THE UNIVERSITY OF THE WEST INDIES
AT ST. AUGUSTINE, TRINIDAD AND TOBAGO

A Research Paper

Submitted in partial requirements

for HUEC 3012

of

The University of the West Indies

Title: Examining the benefits of regular exercise on cardiovascular disease risk factors in students at U.W.I., St. Augustine.

Student Name: Wynelle Archer

Project Supervisor: Selby Nichols, PhD.

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Department of Agricultural Economics & Extension
Faulty of Food and Agricultural

<u>EXAMINING THE BENEFITS OF REGULAR EXERCISE ON CARDIOVASCULAR DISEASE RISK FACTORS IN STUDENTS AT U.W.I, ST. AUGUSTINE.</u>

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Abstract

Objective: To determine whether regular exercise is cardioprotective in this population via anthropometric and laboratory evaluations among athlete and non-athlete participants

Research Methods and Procedures: This study, which utilized a case-control design was conducted at the University of the West Indies (U.W.I), St. Augustine campus. Data collection was conducted in two phases from October 2013 to April 2014. The study population consisted of young adults, primarily from the 18-34 age group, divided into non-athlete (case) and athlete (control) subgroups. A total of 304 participants were recruited via purposive/judgemental sampling. The sample consisted of with one hundred and ninety eight (198) cases and one hundred and six (106) controls. In phase one anthropometric (weight, height, BMI, waist circumference, body composition) and physiologic (fasting blood glucose, HbA1C, lipid panels) data for one hundred and eighty nine (189) participants including one hundred and forty (140) non-athletes and forty-nine (49) athletes was collected. In phase two, part A, one hundred and thirteen (113) participants completed a 40-item questionnaire which assessed demographic data, physical activity levels, exercise frequency, barriers to regular exercise, health perceptions and food frequency. Additionally, anthropometric and blood pressure measurements were taken in this phase. Part B of phase two involved physiologic measurements for the one hundred and one (101) participants that returned inclusive of 51 athletes and 50 non-athletes. Anthropometric and physiologic measurements were used to assess cardiovascular disease (CVD) risk factor prevalence.

Results: Several CVD risk factors were more prevalent in the case group. Eight of ten cardiovascular disease risk factors were more prevalent in non-athletes with large waist circumferences (p=0.014), excess adiposity (p=0.001), low HDL cholesterol (p=0.001) and elevated triglycerides (p=0.01) being significantly more prevalent in cases than controls. The most prevalent CVD risk factor was high body fat percentage (36.9%). The main barrier to exercise was lack of external motivation (59.6%). Red meat consumption was positively correlated with elevated systolic and diastolic blood pressures (p=0.005 and p=0.005 respectively). Several significant correlations were also demonstrated among cardiovascular disease risk factors.

Discussion: Physical activity level within the sample was generally high due to the inclusion of competitive athletes in the sample. Moderate intensity exercise was high in the sample, however the prescribed time criterion was only met by athletes. Overall, athletes were less at risk for cardiovascular disease based on prevalence of the highlighted risk factors. This provides strong evidence to the premise that regular exercise is a necessary cardioprotective mechanism. Athletes also perceived/encountered less barriers to exercise. Male athletes were shown to have higher blood pressure values than non-athletes, a factor that was not previously predicted and requires further investigation. Overweight and obesity (as defined by large waist circumference, high BMI and body fat percentage) was strongly correlated with elevated blood sugar over time (HbA1C) and dyslipidemic values (low HDL cholesterol, high LDL and triglycerides). There were also several significant correlations among dyslipidemic values. A major limitation of the study was the collection of anthropometric and physiologic data at different times

Conclusion: Fewer CVD risk factors were presented in the athlete group as compared to the non-athlete group hence, it was established that regular exercise was indeed cardioprotective. Regular exercise was found to be protective against eight of ten risk factors with the most significant variances found in waist circumference, body fat percentages, and HDL cholesterol levels. The presence of possible confounding factors leading to elevated blood pressure in male athletes was also highlighted. Several meaningful relationships between and among CVD risk factors were shown. . Lack of external motivation was highlighted as the greatest barrier to exercise among males and females, athletes and non-athletes. The study has several implications for future research in terms of overcoming barriers to exercise and the correlations between and among CVD risk factors.

CHAPTER 1: INTRODUCTION

1. INTRODUCTION/ BACKGROUND TO THE STUDY

1.1 Cardiovascular disease: A worldwide epidemic, a growing concern.

The multifaceted nature of the etiology and hence prevention of Cardiovascular Diseases (CVDs) has made this topic the highlight of several studies particularly since the second half of the 20th century. Jarrah et al (2010) notes that this period "witnessed shifts in the pattern of diseases" with an epidemic of chronic non-communicable diseases (CNCDs) such as CVDs arising from changes in dietary and lifestyle patterns.

The World Health Organization (WHO) describes CVDs as a group of disorders of the heart and blood vessels. They include coronary heart disease (heart attack), cerebrovascular disease (stroke), raised blood pressure (hypertension), peripheral artery disease, congenital heart disease, rheumatic heart disease, heart failure and deep vein thrombosis (WHO statistics, 2014).

Globally, cardiovascular disease remains the leading cause of death, claiming an estimated 17.3 million persons in 2008. The WHO projects that by the year 2030 over 23 million persons will die from CVDs annually. Over 80% of cardiovascular deaths occur in low and middle income countries such as those found in the Caribbean region.

The 2006 Report of the Caribbean Commission on Health and Development (CCHD) compiled by the Pan American Health Organization (PAHO) in conjunction with the Caribbean Community Secretariat (CARICOM), states that CNCDs are without a doubt the leading threat to health and well-being in the Caribbean, accounting for the majority of deaths since the late 1990s. The report attributes the prevalence of CVDs to the adoption of "Westernized or Euro-American" lifestyles characterized by unhealthy diets, physical inactivity, overweight and obesity. Among the CVDs mortality occurs mainly as a result of cerebrovascular disease/stroke, followed by coronary heart disease/heart attack.

The continued prevalence of CVDs in the Caribbean prompted the creation of the 2007 "Declaration of Port-of Spain: Uniting to Stop the Epidemic of Chronic Non-communicable Diseases" which was signed by all CARICOM heads. This 15-point declaration seeks to foster co-operation among governments, civil society and the private sector in addressing common risk factors for the major CNCDs and improving the care of persons both at risk for and with these diseases (Samuels and Hospedales 2011).

Reflective of global and regional statistics, The Health Status Report Card for Trinidad and Tobago, published by the Ministry of Health in 2011, highlights that 60% of all deaths in Trinidad and Tobago are due to CNCDs, with cardiovascular disease topping the list, accounting for 25%of all deaths.

1.2 Cardiovascular Disease Risks/Cardiometabloic risk factors

An individual's risk for cardiovascular disease is directly proportional to the number of risk factors present. The more risk factors present, the higher the likelihood of developing CVD (British Heart Foundation 2014).

Risk factors for CVD, are classified as non-modifiable for example family history, ethnicity and age or modifiable for example tobacco exposure, high blood pressure (hypertension), high cholesterol, obesity, physical inactivity, diabetes, unhealthy diets, and harmful use of alcohol (World Heart Federation 2014).

Three specialized CVD surveys have been conducted in the Caribbean in order to gain necessary insights into the pattern of risk found in individual populations. The first study, done in Jamaica in 1972, the Lawrence Tavern Study, focused mainly on blood pressure and cardiac abnormalities. During the 1980s the Saint James CVD Study was conducted by Miller et al in Trinidad. This study compared the incidence of hypertension and type 2 diabetes mellitus and their associated risk factors. At present, a large scale epidemiologic study is being conducted in Spanish Town, Jamaica (CCHD Report, 2006).

The present study focuses on the modifiable risk factors for CVDs, with the exclusion of tobacco exposure and harmful use of alcohol.

1.2.1 High blood pressure/ Hypertension

The term "blood pressure" refers to the force per unit area exerted on arterial walls. A "normotensive" individual has a systolic blood pressure (SBP) of ≤120mmHg and a diastolic blood pressure (DBP), blood pressure of relaxation of ≤80mmHg. Hypertension is diagnosed when SBP is equal to or exceeds 140mmHg and/or DBP is greater than or equal to 90mmHg. Individuals may also be "prehypertensive" which, according to the Joint National Committee on the Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC7) is defined as a SBP of 120-139mmHg and/or a DBP of 80-89mmHg. Similarly, IDF criteria describes "prehypertension" as a SBP of ≥130mmHg but less than 140mmHg and/or a DPB of ≥85 but less than 90mmHg. Elevated blood pressure significantly increases the risk for

CVDs such as left ventricular hypertrophy, congestive heart failure and stroke through the progressive weakening of arteries, reducing their efficiency and effectiveness (World Heart Federation 2014).

1.2.2 Dyslipidemia

Lipids are transported throughout the body via lipoproteins, which, as the term suggests are composed of a lipid interior and a protein shell. The density of lipoproteins is dependent on their lipid-to-protein ratios and the proportion of lipid components they contain. Classifications of lipoproteins in ascending order of density include: 1) chylomicrons which transport dietary lipids after intestinal absorption 2) Very low density lipoproteins (VLDLs) which have approximately the same density as chylomicrons but are smaller in size; 3) Intermediate density lipoproteins (IDL), 4)Low density lipoproteins (LDLs) and 5)High density lipoproteins (HDLs), the smallest and most dense lipoproteins.

The term dyslipidemia refers to a lipid profile that increases the risk of atherosclerotic development. It is typically a combination of elevated LDL levels and low HDL levels however other dyslipidemic conditions may also exist such as the combination of normal LDL and high triglyceride levels (Nelms et al 2011).

The American Heart Association (2012) highlight that LDLs circulate in the blood gradually building up on the inner walls of arteries. In conjunction with other substances, LDLs form plaque, a thick hard deposit which narrows and reduces the flexibility of the arteries in a condition known as atherogenesis. Conversely, HDLs are involved in “reverse cholesterol transport” that is, they carry extra cholesterol deposited in blood vessel walls back to the liver for elimination through the gastrointestinal (GI) tract. Therefore, the greater the HDL level, the higher the capacity for cholesterol removal, hence prevention of accumulation of atherosclerotic plaque. HDLs keep blood vessels dilated, promoting better blood flow; additionally HDLs also reduce blood vessel injury through antioxidant and anti-inflammatory functions (Toth 2005).

Triglycerides are a form of fat made by the body. Elevated triglycerides are often a function of overweight/obesity, physical inactivity, and a diet containing 60% or more of daily calories from carbohydrates. While elevated triglycerides are an independent risk factor for CVD, it is rarely found in the absence of other dyslipidemic conditions. Persons with high triglyceride levels tend to also have high total cholesterol, usually with a high LDL level low HDL level.

TABLE 1.1: INTERPRETATION OF LIPID PROFILE VALUES IN RELATION TO CARDIOVASCULAR DISEASES

Total Cholesterol	
Less than 200mg/dL	"Desirable" level; lower risk for heart disease; a cholesterol level of 200mg/dL or greater increases your risk.
200-239mg/dL	Borderline high
240mg/dL and above	"High" blood cholesterol; a person with this level has more than twice the risk of heart disease compared with someone whose cholesterol is below 200mg/dL
HDL Cholesterol Levels	
Less than 40mg/dL	A major risk factor for heart disease
40-59mg/dL	Normal
60mg/dL and above	An HDL of 60mg/dL and above is considered protective against heart disease
LDL Cholesterol Levels	
Less than 100mg/dL	Optimal
100-129mg/dL	Near optimal/above optimal
130-159mg/dL	Borderline high
160-189mg/dL	High
190mg/dL and above	Very High
Triglyceride Levels	
Less than 150mg/dL	Normal
150-199mg/dL	Borderline high
200-499mg/dL	High
500mg/dL or above	Very high

Adapted from "Nutrition Therapy and Pathophysiology" Nelms et al 2011; pg. 301

1.2.3 Elevated blood glucose/ Glycated Hemoglobin (HbA1C)

Dietary carbohydrate intake is the main determinant of blood glucose levels. Simple carbohydrates have simple chemical structures composed of either one (monosaccharaides) or two (disaccharides) sugar groups. In contrast, complex carbohydrates are made up of three or more sugar groups in addition to fiber, vitamins and minerals. Simple carbohydrates are more readily digested and absorbed and therefore lead to a more immediate and larger spike in postprandial glucose levels. Conversely, complex carbohydrates, due to their chemical structures, are less readily digested, leading to a more gradual increase in postprandial glucose. Elevation of blood glucose is a function of type of carbohydrates consumed and the resultant action of the gluco-regulatory hormones insulin and glucagon.

Insulin is formed by a group of cells called the islets of Langerhans in the pancreas. The rise of blood sugar stimulates the pancreas to release insulin which is needed to enable glucose to enter the body cells and provide energy. As cells absorb glucose and blood levels fall, the pancreas make glucagon signals the liver to release stored glucose. These hormones together ensure that cells throughout the body have a steady supply of blood glucose in the right amounts.

Disorders of carbohydrate metabolism/glucose regulation are common worldwide. Diabetes mellitus (DM) is defined as a group of heterogeneous disorders with characteristic hyperglycemia and glucose intolerance due to insulin deficiency, ineffective insulin action or both. DM is classified on the basis of etiology and how it is presented clinically (International Diabetes Federation (IDF) 2014). Pre-diabetes is defined as high blood glucose levels, not yet at diabetic proportions. It is also referred to as impaired glucose tolerance (IGT) or impaired fasting glucose (IFG) and is a risk factor for future diabetes and cardiovascular disease (Mahan and Escott-Stump 2008).

Blood glucose is most commonly measured using a fasting blood glucose test which is performed after eight hours without a meal. Normoglycemic persons typically have a fasting blood glucose (FBG) level of 70-99mg/dL.

TABLE 1.2: DIAGNOSIS OF DIABETES MELLITUS AND IMPAIRED GLUCOSE HOMEOSTASIS BASED ON FASTING BLOOD GLUCOSE LEVELS

Diagnosis	**FBG (mg/dL)**
Diabetes	≥126mg/dL
Pre-diabetes Impaired fasting glucose Impaired glucose tolerance	100-125mg/dL
Normal	<100mg/dL

Mahan and Escott-Stump (2008). Modified from ADA: Diagnosis and classification of diabetes mellitus.

Glycated hemoglobin (HbA1C) is another commonly used diagnostic criteria. This test identifies average plasma glucose concentration. Over time, hemoglobin (a blood protein) joins with dietary glucose in the blood, becoming “glycated”. Hemoglobin-containing red blood cells survive for a period of 8-12 weeks in the human body before renewal hence, measurement of HbA1C is a more reliable indicator of overall blood glucose levels, as it provides a more long-term blood glucose average (over 2-3 months) rather than at one particular point in time. According to the American Diabetes Association (ADA) criteria, ideally, non-diabetic/ normoglycemic individuals are expected to have an HbA1C reading of 4-5.7%. A reading of 5.7-6.4% and above indicates 1) excess dietary glucose intake, usually in the form of simple carbohydrates and processed sugars; 2) glucose intolerance, 3) insulin resistance.

1.2.4 Overweight and Obesity

The National Heart, Lung and Blood Institute (NHLBI; 2014) describe the terms “overweight” and “obesity” as a body weight that is greater than what is considered healthy for a particular height. This classification of the terms refers to Body Mass Index (BMI), the most commonly used diagnostic criteria in body weight analysis, measured in pounds per square inch ($lbs/inch^2$) or kilograms per square meter (kg/m^2). As Table 3 highlights, “overweight” is considered a BMI of greater than or equal to $25kg/m^2$ but less than $30kg/m^2$. “Obesity” refers to any BMI value equal to and above $30kg/m^2$ and is sub-divided.

TABLE 1.3: BODY WEIGHT CLASSIFICATIONS ACCORDING TO BMI

BMI (kg/m^2)	**Classification**
<18.5	Underweight
18.5-24.9	Normal
25.0-29.9	Overweight
30.0-39.9	Obesity Class 1
35.0-39.9	Obesity Class 2
≥40	Obesity Class 3/Extreme Obesity

Sourced and adapted from National Heart, Lung and Blood Institute (NHLBI)

Overweight and obesity can also be classified on the basis of body fat distribution, particularly central adiposity, most commonly determined by waist circumference. Central adiposity/obesity is considered to be a stronger predictor of CVD risk than BMI alone. Men and women who have waist circumferences greater than 40 inches and greater than 35 inches respectively are considered to be at increased risk for cardiometabolic diseases (Klein et al 2007).

1.2.4.1 Body composition

The term “body composition” relates to the ratio of body fat to lean body mass (bones, blood, muscles, water). Mutanzia (2012) notes that altered body composition, that is, excess fat in relation to lean body mass can significantly increase one’s risk for CVDs. Percentage body fat is strongly associated with the risk of hypertension, dyslipidemia, diabetes mellitus and coronary heart disease.

Bioelectrical Impedance Analysis also referred to as Bioimpedance Analysis (BIA) is a simple, non-invasive, inexpensive and portable method of body composition analysis. BIA is based on the principle that electric currents flow at different rates through the body depending on its composition (Dehghan and Merchant 2008). Fat free mass/lean tissue is composed of over 70% water and is therefore a good conductor of electrical signals unlike fatty tissue which is low in water. BIA therefore measures the amount of resistance or opposition to the flow of the current, that is, how quickly and strongly the signal travels (impedance measure). It then uses this measure and information such as height, weight and gender to predict an individual's body fat percentage and fat free mass.

An individual is generally classified as "overfat" or having excess body fat in relation to lean body mass if their body fat percentage exceeds 25% in males and 35% in females, since males have a higher ratio of lean body mass to fat mass while females have a higher ratio of fat to fat free mass.

1.2.5 Physical inactivity

The terms "physical activity and "exercise" while often used interchangeably, are defined in different ways. Thompson et al (2003) highlights that physical activity is any bodily movement provided by skeletal muscles that results in energy expenditure beyond REE (Resting Energy Expenditure). Exercise is a subset of physical activity that is planned, structured, repetitive and aimed at maintenance or improvement in physical fitness which encompasses cardiorespiratory fitness, muscle strength, body composition and flexibility.

