.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (lbs)</td>
<td>72</td>
<td>213.48 ± 45.7</td>
<td>203.59 ± 46.53</td>
<td>-9.52 ± 7.45</td>
<td>4.43 ± 3.43</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>69</td>
<td>33.64 ± 6.79</td>
<td>32.23 ± 6.69</td>
<td>-1.46 ± 1.19</td>
<td>4.37 ± 3.64</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Waist circumference (in)</td>
<td>67</td>
<td>40.77 ± 6.97</td>
<td>38.52 ± 6.45</td>
<td>-2.25 ± 1.77</td>
<td>5.37 ± 4.09</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Body composition</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% Body fat</td>
<td>69</td>
<td>43.33 ± 8.28</td>
<td>40.71 ± 9.05</td>
<td>-2.62 ± 2.22</td>
<td>6.52 ± 6.44</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Fat mass</td>
<td>72</td>
<td>94.52 ± 31.20</td>
<td>84.81 ± 30.99</td>
<td>-9.27 ± 6.30</td>
<td>10.53 ± 8.32</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Lean mass</td>
<td>72</td>
<td>118.94 ± 23.99</td>
<td>118.75 ± 23.98</td>
<td>-0.25 ± 3.53</td>
<td>0.13 ± 2.91</td>
<td>&gt; .05</td>
</tr>
<tr>
<td>Cholesterol (mg/dL)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>63</td>
<td>193.68 ± 36.21</td>
<td>179.14 ± 36.32</td>
<td>-14.54 ± 19.32</td>
<td>7.25 ± 9.84</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>HDL</td>
<td>72</td>
<td>50.54 ± 13.40</td>
<td>48.10 ± 11.99</td>
<td>-1.92 ± 6.68</td>
<td>2.33 ± 14.09</td>
<td>.026</td>
</tr>
<tr>
<td>Blood pressure (mm Hg)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic</td>
<td>69</td>
<td>135.13 ± 16.46</td>
<td>129.30 ± 15.72</td>
<td>-5.83 ± 1.66</td>
<td>3.78 ± 10.19</td>
<td>.001</td>
</tr>
<tr>
<td>Diastolic</td>
<td>71</td>
<td>83.38 ± 9.58</td>
<td>79.45 ± 9.51</td>
<td>-4.35 ± 9.48</td>
<td>4.55 ± 11.41</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>
(Table 16, continued)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>n</th>
<th>Baseline</th>
<th>100 Days</th>
<th>Absolute change</th>
<th>% Change</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Triglycerides (mg/dL)</td>
<td>63</td>
<td>136.97±87.61</td>
<td>113.06±54.34</td>
<td>-23.90 ± 63.45</td>
<td>10.61 ± 25.55</td>
<td>.004</td>
</tr>
<tr>
<td>Glucose (mg/dL)</td>
<td>61</td>
<td>100.87±31.25</td>
<td>94.07±17.02</td>
<td>-6.80 ± 20.76</td>
<td>4.46 ± 11.34</td>
<td>.013</td>
</tr>
<tr>
<td>Relative VO$_2$ max (mL/kg/min)</td>
<td>69</td>
<td>28.05±5.00</td>
<td>32.09±5.32</td>
<td>+4.04±2.22</td>
<td>14.98 ± 8.61</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

*Note.* Data are means ± standard deviation; BMI = Body mass index; HDL = High-density lipoprotein; LDL = low-density lipoprotein; VO2 Max = Maximal oxygen consumption.
CHAPTER 5: DISCUSSION

The purpose of this study was to evaluate the efficacy of the RRP on risk factors for cardiovascular disease in an at-risk population after the first 100 days of treatment. The results support this multidisciplinary lifestyle intervention program as effective in reducing cardiovascular disease risk factors among adult participants during their first 100 days of treatment in the program. This study is unique because of the relative short duration of this program (100 days), the multidisciplinary nature of the intervention, the pooled sample of men and women, and the outcome measures used. The results of this study are similar to those of other multidisciplinary cardiovascular risk reduction programs, suggesting that a multidisciplinary approach to risk reduction is an effective method of treatment.

