The relationship between physical activity behavior and cardiovascular health among university employees

By

Hsien Hsieh

A Thesis
Submitted in Partial Fulfillment of
the Requirements for the Degree of

Master of Science in Clinical Exercise Physiology

Jodee Schaben, Ph.D.	Date
Joseph O'Kroy, Ph.D.	Date
Doug Margolis, Ph.D.	Date
Director, Graduate Studies	Date

University of Wisconsin-River Falls

2018

CONTENTS

ABSTRACT

Hsien Hsieh, MS Candidate, University of Wisconsin-River Falls, Dept. of Health and Human Performance, River Falls, WI.

PURPOSE: The purpose of this study was to evaluate the relationship between physical activity behavior and cardiovascular health among university employees (N = 30). In addition, the research also attempted to explore and explain potential underlying barriers to being physically active. METHODS: Healthy university employees from 30-65 years of age were recruited for this study and the following data was collected – physical activity rating, blood pressure, BMI, and waist circumference. A non-exercise fitness test was conducted to predict VO2 max. The Pearson correlation coefficient was used to test the correlation between physical activity behavior and several cardiovascular disease (CVD) risk factors. RESULTS: The research data indicated that various CVD risk factors were found, including sedentary lifestyle (83%), hypertension (67%), overweight or obesity (50%), central obesity (40%) and poor VO2 max (77%). A significant correlation was found between physical activity behavior and excess body fat ($r = 0.89$), hypertension ($r = 0.599$; $P < 0.01$), central obesity ($r = 0.365$; $P < 0.05$) and poor VO2 max ($r = 0.539$; $P < 0.01$). In addition, the lack of time was the most common barrier to being physically active. CONCLUSION: The results showed a severe phenomenon for a high risk of CVD among university employees. Occupational sedentary behavior accounted for the high risk of CVD, which resulted from poor self-efficacy. Exercise interventions were confirmed to be effective to improve self-efficacy. Future research should employ randomized controlled trials, larger sample sizes, and physical activity counseling to strengthen intervention effects in order to promote physical activity and prevent occupational sedentary behavior.

List of Abbreviations and Symbols

CVD	Cardiovascular disease
CDC	Centers for Disease Control and Prevention
CAD	Coronary artery diseases
BMI	Body mass index
CRF	Cardiovascular fitness
UWRF	University of Wisconsin-River Falls
VO2max	Maximal oxygen uptake
AVM	Arteriovenous malformation
CI	Confidence interval
SBP	Systolic blood pressure
DBP	Diastolic blood pressure
WHO	World Health Organization
SCORE	Systematic Coronary Risk Evaluation
MET	Metabolic equivalent of task
NASA	National Aeronautics and Space Administration
ANOVA	Analysis of variance
IRB	Institutional Review Board
PAR	Physical Activity Rating
SPSS	Statistical Package for the Social Sciences
WC	Waist circumference
NCD	Noncommunicable disease
M	Mean

SD	Standard deviation
N:	Participants in a portion of the total sample
R	Pearson correlation coefficient
OR	Odds ratio
%	Percent
<	Less than
=	Equal to
>	Higher than

Introduction

Cardiovascular disease (CVD) is a leading cause of death and disability in the United States. Approximately one-fourth of deaths in the US result from heart disease (Gersh, Sliwa, Mayosi, & Yusuf, 2010; Dobler & Ecker, 2017). CVD includes diseases that affect the heart, the brain, and the peripheral circulatory system (Balakumar, Maung, & Jagadeesh, 2016; Salvi, 2016). The pathophysiologic mechanisms of CVD are associated with the accumulation of substances, such as fatty material, cholesterol, cellular waste products, calcium, and fibrin, on the artery walls. These deposits accumulate and develop into an arterial plaque. The plaque deposits in the artery walls limit, and ultimately block the flow of blood within the arteries. In addition, the growing plaques can rupture, which may result in serious cardiovascular complications (Gersh et al., & Yusuf, 2010; Dobler & Ecker, 2017; Balakumar et al., 2016; Salvi, 2016; Ahmed et al., 2015).