Physical inactivity can be thought of as the most important modifiable risk factor for CVD since an increase in physical activity results in improvements in several other modifiable risk factors. It is the general consensus among researchers that regular exercise leads to improvements in several CVD risk factors namely: the reduction of body weight, blood pressure and LDL cholesterol and the increase in HDL cholesterol and insulin sensitivity.

Exercise intensity is generally measured in kilocalories (kcal) burned per minute of activity or metabolic equivalents (MET/METs) which is defined as the ratio of the metabolic rate during exercise to the metabolic rate at rest. Moderate-intensity exercise for example brisk walking expend approximately three and a half to seven kcal/minute or three to six METs while vigorous activities such as running burn greater than seven kcal/minute or greater than six METs (Bassuk and Manson 2005). The Centers for Disease Control and Prevention (CDC) and American College of Sports Medicine (ACSM) recommend that individuals engage in 30 minutes or more of moderate physical activity at least five times per week.

Physical fitness is described as a physiologic state of well-being that allows an individual to meet the demands of daily living, sports performance or both. Physical fitness is a function of physical activity which encompasses cardiovascular fitness, musculoskeletal fitness, body composition and metabolism. Wharburton et al (2006) notes that being physical fitness is similar to physical activity in terms of cardioprotective effects, however, physical fitness is thought to be a stronger determinant in CVD risk reduction. The authors state that being highly fit is associated with a 50% decrease in CVD risk.

1.2.5 Unbalanced diets

In the Caribbean, a “balanced diet” is composed of foods from six food groups: staples, legumes, vegetables, fruits, food from animals and fats and oils. The Caribbean Food and Nutrition Institute (CFNI) recommends that four or more servings of staples be consumed each day; at least one serving of legumes/nuts; two or more servings of dark green leafy and other non-starchy vegetables, fruits and foods from animals; three or more servings of fats and oils daily, with an emphasis polyunsaturated fats (The Jamaica Gleaner 2012).

The contribution of dietary intake to the development of CVDs is often summed up into the “atherogenic diet” which refers to a pattern of eating and food choices that promotes plaque deposition in artery wall. Typical characteristics of the atherogenic diet as highlighted by Brown, 2011 are:

1. High saturated fat (>10% of daily calories)
2. Trans fatty acid (trans fat) intake
3. Dietary cholesterol intake >300mg/day
4. Low antioxidants, low fruit and vegetable intake
5. Low intake of whole grains
6. No or excess alcohol
7. High sodium
8. Low potassium
9. Low milk and dairy foods

The American Heart Association (AHA) recommends a diet rich in a variety of fruits and vegetables, grain products, fat free and low fat dairy products, legumes, poultry and lean meats. Fish, preferably oily fish is recommended at least twice per week. Diets rich in fruits and vegetables have been shown to decrease blood pressure and other CVD risk factors. Fruits and vegetables are also important in controlling energy intake by lowering the energy density and increasing the nutrient density of the diet. Fiber obtained through fruits, vegetables and most importantly whole grain products also increases the quality of the diet. Dietary fiber also slows gastric emptying thereby promoting satiety and reducing overall calorie intake. Soluble fiber is associated with modest LDL cholesterol decrease; it is believed to increase short-chain fatty acid synthesis which hampers endogenous cholesterol production. Insoluble fiber is associated not only with CVD risk reduction but also slower progression to CVD morbidity in high-risk individuals.

1.3 Rationale for the study

The current epidemic of cardiovascular diseases worldwide draws attention to the need for early risk detection and implementation of preventative measures. These measures are particularly important to developing nations where persons succumbing to cardiovascular diseases tend to be younger than those in developed countries (Laslett et al 2012). The increasing rates of CVDs is simultaneous with and compounded by an increase in physical inactivity: one of the five main modifiable risk factors for CVDs (WHO 2014). Physical activity and exercise play an invaluable role in CVD risk reduction yet information regarding the benefits of regular exercise on cardiovascular risk remains limited particularly in the Caribbean.

In order to address the problem of increased physical inactivity it is first necessary to gauge what barriers hinder the beginning and continuance of an active lifestyle (Gomez-Lopez et al 2010). In Trinidad and Tobago, low levels of physical activity have been reported not solely in adulthood but beginning in childhood and adolescence (PAHO 2006). In light of this, the present study will not only determine whether students who engage in regular exercise are less at risk for CVD but also highlight common barriers to physical activity; additionally, since dietary factors also contribute significantly to CVD risk, the study will identify any possible dietary characteristics associated with CVD risk factors observed.

Several international studies have been conducted on either CVD risk factor prevalence or barriers to physical activity however, there is a lack of information regarding these topics in Trinidad and Tobago. There is no evidence of prior research done into perceived barriers to exercise in the country. The present design is also unique in its two-fold nature, it will not only highlight the differences in CVD risk between persons engaging in regular exercise and the physically inactive but will also compare barrier perceptions between the two groups.

The purpose of this study is to increase knowledge and understanding of regular exercise as a cardioprotective mechanism and to provide insight into barriers/perceived barriers to exercise. This research will be beneficial to medical and dietetics professionals and students as it will highlight differences in CVD risk between the subgroups used, identifying probable confounding factors that may prompt further investigation.

1.4 Hypothesis

Null Hypothesis: H_0: Regular exercise is not cardioprotective

Alternate hypothesis H_A: Regular exercise is cardioprotective as evidenced by a greater prevalence of cardiometabolic risk factors in the case group (non-athletes) as compared to the control group (competitive athletes).

1.5 Aim of study

To determine whether regular exercise is cardioprotective in this population via anthropometric and laboratory evaluations among athlete and non-athlete participants.

1.6 Objectives

1. To highlight and evaluate differences in the prevalence of CVD risk factors between competitive athlete and non-athlete participants based on a)anthropometric analyses: weight, height, BMI waist circumference and body composition and b)clinical/laboratory data: blood pressure, fasting blood glucose, glycated hemoglobin (HbA1C) and lipid profiles (Total cholesterol, HDL cholesterol, LDL-cholesterol and total triglycerides).
2. To identify commonly reported barriers/perceived barriers to exercise between the subgroups used and investigate whether more barriers are encountered/perceived within the case group (non-athletes).
3. To determine whether dietary factors were associated with CVD risk.
4. To establish regular exercise as a necessary cardioprotective mechanism by displaying correlational relationships between this variable and CVD risk as determined by anthropometric and laboratory assessments.

CHAPTER 2: LITERATURE REVIEW

2. LITERATURE REVIEW

2.1 The worldwide environment of Cardiovascular Disease: Risk Factor Prevalence and Global Statistics.

Chronic non-communicable diseases (CNCDs), a class of disorders to which CVDs belong, account for the majority of the world's disease burden. CVDs account for approximately half of all CNCDs and are currently the leading cause of death worldwide, responsible for an estimated 17.3 million deaths annually, a figure that is projected to exceed 23.6 million by the year 2030 (Laslett et al 2012).

According to the authors, low and middle income countries (also known as "developing countries") such as those found in Eastern Europe, Central Asia, the Middle East, North Africa and the Caribbean region are becoming increasingly affected by CVDs. Eighty percent (80%) more of the deaths due to CVDs in these countries occur at younger ages than in high-income countries, often leading to an overall loss of productivity. In 2004, approximately 82% of 17 million CVD related deaths occurred in low and middle income countries; for example, in Latin America and the Caribbean, CVDs caused an average of 900 000 deaths in both 2004 and 2008. In the English-speaking Caribbean for the period 2003-2008, mortality due to CVDs was approximately 250 per 100 000 persons (Ferguson et al. 2011).

The main risk factors for CVDs can be described as "perpetuated through social norms and practices" (Maner and Sridhar 2012). These risk factors include overweight and obesity, elevated blood pressure, high blood sugar/glucose, dyslipidemia, unhealthy diets and physical inactivity. The researchers point out that the impacts of these factors are usually not immediately seen but progress and worsen over time, ultimately leading to morbidity and mortality. A reflection of this finding is seen in a review of the epidemiology of CVD in the Caribbean. A high prevalence of obesity, hypertension, prehypertension, diabetes and dyslipidemia perpetuated by low levels of physical activity, inadequate consumption of fruits and vegetables and predominance of frying as a cooking method were the main highlights.

The World Health Organization (WHO; 2009) lists high blood pressure/hypertension as the risk factor responsible for the highest mortality worldwide- 12.8% (7.5 million persons) annually. High blood glucose, physical inactivity, overweight and obesity, and high cholesterol account for 5.8% (3.4 million), 5.5% (3.2 million), 4.8% (2.8 million) and 4.25% (2.6 million) of yearly global mortality respectively.

The majority of the disease burden in Trinidad and Tobago (60%) is attributable to CNCDs with CVDs alone accounting for 25% of mortality. The Pan American Health Organization (PAHO; 2006) ranks "diseases of the heart" as leading cause of death among both males (1202 per year) and females (1062 per year). Diabetes mellitus and hypertension, common risk factors for CVD account for approximately 12%

each of deaths in the country. Low levels of physical activity was reported, beginning in childhood and adolescence. The Global School-Based Health Survey reported that 74.3% of students in Trinidad and Tobago did not engage in physical activity. As highlighted by several studies, girls were also found to be less physically active than boys with 81.6% being inactive versus 66.7% of boys.

According to Laslett et al (2012), the global prevalence of obesity doubled between 1980 and 2008, with 2.8 million deaths per year being attributed to overweight (BMI $\geq$25kg/m^2) and obesity (BMI $\geq$30kg/m^2). The authors note that women were more obese than men; 14% of women as compared to 10% of men. A report released by the United Nation's Food and Agriculture Organization (FAO; 2008) showed that 30% of adults in Trinidad and Tobago were obese. Additionally, in 2013 the country was ranked by FAO is the world's sixth most obese country.

Research conducted at Jordan University by Jarrah et al. (2011), found that male students were more overweight and obese (22% and 10.6% respectively) than females (16.9% overweight; 2.3% obese). This finding is thought to be reflective of healthier food choices made by female students due to their desire for a thinner figure while males seek increased muscle mass. With respect to physical inactivity, 55.1% of the sample reported that they exercised irregularly. Daily exercise was performed by 18.6% of the sample, weekly exercise by 20.1% and monthly exercise by 6.2%. Similar to PAHO findings in Trinidad and Tobago, males were found to be more physically active than females with 49.1% of males exercising irregularly compared to 67.7% of females.

Previous research, utilizing various methodologies, indicated a significant relationship between abdominal obesity and risk for CVDs. Overweight and obesity as diagnosed by BMI alone is regarded as a weak predictor of CVD risk. Anthropometric measures of abdominal obesity, particularly waist circumference and waist-to-hip ratio have been shown to be more strongly associated with metabolic risk factors and CVD morbidity and mortality. Central to the cardiometabloic risk associated with abdominal adiposity, is visceral adipose tissue (VAT; also referred to as visceral fat) which increases the risk for insulin resistance, dyslipidemia and hypertension. Waist circumference is the most common measure of VAT (Koning et al 2007). The authors highlight that for every one centimeter increase in waist circumference, there is a 2% increase in CVD risk.

Global statistics indicate that an estimated 40% of persons over the age of 25 have been diagnosed with hypertension (systolic blood pressure (SBP) $\geq$140mmHg and/or diastolic blood pressure (DBP) $\geq$90mmHg). SBP has been found to be highest in low and middle-income countries. Prehypertension (SBP of approximately $\geq$130mmHg but less than 140mmHg and/or DBP of $\geq$85mmHg but less than 90mmHg) is also prevalent worldwide; for example, in an Israeli study, Grotto and colleagues (2006) noted a prevalence of 48.9% in subjects examined: 50.6% of males and 35.9% of females. The authors note that persons within the prehypertensive group also had elevated BMI, total cholesterol, LDL and triglyceride levels with simultaneously low HDL levels. Similarly, a study conducted by Ferguson et al. (2008) showed that 30% of Jamaican adults 15-74 in the sample were prehypertensive, with a higher prevalence among men (35%) than women (25%). Hypertension is responsible for 51% and 45% of mortality due to stroke and coronary heart disease (CHD) respectively (Laslett et al 2012).

Research conducted by The National Academies Press (2010) indicates that men are more prone to CVD morbidity and mortality. This difference in prevalence among genders is attributed to the protective effect of estrogen, specifically in the pre-menopausal period. While researchers remain uncertain about the specific mechanisms involved, estrogen is thought to contribute to the tendency for women to have lower systolic blood pressure, higher levels of HDL cholesterol, and lower triglyceride levels than men.

Distribution of risk factors differs from country to country. For example, as Gersh and colleagues (2010) highlight, in South Africa the most prevalent risk factors for CVDs are obesity and hypertension while in China, a major role is played by elevated blood lipids- commonly found even in normal weight individuals. The prevalence of dyslipidemia in China is further explained by research conducted by The National Academies Press in 2010 which found that total caloric intake and meat consumption increased by 246% between the late 20th century and early 21st century. Additionally, there was a significant increase in the consumption of palm, soyabean and vegetable oils; these oils are known to contain high levels of atherogenic saturated fats. Palm oil for example, is composed of 45% saturated fats. An unhealthy diet is believed to be responsible for 30% of acute myocardial infarction (heart attack) risk worldwide (Gersh et al. 2010).

Smith (2007) attribute 80% of lipid disorders to diet and lifestyle. The authors reference the American Heart Association (AHA) statistics which state that approximately one third of Americans (100 million persons) have total cholesterol levels above 200mg/dL and 34 million individuals have levels in excess of 240mg/dL. Toth et al (2012) expand on these findings, noting that 27% (53.3 million) have high LDL cholesterol, 23% (46.4 million) have low HDL cholesterol and 30% (58.9 million) have high triglyceride levels. Diabetes is generally viewed as closely related to dyslipidemia since persons with this condition also tend to have LDL cholesterol levels greater that 140mg/dL. Worldwide, there are almost 200million persons with diabetes which accounted for 1.1 million deaths in 2005. More than 75% of persons with diabetes have CVD (Smith 2007). Gersh et al. (2010) state that six of ten countries with the highest prevalence of diabetes are in the Middle East and Eastern Mediterranean. According to 2012 ADA statistics, fewer than 50% of U.S. adults with diabetes meet the glycated hemoglobin (HbA1C) goal of less than 7.0%. The American Association of Clinical Endocrinology had a similar report with 67% of persons not meeting their criteria of less than 6.5%.

2.2 Common barriers to physical activity and exercise

The 1995 recommendation of the Centers for Disease control and Prevention (CDC) and American College of Sports Medicine (ACSM) that each individual should engage in at least 30 minutes moderate-intensity exercise at least five, preferably seven days per week is generally accepted as standard, however, studies commonly report that several countries worldwide fail to meet this criteria.

A 2008 survey conducted in Queenslanders Australia found that 53% of the adult population (aged 18-75 years) did not report physical activity levels sufficient to gain health benefits. An English health survey conducted in 2006 showed that 68% of the adult population did not meet CDC and ACSM criteria, meanwhile this figure was approximately 50% for U.S adults in 2007 (Lovell et al. 2010).

The reduction in physical activity and exercise levels as one transitions from adolescence into adulthood is of growing concern, due to the increasing global burden of chronic non-communicable diseases (CNCDs), a problem in which physical inactivity plays a major role. As regards the university student, Lovell et al. (2010) notes that students enjoy a greater level of freedom to make dietary and physical activity choices than in their pre-university years where their choices would have been largely influenced and/or moderated by older adults (parents and guardians); however, this has led to a "rise in the disregard of a healthy lifestyle" and a decrease in the practice of physical activity (Gomez-Lopez et al 2010), hence a greater prevalence of cardiometabolic risk.

Physical activity and exercise levels can be thought of as a function of two cognitive variables, namely, perceived benefits and perceived barriers. Perceived benefits bring about increased participation in exercise while perceived barriers lead to exercise reduction. The frequency and extent to which an individual partakes in exercise is often directly proportional to their perception of benefits gained versus barriers/obstacles faced. Research indicates that university students are becoming increasingly inactive with results from different studies confirming that students who perceive more barriers to exercise have less probabilities of becoming active (Daskapan et al. 2006). In opposition to this general finding was research conducted by Greene et al. (2011) in which the majority of students, in a sample of 1689 persons from eight (8) universities in the U.S, were shown to have high activity levels (54.2%) with 28.9% being overweight or obese. Three percent (3%) of men and 58.9% of women from the overweight/obese group were at elevated risk for cardiometabolic disorders based on waist circumference.

A basic assumption pertinent to the study of barriers to physical activity and exercise is the existence of both internal and external barriers. Commonly reported internal barriers include lack of energy, motivation and self-efficacy; lack of time, resources and social support have the highest ranks among external barriers (Daskapan et al. 2006; Gomez-Lopez et al. 2010). Both of these studies note that external barriers take precedence over internal. Daskapan and colleagues showed that the prevalence of external barriers was statistically significant (p=<0.001) while internal barriers were not (p=0.470). Lack of time was the most reported external barrier while lack of energy was the most common internal barrier. With respect to gender, males tend to perceive less barriers to physical activity with females reporting a greater need for social support in order to engage in physical activity (Gomez-Lopez et al, 2010). Lovell et al. (2010) investigated perceived benefits of and barriers to physical activity among female university students. In contrast to the findings of Daskapan et al (2006) and Gomez-Lopez et al. (2010), the authors found the greatest perceived barrier was physical exertion, which was rated significantly higher than lack of time. Notably, whilst students reported that they were physically inactive, perceived benefits of exercise outweighed perceived barriers (p=<0.001) with improved physical performance being the most reported perceived benefit.

2.3 Dietary factors contributing to CVD risk

Recent studies indicate that the incidence and prevalence of CVDs has been and continues to be exacerbated by poor dietary choices. Alzahrare and Zwi (2012) attributes current dietary choices to the marketing of foods high in salt and sugar through the mass media. The authors believe that the role media promotion of unhealthy food options has been particularly important in poor countries where persons are not financially equipped to purchase healthy foods and beverages.