Effect of the RRP on Body Weight, % Body Fat, Lean Weight, Fat Weight, BMI, Waist Circumference, and VO\textsubscript{2} Max

The first aim of this study was to determine the effect of the RRP on body composition measures including: body weight, percent body fat, lean weight, fat weight, BMI, waist circumference and VO\textsubscript{2} max, from preprogram measures to 100 days of participation. It was hypothesized that the RRP would have a positive effect on these variables from preprogram measures to 100 days of participation. Because all of these parameters relate to cardiovascular disease risk, findings of significant improvements equate to improvements in cardiovascular health, and decreased risk for cardiovascular disease. As Table 16 demonstrates, significant improvements were observed in all
aforementioned body composition parameters except lean body mass, which supported the hypothesis that the RRP had a positive impact on body composition parameters related to cardiovascular disease risk factors.

The RRP participants demonstrated a significant reduction in body weight ($p < 0.001$) after 100 days of treatment. The average change in total body weight was $-9.52 \pm 7.45$ lbs, or an average reduction of $4.43 \pm 3.43\%$. The NHLBI (1998) recommends achieving a 9% reduction in body weight after 6 months of treatment (NHLBI, 1998). The 4.4% reduction observed in the RRP places the participants on track to meet this goal and further demonstrates the effect of the program on body weight. The amount of weight loss in this study is an affirmation of the effectiveness of recommendations to combine dietary therapy with physical activity to increase weight loss (NHLBI, 1998). Similar reductions in body weight were seen in other multidisciplinary studies (Aizawa, Shoemaker, Overend, & Petrella, 2009; Arrebola et al., 2011; Chen et al., 2009; Cocco & Pandolfi, 2011; Goodpaster et al., 2010; Jordan et al., 2008; Kim et al., 2006; Oh et al., 2010), further supporting the combination of dietary therapy and exercise training.

Interestingly, when compared to many studies, the RRP produced a similar percentage of weight loss ($4.43 \pm 3.43\%$) in a shorter amount of time (see Table 16). Other studies also reported greater weight loss in female subjects verses male subject (Arrebola et al., 2011).

After 100 days of treatment in the RRP, a significant decrease in fat mass $-9.27 \pm 6.30$ lbs was observed. In addition to this $10.53 \pm 8.32\%$ change, the RRP did not result in a significant reduction in lean body mass ($p > .05$) $-0.25 \pm 3.53$. These results are
consistent with results from Miller, Koceja, and Hamilton, 1997, who reported that individuals participating in programs combining diet and exercise lost greater amounts of fat mass than those participating in programs consisting of just one intervention variable alone. The preservation of lean mass during weight loss is beneficial to cardiovascular health and is consistent with results from other studies. A meta-analysis by Ballor and Poehlman, 1994, reported the addition of exercise training to diet-induced weight loss reduced the amount of fat-free mass lost from 25% to 12.5% in adult men and women. In a more recent study by Hunter et al. (2008), 94 overweight African-American and European-American women found that resistance training conserved fat-free mass after weight loss. A systematic review by Weinheimer, Sands, and Campbell (2010) assessed the results of exercise-only, energy restriction-only, and exercise + energy restriction interventions, on the body composition of overweight and obese adults. The results supported that the exercise-only intervention had both the least amount of body weight loss and the most preserved fat free mass (Weinheimer et al., 2010). These results enhance the theory that exercise plays a substantial role in preserving and maintaining lean body tissue during weight loss. This phenomenon is associated with reduced risk for cardiovascular disease (Hill & Wyatt, 2005).