Many studies show that CVD is preventable (Booth, Roberts, & Laye, 2012; Wang et al., 2017; Zanesco & Antunes, 2007). Risk factors, such as hypertension and obesity, are treatable and manageable by an increase in physical activity. People who participate in 150 minutes of moderate-intensity physical activity or 75 minutes of vigorous-intensity physical activity every week can significantly lower their blood pressure and body weight (Dobler & Ecker, 2017; Balakumar et al., 2016; Mcmurray, Ainsworth, Harrell, Griggs, & Williams, 1998). However, nowadays physical inactivity is a severe health issue worldwide (Booth et al., 2012; Sweeting, Ingles, Ball, & Semsarian, 2015). More and more people spend the majority of their waking hours sedentary, especially “white-collar” workers. White collar workers are considered to be those people who perform non-labor jobs in a cubicle or office, including office workers, administrators, and researchers (Watanabe, Kawakami, Otsuka, & Inoue, 2018). The occupational environment causes those employees to become physically inactive during the work day, which potentially increases CVD risk factors, such as, high blood pressure and excess body weight. Alkhatib (2013) found that the sedentary lifestyle is a widespread phenomenon within the university workplace. The majority of university employees tend to sit long periods of time, due to their job duties, such as office administration, a myriad of meetings and academic research. Many studies have been conducted to investigate the relationship between a sedentary lifestyle and the risk of CVD among different races, countries, or generations (Dobler & Ecker, 2017; Balakumar et al., 2016; Ahmed et al, 2015; Booth et al., 2015); however, few studies have examined this issue among university employees. Moreover, in order to further improve understanding of this issue, it is crucial to figure out potential factors that lead to a sedentary lifestyle. Another study demonstrated that inefficient time management, lack of interest, and an inclination to do other activities are three major reasons that prevent people from being physically active (Hoare, Stavreski, Jennings, & Kingwell, 2017). Hence, this research aims to not only identify the negative effects of a sedentary lifestyle on this population, but also to evaluate the significant barriers to physical activity.

There is a number of risk factors influenced by physical inactivity such as blood pressure, waist circumference, and body mass index (BMI). Those risk factors are reliable measurements to assess cardiovascular health for a majority of people and researchers (Gu et al., 2018). Recently, the updated blood pressure guidelines were issued by the American College of Cardiology and the American Heart Association. According to the new guideline, having either systolic blood pressure higher than 130 mmHg or diastolic blood pressure higher than 80 mmHg meets the criteria for hypertension, rather than 140 and 90 mmHg in the past, respectively. High blood pressure increases cardiac workload, and thus the heart has to work harder in order to pump blood throughout the body. The increase of cardiac workload causes damage to the blood vessels and raises the potential for stroke, myocardial infarction, and heart failure (Gaziano & Gaziano, 2014).

Measures of weight distribution and body composition are also important health indicators. Waist circumference provides an indicator of abdominal adiposity. People who had a waist circumference that is greater than 40 inches for men or 35 inches for women showed a higher risk of CVD (Gu et al., 2018). In addition, past research indicated that central obesity is one of the main risk factors that contributes to numerous chronic diseases, including type II diabetes mellitus, hypertension, dyslipidemia, and CVD (Lamberti, 2006). In addition, BMI is an index designed to measure body fat. The formula for BMI uses height and weight to calculate body fat percentage and is applied for adult males and females. In general, an individual's BMI should fall within a range from 18.5 to 24.9. Excess BMI is highly associated with high blood pressure, insulin resistance, cancer and CVD (Kearns, Dee, Fitzgerald, Doherty, & Perry, 2014).

Cardiovascular fitness (CRF) is another piece of critical information that needs to be considered. Araújo et al. (2012) found that CRF can be viewed as an effective indicator of cardiovascular risk. There is a relationship between reduced CRF and risks of high blood pressure and insulin resistance – poor CRF has a significant impact on the development of chronic diseases. Additionally, VO2 max is the maximum amount of oxygen consumed by an individual during high-intensity exercise and it reveals an individual's cardiovascular capacity (Dlugosz, 2013). VO2 max is broadly used by scientists and fitness trainers as an indicator of CRF.