The World Heart Federation (2014) highlights several dietary contributors to CVD risk. High consumption of saturated fats, trans-fats and sodium (salt) combined with low intake of fruits and vegetables is linked to cardiometabolic risk. Compared with a typical “Western diet” a diet low in saturated fat and high in fruits and vegetables is thought to reduce the risk of cardiac events by 73%. A diet high in saturated fats (found in animal products) and trans fats (commonly used in pastries and fast food) increase total cholesterol levels. It is recommended that trans fats be eliminated and saturated fats replaced by monounsaturated and polyunsaturated fats (found in fish, nuts, seeds and vegetables) which lower CVD risk by improving cholesterol levels. An estimated 1.7 million (2.8%) of deaths worldwide have been attributed to low fruit and vegetable intake. Currently, the estimated daily sodium intake is 9-12 grams per person. The WHO recommends a sodium intake of less than five grams (5000mg) per day to help reduce CVD incidence. Recommendations made by the American Heart Association (AHA) include consumption of four or more cups per day of fruits and vegetables; at least two three and a half ounce servings of fish per week; greater than or equal to three one ounce servings of fiber-rich whole grains daily; no more than1500mg/ day of sodium and sugar-sweetened beverages less than 36oz weekly.

2.4 Regular exercise as a necessary cardioprotective mechanism

"Physical activity can improve several metabolic risk factors associated with cardiovascular disease (CVD) and is associated with a lower risk of CVD mortality." Reddigan et al 2011.

Reddigan and colleagues (2011) conducted a large retrospective cohort study (N=10,261), which utilized data from the Third National Health and Nutrition Examination Survey (NHANES III), a U.S.-based cross-sectional survey. One of the primary aims of the study was to determine whether physical activity provides protective effects against CVD mortality in 1) healthy adults and 2) those with metabolic risk factors. Over the study period (analysis of data from 1988-2006), there were 2,433 deaths, approximately 45% of which (1,095) were due to CVD. Dyslipidemia, type 2 diabetes, hypertension and inflammation were the greatest determining factors of CVD mortality. The authors demonstrated a correlational relationship between the number of risk factors present and the risk for CVD mortality: individuals having three or more risk factors had the highest CVD mortality. It was found that engaging in light or moderate physical activity led to a more favourable metabolic profile and was associated with a 30% reduction in CVD mortality, regardless of the number of risk factors present ($p=<0.05$). Adding to these findings, Sundquist et al. (2004) found that there was a 41% lower risk for developing coronary heart disease (CHD; one of the most common CVDs), in those who performed leisure-time physical activity at least twice per week while Nocon et al. (2008) noted that physical activity was associated with a 35% CVD risk reduction in Germany.

Within the context of the effects of exercise on individual cardiometabolic risk factors, exercise was attributed to type 2 diabetes prevention, energy expenditure and balance hence maintenance of BMI at normal levels (Sundquist et al. 2004). The precise mechanisms by which engaging in regular exercise is cardioprotective is complex and require further investigation as they are not yet fully understood. With reference to type 2 diabetes reduction, exercise has been shown to improve adaptations that affect glucose metabolism, for example, increasing glycogen synthase and hexokinase activity (enzymes required for conversion of blood glucose into glycogen for storage in the liver). Additionally, exercise improves muscle capillary density, allowing for a more efficient delivery of glucose to the muscles (Wharburton et al. 2006). As a cardioprotective mechanism, regular exercise also decreases arterial stiffness, which is associated with systolic hypertension and left-ventricular hypertrophy (Schuler et al. 2013). In a review of clinical investigations, the authors discovered that arterial stiffness was lower in persons performing regular aerobic exercise as compared to similar groups of sedentary adults. Exercise is believed to bring about structural changes in collagen and elastin which are key to the development of arterial stiffness.

Ahmed et al. (2012) highlights a correlation between physical activity, triglyceride reduction, HDL increase and change in LDL particle size. Small dense LDL particles have been found to be the most atherogenic. Citing the results of two cross-sectional studies reviewed, the authors note that patients reporting higher levels of physical activity had lower concentrations of these small, dense LDL particles even when total LDL concentrations remained the same. Bassuk and Manson (2005) obtained a similar result; although no decrease in total LDL concentration in dyslipidemic participants was recorded, exercise intervention led to alterations in LDL subfraction parameters. There was a decrease in the number of non-type A LDLs, that is, the small, dense atherogenic subfractions. Larger LDL subfractions (type A) are less atherogenic. The reduction in total cholesterol, total LDL levels and LDL particle size due to exercise was directly proportional to weight loss. Conversely, HDL increase and triglyceride reduction were independent of weight loss (Ahmed et al. 2012). Moderate intensity exercise for 30-60 minutes, three to five times per week, led to a significant increase in HDL concentration by 0.05mmol/L while triglycerides fell by 0.21mmol/L ($p=0.01$) (Carroll and Dudfield 2004).

2.4.1 Cardiovascular disease in athletes

Research confirms regular exercise as a necessary cardioprotective mechanism however, over the past decade a number of studies have emerged highlighting the topic of CVD and CVD risk factors in athletic populations. Athletes are typically young individuals who appear to be in good health, hence, are generally regarded as a population at low cardiovascular risk (Bruno et al 2011). The authors note that the incidence of cardiovascular deaths in U.S athletes is less than 300 per year in an athlete population of about 10-15 million. However, while incidence remains rare and data is limited, several studies have discussed the impact of athletic conditioning on the restructuring or “remodeling” of the cardiovascular system and possible negative implications such as sudden cardiac death.

In a U.S-based study, Harmon and colleagues (2011) investigated the incidence of sudden cardiac death (SCD) in National Collegiate Athletic Association (NCAA) athletes. From January 2004 to December 2008 among medical causes of death, CVD was the leading cause, accounting for 56% of cases and 75% of sudden deaths due to exertion. The authors highlighted that risk of SCD varied significantly by sporting discipline with basketball being the highest risk sport. This view was reiterated by Maron and Pelliccia (2006) who noted that SCD incidence was highest in basketball and football. It was also found that SCD was more likely to occur in males. Chevalier et al. (2012) adds to this finding, stating that it was “well known” that age, sex, body size and race play a pivotal role in cardiac events among athletes with male participants and individuals of Afro-Caribbean descent being more susceptible to SCD (O'Keefe et al. 2012). The general view, however is that type of sport and its specific demands is the most important determining factor.

Additionally, Maron and Pelliccia (2006) highlight, that there has been considerable focus on the collection of alterations known as "athlete's heart". This condition is described as an increase in cardiac mass with circulatory and morphological changes, thought to occur as a direct adaptation to systematic training. Approximately 50% of trained athletes are said to show evidence of cardiac remodeling.

The researchers note that previous studies have shown that heart size is increased particularly in endurance athletes who have large aerobic requirements. Short-term responses to endurance training include increased maximum oxygen consumption, cardiac output, stroke volume and systolic blood pressure. O'Keefe et al. (2012) hypothesize that over months to years, this recurrent process of "injury" and recovery may lead to cardiovascular complications such as artery calcification, diastolic dysfunction and large-artery wall stiffening. Citing previous research, it was highlighted that a greater atherosclerotic burden, as evidenced by higher coronary artery calcium stores, was found in former marathon runners than in an inactive group of similar demographic characteristics. The authors liken regular exercise to a pharmacologic agent: the possibility of a safe upper-dose/limit exists, beyond which adverse effects may be seen. For example, highly trained athletes may accumulate (exercise) work loads of 200-300 MET (metabolic equivalents) hours per week which is five to ten times greater than the standard exercise training dose recommended for CVD reduction. In addition, Baggish and Wood (2011) state that "cardiac output, the product of stroke volume and heart rate" may increase by five to six times during maximal exercise effort. Heart rate in the athlete can "travel" across a broad range from less than forty (40) at rest to greater than 200 at maximal exercise effort. According to Bruno et al 2011, hypertension is the most prevalent CVD risk factor among athletes; this may be a function of increases in ventricular and end-diastolic volume plus reduced end-systolic volume, resulting in increased stroke volume, hence cardiac output. Prolonged exercise training increases stroke volume both during exercise and at rest. (Baggish and Wood 2011).

The precise mechanisms by which athletes may be susceptible to CVDs remain inconclusive however it is the general consensus among researchers that adverse cardiovascular effects occur as a result of excessive/chronic athletic training; additionally research shows that while the problem is important and requires further investigation, incidence of such events remain low. As Maron and Pelliccia (2006) sums up, there is currently no concrete evidence that cardiac remodeling/ "athlete's heart" leads to "long term disease progression, cardiovascular disability or sudden cardiac death" however, the possibility that exercise-induced cardiovascular changes may lead to both temporary and long-term adverse effects cannot be excluded with certainty.

The purpose of this study is to advance knowledge and understanding of regular exercise as a necessary cardioprotective mechanism by comparing CVD risk factor prevalence between athletic and non-athletic University students. The present study has two main aims: to fill in the knowledge gaps about CVD risk factor prevalence among university students and to provide additional insight into common reasons why students find it difficult to engage in regular exercise. It is hoped that this study will highlight the need for early CVD risk assessment and provide a basis for the promotion of regular exercise as a necessary CVD risk management strategy.

CHAPTER 3: METHODOLOGY

3. METHODOLOGY

This study, which utilized a case-control design was conducted at the University of the West Indies, St. Augustine campus over the period October 2013-April 2014. The sample population was a group of students aged 18-40 years old; participants were divided into two subgroups, non-athletes (cases) and athletes (controls). A total of three hundred and four (304) participants were involved, one hundred and ninety eight (198) cases and one hundred and six (106) controls.

Data collection was conducted in two (2) phases. Phase one (1) ran from October-November 2013 and involved the collection of anthropometric (weight, height, BMI, waist circumference, body composition) and physiologic (fasting blood glucose, HbA1C, lipid panels) data for one hundred and eighty nine (189) participants including one hundred and forty (140) non-athletes and forty-nine (49) athletes.

Phase two (2) spanned the period February-April 2014 and was subdivided. Preliminary data collection in phase two involved the administration of a questionnaire, blood pressure measurements and anthropometric evaluations for one hundred and thirteen (113) participants: fifty eight (58) non-athletes and fifty seven (57) athletes. This part of the process was conducted over two weeks, three days per week, from February 18th- February 27th 2014.

Physiologic measurements- HbA1C and lipid panels- were taken in Phase two (2) part two (2). Of the initial 113 persons completing phase one (1), one hundred and one returned: fifty (50) non-athletes and fifty-one (51) athletes. Testing was done from Friday 28th March-Tuesday 15th April 2014. In both phases, flexible time slots were created in order to accommodate the students' varied schedules.

TABLE 3.1: PHASE 2 DATA COLLECTION SCHEDULE

PHASE 2 PART 1		
Month	**Day**	**Time(s)**
February	Tuesday 18th	3-7pm
	Wednesday 19th	9am-1pm; 4-7pm
	Thursday 20th	9-11am; 2-4pm; 6-7pm
	Tuesday 25th	1-5pm
	Wednesday 26th	4-9pm
	Thursday 27th	10am-4pm
PHASE 2 PART 2		
March	Friday 28th	3-5pm
April	Tuesday 1st –Thursday 3rd	1:30-5pm
	Friday 4th	3-5pm
	Monday 7th-Thursday 10th	3-5pm
	Friday 11th	3:15-6pm
	Monday 14th	11am-4pm
	Tuesday 15th	2-5:30pm

Table 3.1 shows the dates and time slots allotted for the study.

3.1 Recruitment and sampling techniques

A purposive/judgmental sampling technique was used in the recruitment process. The study set out to recruit non-athletic and athletic individuals who were at the time of the research students at the University. The only exclusion criteria were 1) over the age of 40 2) not currently enrolled at UWI, St. Augustine. An overview of the study in addition to the official letter to students that was drafted was given to all participants. Non-athletes were approached randomly at the campus and invited to participate in the study. Athletes and/or their coaches were approached at training times. A database of all volunteers that included exercise status, sport played (for the athletes) and contact information was constructed.

The sample size was determined via calculation with the aim of utilizing a 2:1 ratio of cases (non-athletes) to controls (athletes). A 95% confidence interval was assumed with an 80% power/ chance of detecting the condition (CVD risk factors). An odds ratio of 2.0 was assumed. The hypothetical proportion of cases with the exposure was calculated as 57.14 while the hypothetical proportion of controls with the exposure was 40. With these assumptions, a minimum sample of 299 persons: 199 cases and 100 controls was recommended. The sample obtained (304 persons: 198 cases and 106 controls) was similar to this recommendation.

3.2 Questionnaire

A four-part 40-item questionnaire was constructed and administered. The questionnaire was pretested using a sample of ten (10) persons from both subgroups (six non-athletes and four athletes). Suggestions were taken and necessary changes made.

Section one (1) of the questionnaire pertained to demographic characteristics such as age, gender, level of education completed, marital status and ethnicity. Section two (2) included body image perceptions, physical activity levels, exercise frequency and screen time. Since the primary exposure examined in this research was exercise frequency, participants were asked to rate their physical activity level as low, moderate or high then frequency and duration of light, moderate and vigorous intensity exercise was investigated. Section three (3) involved participants' perceptions of their current health in terms of risk for chronic disease, general health status and health status in comparison to the previous year. Additionally, perceived barriers to exercise were examined via ten (10) statements rated on a five-point Likert scale. Section four (4)- the food frequency questionnaire- examined the types, amounts and frequency of foods consumed (whole grain, dairy, vegetables, fruits, red meats, nuts, fried foods, processed snacks, sodas and water).

A fifth section, the “Lab data form”, was reserved for use by the researchers and included sections for anthropometric (height, weight, BMI, waist circumference, body composition), blood pressure (repeated twice on each arm then averaged) and blood analysis (HbA1C, total triglycerides, total cholesterol, HDL and LDL cholesterol).

3.3 Anthropometric and Physiologic testing

This phase of data collection was conducted in a room with three (3) stations. At station one (1) participants completed the questionnaire then proceeded to either station two (2) or three (3) based on availability or preference. Station 2 was designated for blood pressure testing while at station 3, height, weight, BMI, body composition and waist circumferences were measured.

3.3.1 Measurement procedures

Blood pressure (systolic and diastolic) and heart rate were measured using an automatic monitor, the Omron® Arm Blood Pressure Monitor (model #HEM-712C) which determines blood pressure via oscillometry: the vibration of the blood as it flows through the arteries.

Participants were instructed to sit in an upright but relaxed position for five to ten minutes with their legs uncrossed and feet flat on the floor. Subsequent to this, blood pressure measurements were taken twice on each arm (with a two-minute delay between readings) with palms facing upright. The pulse of the brachial artery (main blood vessel in the upper arm) was located using the middle and forefingers; the cuff was fastened securely (but not tightly) around the upper arm with the sensor/bladder of the cuff positioned at the brachial artery. The monitor was then started and within 30 seconds systolic and diastolic blood pressure and heart rate readings were attained. An average of all four systolic, diastolic and heart rate readings was then calculated.

Height was measured in feet and inches as well as centimeters using a portable stadiometer. Participants were instructed to remove their shoes and look straight ahead with their heads aligned in the Frankfurt plane. The Omron® Full Body Sensor Scale and Body Composition Monitor (model #HBF-510) was used to measure weight, BMI and body composition: total fat and skeletal muscle percentages and visceral fat (intra-abdominal fat/fat around the organs). Participants were instructed to keep their shoes off and additionally to remove socks, jewelry and any other metal objects on their person. The sensor/scale used measures body composition via a small, undetectable electrical signal passed through the palms of hands and soles of the feet through four (4) electrodes. Waist circumference (measured in inches) was taken using an inelastic nylon tape, approximately two centimeters (2cm) above the navel, below the ribcage. Participants were instructed to stand upright and remain still.

Phase two (2) part two (2) was the testing of glycated hemoglobin and lipid profiles. A room was set up with two stations: station 1 was the waiting area where persons could observe the procedure that was taking place at station 2, the blood collection and testing area.

3.3.2 Testing procedures

Blood samples for the glycated hemoglobin and lipid profiles were obtained through a "finger-prick" via the use of an automated lancet. Glycated hemoglobin (HbA1C) was tested using the HumaMeter A1C® glycated hemoglobin monitor. This machine is comprised of the digital analyzer and barcode scanner for calibration. The machine uses a reagent to react with the blood. After the reagent was inserted into the analyzer and "rehydrated" the blood was collected a sampling stick which was then inserted into the reagent. The machine required only about 4 microliters of blood and within four minutes an HbA1C percentage reading was obtained.

The lipid panels were done using the Cardiocheck® PA device. Approximately four (4) drops of blood were collected in a micropipette and upon prompting by the machine, applied to the testing strip inserted. Results for total cholesterol, HDLs, LDLs and triglycerides in milligrams per deciliter of blood were obtained within three (3) minutes.

3.4 Defining CVD risk factors

The presence of CVD risk factors was determined via measurements exceeding the cut off values below:

1. BMI ≥25kg/m^2
2. Waist circumference ≥35 inches in females and ≥40inches in males
3. Body fat percentage 35% in females, >25% in males
4. HbA1C ≥5.7%
5. Total cholesterol >200mg/dL
6. HDL cholesterol <50mg/dL in females, <40mg/dL in males
7. LDL cholesterol >100mg/dL
8. Triglycerides >150mg/dL
9. Systolic blood pressure ≥130mm/Hg
10. Diastolic blood pressure ≥85mm/Hg

3.5 **Statistical analysis**

Data collected via questionnaires, anthropometric measurements and physiologic tests were entered into the Statistical Package for Social Science (SPSS) software, version 12. Mean values and standard deviations from the mean (Mean ±SD) for continuous data such as the anthropometric and physiologic test results between the subgroups were calculated via independent samples t-tests (two-sample, unpaired t-tests). The significance of the difference between means was tested at the five percent (%) level, that is, $p<0.05$, using a 2-tailed significance. Chi-squared testing was used to compare the means of categorical data such as the prevalence of cardiometabolic risk factors (as defined in section 3.4) and barriers to physical activity between subgroups (males versus females; cases versus controls). Pearson's correlation coefficient (2-tailed significance) was used to determine the significance of relationships among cardiometabolic risk factors and between risk factors and dietary components.