Improvements in body composition, as a result of the RRP, are further confirmed by the significant decreases in BMI -1.46 ± 1.19 kg/m², waist circumference -2.25 ± 1.77 in, and body fat % -2.62 ± 2.22%. The accuracy of BMI as an individual marker for adiposity is questionable (Frankenfield, Rowe, Cooney, Smith, & Becker, 2001; Gomez-Ambrosi et al., 2011; Romero-Corral et al., 2008). However, the relationship between
increased BMI and mortality rates associated with cardiovascular disease is well documented (Must et al., 1999). Waist circumference, a measure of abdominal adiposity, is more closely associated with percentage of body fat than BMI (Yusuf et al., 2004). However, the significant reduction of the percentage of body fat, waist circumference, and BMI observed in the RRP suggests a decrease in adiposity as well as central obesity (Flegal et al., 2009). Reduction of overweight and obesity (particularly central adiposity) is associated with improved metabolic functioning, resulting in reduced risk for type 2 diabetes, metabolic syndrome, hypertension, dyslipidemia, and ultimately, cardiovascular disease (Alberti et al., 2009; Klein et al., 2004; Must et al., 1999). Similar results were seen in other multidisciplinary studies further supporting improved cardiovascular disease risk (Aizawa, Shoemaker, Overend, & Petrella, 2009; Chen et al., 2009; Oh et al., 2010),

The measurement of VO2 max is considered the gold standard for determination of cardiorespiratory fitness. The results of this study indicated a significant improvement (p < .001) in VO2 max. Improvements in cardiovascular health, as well as physical fitness, result in improvements in VO2 max. In this study, VO2 max increased as a result of exercise training from 28.05±5.00 to 32.09±5.32 ml/kg/min. This equates to about a 14.40% increase and is similar to other multidisciplinary programs (Aizawa et al., 2009; Eriksson, Westborg, & Eliasson, 2006). A similar study that included a DASH plus weight management intervention reported a 19% increase in VO2 max after 4 months of treatment (Blumenthal et al., 2010), which leads to the stipulation that the RRP participants will continue to improve. The HERITAGE Family Study, a study of the role
of genotype in response to aerobic exercise training, showed that among sedentary adults, VO2 max is up to 50% genetically influenced. Results of the HERITAGE Family Study also demonstrated that changes in VO2 max, in response to exercise training, are up to 47% genetically influenced (Bouchard et al., 1999). Deconditioned patients, and those with very low pretraining VO2 max values, generally demonstrate the largest increases in VO2 max in response to exercise training programs. The type of exercise training also has an effect on VO2 max. Studies have shown that endurance (aerobic) training results in the largest improvements in VO2 max (Valkeinen, Aaltonen, & Kujala, 2010).

Effect of the RRP on Total, HDL, and LDL Cholesterol Levels, Triglycerides, Blood Pressure, and Blood Glucose

Another aim of this study was to determine the effect of the RRP on total, HDL, and LDL cholesterol levels, triglycerides, blood pressure, and blood glucose levels. It was hypothesized that the RRP would have a positive effect on total, HDL, and LDL cholesterol levels, triglycerides, blood pressure, and glucose levels from preprogram measures to 100 days of participation. As all of these parameters relate to cardiovascular disease risk, findings of significant improvements would equate to improvements in cardiovascular health, and decreased risk for cardiovascular disease. As Table 16 demonstrates, significant reductions were observed in all aforementioned serum composition parameters. Significant reductions in triglycerides -23.90 ± 63.45 mg/dL, total cholesterol -14.54 ± 19.32 mg/dL, HDL-cholesterol -1.92 ± 6.68 mg/dL, and LDL cholesterol -7.92 ± 13.44 mg/dL, were observed after 100 days of treatment. The
reductions observed in triglycerides, total cholesterol, and LDL cholesterol are consistent with other risk reduction programs, and recommended for improved cardiovascular health (Chen et al., 2009; Eriksson, Westborg, & Eliasson, 2006). The decrease in HDL cholesterol, although not favorable to cardiovascular health, is not an unusual observation. A similar study designed to reduce cardiovascular disease risk in obese and overweight women by Chen et al. (2009) also reported a decrease in HDL-cholesterol (-3%; (see Table 16). These results are consistent with a meta-analysis of the effects of weight reduction on blood lipids and lipoproteins (Dattilo & Kris-Etherton, 1992), which summarized that active weight loss is associated with decreased levels of HDL cholesterol. Once weight reduction was stabilized, increases in HDL cholesterol levels (0.14 mmol/L) were observed. Because this study was only a measure of the first 100 days of the RRP, the participants are considered to be in active weight loss. Therefore, the decrease in HDL cholesterol level is not considered to be a sustained consequence of the risk reduction program. The INTERHEART study of 52 countries identified abnormal lipid composition (dyslipidemia) as the second most important risk factor associated with cardiovascular disease (Yusuf et al., 2004). The reductions in serum lipid and cholesterol levels achieved by the RRP are therefore significant to cardiovascular disease risk reduction.