Purpose of the Study

The purpose of this study is to identify the relationship between physical activity behavior and cardiovascular health among university employees. Physical inactivity is a dangerous risk factor highly associated with a wide range of chronic diseases such as type 2 diabetes, CVD and certain cancers. Moreover, few studies have evaluated the prevalence of physical inactivity among university employees, which may be a potential sedentary population (Alkhatib, 2013). In addition, the study also evaluates the main barriers that contribute to physical inactivity. Understanding the determinants of physical activity behavior can not only help researchers to recognize multiple influences that impede an individual to participate in physical activity, but also assist health professionals to develop beneficial strategies and exercise interventions to enhance physical activity.

Limitations

There were several limitations to the study design:

1. The use of convenience sampling might cause selection bias, meaning the subjects might not represent the faculty and staff.

2. This research was cross-sectional, which cannot determine causation, but can show relationships.

3. The research data was collected from one single university, limiting the generalizability of the findings.

4. The self-report measures depend on the truthful and accurateness of potential responses.

4. The sample size was small.

Delimitations

The following delimitations describe important boundaries that were set for the study:

1. The sample population consisted of university employees at University of Wisconsin-River Falls, Wisconsin (UWRF) during the fall 2017 and spring 2018 semesters.

2. Participants selected in this research had to meet the specific age and health behavior criteria.

3. A Physical Activity Rating Questionnaire was used to obtain physical activity level data.

4. A Barrier to Being Physically Active Questionnaire was used to obtain data concerning the barriers to physical activity.

5. A non-exercise regression equation was used to obtain VO2 max.

Research Hypothesis

It is hypothesized that one of the most harmful CVD risk factors, a sedentary lifestyle, exists among UWRF employees. Because of their physical inactivity, UWRF employees will have poor cardiovascular health, as determined by having high blood pressure, high BMI, high waist circumference, and low VO2 max. Furthermore, it is hypothesized that lack of time is the main barrier for UWRF employees to engage in physical activity.

Literature Review

The aim of this review of literature is to elaborate on the pathophysiology of CVD and its risk factors including sedentary lifestyle, hypertension, obesity, BMI, waist circumference and cardiovascular fitness based on published research articles.

Cardiovascular Disease

Cardiovascular disease (CVD) is an umbrella term that encompasses diseases involving the heart, brain and vascular systems. CVD is the leading cause of death and disability in the United States, which killed more than 800,000 Americans in 2017. On the international level, CVD accounts for over 17.3 million deaths every year, consisting of 31% of all deaths worldwide (Mendis, Puska, & Norrving, 2011).

Atherosclerotic disease is one of the primary underlying causes of CVD (Balakumar, 2016). Atherosclerosis is a complicated pathological mechanism within the arterial walls, which clot arteries with plaques. Atherosclerosis usually takes several years to develop. Plaques are made of substances, such as fatty material, cholesterol, cellular waste products, calcium and fibrin. Those substances deposit and accumulate inside the lumen of arteries, leading to the formation and development of plaques. Then, this accumulation of plaques makes artery walls become thicker and narrows the inner space of the arteries. Consequently, plaques cause an increase in pressure within the arteries; this pressure may eventually cause the plaque to rupture and lead to the formation of a thrombus (blood clot). The blockage of a coronary blood vessel or a cerebral blood vessel is created by a large thrombus and can lead to severe cardiovascular complications such as heart attack and stroke, respectively (Balakumar, 2016; Arroyo, 1999).

Heart attack, or myocardial infarction, happens when the supply of oxygen and nutrients to the heart is suddenly blocked by a blood clot. Constant blood flow provides sufficient oxygenated blood to the cardiac muscle and nourishes it. If the blood flow through the heart is limited, it leads to angina (chest pain) because of myocardial ischemia. Ischemic heart disease may last a few months or years without a heart attack. However, if there is a total occlusion of blood flow within a coronary artery, in a short period of time, a portion of cardiac myocytes die. Death of cardiac myocytes results in permanent damage to the cardiovascular system and triggers a heart attack (Balakumar, 2016; Schmitz & Torzewski, 2001).