CHAPTER 4: PRESENTATION OF FINDINGS

4. PRESENTATION OF FINDINGS

Data collection (Part A) for the study involved laboratory and anthropometric measurements for 189 participants: 140 cases (non-athletes) and 49 controls (athletes).

Part B of the process was subdivided. Preliminary data collection (the questionnaire, anthropometric and blood pressure measurements) was completed by one hundred and thirteen (113) students of U.W.I, St. Augustine. Fifty four (57) belonged to the athlete subgroup while fifty eight (56) were non-athletes. One hundred and one (101) participants from the initial sample returned for part two of the data collection process (glycated hemoglobin and lipid panels). This figure included fifty one (51) athletes and fifty (50) non-athletes.

The combined sample size was therefore three hundred and four (304), including one hundred and six (106) athletes (controls) and one hundred and ninety eight (198) non-athletes (cases).

4.1 SOCIDEMOGRAPHIC CHARACTERISTICS

TABLE 1: SOCIODEMOGRAPHIC CHARACTERISTICS OF PARTICIPANTS ACCORDING TO EXERCISE STATUS

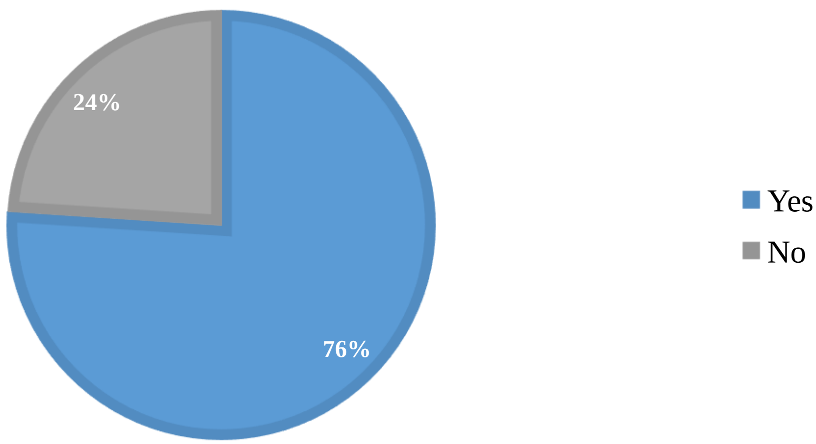
VARIABLE	NON-ATHLETE N (%)	ATHLETE N (%)	TOTAL N (%)	p-value
Gender				
Male	69 (34.8)	50 (47.2)	119 (39.1)	**0.048**
Female	129 (65.2)	56 (52.8)	185 (60.9)	
Age group (years)				
18-24	156 (83.0)	95 (89.6)	251 (85.4)	0.158
25-29	19 (10.1)	8 (7.5)	27 (9.2)	
30-34	11 (5.9)	1 (0.9)	12 (4.1)	
35-39	1 (0.5)	2 (1.9)	3 (1.0)	
40+	1 (0.5)	0 (0)	1 (0.3)	
Ethnicity				
African descent	68 (34.7)	62 (58.5)	130 (43.0)	**<0.001**
Indian descent	86 (43.9)	7 (6.6)	93 (30.8)	
Chinese descent	1 (0.5)	1 (0.9)	2 (0.7)	
Caucasian descent	1 (0.5)	1 (0.9)	2 (0.7)	
Mixed descent	40 (20.4)	35 (33.0)	75 (24.8)	

VARIABLE	NON-ATHLETE N (%)	ATHLETE N (%)	TOTAL N (%)	p-value
Level of education completed				
Secondary	31 (55.4)	26 (45.6)	57 (50.4)	0.264
Technical	3 (5.4)	1 (1.8)	4 (3.5)	
Tertiary	22 (39.3)	30 (52.6)	52 (46.0)	
Marital Status				
Single	55 (98.2)	55 (96.5)	110 (97.3)	1.000
Married	1 (1.8)	2 (3.5)	3 (2.7)	

Table 1 shows the sociodemographic characteristics of non-athlete and athlete participants. The majority, 65.2%, of non-athletes were female as compared to 34.8% males. Gender within the athlete subgroup did not differ greatly with 52.8% females and 47.2% males. There is a significant difference between genders based on exercise status (p=0.048). More males were athletes while more females were non-athletes. The most common age group was 18-24 years with no significant difference being seen between the subgroups (p=0.158). Distribution of ethnicities between athletes and non-athletes were significantly different (p=<0.001). In both subgroups, African descent was the most common ethnic group with 34.7% of non-athletes and 58.5% of athletes. There was however a significantly higher percentage of non-athletes of Indian descent (43.9%) than athletes of Indian descent (6.6%). In both subgroups, the majority of persons reported having completed up to secondary-level education. Marital status was identified as either "single" or married; none of the other status groups on the questionnaire ("Married with children" and "Divorced") were chosen. There was a notable disparity between the percentage of single versus married participants in both subgroups; 98.2% and 97.3% of non-athletes and athletes respectively, were single as compared to 1.8% married non-athletes and 3.5% married athletes.

4.2 PHYSICAL ACTIVITY LEVELS AND CHARACTERISTICS OF PARTICIPANTS

FIGURE 1: SELF-REPORTED ENGAGMENT IN EXERCISE IN THE TOTAL POPULATION



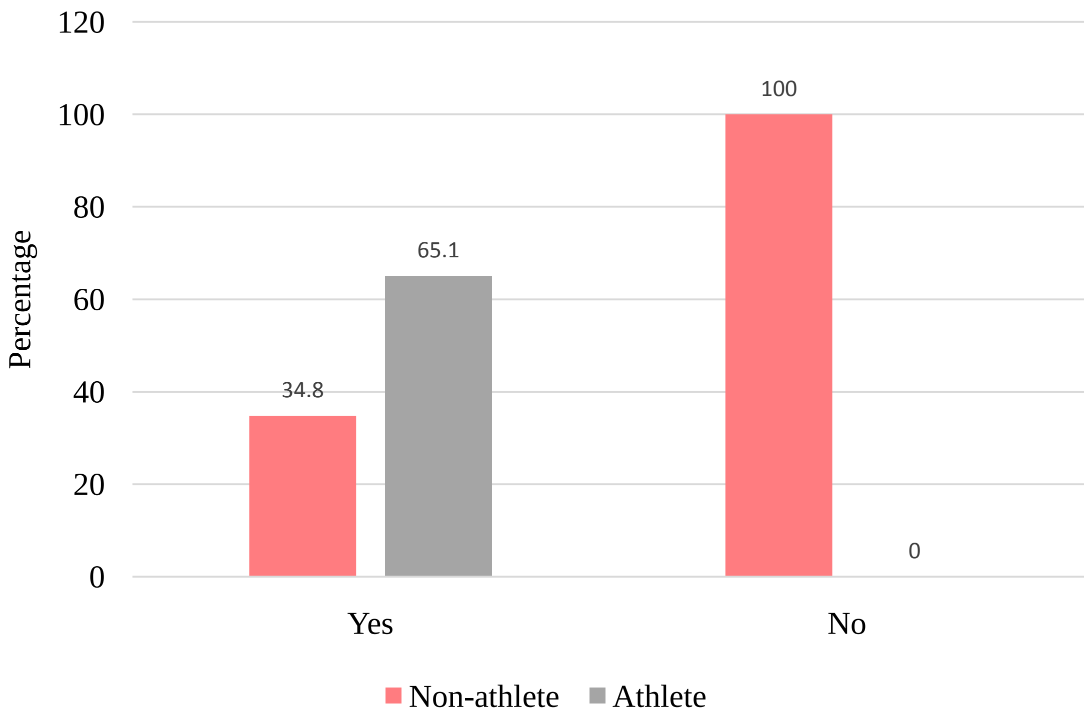


Figure 1 shows the percentages of persons reporting that they do (76%) or do not (24%) engage in exercise outside of the current occupation. The majority of persons responding "yes" were athletes (65.1%) while all persons who do not engage in physical activity were non-athletes.

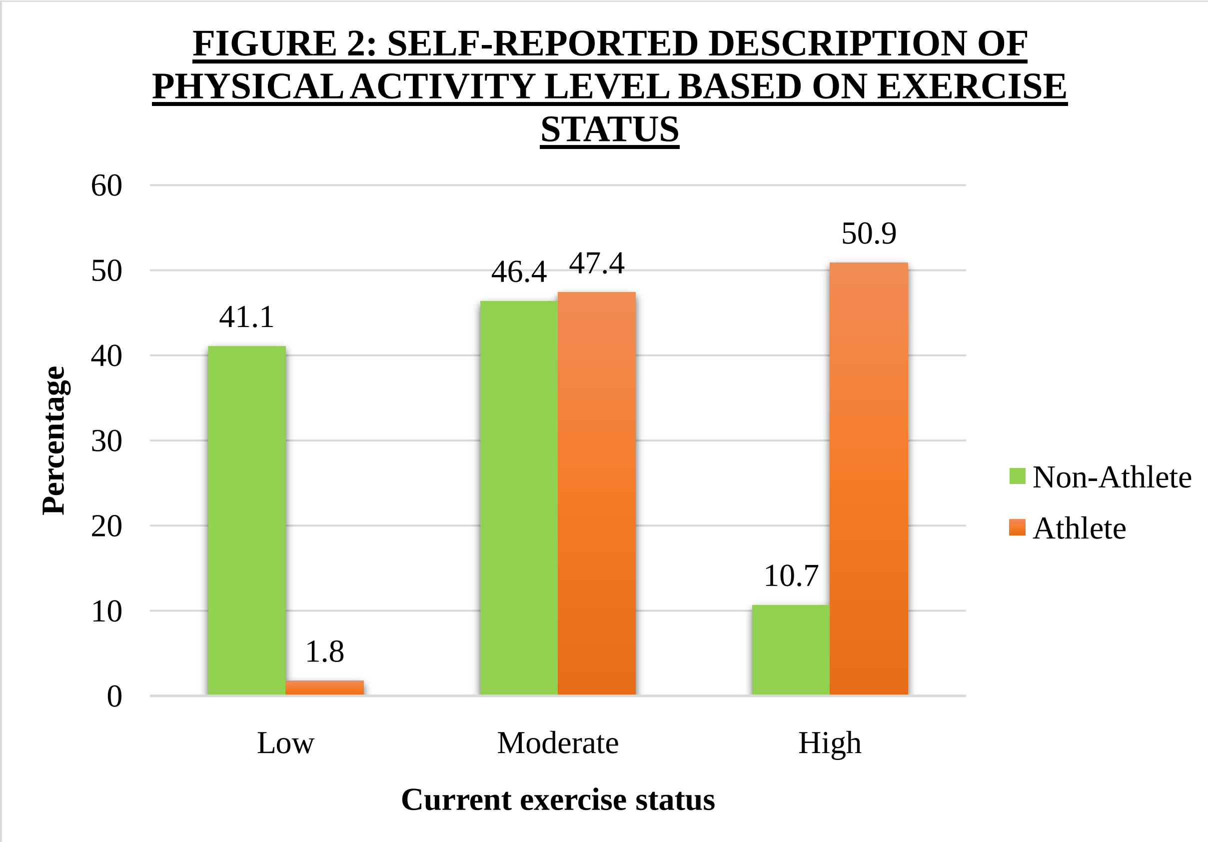


Figure 2 shows the self-reported current level of physical activity based on exercise status. A significantly larger percentage of non-athletes described their level of physical activity as low, 41.1% as compared to 1.8% of athletes. Moderate levels of physical activity was similar between the subgroups while a marked difference was seen in the percentages of athletes versus non-athletes reporting a high level of physical activity (50.9% and 10.7% respectively).

TABLE 2: REPORTED EXERCISE INTENSITY AND FREQUENCY BASED ON EXERCISE STATUS

Exercise Intensity	**Number of days per week**	**Non-Athlete N (%)**	**Athlete N (%)**	**Total N (%)**	**p-value**
Light	**0**	4 (7.1)	3 (5.3)	7 (6.2)	
	1-4	30 (53.5)	31 (54.4)	61 (54)	0.242
	5-7	22 (39.3)	23 (45.0)	45 (39.9)	
Total		**52 (92.8)**	**54 (99.4)**	**106 (93.9)**	
Moderate	**0**	8 (14.3)	3 (5.3)	11 (9.7)	
	1-4	29 (51.7)	27 (47.4)	56 (49.5)	**0.027**
	5-7	19 (33.9)	27 (47.4)	46 (40.7)	
Total		**48 (85.6)**	**54 (94.8)**	**102 (90.2)**	
Vigorous	**0**	26 (46.4)	6 (10.5)	32 (28.3)	
	1-4	27 (48.3)	44 (77.6)	71 (62.8)	**<0.001**
	5-7	3 (5.4)	7 (12.4)	10 (8.9)	
Total		**30 (53.7)**	**51 (90.0)**	**81 (71.7)**	

Table 2 displays the frequency of exercise and the intensities at which exercise was performed among participants based on exercise status. The most common exercise intensity was "Light" intensity exercise with 93.9% of participants. In both subgroups, participants were more likely to engage in light exercise 1-4 days per week than 5-7 days per week. There was no significant difference between the subgroups for this exercise intensity. Moderate intensity exercise activities were more commonly reported among athletes (94.8%) than non-athletes (85.6%); p=0.027. Athletes also participated in moderate exercise on more days per week than non-athletes 47.4% versus 33.9% 5-7 days per week respectively. The most marked difference between the subgroups was seen in the performance of vigorous exercise (p=<0.001). A large percentage of non-athletes reported that they never take part in vigorous exercise (46.4%) as compared to 10.5% of athletes. It was also more common for both athletes and non-athletes to engage in vigorous activities 1-4 days per week than 5-7 days per week. Participation in vigorous exercise activities 5-7 days per week was low in both subgroups (12.4% and 5.4% in athletes and non-athletes respectively).

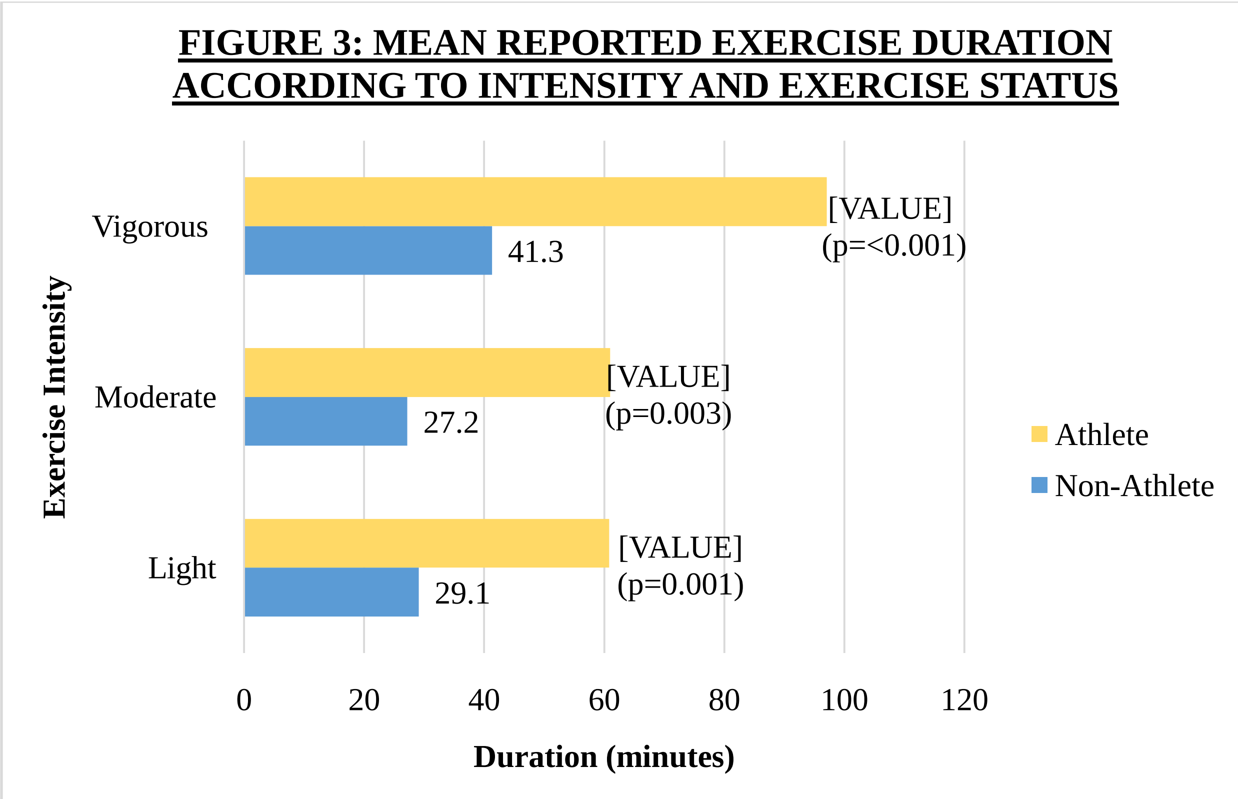


Figure 3 shows the average reported duration of exercise at each intensity based on exercise status. In all three divisions of exercise duration, time spent on each episode was significantly greater in athletes (Light intensity p=0.001; Moderate intensity p=0.003; Vigorous intensity p=<0.001). Athletes reported spending above 60 minutes exercising, at each intensity. Non-athletes generally spent less than 30 minutes on each episode with the exception of vigorous intensity exercise on which they spent an average of 41.3 minutes.