The RRP program participants also demonstrated significant reductions in blood glucose levels after 100 days. An average decrease of -6.80 ± 20.76 mg/dL, or 4.46 ± 11.34% was observed. These results parallel those seen in similar multidisciplinary studies (Aizawa, Shoemaker, Overend, & Petrella, 2009; Chen et al., 2009; Goodpaster et
al., 2010; Kim et al., 2006; Oh et al., 2010). The American Diabetes Association (2011) recognizes that most people with type 2 diabetes, impaired insulin function, and those with prediabetes, are obese and/or exhibit abdominal obesity (American Diabetes Association, 2011). These findings also support recommendations from the American College of Sports Medicine, American Heart Association, and the American Diabetes Association that implicate physical activity and dietary therapy in the improvement of blood glucose levels (Albright et al., 2000; Grundy et al., 1999). The reduction of other cardiometabolic risk factors including overweight and obesity, weight circumference, high blood pressure, and dyslipidemia have also been linked to improved plasma glucose levels (American Diabetes Association, 2011; Chobanian et al., 2003; Grundy et al., 1999; NHLBI, Adult Treatment Panel III, 2002). A reduction in all of these parameters was observed in the RRP, which could also account for the improvements in plasma glucose levels.

Participants in the RRP demonstrated significant reductions in blood pressure (p = .001 systolic; p < .001 diastolic) levels after 100 days of treatment. These results are consistent with the results of The Trials of Hypertension Prevention, phase II study, which showed that weight loss, reduced sodium diet, and a combination of both, were effective in reducing systolic and diastolic blood pressure in overweight adults. After 6 months of treatment, the combined group (weight loss and reduced sodium diet) had the greatest reductions in systolic and diastolic blood pressure (The Trials of Hypertension Prevention Collaborative Research Group, 1997). The results of the RRP also support the recommendations set by the Seventh National Joint Committee (JNC-7) on Prevention,
Detection, Evaluation, and Treatment of High Blood Pressure by affirming the effectiveness of weight reduction, physical activity, and dietary interventions to reduce blood pressure (Chobanian et al., 2003). A similar study by Blumenthal et al. (2010; the ENCORE study) examined the effects of a multidisciplinary intervention on overweight and obese individuals with high blood pressure. This study reported greater blood pressure improvements in the DASH diet plus behavioral weight management intervention (SBP -16.1; DBP -9.9) than those that received the DASH intervention alone. Qualifying participants for this study were overweight and obese individuals with high blood pressure (Blumenthal et al., 2010).

Conclusions and Recommendations

Conclusions

This study was designed to determine the effectiveness of a multidisciplinary treatment program that combined all treatment variables recommended by the American Heart Association (dietary intake and exercise), plus stress management techniques and behavior modification counseling, to reduce the prevalence and mortality rates caused by cardiovascular disease. Specifically, the RRP combined a tailored exercise regimen, stress reduction via yoga classes, and individualized dietary intervention plus education. The purpose of the study was to evaluate the efficacy of the RRP on risk factors for cardiovascular disease in an at-risk population after the first 100 days of treatment. Although studies have been published that include all the treatment variables recommended by the American Heart Association, the inclusion of stress reduction
techniques via yoga classes in addition to the extensive array of biological measurements reported in this study makes the present RRP unique.