A stroke is a “brain attack” (Brown, 2002). It is a mechanism similar to a heart attack called ischemic stroke. When the blood flow through the brain is totally occluded by the presence of a thrombus in a cerebral blood vessel, the brain cells stop functioning due to oxygen deprivation and those cells start to die within a few minutes (Mendis et al., 2011). In addition, there is another type of stroke called a hemorrhage (bleeding) stroke. A hemorrhagic stroke results from the bursting of a weakened blood vessel that bleeds into the surrounding brain areas, damaging brain cells and tissue. An aneurysm, an expanded spot of an artery (Balakumar et al., 2016; Sadasivan, Fiorella, Woo, & Lieber, 2013), and an arteriovenous malformation (AVM), a tangle of genetic abnormal blood vessels binding arteries and veins in the brain, are two types of weakened blood vessels that can rupture and spill blood into the brain.

Sedentary Lifestyle

Sedentary lifestyle is a type of lifestyle in which people have little or no physical activity. A person with a sedentary lifestyle spends most of their time sitting or lying down while engaged in activities such as studying, watching television, playing computer games, or using a mobile phone (Peterson & Cheng, 2012). According to the CDC’s criteria for a sedentary lifestyle, people who participate in less than 150 minutes of moderate-intensity physical activity per week, or 75 minutes of vigorous-intensity physical activity per week are defined as having a sedentary lifestyle. To date, over 3.2 million deaths worldwide each year are associated with physical inactivity (Mendis et al., 2011). Studies showed that people who were physically inactive had approximately 30% higher risk of CVD and 27% higher risk of diabetes than those who participated in at least 150 minutes of moderate exercise each week (Backer, 2007; Oja & Titze, 2011). A meta-analysis reported that sufficient physical activity significantly decreased the risk of CVD in a dose-response relationship, those individuals with greater levels of physical activity had lower risks of coronary heart disease (Berlin & Colditz, 1990). Another meta-analysis examined the impact of exercise on CVD risk factors on 3936 participants (Cornelissen & Fagard, 2005). The results suggested that physical activity enhances energy expenditure as well as vasodilation and vasoconstriction functions in the blood vessels, which play a vital role in improving blood pressure, lipid profile, insulin sensitivity and body composition. Therefore, in order to decrease the risk of CVD, new strategies and exercise promotion programs are needed to prevent a sedentary lifestyle.

Barriers to Physical Activity

Previous studies showed that the lack of time/motivation was the most common exercise barrier (Hoare et al., 2017; Salmon, Owen, Crawford, Bauman, & Sallis, 2003). Alharbi et al. (2016) analyzed the exercise barriers and the relationship to self-efficacy for exercise among patients with chronic diseases. In this study, 135 participants with coronary heart disease and/or type 2 diabetes were recruited. The data showed that the most typical barriers to exercise were the lack of time (47.8%) and the lack of motivation (40.3%). Low self-efficacy was negatively associated with physical activity adherence in the diseased population. Moreover, Hoare et al. (2017) conducted a study to evaluate 894 healthy subjects and concluded that lack of time was the greatest barrier to physical activity (CI: 50.0%, 95% CI 43.0-56.8 %), which was higher than lack of enjoyment (CI: 43.9%, 95% CI 37.1-51.0%) or the preference to do other things (CI: 42.9%, 95% CI 36.2-50.0%). In addition, there was no statistical discrepancy between men and women. Additional research was conducted with a population-based mail survey. Based on 1,332 respondents, higher exercise enjoyment and preference for doing physical activity were reported among physically active people compared to those who were physically inactive (Salmon et al., 2003). In conclusion, inefficient time management, lack of interest and inclination to do other activities are three potential barriers to physical activity (Hoare, 2017; Salmon et al., 2003; Alharbi et al., 2016).

Hypertension

Blood pressure is the force created by blood flowing through and pushing against the walls of arteries. There are two induces for blood pressure, which are measured in millimeters of mercury (mmHg) (Vischer & Burkard, 2016):

1. Systolic blood pressure (maximum blood pressure during one cardiac pump)
2. Diastolic blood pressure (minimum blood pressure in between two cardiac pumps)

In 2017, the American College of Cardiology and the American Heart Association launched a new guideline for blood pressure. Table 1 provides the four new blood pressure categories.