FIGURE 4: CLASSIFICATION OF ATHLETES BASED ON TYPE OF SPORT

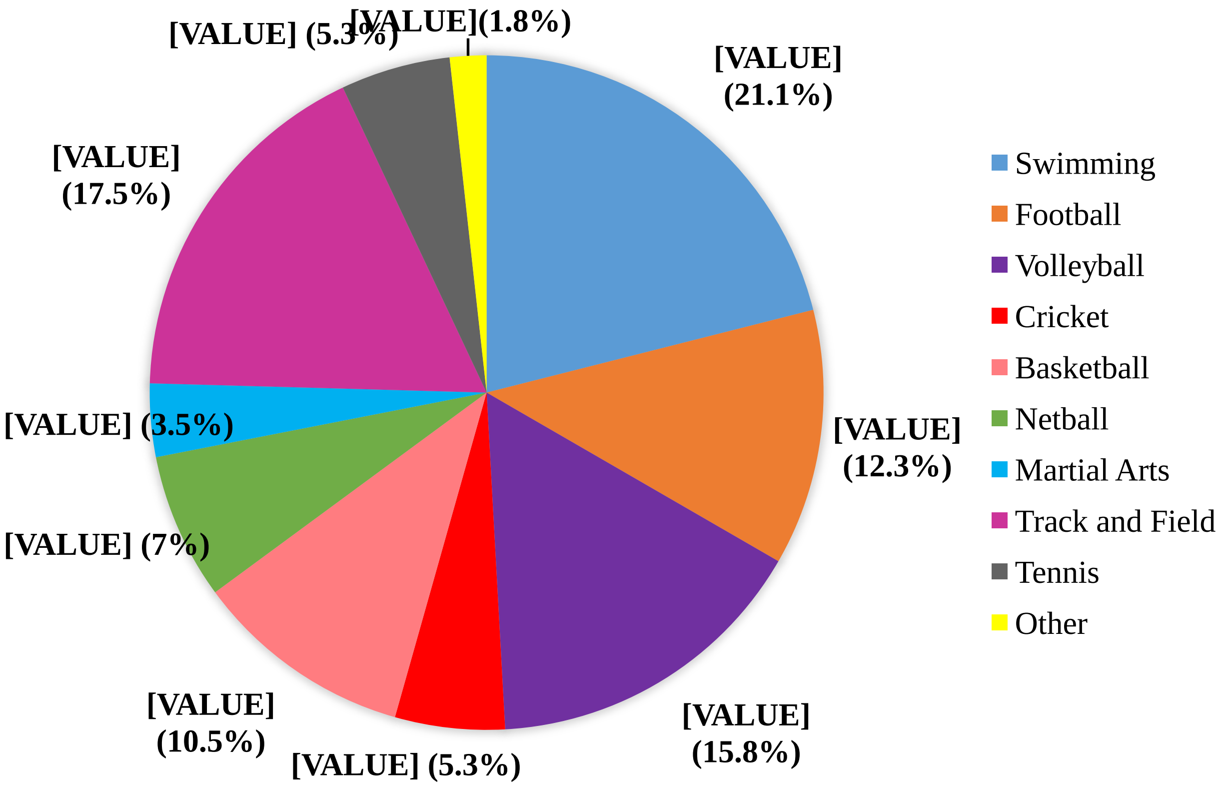


Figure 4 shows the number of competitive athletes from the sample population in each respective sporting discipline. There were nine (9) disciplines among the 57 athletes completing the questionnaire. The majority of athletes were swimmers (21.1%) while martial arts was the least common sport amongst participants (3.5%).

4.3 HEALTH PERCEPTIONS

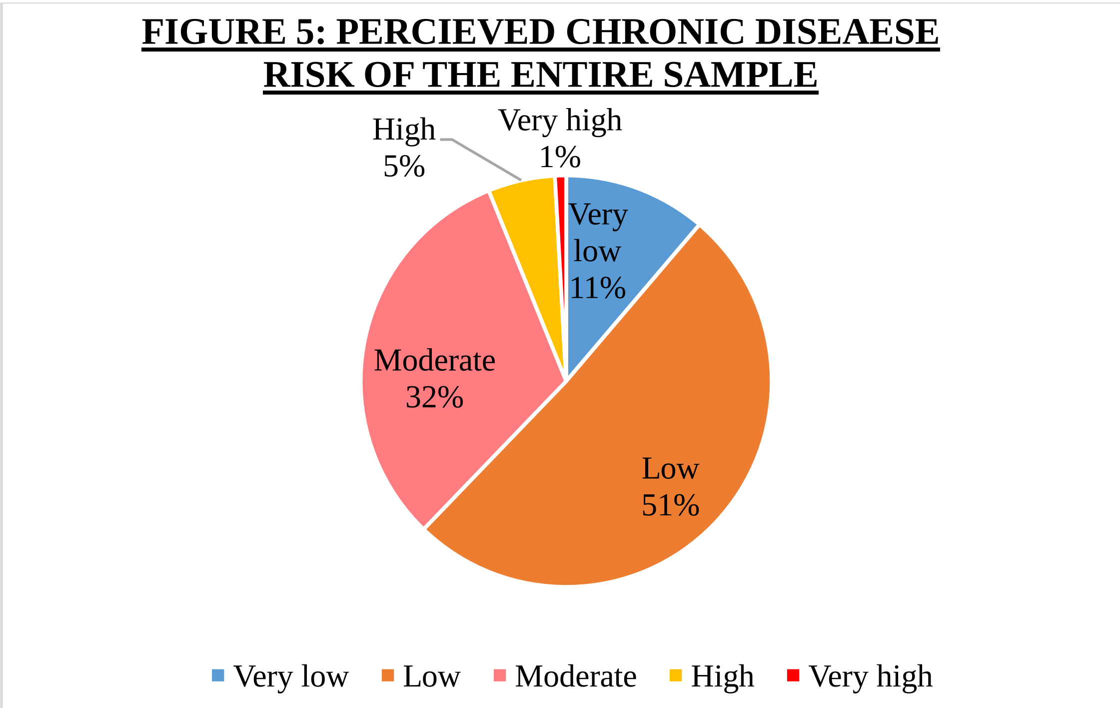


Figure 5 shows the self-reported risk of getting a chronic disease among participants. Of the 113 respondents, more than half (51%) saw themselves as being at low risk while only 1% perceived themselves to be at very high risk.

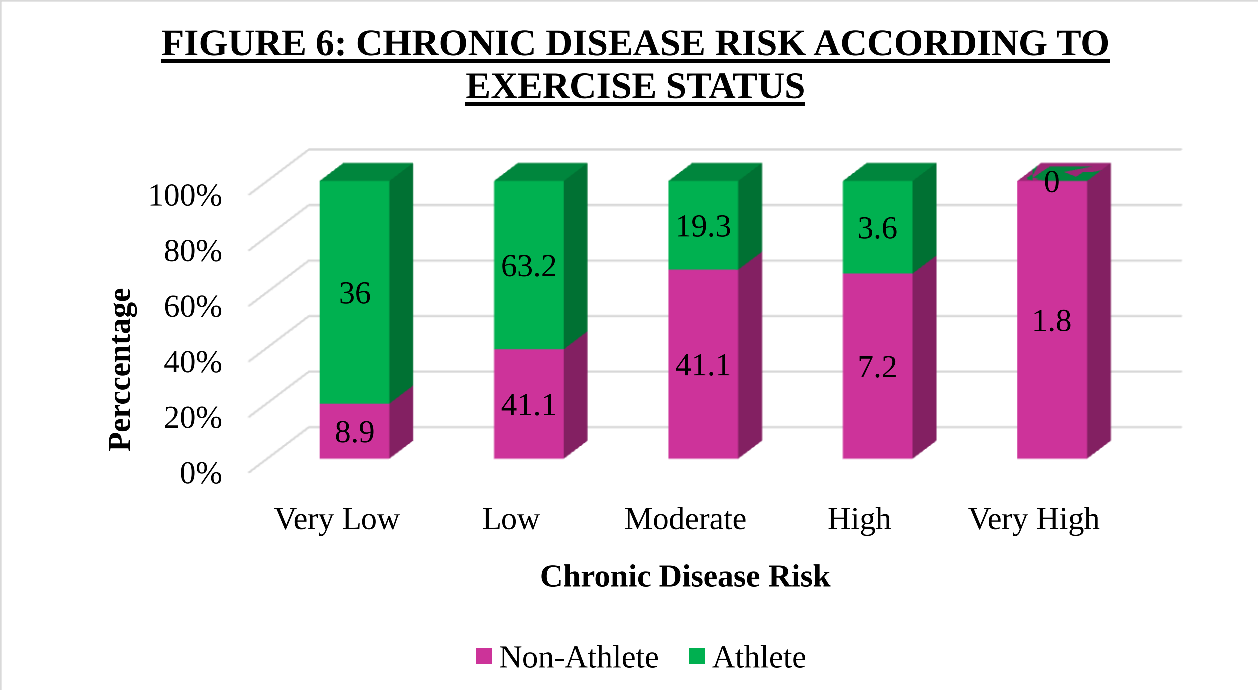


Figure 6 shows perceived risk of getting a chronic disease according to exercise status. Risk perception varied significantly between the subgroups (p=0.006). Athletes were more likely than non-athletes to see themselves at very low risk (36% of athletes versus 8.9% of non-athletes) and low risk (63.2% versus 41.1% of athletes and non-athletes respectfully) of getting a chronic disease while non-athletes were more likely to perceive themselves as having a moderate to high risk for chronic disease. None of the athletes in the sample saw themselves as being at a very high risk for chronic disease.

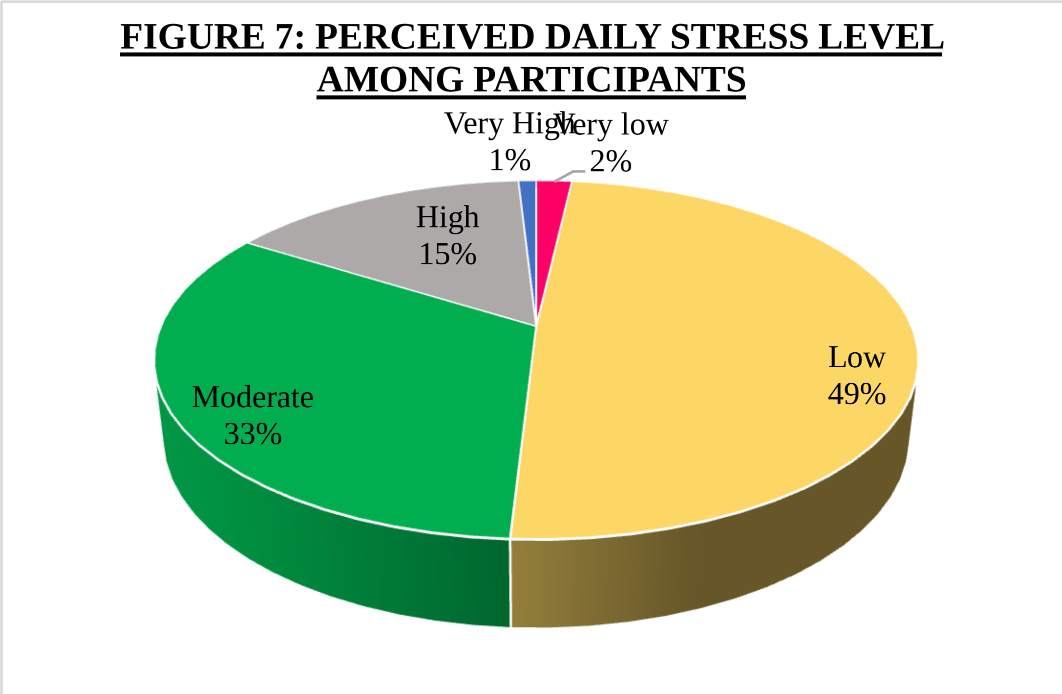


Figure 7 shows perception of daily stress levels among participants. The majority of participants reported a low daily stress level (49%) while the minority reported a very high (1%) or very low (2%) level of daily stress.

FIGURE 8: PERCEIVED DAILY STRESS LEVELS ACCORDING TO EXERCISE STATUS

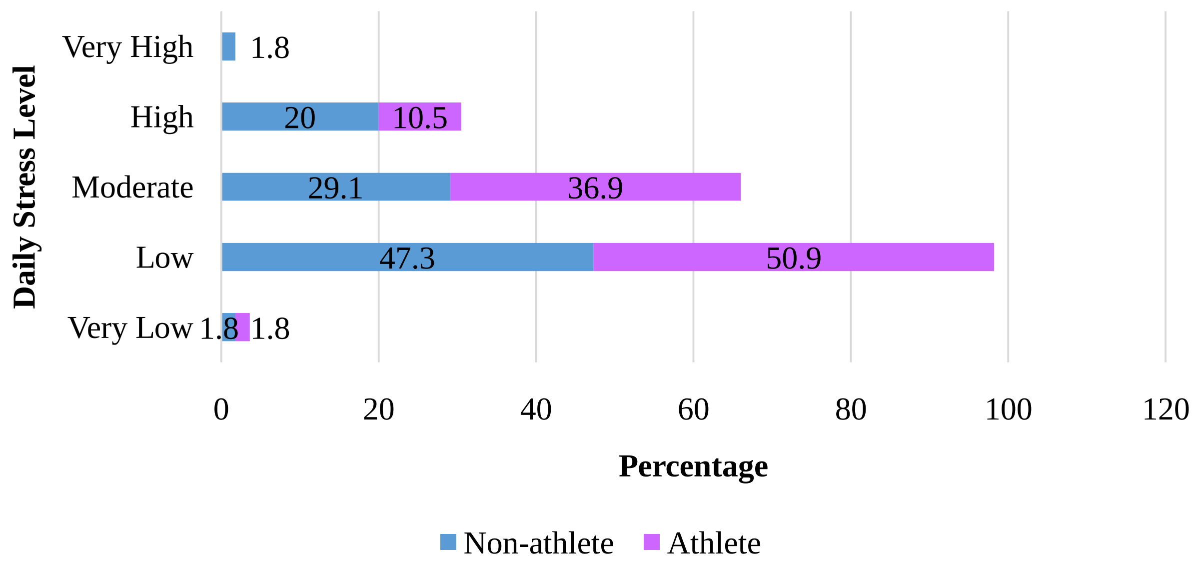


Figure 8 shows perceived level of daily stress based on exercise status. There was no significant difference in this variable (p=0.341). The majority of participants in both subgroups reported a low level of daily stress (47.3% of non-athletes and 50.9% of athletes). Equal percentages of non-athletes and athletes (1.8% each) reported a very low level of daily stress. The minority of participants in both subgroups perceived a very high level of stress: 1.8% of non-athletes, no athletes reported a very high level of stress.

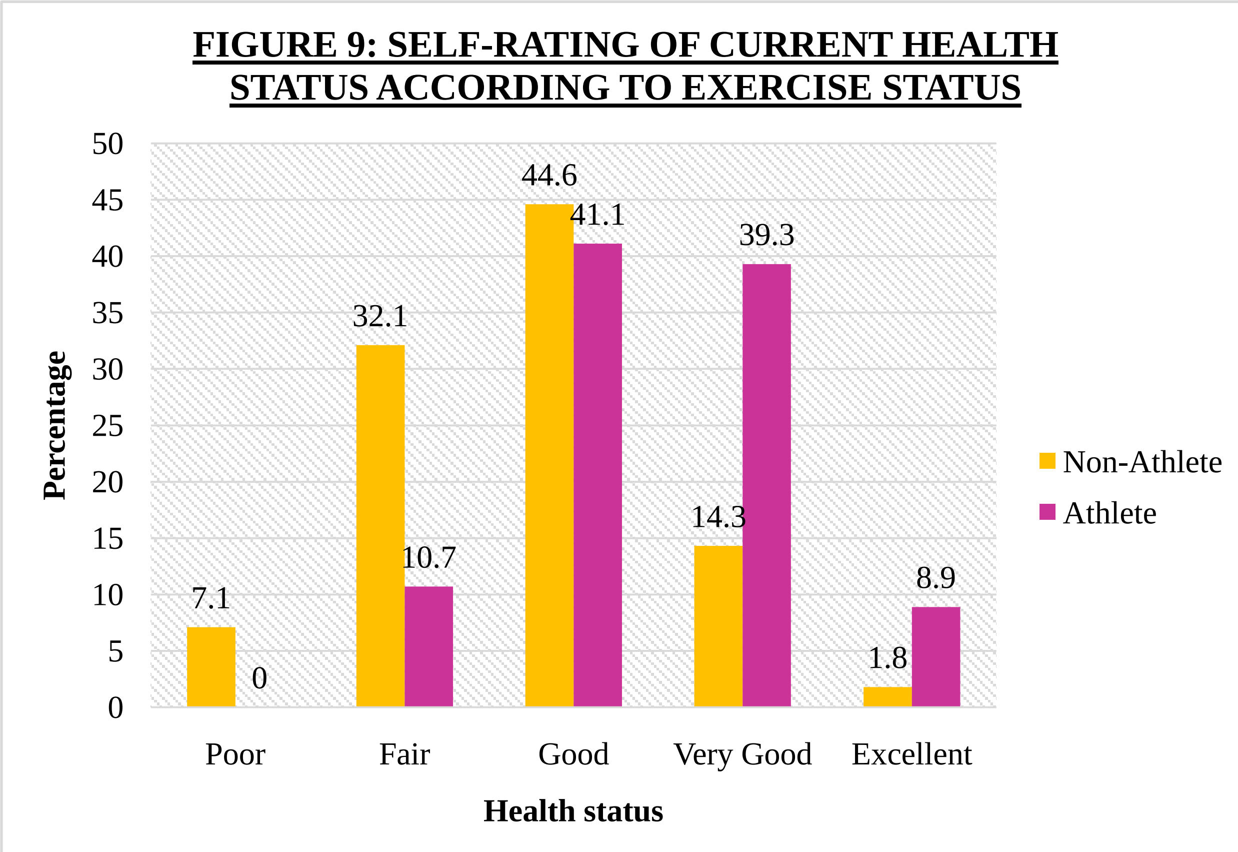


Figure 9 shows the general perception of current health status between the subgroups. Perception of health status differed significantly (p=0.001) with more non-athletes than non-athletes perceiving their health as either "poor" or "fair". None of the participants in the athlete group rated their health as poor as opposed to 7.1% of non-athletes. While 32.1% of non-athletes thought they were in fair health, only 10.7% of athletes had this perception. In contrast, athletes were more likely to rate their current health as "very good" or "excellent". 39.3% of athletes as compared to 14.3% of non-athletes believe that their health is very good; while few participants perceived their health to be "excellent" this rating was more common among athletes (8.9%) than non-athletes (1.8%).