After 100 days of treatment, the RRP demonstrated significant increases in VO$_2$ max, preservation of lean body mass, and improvements in body composition (body weight, waist circumference, BMI, percentage of fat mass). The physical activity component of this multidisciplinary program was effective in improving cardiorespiratory fitness, which was demonstrated by the improvements in VO$_2$ max and preservation of lean body mass. The significant loss in body weight, decrease in waist circumference, and reduction in both BMI and percentage of body fat, further support the RRP as an effective intervention. These results also support the NHLBI’s recommendations for instituting multidisciplinary therapy to reduce overweight and obesity and obesity related risk. These results are also consistent with the American Heart Associations recommendations to achieve ideal cardiovascular health.

The significant improvements in total cholesterol, LDL cholesterol, triglyceride levels, and blood glucose also demonstrate the effectiveness of the dietary and physical activity interventions employed in the RRP described in this thesis. The significant decrease in HDL cholesterol should be viewed as an indication that participants are in an active weight loss state rather than a permanent consequence of the RRP. The reduction in total, LDL, and triglycerides observed in the RRP support recommendations from the Third Report of the National Cholesterol Education Program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (NHLBI, Adult Treatment Panel III). The reduction in cholesterol levels can also be explained by The
Lyon Heart Mediterranean diet study, which demonstrated the positive effect of mono and polyunsaturated fats on cholesterol levels, a part of the RRP dietary therapy (de Lorgeril et al., 1997). The combination of significant improvements in blood pressure and cholesterol are a reflection of the RRP’s physical activity intervention as well as Mediterranean and DASH-like dietary interventions. The RRP demonstrated significant improvements in systolic and diastolic blood pressure levels consistent with recommendations from the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. The RRP was a pooled sample of participants with various risk factors for cardiovascular disease; therefore not all participants demonstrated high blood pressure. Because individuals with higher blood pressure levels generally experience the greatest decreases from exercise and dietary therapy, the lower baseline blood pressure values could have impacted the amount of change. However, the reduction of both systolic and diastolic blood pressure supports the recommendations from Joint National Committee that physical activity and dietary intervention could be the sole method of treatment for those with slightly high blood pressure values. The positive effect on LDL and total cholesterol levels is an indication of improved metabolic functioning and overall cardiovascular health.

**Recommendations**

Several limitations were recognized in this study. While dietary instruction and nutrition prescription were provided, specific dietary intake could not be controlled, and all dietary intake was self-reported. Lack of precise information of dietary intake limits interpretation of the results. Due to the extreme time commitment of the program,
participants were allowed to schedule exercise and nutrition counseling appointments at varying times throughout the week. Frequency and duration were controlled for, but the parameters for exercise and nutrition counseling were set for a weekly basis, and exact days between sessions or appointments were not controlled. The dietary, nutrition, and stress reduction interventions were consistent in all participants; however, there was neither a control group nor a diet/exercise only intervention. This inhibited the comparison of the effectiveness of the RRP to no intervention, or diet/exercise alone.

While endothelial dysfunction is discussed as a major factor associated with cardiovascular disease pathology, the present study did not include a biological measure of endothelial dysfunction. This excluded endothelial dysfunction from the results interpretation. This is also true for the stress management portion of this multidisciplinary program. Although stress reduction was included in the intervention, there was no measure of stress reduction. Behavior modification therapy was utilized throughout the RRP; however, no there were no measures of behavior change.

Future studies should examine the effect of the year-long portion of this program to determine if significant improvements were maintained. Because the decrease in HDL levels were attributed to active weight loss in this study, future studies should measure HDL levels when participants are no longer in active weight loss to determine if levels improve. Future research should also examine measures of self-efficacy and established stages of behavior change to determine the effectiveness of these interventions. Dietary adherence through rigorous self-monitoring and daily weights should be included in future studies to better evaluate the role of dietary therapy. A measure of endothelial
function is suggested for future studies to determine the impact of the RRP on arterial health. Finally, a study of the RRP in a younger population (youth and younger adults) is suggested to clarify the effects of this type of multidisciplinary program on their health outcomes.
REFERENCES


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