Table 1. Blood pressure categories

Category	Systolic		Diastolic
Normal	< 120 mmHg	and	< 80 mmHg
Elevated blood pressure	120-129 mmHg	and	< 80 mmHg
Stage 1 hypertension	130-139 mmHg	or	80-89 mmHg

Stage 2 hypertension	>/= 140 mmHg	or	>/= 90 mmHg

According to Balakumar et al. (2016) the prevalence of hypertension is attributable to 7.5 million deaths worldwide each year. There is no doubt that there is a curvilinear relationship between hypertension and an increase in CVD. Redon et al. (2016) collected data from 52,007 CVD-free male and female in order to investigate the effect of hypertension on the risk of CVD. The results showed that hypertension was the major risk factor for CVD events and mortality. Twelve different CVDs are associated with hypertension, including stable/unstable angina, heart attack, stroke, heart failure, coronary heart disease, peripheral arterial disease as well as others (Ostchega, Zhang, Kit, & Nwankwo, 2017).

Hypertension is referred to as a silent killer because of its lack of obvious signs and symptoms (Dobler & Ecker, 2017). Many CVD patients do not even know that they have hypertension if they do not check their blood pressure regularly. Research from the National Center for Health Statistics indicated that approximately 1 in 3 individuals in the United States have high blood pressure; however, merely half of those patients take some actions such as changing their diet, quitting smoking, exercising or taking medication to manage their blood pressure (Ostchega et al., 2017).

Obesity

Obesity is referred to as excess body fat that leads to a variety of harmful health effects ranging from cardiovascular, respiratory and reproductive dysfunctions to decreased quality of life, memory loss and psychological disorders (James, 2010; Purnamasari, Badarsono, Moersadik, Sukardji, & Tahapary, 2011). Excess body fat (BMI of 30 or higher) increases the risk of several chronic diseases such as type 2 diabetes, obstructive sleep apnea, cancer, osteoarthritis and CVD. In the United States, the number of obese people has been increasing rapidly and it has become a severe public health concern. Flegal, Kit, Orpana, & Graubard (2013) showed that the prevalence of obesity was 35.5% in adult men and 35.8% in adult women in 2012. More than 1 in 3 adult males and females in the United States were classified as obese.

A meta-analysis evaluated the relationship between BMI and coronary artery disease (CAD). Twenty-one cohort studies with over 300,000 subjects identified a linear relationship between obesity and CAD (Bogers, 2007). After adjusting for relative risks such as age, gender and physical activity, the obese population had a 32% greater risk of CAD. The harmful influence of hypertension is attributable to approximately a 45% higher risk of CAD due to obesity. In addition, another systematic review indicated that there was a significant relationship between obesity and the risk of ischemic stroke. Strazzullo et al. (2010) collected and examined 25 prospective cohort studies with nearly 2.3 million participants and found that after adjusting for other relative risks such as blood pressure, blood cholesterol, age, levels of physical activity and type 2 diabetes, obesity was related to a higher risk of ischemic stroke independently. People who were obese had a 64% higher risk of ischemic stroke, although there was no statistical correlation between obesity and hemorrhagic (bleeding-caused) stroke.

Body Mass Index, BMI

BMI is a measurement of body composition, which is calculated by dividing weight (in kilograms) by height (in meters) squared (Dobler & Ecker, 2017). People can easily calculate their BMI to acquire the information of a healthy body for their heights and define their overweight and obese status. The World Health Organization (WHO) reported the standard healthy BMI for adults ranges from 18.5 to 24.9; overweight is a BMI ranging from 25.0 to 29.9; obese is a BMI ranging from 30.0 or higher. In addition, a relationship between BMI and CVD mortality was reported by an Irish research team. Systematic Coronary Risk Evaluation (SCORE) data comprised of 12 cohort studies of CVD risk factors with 186,308 adults (107,590 males, 57.8% and 78,718 females, 42.2%) were examined in this research. The data showed that after adjusting a wide range of CVD risk factors, such as age, self-report of tobacco smoking, total blood cholesterol level and systolic blood pressure, every 5-unit increase of BMI augmented CVD mortality in both male and female by 34% and 29%, respectively (Linden, 2011). Khan, et al. (2018) proposed a significant association between excess BMI and higher risk of cardiovascular morbidity and mortality. A total of 190,672 in-person surveys were collected in this study. Competing hazard ratios indicated that compared to normal body weight individuals (BMI between 18.5 and 24.9), obese individuals (BMI of 30 or higher) had the highest association with incidence of CVD and lower longevity. Therefore, BMI was an efficient and effective indicator of CVD risk.