TABLE 3: RATING OF CURRENT HEALTH IN COMPARISON TO THE PREVIOUS YEAR BASED ON EXERCISE STATUS

Current health versus health previous year	**Non-Athlete N (%)**	**Athlete N (%)**	**Total N (%)**	**p-value**
Much worse	3 (5.4)	0 (0)	3 (2.7)	**0.033**
Somewhat worse	13 (23.2)	6 (10.5)	19 (16.8)	
About the same	18 (32.1)	15 (26.3)	33 (29.2)	
Somewhat better	15 (26.8)	19 (33.3)	34 (30.1)	
Much better	7 (12.5)	17 (29.8)	24 (21.2)	

Table 3 shows the participants' perception on their current health as compared to their health one year ago. Generally, the majority of participants viewed their health as "about the same" (29.2%) or "somewhat better" (30.1%) than the previous year. There was a significant difference between the subgroups (p=0.033) with non-athletes being more likely to view their health as much worse (5.4% versus none of the athletes) and somewhat worse (23.2% versus 10.5% of athletes). In comparison, more athletes viewed their health as somewhat better (33.3% versus 26.8% of non-athletes) and much better (29.8% versus 12.5%) currently than in the previous year.

4.4 PERCEIVED BARRIERS TO EXERCISE AND SEDNTARY BEHAVIOURS AMONG PARTICIPANTS

TABLE 4: PERCEIVED BARRIERS TO EXERCISE BASED ON GENDER

1. I have enough time to exercise				
	Male **N (%)**	**Female** **N (%)**	**Total** **N (%)**	**p-value**
Strongly disagree	3 (5.4)	4 (7.0)	7 (6.2)	0.552
Disagree	7 (12.5)	13 (22.8)	20 (17.7)	
Neutral/Undecided	16 (28.6)	17 (29.8)	33 (29.2)	
Agree	18 (32.1)	15 (26.3)	33 (29.2)	
Strongly agree	12 (21.4)	8 (14.0)	20 (17.7)	
2. I have adequate facilities for exercise				
Strongly disagree	4 (7.3)	5 (8.8)	9 (8.0)	0.724
Disagree	10 (18.2)	6 (10.5)	16 (14.3)	
Neutral/Undecided	13 (23.6)	16 (28.1)	29 (25.9)	
Agree	13 (23.6)	17 (29.8)	30 (26.8)	
Strongly agree	15 (27.3)	13 (22.8)	28 (25.0)	
3. There is a safe environment for exercise				
Strongly disagree	3 (5.4)	6 (10.5)	9 (8.0)	0.634
Disagree	9 (16.1)	5 (8.8)	14 (12.4)	
Neutral/Undecided	11 (19.6)	12 (21.1)	23 (20.4)	
Agree	16 (28.6)	19 (33.3)	35 (31.0)	
Strongly agree	17 (30.4)	15 (26.3)	32 (28.3)	

4. I have a physical disability that prevents me from exercising				
	Male **N (%)**	**Female** **N (%)**	**Total** **N (%)**	**p-value**
Strongly disagree	51 (91.1)	46 (80.7)	97 (85.8)	0.296
Disagree	2 (3.6)	6 (10.5)	8 (7.1)	
Neutral/Undecided	1 (1.8)	2 (3.5)	3 (2.7)	
Agree	2 (3.6)	1 (1.8)	3 (2.7)	
Strongly agree	0 (0)	2 (3.5)	2 (1.8)	
5. Exercise is not for me				
Strongly disagree	48 (85.7)	40 (70.2)	88 (77.9)	0.083
Disagree	3 (5.4)	7 (12.3)	10 (8.8)	
Neutral/Undecided	2 (3.6)	8 (14.0)	10 (8.8)	
Agree	2 (3.6)	0 (0)	2 (1.8)	
Strongly agree	1 (1.8)	2 (3.5)	3 (2.7)	
6. I am motivated by family and friends to exercise				
Strongly disagree	16 (28.6)	9 (15.8)	25 (22.1)	0.380
Disagree	9 (16.1)	15 (26.3)	24 (21.2)	
Neutral/Undecided	16 (28.6)	16 (28.1)	32 (28.3)	
Agree	10 (17.9)	9 (15.8)	19 (16.8)	
Strongly agree	5 (8.9)	8 (14.0)	13 (11.5)	

7. I need company to exercise				
	Male N (%)	**Female** N (%)	**Total** N (%)	**p-value**
Strongly disagree	24 (43.6)	15 (26.3)	39 (34.8)	0.293
Disagree	4 (7.3)	8 (14.0)	12 (10.7)	
Neutral/Undecided	13 (23.6)	13 (22.8)	26 (23.2)	
Agree	9 (16.4)	12 (21.1)	21 (18.8)	
Strongly agree	5 (9.1)	9 (15.8)	14 (12.5)	
8. I am too tired to exercise				
Strongly disagree	24 (42.9)	15 (26.8)	39 (34.8)	0.235
Disagree	14 (25.0)	11 (19.6)	25 (22.3)	
Neutral/Undecided	10 (17.9)	16 (28.6)	26 (23.2)	
Agree	4 (7.1)	8 (14.3)	12 (10.7)	
Strongly agree	4 (7.1)	6 (10.7)	10 (8.0)	
9. Exercising is too expensive				
Strongly disagree	34 (60.7)	35 (61.4)	69 (61.1)	0.792
Disagree	10 (17.9)	13 (22.8)	23 (20.4)	
Neutral/Undecided	7 (12.5)	4 (7.0)	11 (9.7)	
Agree	4 (7.1)	3 (5.3)	7 (6.2)	
Strongly agree	1 (1.8)	2 (3.5)	3 (2.7)	

Table 4 highlights several perceived barriers to exercise based on gender. Barrier perceptions were generally similar between genders: for both males and females, the most commonly reported perceived barrier was the lack of social support. 31.3% of the population reported that they need company to exercise while 28.3% required motivation by family and friends (as determined by combining the results for the “agree” and “strongly agree” scales for each barrier). Females were more likely to report barriers to exercise with the most commonly reported barrier in this subgroup being the lack of social support. 36.9% of females reported needing company to exercise as opposed to 25.5% of males. 29.8% of females reported a lack of motivation by family and friends. This barrier, in addition to a lack of adequate facilities was the most commonly reported among males with 25.5% in each category. Lack of time was also a more significant barrier to exercise among females (29.8%) than males (17.9%). The least common barriers to exercise in both genders were the presence of a physical disability preventing exercise (4.5%) and “exercise is not for me” (4.5%).

TABLE 5: PERCEIVED BARRIERS TO EXERCISE BASED ON EXERCISE STATUS

1. **I have enough time to exercise**				
	Non-athlete N (%)	**Athlete N (%)**	**Total N (%)**	**p-value**
Strongly disagree	6 (10.7)	1 (1.8)	7 (6.2)	**0.030**
Disagree	10 (17.9)	10 (17.5)	20 (17.7)	
Neutral/Undecided	13 (23.2)	20 (35.1)	33 (29.2)	
Agree	21 (37.5)	12 (21.1)	33 (29.2)	
Strongly agree	6 (10.7)	14 (24.6)	20 (17.7)	
2. **I have adequate facilities for exercise**				
Strongly disagree	6 (10.7)	3 (5.4)	9 (8.0)	0.632
Disagree	9 (16.1)	7 (12.5)	16 (14.3)	
Neutral/Undecided	15 (26.8)	14 (25.0)	29 (25.9)	
Agree	15 (26.8)	15 (26.8)	30 (26.8)	
Strongly agree	11 (19.6)	17 (30.4)	28 (25.0)	
3. **There is a safe environment for exercise**				
Strongly disagree	3 (5.4)	6 (10.5)	9 (8)	0.357
Disagree	8 (14.3)	6 (10.5)	14 (12.4)	
Neutral/Undecided	13 (23.2)	10 (17.5)	23 (20.4)	
Agree	20 (35.7)	15 (26.3)	35 (31.0)	
Strongly agree	12 (21.4)	20 (35.1)	32 (28.3)	

4. I have a physical disability that prevents me from exercising				
	Non-athlete **N (%)**	**Athlete** **N (%)**	**Total** **N (%)**	**p-value**
Strongly disagree	48 (85.7)	49 (86.0)	97 (85.8)	0.615
Disagree	4 (7.1)	4 (7.0)	8 (7.1)	
Neutral/Undecided	1 (1.8)	2 (3.5)	3 (2.7)	
Agree	1 (1.8)	2 (3.5)	3 (2.7)	
Strongly agree	2 (3.6)	0 (0)	2 (1.8)	
5. Exercise is not for me				
Strongly disagree	37 (66.1)	51 (89.5)	88 (77.9)	**0.032**
Disagree	7 (12.5)	3 (5.3)	10 (8.8)	
Neutral/Undecided	9 (16.1)	1 (1.8)	10 (8.8)	
Agree	1 (1.8)	1 (1.8)	2 (1.8)	
Strongly agree	2 (3.6)	1 (1.8)	3 (2.7)	
6. I am motivated by family and friends to exercise				
Strongly disagree	11 (19.6)	14 (24.6)	25 (22.1)	0.756
Disagree	14 (25.0)	10 (17.5)	24 (21.2)	
Neutral/Undecided	17 (30.4)	15 (26.3)	32 (28.3)	
Agree	9 (16.1)	10 (17.5)	19 (16.8)	
Strongly agree	5 (8.9)	8 (14.0)	13 (11.5)	

7. I need company to exercise				
	Non-athlete N (%)	**Athlete** N (%)	**Total** N (%)	**p-value**
Strongly disagree	16 (26.6)	23 (41.1)	39 (34.8)	0.265
Disagree	5 (8.9)	7 (12.5)	12 (10.7)	
Neutral/Undecided	12 (21.4)	14 (25.0)	26 (23.2)	
Agree	14 (25.0)	7 (12.5)	21 (18.8)	
Strongly agree	9 (16.1)	5 (8.9)	14 (12.5)	
8. I am too tired to exercise				
Strongly disagree	13 (23.2)	26 (46.4)	39 (34.8)	**0.001**
Disagree	5 (8.9)	16 (28.8)	25(22.3)	
Neutral/Undecided	12 (21.4)	7 (12.5)	26 (23.2)	
Agree	14 (25.0)	6 (10.7)	12 (10.7)	
Strongly agree	9 (16.1)	1 (1.8)	10 (8.9)	
9. Exercising is too expensive				
Strongly disagree	26 (46.4)	43 (75.4)	69 (61.1)	**0.038**
Disagree	16 (28.6)	7 (12.3)	23 (20.4)	
Neutral/Undecided	7 (12.5)	4 (7.0)	11 (9.7)	
Agree	5 (8.9)	2 (3.5)	7 (6.2)	
Strongly agree	2 (3.6)	1 (1.8)	3 (2.7)	

Table 5 highlights the perceived barriers to exercise according to exercise status. There were several significant differences in barrier perceptions between the subgroups. Non-athletes were more likely to perceive barriers to exercise than athletes. The most commonly reported barrier to exercise in both subgroups was the lack of social support with 31.3% of participants needing company to exercise and 28.3% requiring motivation by family and friends (as determined by combining the "agree" and "strongly agree" scales). The need for social support was however higher in non-athletes (41.1% needing company versus 21.4% of athletes). Meanwhile, athletes reported having more social support in terms of being motivated by family and friends. 31.5% of athletes were externally motivated compared to 25% of non-athletes. A significantly lower number of athletes than non-athletes reported that time was a barrier (p=0.030): 19.3% of athletes versus 28.6% of non-athletes. "Exercise is not for me" was also more of a barrier to non-athletes (p=0.032). More non-athletes reported being too tired to exercise (p=0.001). 26.8% of non-athletes as compared to 12.5% of athletes. The most common barrier to exercise among athletes was needing company to exercise (21.4%). Not having a safe environment to exercise was more of a barrier to athletes (21%) than non-athletes (19.7%). The least common barriers to exercise in both groups were 1) the presence of a physical disability (4.5%) and 2) "exercise is not for me" (4.5%).

TABLE 6: AVERAGE SEDENTARY HOURS AS ESTIMATED BY SCREEN TIME ACCORDING TO EXERCISE STATUS.

Exercise Status	**Mean screen time (hours)**	**Standard Deviation (SD; hours)**	**p-value**
Non-Athlete	5.44	3.38	0.069
Athlete	4.31	3.10	

Table 6 shows the average number of hours spent watching television, on the computer or similar sedentary activities per day based on exercise status. Average screen time was lower for athletes (4.31hours/day) than non-athletes (5.44 hours/day) however the difference was not statistically significant (p=0.069).

4.5 DIETARY ANALYSIS: FOOD FREQUENCY AND RELATIONSHIP BETWEEN DIET AND CVD RISK

FIGURE 10: FOOD FREQUENCY ACCORDING TO EXERCISE STATUS

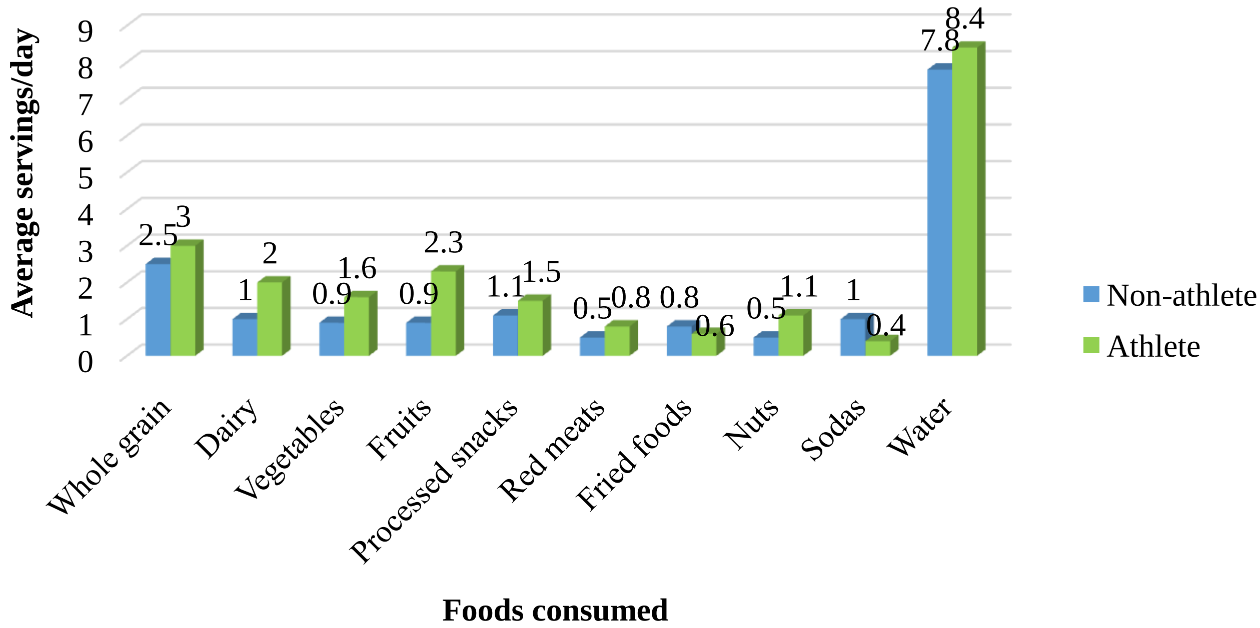


Figure 9 shows the number of servings of particular foods consumed daily based on exercise status. Whole grain (p=0.32), vegetable (p=0.097), processed snacks (p=0.37), red meat (p=0.080), fried foods (p=0.49) and water consumption did not differ significantly between the subgroups. Non-athletes consumed significantly more sodas than athletes (p=0.032). Consumption of dairy (p=0.015), fruits (p=<0.001) and nuts (p=0.022) was significantly higher in athletes than non-athletes.

Table 7 shows the relationship between diet and presence of CVD risk factors as defined by values exceeding or under prescribed cut off points, among participants. There was a significant positive correlation between vegetable consumption and HDL levels (p=0.024), that is, low vegetable intake was related to low HDL cholesterol level. The negative correlation between fruit intake and low HDL levels approached statistical significance (p=0.053): low fruit intake was associated with the presence of high HDL cholesterol level. The most significant correlations were between red meat consumption and blood pressure. High red meat intake was associated with both elevated systolic (p=0.001) and diastolic (p=0.005) pressure levels.