Waist Circumference

Waist circumference is one of the easiest and most common methods to measure the level of body fat and determine whether or not a person is obese (Hu, 2008). It is a measurement of the circumference of the abdomen, measuring at the level of the umbilicus (belly button). The American Heart Association/National Heart, Lung, and Blood Institute issued the diagnostic criteria for metabolic syndrome in 2005, a waist circumference that is greater than 40 inches (102 cm) in men or 35 inches (88 cm) in women is defined as abdominal obesity (Howard, 2006). The amount of abdominal fat has a considerable impact on health. A follow-up study with 920 participants (470 male, 450 female) was conducted to assess if the risk of CVD was associated with obesity in terms of waist circumference. There were 333 incidence of CVD (156 men, 177 women) reported in the follow-up investigation. Data showed that higher waist circumference increased the incidence of CVD in both men and women (Adegbija, Hoy, & Wang, 2015). A meta-regression analysis examined the relationship between central body fat and the risk of CVD. Fifteen articles were analyzed (258,114 participants and 4355 CVD events) and the results displayed that every 1 cm increase of waist circumference augmented 2% risk of CVD (Koning, Merchant, Pogue, & Anand, 2007). The study established that waist circumference was significantly related to incidence of CVD. Consequently, this simple as well as essential tool for measuring abdominal obesity should be widely used in the clinical research.

Cardiorespiratory Fitness

Cardiorespiratory fitness (CRF) refers to the ability of the body to provide sufficient oxygen to skeletal muscles through circulatory and respiratory systems during sustained physical activity. The major estimate of CRF is VO2max (Ross, 2016). Al-Mallah, Sakr, & Al-Qunaibet (2018) claimed that CRF was inversely associated with the risk of CVD and poor CRF could result in reduced longevity and quality of life because of increased incidence of CVD, including hypertension, atherosclerosis, heart failure, and cardiac arrhythmias. A study examined the relationship between CRF and incidence of CVD. The result obtained from 29,854 participants determined that people who had coronary heart disease had lower CRF (10.9 metabolic equivalent of tasks (METs)) compared to those who did not have coronary heart disease (12.0 METs) ($p < 0.001$) (Gander et al., 2015). In addition, based on hazard ratio, every 1-unit increase of MET resulted in approximately a 20% decreased risk of coronary heart disease (0.80; 95% CI, 0.77–0.83). Hence, lower CRF accounted for higher CVD risk. In other words, people can reduce their risk of CVD by improving their CRF. Lamonte et al. (2000) collected data from 4360 individuals to examine CRF and CVD risk factors. Treadmill exercise testing was used to gather their gender-specific CRF in term of VO2 max quintiles. After adjusting for numerous relative risks, including body composition, age, tobacco use, and family history, researchers proposed that higher levels of CRF were associated with lower levels of cardiovascular disease risk factors. Accordingly, CRF plays a crucial role in preventing and managing CVD risk factors among both the healthy and diseased populations.

VO2 Max

The term maximal oxygen consumption (VO2 max) was invented by Hill and Lupton in 1923 as a measurement of maximal rate of oxygen consumed during maximal exertion (Shephard, 2008). VO2 max is recorded as a comparative parameter which is a certain amount of oxygen attained in a milliliter per kilogram of body weight per minute (ml/kg/min). According to ACSM's Guidelines, typical VO2 max norms for 30-year-old men and women are 44-47 ml/kg/min and 37-40 Ml/kg/min, respectively (Gibson, Wagner, & Heyward, 2006). The estimates of VO2 max were classified into five levels as Table 2 presents below (Riebe, Ehrman, Liguori, & Magal, 2018):

Table 2 VO2 Max Guidelines

VO2max ($mL \cdot kg^{-1} \cdot min^{-1}$) Classifications for Women

Age (years)	Poor	Fair	Good	Excellent	Superior
20 - 29	≤ 35	36 - 39	40 - 43	44 - 49	50+
30 - 39	≤ 33	34 - 36	37 - 40	41 - 45	46+
40 - 49	≤ 31	32 - 34	35 - 38	39 - 44	45+
50 - 59	≤ 24	25 - 28	29 - 30	31 - 34	35+
60 - 69	≤ 25	26 - 28	29 - 31	32 - 35	36+
70 - 79	≤ 23	24 - 26	27 - 29	30 - 35	36+