4.6 ANTHROPOMETRIC AND PYSIOLOGIC TESTS OF PARTICIPANTS

TABLE 8: CHARACTERISTICS OF PARTICIPANTS BY GENDER

	Females N=185	**Males N=119**	
Variable (unit)	**Mean (SD)**	**Mean (SD)**	**p-value**
Weight(lbs)	138.5 (28.6)	165.8(36.6)	**<0.001**
Height (cm)	164.4 (7.1)	175.6(7.6)	**<0.001**
Waist circumference (inches)	29.4(3.8)	32.2(4.1)	**<0.001**
BMI (lbs/inch^2)	23.1(4.3)	24.1(4.6)	**0.05**
Body fat (%)	33.1(9.1)	21.4(8.3)	**<0.001**
Visceral fat (%)	4.0(1.7)	6.3(3.9)	**<0.001**
Skeletal mass (%)	27.2(4.6)	39.0(5.2)	**<0.001**
Glycated Hemoglobin (%)	5.2(0.53)	5.2(4.4)	0.73
Blood sugar (mg/dL)	88.9(11.7)	89.2(12.6)	0.90
Total cholesterol (mg/dL)	149.0(45.1)	138.3(45.8)	**0.05**
HDL-cholesterol (mg/dL)	56(17.2)	48.8(15.1)	**<0.001**
LDL-cholesterol (mg/dL)	74.7(39.0)	79.7(46.7)	0.39
Total triglycerides (mg/dL)	99.3(75.2)	86.6(62.7)	0.14
Systolic Blood Pressure (mmHg)	109.0(9.2)	125.3(11.5)	**<0.001**
Diastolic Blood Pressure (mmHg)	67.7(6.5)	70.9(8.2)	**<0.001**
Heart rate (bpm)	76.0(11.5)	71.3 (12.7)	**0.001**

Table 8 shows anthropometric and cardiometabolic characteristics based on gender. Males were significantly taller (p=<0.001) and heavier (p=<0.001) than females. Additionally, they had significantly higher waist circumferences (p=<0.001), BMI (p=0.05), visceral fat (p=<0.001), skeletal mass (p=<0.001), systolic blood pressure (p=<0.001), diastolic blood pressure (p=<0.001), and heart rates (p=0.001). Females had higher body fat percentages (p=<0.001), total cholesterol (p=0.05) and HDL cholesterol levels (p=<0.001). There were no significant differences in ages, glycated hemoglobin (p=0.73), blood sugar (p=0.90) and triglycerides (p=0.14) between genders

<u>TABLE 9: CHARACTERISTICS OF FEMALE PARTICIPANTS BASED ON EXERCISE STATUS.</u>

	Non-athlete N=129	**Athlete N=56**	
Variable (unit)	**Mean (SD)**	**Mean (SD)**	**p-value**
Weight(lbs)	138.2(31.0)	139.1(23.1)	0.83
Height (cm)	163.7(7.3)	165.9(6.3)	**0.05**
Waist circumference (inches)	29.6(4.2)	28.8(2.7)	0.16
BMI (kg/m^2)	23.3(4.8)	22.7(3.3)	0.34
Body fat (%)	33.8(9.8)	31.6(7.2)	0.09
Visceral fat (%)	4.2(1.2)	3.6(1.2)	**0.01**
Skeletal mass (%)	26.5(5)	28.7(3.1)	**0.002**
Glycated Hemoglobin (%)	5.3(0.53)	5.1(0.47)	**0.04**
Blood sugar (mg/dL)	88.8(12.6)	89.6(7.7)	0.75
Total cholesterol (mg/dL)	152.9(49.2)	140.0(32.4)	0.08
HDL-cholesterol (mg/dL)	53.7(17.5)	61.1(15.6)	**0.010**
LDL-cholesterol (mg/dL)	77.4(40.6)	65.5(32.2)	**0.012**
Total triglycerides (mg/dL)	104.4(73.1)	87.0(79.4)	0.17
Systolic Blood Pressure (mmHg)	108.4(73.1)	109.8(9.5)	0.46
Diastolic Blood Pressure (mmHg)	68.5(6.2)	66.0(6.6)	**0.02**
Heart rate (bpm)	78.4(10.9)	70.7(11.3)	**<0.001**

Table 9 shows anthropometric and cardiometabolic characteristics in female participants based on exercise status. Athletes were significantly taller (p=0.05). Non-athletes had significantly higher visceral fat percentages (p=0.01), glycated hemoglobin (p=0.04), LDL cholesterol (p=0.012), diastolic blood pressure (p=0.02) and heart rate (p=<0.001). Skeletal mass (p=0.002) and HDL-cholesterol (p=0.01) values were higher in the athlete group. No significant differences were found in weight (p=0.83), waist circumference (p=0.16), BMI (p=0.34), body fat % (p=0.09), blood glucose (p=0.75), total cholesterol (p=0.08), triglycerides (p=0.172) and systolic blood pressure (p=0.46)

TABLE 10: CHARACTERISTICS OF MALE PARTICIPANTS BASED ON EXERCISE STATUS

	Non-athlete N=69	**Athlete N=50**	
Variable (unit)	**Mean (Standard deviation from the mean)**	**Mean (Standard deviation from the mean)**	**p-value**
Weight(lbs)	165.0 (41.3)	166.8 (29.6)	0.078
Height (cm)	175.8 (7.9)	175.4 (7.2)	0.081
Waist circumference (inches)	32.6 (4.4)	31.6 (3.6)	**0.02**
BMI (kg/m^2)	24.3 (5.2)	23.9 (3.7)	0.72
Body fat (%)	22.9 (8.8)	19.4 (7.2)	**0.02**
Visceral fat (%)	6.7 (4.3)	5.8 (3.3)	0.20
Skeletal mass (%)	37.9 (5.6)	40.4 (4.3)	**0.01**
Glycated Hemoglobin (%)	5.2 (0.47)	5.2 (0.38)	0.46
Blood glucose (mg/dL)	87.6 (13.6)	91.8 (10.3)	0.21
Total cholesterol (mg/dL)	141.5 (45.4)	133.8 (46.5)	0.38
HDL-cholesterol (mg/dL)	46.0 (14.5)	52.9 (15.2)	**0.02**
LDL-cholesterol (mg/dL)	88.1 (45.6)	66.9 (46.1)	**0.04**
Total triglycerides (mg/dL)	87.5 (63.1)	85.3 (62.8)	0.85
Systolic Blood Pressure (mmHg)	123.5 (11.5)	127.711.1)	**0.05**
Diastolic Blood Pressure (mmHg)	71.7 (7.6)	69.8 (8.9)	0.19
Heart rate (bpm)	76.7 (12.2)	63.9 (9.0)	**<0.001**

Table 10 shows anthropometric and cardiometabolic characteristics in male participants based on exercise status. Waist circumference (p=0.02), body fat percentage (p=0.02), LDL-cholesterol (p=0.04) and heart rate (p=<0.001) were significantly higher in non-athletes. Athletes displayed significantly higher values for HDL-cholesterol (p=0.02) and systolic blood pressure (p=0.05). No significant variances were found for weight (p=0.078), height (p=0.081), BMI (p=0.72), glycated hemoglobin (p=0.46), blood glucose (p=0.21), total cholesterol (p=0.38), total triglycerides (p=0.85) and diastolic blood pressure (p=.019) between the subgroups.

TABLE 11: PREVALENCE OF CARDIOMETABOLIC RISK FACTORS BASED ON GENDER

Risk Factor	**Male N (%)**	**Female N (%)**	**Total N (%)**	**p-value**
Waist Circumference Females ≥35 inches Males ≥40 inches	6 (5.2)	18 (10.0)	24 (8.1)	0.19
BMI ≥25 lbs/inch^2	36 (31.6)	54 (32.3)	90 (32.0)	1.00
Body Fat % ≥35 Females ≥25 Males	33 (28.7)	76 (42.2)	109 (36.9)	**0.019**
HbA1C ≥5.7%	8 (14.0)	17 (19.3)	25 (17.2)	0.50
Total Cholesterol >200mg/dL	6 (5.4)	10 (5.7)	16 (5.6)	1.000
HDL <50mg/dL Females <40mg/dL Males	28 (25.2)	65 (38.0)	93 (33.0)	**0.028**
LDL >100mg/dL	20 (23.8)	28 (19.7)	48 (21.2)	0.50
Triglycerides >150mg/dL	12 (10.8)	29 (17.1)	41 (14.6)	0.17
Systolic Blood Pressure >130mmHg	39 (33.1)	6 (3.3)	45 (15.0)	**< 0.001**
Diastolic Blood Pressure >85mmHg	8 (6.8)	0 (0)	8 (2.7)	**<0.001**

Table 11 shows the prevalence of cardiometabolic risk factors in the sample based on gender. Males were more likely to have systolic (p=<0.001) and diastolic (p=<0.001) blood pressures exceeding prescribed cut-off points. Among females, elevated body fat percentage (p=0.019) and HDL cholesterol below the recommended value (p=0.028) were significantly more common than in males. No significance was found between gender in terms of elevated waist circumference (p=0.19), BMI (p=1.00), HbA1C (p=0.50), total cholesterol (p=1.00), LDLs (p=0.50) and triglycerides (p=0.17); however in females, waist circumference (10.0%), HbA1C (19.3%) and triglycerides (17.1%) were more likely to be elevated than in males (5.2%, 14.0% and 10.8% respectfully). Males had a higher prevalence of elevated LDL levels (23.8%) than females (19.7%). Prevalence of elevated BMI and total cholesterol were very similar between genders. Elevated BMI: 31.6% of males, 32.3% of females; high total cholesterol: 5.4% of males, 5.7% of females.

TABLE 12: PREVALENCE OF CARDIOMETABOLIC RISK FACTORS BASED ON EXERCISE STATUS

Risk Factor	Non-athlete N (%)	Athlete N (%)	Total N (%)	p-value
Waist Circumference Females ≥35 inches Males ≥40 inches	21 (10.9)	3 (2.9)	24 (8.1)	**0.014**
BMI ≥24.9 lbs/inch^2	61 (34.9)	29 (27.4)	90 (32.0)	0.24
Body Fat % ≥35 Females ≥25 Males	83 (43.9)	26 (24.5)	109 (36.9)	**0.001**
HbA1C ≥5.7	21 (21.2)	4 (8.7)	25 (17.2)	0.096
Total Cholesterol >200mg/dL	13 (7.0)	3 (3.1)	16 (5.6)	0.28
HDL <50mg/dL Females <40mg/dL Males	73 (39.5)	20 (20.6)	93 (33.0)	**0.001**
LDL >100mg/Dl	38 (23.8)	10 (15.2)	48 (21.2)	0.21
Triglycerides >150mg/dL	30 (16.1)	11 (11.6)	41 (14.6)	0.37
Systolic Blood Pressure >130mmHg	21 (10.8)	24 (22.6)	45 (15.0)	**0.01**
Diastolic Blood Pressure >85mmHg	3 (1.5)	5 (4.7)	8 (2.7)	0.13

Table 12 shows the prevalence of cardiometabloic risk factors based on exercise status as determined by values exceeding prescribed cut off points. A significantly greater percentage of non-athletes had waist circumferences (p=0.014) and body fat percentages (p=0.001) higher than the recommended limits. HDL cholesterol was significantly lower in the non-athlete group (p=0.001). Athletes displayed a greater likelihood of having Systolic blood pressure >130mmHg (p=0.01). There were no significant differences in BMI (p=0.24), HbA1C (p=0.096), total cholesterol (p=0.28), LDL cholesterol (p=0.21), triglyceride (p=0.37) or diastolic blood pressure (p=0.13) values between the groups; however elevated BMIs (34.9%), HbA1C (21.2%), total cholesterol (7.0%), LDL cholesterol (23.8%) and triglycerides (16.1%) were more prevalent in the non-athlete subgroup than the athlete subgroup (27.4%, 8.7%, 3.1%, 15.2%, and 11.6% respectfully). Diastolic blood pressure exceeding the prescribed cut-off value was higher in athletes (4.7%) than non-athletes (1.5%).

Table 13 shows the relationships among cardiometabolic risk factors. High waist circumference was significantly positively correlated with elevated BMI (p=<0.001), body fat (p=<0.001), HbA1C (p=0.002), systolic blood pressure (p=0.022) and low HDL (p=<0.001) levels. In addition to a large waist circumference, persons with a BMI ≥25 also had elevated body fat percentages (p=<0.001), low HDL levels (p=<0.001) and high triglyceride levels (p=0.005). The relationship between high BMI and Elevated SBP approached statistical significance (p=0.052). High body fat percentage was related to several other cardiometabolic risk factors. Excluding large waist circumference and high BMI, persons with high body fat percentages tended to have elevated HBA1C (p=0.007) and triglyceride (p=<0.001) levels and low HDL cholesterol (p=<0.001). Elevated HbA1C was significantly correlated with elevated triglyceride (p=0.004) and SBP (p=0.016) levels in addition to high waist circumference and body fat percentages. Elevated total cholesterol was significantly correlated with low HDL (p=0.019), high LDL (p=<0.001) and high triglyceride (p=<0.001) levels. A high LDL level was significantly associated with elevated total cholesterol only. In addition to the aforementioned variables, the relationship between low HDL level and elevated triglygerides approached statistical significance (p=0.054). Elevated DPB was only significantly correlated with elevated SBP (p=<0.001)

CHAPTER 5: DISCUSSION OF FINDINGS

5. DISCUSSION OF FINDINGS

The premise that cardiovascular disease is a worldwide epidemic is well established. It is also the general consensus that much of the disease burden can be alleviated through improved social norms and practices (Maner and Sridhar 2012). Central to cardioprotection is physical activity/ exercise which is regarded as one of the most important modifiable factors since it leads to improvements in many observed risk factors and therefore CVD as a whole.

This study, conducted among a young adult group of University students, primarily aged 18-24 years (85.4% of total sample) sought to highlight differences in CVD risk factor prevalence among regularly exercising (control group/athletes) and sedentary individuals (case group/non-athletes). It was first necessary to establish baseline information on perceived levels of physical activity and health status between the groups. Perceived barriers to exercise were also examined since, fundamental to the establishment and promotion of regular exercise as a cardioprotective mechanism is knowledge and understanding of barriers/ perceived barriers to the beginning and maintenance of active lifestyles (Gomez-Lopez et al 2010).

5.1.1 Exercise levels and Health Status in total population and across exercise status

In a self-reported analysis of physical activity prevalence, it was found that the majority of the population reported that they engaged in exercise outside of their daily activities/were physically active (76.1%) as compared to 24% being completely inactive. This finding was similar to that of Greene et al (2011) who noted a high level of physical activity in their sample (54.2%). In contrast, Jarrah et al. (2011) noted a 55.1% prevalence of physical inactivity among Jordan University students. Additionally, PAHO (2006) noted that 74.3% of students in Trinidad and Tobago did not engage in physical activity. These results were not unexpected since the present design utilized persons known to be physically active, that is, the athlete group. Exercise status played a major role in determining engagement in exercise outside of one's current occupation. None of the athletes reported not engaging in exercise while the majority of those who did exercise in the sample (65.1%) were from this subgroup as compared to 34.6% of non-athletes.

Level of physical activity was generally described as moderate (46.9% of total population). As predicted, a much larger percentage of non-athletes than athletes (41.1% versus 1.8%) reported having a low level of physical activity meanwhile a higher percentage of athletes (50.9% versus 10.7%) had a high level of physical activity. In an expanded view, the majority of the population reported that they engage in light exercise (93.9%). There was also a high prevalence of moderate intensity activity (90.2%) while high intensity exercise was conducted by 71.7% of the population, primarily athletes. ACSM and CDC recommendations of at least 30 minutes moderate-intensity exercise most days of the week (Bassuk and Manson 2005), prompted further investigation of the 90.2% prevalence of moderate-intensity activity, particularly in light of much lower prevalence statistics in prior research (Lovell et al 2010). As expected, exercise status played a major role in this finding. With regards to frequency, 40% of the sample engaged in moderate-intensity of activity 5-7 days per week, with the majority (58.6%) coming from the control group. The frequency of moderate intensity exercise was higher than expected in the non-athlete group with 41.3% engaging in moderate activities 5-7 days per week; however, as regards time, non-athletes did not meet ACSM and CDC criteria of at least 30 minutes, since the mean duration was 27.2 minutes each episode. In contrast, the athletes met and exceeded the criteria at an average duration of 61 minutes each episode.

In developing countries, there is an increasing prevalence of cardiovascular deaths in persons under the age of 65 (35-64 years old) however, many do not perceive themselves as at risk for CVDs (Fuster and Kelley 2010). This was reflected in the present design with 51% of the population reporting a low risk for chronic disease; however, this perception also varied across exercise status. Athletes had a generally better health perception than non-athletes, for example, 36% of athletes viewed their chronic disease risk as very low in comparison to 8.9% of non-athletes; in terms of low risk, 63.2% and 41.1% of athletes and non-athletes respectively, made this report. Athletes were less likely to view themselves as having a high (3.6% versus 7.2%) or very high (none of the athletes versus 1.8% of non-athletes) risk for chronic disease. The majority of non-athletes (44.6%) and athletes (41.1%) rated their current health status as "good" however, non-athletes were much more likely to view themselves as being in poor (7.1% versus none of the athletes) or fair (32.1% versus 10.7%) health. In comparison, 39.3% of athletes perceived themselves to be in very good health while only 14.3% of non-athletes had this view. The perception of health as "excellent" was generally low, however athletes (8.9%) had a higher tendency than non-athletes (1.8%) to see themselves as being in excellent health. Most persons viewed their health as either "about the same" (29.2%) or "somewhat better" (30.1%) than the previous year, however, athletes were more likely to view their health as better (sum of "somewhat better" and "much better" categories: 39.3% and 63.1% of non-athletes and athletes respectively) while non-athletes were more likely to view their health as worse (sum of "somewhat worse" and "much worse" categories: 28.6% and 10.5% of athletes and non-athletes respectively). These findings highlight an important correlation between physical activity level/exercise status and health perception, that is, engaging in regular exercise improves an individual's view of his/her health status.

5.1.2 <u>Perceived barriers to physical activity across gender and exercise status</u>

In contrast to prior research which noted lack of time as the most common barrier to exercise (Daskapan et al. 2006, Gomez-Lopez et al. 2010), the present study found that a lack of social support was the strongest predictor of physical inactivity (59.6%:31.3% of the population reported a need for company to exercise and 28.3% required motivation by family and friends).

Barrier perceptions between genders did not reach statistical significance for any of the variables investigated however, several differences were noted between the subgroups. Reflective of the findings of Gomez-Lopez et al. (2010), females were found to perceive more barriers to exercise than males and also have a larger social support requirement: 36.9% of females as compared to 25.5% of males.

Exercise status was a stronger predictor of perceived barriers to exercise. As expected, non-athletes were significantly more likely to perceive several of the examined barriers. Most notably, non-athletes were more likely to highlight internal barriers such as "exercise is not for me" (p=0.032) and lack of energy (p=0.001) which were found to be two of three most prevalent internal barriers by Daskapan et al (2006). In terms of external barriers, more non-athletes reported that exercising was too expensive (p=0.038). The need for social support was higher in non-athletes (41.1%) than athletes (21.4%) with more athletes (31.5%) than non-athletes (25%) being motivated by family and friends to exercise. The finding that persons who exercise more (athletes) also had a higher level of external motivation is fundamental to understanding exercise behaviours; it prompts further investigation into motivation as a determining factor in physical activity/exercise commencement and maintenance.

5.1.3 <u>Dietary contributions to cardiovascular disease risk</u>

Present literature is replete with correlational relationships between diet and CVD risk, which generally require further investigation. This study found few significant relationships between diet and CVD risk factors. There was a negative correlation between vegetable intake and prevalence of low HDL cholesterol (r= -0.232, p=0.024); additionally, the relationship between fruit consumption and low HDL levels approached statistical significance (r= -0.199, p=0.053). The relationship between increasing vegetable intake and higher levels of HDL cholesterol is yet to be investigated in depth since research thus far has primarily focused on total and LDL cholesterol decrease rather than HDL increase. Middaugh et al. (2011) simply stated that fruit and vegetable intakes were "weakly associated" with increased cholesterol levels. A recent study conducted by Daniels et al (2014) provided a more in depth analysis. According to the authors, the relationship between fruit and vegetable intake and HDL levels is based on their antioxidant properties. As highlighted previously, HDL cholesterol is believed to protect against blood vessel damage via its anti-inflammatory and antioxidant properties (Toth 2005). The explanation put forth by Daniels and colleagues (2014) is that several antioxidants gained from fruits and vegetables such as carotenoids are transported by lipoproteins including HDLs. Lycopene (the carotenoid derived from red fruits and vegetables) in particular, was found to influence the cardioprotective properties of HDLs by stimulating anti-atherogenic increases in the main enzymes within HDL associated with its antioxidant properties (paraoxonase-1 (PON-1) and lecithin cholesterol acyltransferase (LCAT)).

The most significant correlation was found between red meat consumption and blood pressure. Increased red meat consumption was associated with and both elevated systolic (r= 0.317, p=0.001) and diastolic (r=0.262, p=0.005) blood pressure. The exact mechanisms by which red meats may lead to blood pressure elevation remain unknown, however, the general view is that the association occurs as a result of high saturated fat, sodium and cholesterol commonly found in red meats (Larsson et al, 2011; Steffen et al. 2005). Another explanation put forth is the effect of “iron overload” that may be experienced by persons consuming large amounts of red meats-major sources of heme iron, the more bioavailable source of iron. Larson et al. (2011) state that large iron stores increase oxidative injury which in turn increases a number of CVD risk factors. The authors note a positive correlation between red meat consumption, blood pressure and incidence of hypertension. There was a weak but significant correlation between red meat consumption and both systolic (r=0.08, p=<0.001) and diastolic (r=0.07, p=<0.001) in middle aged and elderly women (Wang et al. 2008). This was reiterated by Steffen et al. (2005) who highlighted a positive dose-response relationship between elevated blood pressure and higher levels of red meat consumed (p=<0.001) in a 15 year follow-up study of young African-American adults aged 18-30, the population most similar to the present design in terms of demographics. In contrast to the findings in this study and the aforementioned authors, Micha et al. (2010) in their systematic review and meta-analysis, found no relationship between red meat intake and blood pressure in four prior studies. McAfee et al (2009) shared this view, noting that moderate consumption of lean red meat as part of a balanced diet had no effect on blood pressure, however, the effect of red meats with higher fat contents was not highlighted. Red meat consumption was low within the sample as a whole but higher among athletes (0.8 servings as compared to 0.5 servings per day in non-athletes). A plausible explanation for this finding is the athletes’ need for larger amounts of protein therefore a higher meat and legume consumption was expected and found in this subgroup.

5.1.4 Anthropometric and physiologic parameters: Prevalence of CVD risk factors in the entire sample and across gender

The study tested individual parameters that are commonly used to determine cardiovascular disease risk. Several researchers take the position that prevalence of CVDs as a whole as well as individual risk factors are more prevalent among males than females (Grotto et al., 2006; Ferguson et al., 2008; National Academies Press, 2010). Significant variations between genders were found in the variables tested. Males were significantly taller and heavier hence had higher BMIs. This finding is explained by the larger muscle mass in males as compared to females; mean skeletal mass 27.2% for females and 39.0% for males (p=<0.001). Systolic and diastolic blood pressures were significantly higher in males while heart rate was significantly faster in females. HDL cholesterol was also significantly higher in females. The assumption behind these findings is that premenopausal women such as those examined in the study tend to have lower blood pressures, higher levels of HDL cholesterol and lower triglycerides (not shown in this study) than men due to the cardioprotective effects of estrogen (Fuster and Kelly 2010). With respect to gender differences in heart rate, recent studies are limited however, Taneja et al. (2001) highlight that women tend to have a faster baseline heart rate since men have larger body surface areas and heart size. The smaller heart size means that a larger number of beats per minute is required to maintain cardiac output. The heartbeat of a woman is also considered to be more efficient in terms of blood pressure maintenance: this provides additional justification for the blood pressure variances seen between genders.

The top three cardiovascular disease risk factors in the sample were 1) elevated body fat percentage as defined as values exceeding 35% in females and 25% in males: 36.9% of the sample fell into the excess adipose group; 2) Low HDL cholesterol (33.0% of the sample) and 3) BMI exceeding 24.9lbs/inch^2 (32.0%). In contrast to previous research, females were more likely to exhibit cardiovascular disease risk factors than males. Of the ten (10) cardiovascular disease risk factors examined, women were more likely than men to have six cardiometabolic variables (high waist circumference, BMI, body fat percentage, elevated HbA1C percentage, total cholesterol and low HDL cholesterol); however, statistical significance was found only for excess adiposity (p=0.019) and low HDL cholesterol levels (p=0.028). Similar to research done by Laslett et al. (2012) yet in contrast to the findings of Jarrah et al. (2011), overweight/ obesity as defined by waist circumference, BMI and high body fat percentages was more prevalent in females than males.

In reflection of the findings discussed above which noted higher mean systolic and diastolic blood pressures in males as compared to females, blood pressure as a CVD risk factor (defined by SBP ≥130 and a DBP≥85) was significantly more prevalent in males than females (p=<0.001 for both SBP and DBP).

5.1.5 Exercise as a necessary cardioprotective mechanism: Comparison of CVD risk between case (non-athlete) and control (athlete) groups

The difference between mean values of cardiometabolic parameters across activity status was analyzed based on gender due to expected differences in values and prescribed cut off points. Female athletes had significantly lower visceral fat, glycated hemoglobin, LDL cholesterol, SBP and DBP values than female non-athletes. Skeletal mass and HDL cholesterol levels were significantly higher in the athlete subgroup. Male athletes had significantly lower waist circumferences, body fat percentages, LDL cholesterol and heart rate values. Skeletal mass, HDL cholesterol and SBP were significantly higher in the athlete group. The examination of cardiovascular disease risk between subgroups did not require gender separations since risk factors were delineated based on gender where applicable. Reflective of the findings between athletes of the same gender, several risk factors were found to be more prevalent in the case group. This result was expected since the benefits of regular exercise is well documented in present literature. Non-athletes were more likely to have eight of the ten CVD risk factors examined: large waist circumferences, elevated BMI, excess adiposity, elevated HbA1C, total cholesterol, LDLs and triglyceride values and low HDL cholesterol. With respect to anthropometric values, Warburton et al. (2006) note that physical fitness encompasses several health-status parameters including musculoskeletal fitness, evidenced here by a larger skeletal mass in both male and female athletes as compared to their non-athlete counterparts. In addition, there was a significantly higher (p=0.001) prevalence of excess adiposity in the non-athlete group (43.9%) as compared to the athlete group (24.5%).

The literature is replete with references to exercise and improved lipid profiles. Ahmed et al. (2012) highlighted a correlation between physical activity, lower triglyceride levels and change in LDL particle size. Carroll and Dudfield (2004) highlighted that moderate intensity exercise for 30-60 minutes 3-5 times per week led to a significant increase in HDL concentration by 0.05mmol/L and a triglyceride reduction of 0.2mmol/L. Concurrent to these prior research findings, in the present study, physiologic values were markedly different between the groups, most notably in terms of HDL cholesterol level which was significantly higher in both male and female athletes (p=0.01 in females and p=0.02 in males). Low HDL as a cardiometabolic risk factor was more common in non-athletes (39.5%) than non-athletes (50.6%). In terms of elevated total cholesterol and triglyceride levels, both risk factors were lower in athletes but did not reach statistical significance. While the present study did not test for LDL particle size, a higher prevalence of elevated LDLs as a cardiometabolic risk factor was found in the non-athlete group: 23.8% as compared to 15.2% in athletes, though this difference did not reach statistical significance.

Athletes were found to have a significantly higher prevalence of elevated SBP and DBP, a finding that was not initially predicted. It must be noted however that this finding in the general population is a function of elevated blood pressure values among the male athletes. Female athletes did not display blood pressure values exceeding that of their non-athlete counterparts; the converse was in fact true. Researchers have put forward several plausible explanations for the presence of elevated blood pressures among athletes however findings remain largely inconclusive. A dominant focus in the literature is hypertension, sudden cardiac death and cardiac remodeling/ "athletes heart", however, valuable insight was gained from work done by Baggish and Wood (2011) who stated that increased blood pressure in athletes may in fact simply be the result of increased cardiac output required by regularly active individuals; as Bruno et al. explains further, hypertension in athletes may be a function of increased ventricular and end-diastolic volume combined with reduced end-systolic volume which leads to increased stroke volume and in turn cardiac output. Increased stroke volume occurs both at rest and during exercise in athletes who have undergone prolonged training.

Gender differences in prevalence of hypertension among athlete is explained by the previously discussed differences in heart size, heart rate and hence efficiency of cardiac output.

5.1.6 <u>Relationship among CVD risk factors</u>

Cardiovascular disease risk is multifaceted and dependent on the number of and interplay among risk factors present. As Reddigan and colleagues note, individuals with three or more risk factors tend to be the most at risk for CVD. While risk factors are often individually examined, it is important to note that the presence of one influences or perpetuates the presence of another.

Several correlations were found between anthropometric and physiologic CVD risk factors. High waist circumference, the most common method of central adiposity analysis was found to be positively correlated with elevated BMI, excess adiposity, elevated HbA1C, low HDL cholesterol and high systolic blood pressure. All anthropometric determinants of overweight and obesity were positively correlated; as expected, persons with large waist circumferences also had high BMIs and excess adiposity and vice versa. Similarly to elevated waist circumference, high BMI and elevated body fat percentages were also positively associated with low HDL levels. According to Koning et al. (2007), central adiposity as determined by waist circumference is a stronger predictor of CVD than obesity as defined by BMI alone. Central adiposity has been linked to increased risk for insulin resistance, dyslipidemia and hypertension. This study reflected these findings to a large extent with positive correlations being seen between waist circumference and low HDL cholesterol (a dyslipidemic factor) and elevated systolic blood pressure. There was however no significant correlation between other dyslipidemic values such as elevated total cholesterol, LDL cholesterol and triglycerides. Additionally, elevated BMI was found to be a stronger predictor of prehypertension and hypertension in the sample with a significant positive correlation being found between BMI and SBP and a relationship between BMI and DBP that approached statistical significance (p=0.052). These findings in combination with the positive correlation between excess adiposity and SBP alone (not DBP) highlight a greater tendency for SBP to be raised than DBP. This can be explained by what SBP measures versus what DBP indicates. SBP is the pressure of contraction; it is the pressure in the arteries when the heart beats. DBP on the other hand is the pressure of relaxation; it indicates arterial pressure between heart beats, the pressure when the heart is refilling with blood (American Heart Association 2014). It can be assumed that excess body fat as a structural component exerts extra-arterial pressure on the artery walls while inter-arterial pressure is elevated via the increased viscosity of "fatty" blood. These factors work in tandem to prevent efficient arterial contraction hence a rise in SBP is required for cardiac work to be achieved. It also brings to light the fact that overweight and obesity must be assessed holistically that is, using several parameters in order to gauge adequate insight into the effect of this risk factor on other cardiometabolic risk parameters.

Central adiposity and high body fat percentages were positively correlated with elevated HbA1C readings. Obesity is a well-documented risk factor for prediabetes and diabetes. As Eckel et al. (2011) notes, several mechanisms have been proposed to explain the relationship between these two cardiometabolic risk parameters. For example, obesity particularly central obesity, leads to the production of proinflammatory cytokines which in turn leads to a decrease in adiponectin (a major gluco-regulatory hormone) hence reduced glucose control and resultant prediabetic and diabetic conditions. Elevated blood glucose has been shown to correlate closely with dyslipidemia, particularly elevated LDL levels (Smith 2007). In this study, there was no significant correlation between elevated HbA1C and LDL values, however the link between high blood glucose and dyslipidemia was seen as a significant positive correlation between elevated HbA1C and triglyceride readings.

In a study conducted by Grotto et al. (2006), persons with prehypertension also had elevated BMI, total cholesterol and triglyceride levels with low HDL levels. In this study however, the only near-significant (p=0.052) relationship noted was between elevated systolic blood pressure and BMI with high DBP being significantly correlated with only high SBP. Although the authors' focus was on prehypertension in relation to presence of other cardiometabolic risk factors, a valuable interrelationship was highlighted among total cholesterol, triglycerides and HDL cholesterol. The present study found that elevated total cholesterol level was positively related to high triglyceride levels and negatively associated with low HDL levels. As total cholesterol levels increased, so too did triglyceride readings, conversely, as total cholesterol increased, there was a resultant decrease in HDL values. Additionally, a positive correlation was found between elevated triglycerides and high LDL readings a common occurrence in dyslipidemic profiles (Nelms et al. 2011).

5.2 Limitations of the Study

5.2.1 Sample size

The subset of the population answering the questionnaire (113 participants) was too small. This was evidenced particularly in the dietary analysis where significant correlations between diet and cardiometabolicc risk factors were rare. Additionally, some values approached but did not reach statistical significance. A larger sample size would have also been beneficial to the analysis of perceived barriers between genders where several differences were seen but no statistically significant values were obtained.

5.2.2 Selection bias

The prospective/judgmental method used in correlation with the voluntary nature of the study allowed the researcher to select participants who were deemed most likely to exhibit CVD risk. For example, in the case group, the researcher may have included persons expected to be at high risk for CVD based on their appearance such as those with evident overweight/obesity; those who were less obviously at risk could have been deliberately excluded.

5.2.3 Response bias

The questionnaire, as is customary, involved self-reported data which is always susceptible to misunderstanding, under or over exaggeration or responses that the participants believe the researcher "expects" rather than what is truthful. Although the questionnaire was pretested, there was misunderstanding with respect to the level of education completed. Many participants selected "tertiary" when, in fact, based on the prevalence of the 18-25 age group, the majority would have completed up to secondary level education and were presently pursuing their undergraduate degrees. This misinterpretation led to an inaccurate assessment of education level among participants.

5.2.4 Sectioning of data collection

Due to unforeseen circumstances, that is, the unavailability of equipment, anthropometric and physiologic data were collected at different times. In the case of some participants, several weeks elapsed between initial data collection (questionnaire, anthropometry and blood pressure) and physiological testing. This decreased the overall response rate: 101 of 113 participants completing Phase 2 part A returned for part B. Additionally, within that time period, changes in exercise and dietary patterns may have been made possibly leading to either an increased or decreased presentation of particular CVD risk factors.

5.2.5 Repetition of physiologic tests

Physiologic tests were performed once due to limited resources. In several cases, the Cardiocheck® PA machine was unable to detect LDL levels due to low total cholesterol and/or triglyceride values. Measurements taken at different times would have accounted for fluctuations in lipid profile values which tend to be affected by duration between last meal and testing as well as types of food/drink consumed prior to evaluation.

5.3 <u>Recommendations</u>

5.3.1 Increase sample size

The questionnaire was most affected by the sample size since of 304 total participants, only 37% of the sample completed the questionnaire. In order to improve the statistical significance of responses at least 50% of the total sample should be required to complete the questionnaire.

5.3.2 Use random sampling to eliminate selection bias

Case-control studies such as this can benefit from the use of stratified random sampling in which the total population is divided into (demographically) homogenous subgroups or strata. A simple random sample is then selected in which participants are assigned a number from one to N. The ratio of cases to controls would be 1:1.

5.3.3 Re-word misinterpreted questionnaire items and repeat pretest

Misinterpreted questions should be restructured. For example, "level of education completed" can be made to read "highest level of education obtained (for which you have received official certification)". Two pretest groups can be used: first and second draft respondents. Comparisons between the two groups of responses can then be made to determine whether changes made after initial feedback were effective prior to mass production and administration of the questionnaire.

5.3.4 Conduct anthropometric and physiologic tests simultaneously

All measurements and tests should be carried out at the same time so as to eliminate potential skewing of results due to individual changes made. Validity of the research would be improved in this way since correlations between risk factors would not be subject to change.

5.3.5 Repeat physiologic tests

Test-retest reliability is the measure of reliability obtained from administering the same test twice (Phelan and Wren 2006). It lays the foundation for CVD risk diagnoses since risk factors observed twice are more stable indicators of CVD risk than a "one-off" reading that may be a function of confounding factors not taken into account.

5.4 Conclusion

The research has highlighted several essential differences in CVD risk factor prevalence between non-athletic (case) and athletic (control) students. Fewer CVD risk factors were presented in the athlete group as compared to the non-athlete group hence, it was established that regular exercise (as determined by exercise status) was indeed cardioprotective therefore the null hypothesis (H_0) was disproved and the alternate hypothesis (H_A) was accepted. Regular exercise was found to be protective against eight of ten risk factors evaluated, namely, large waist circumference, elevated BMI, excess adiposity, elevated blood glucose over time (as estimated by HbA1C percentage), elevated total cholesterol levels, LDL and triglycerides and low HDL cholesterol. The most significant variances were found in waist circumference, body fat percentages, and HDL cholesterol levels. The presence of possible confounding factors leading to elevated blood pressure in male athletes was also highlighted. Several meaningful relationships between and among CVD risk factors were shown. Significant differences were found between the case and control groups in terms of diet patterns with a higher consumption of sodas in non-athletes and a lower consumption of dairy, fruits and nuts. While some correlations were shown between diet and cardiovascular risk, the results in this study were not comprehensive. Insight was gained into commonly perceived barriers to regular exercise among students. As expected, athletes perceived less barriers to regular exercise than non-athletes. Lack of external motivation was shown to be the greatest barrier to exercise among males and females, athletes and non-athletes with athletes reporting that they in fact receive a higher level of motivation to exercise from family and friends.

The study has several implications for future research. Further investigation is required into the correlation between diet and exercise and the interplay among CVD risk factors in terms of the mechanisms by which one leads to the other. The finding that higher motivation is experienced by athletes is an important implication for future studies into overcoming exercise barriers and establishing exercise promotion strategies, particularly among university students.

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APPENDIX