VO2max ($mL \cdot kg^{-1} \cdot min^{-1}$) Classifications for Men

Age (years)	Poor	Fair	Good	Excellent	Superior
20 - 29	≤ 41	42 - 45	46 - 50	51 - 55	56+
30 - 39	≤ 40	41 - 43	44 - 47	48 - 53	54+
40 - 49	≤ 37	38 - 41	42 - 45	46 - 52	53+
50 - 59	≤ 34	35 - 37	38 - 42	43 - 49	50+
60 - 69	≤ 30	31 - 34	35 - 38	39 - 45	46+
70 - 79	≤ 27	28 - 30	31 - 35	36 - 41	42+

In 2017, the American Heart Association issued a statement that VO2 max is not only the best indicator of cardiovascular capacity, but also could be extensively used in clinical settings as a fundamental vital sign (Ross, 2016; Nabi, Rafiq, & Qayoom, 2015). Pronk, Boyle, & Oconnor, (1998) conducted a study to examine the correlation between VO2 max and chronic diseases. The study analyzed 4121 subjects, age 40 and over, who were either healthy or had chronic diseases such as hypertension, type 2 diabetes, dyslipidemia or CVD. The research data showed a significantly higher VO2 max among healthy subjects (29.8±7.7 ml/kg/min) compared to those who had one chronic condition (25.9±7.8 ml/kg/min) and those who had more than two chronic conditions (25.7±7.9 ml/kg/min) ($p < 0.0001$). Patients with hypertension (25.1±7.6 ml/kg/min), type 2 diabetes (24.5±8.1 ml/kg/min) and CVD (26.2±8.0 ml/kg/min) had a significantly lower VO2 max compared with healthy subjects ($p < 0.0001$). VO2 max among chronic disease patients appeared significantly lower than healthy individuals (Pronk et al., 1998). In recent years, VO2 max has been broadly considered by many medical professionals and scientists as an essential piece of information for predicting morbidity and mortality for CVD in clinical research (Ross et al., 2016; Nabi et al., 2015).

Non-Exercise Fitness Test

The non-exercise fitness test is a tool that uses a regression equation to calculate VO2 max without exercise (Schembre & Riebe, 2011). Because all variables for the regression equation are either commonly available or simple to acquire for overall population, non-exercise fitness test is a more economic and feasible method to obtain VO2 max than exercise testing (Stamatakis, Hamer, Odonovan, Batty, & Kivimaki, 2012). VO2 max exercise testing requires participants to give maximal effort until they reach exhaustion in order to obtain accurate data. It can be difficult to recruit participants because of the testing procedure. Furthermore, it is also impractical in research with a large sample size as a result of excessive cost and time consumption (Schembre & Riebe, 2011). Also, for obese and older people, as well as those who are exercise intolerant, meaning an inability or lower ability to perform exercise, exercise testing is difficult and risky to be implemented among those subjects. Although, the non-exercise fitness test may not be as precise due to self-reported physical activity level, the method is a comparable approach, a safe tool to gather VO2 max and can be widely used in larger groups such as epidemiological research and extensive clinical practices. In this research, we used the regression equation developed by the National Aeronautics and Space Administration (NASA) to acquire VO2 max (Jackson et al., 1990). Required values for the regression equation include self-reported physical activity level, age, BMI and gender. The regression equation is shown below: VO2 max = 56.363 + 1.921 (physical activity rating) – 0.381 (age in year) – 0.754 (BMI) + 10.987 (gender; 0 for women, 1 for men).

Research Method

This study was conducted at a small Midwestern university, where faculty, researchers and staff were recruited. Before collecting data, the Institutional Review Board (IRB) of the University of Wisconsin-River Falls (UWRF) reviewed the research proposal and approved the study for a period of one year. Approval was based on identification that the study had met federal regulations set forth in 45 CFR 46.111. Approval was granted on December 22, 2017, expires on December 21, 2018. All data were collected after procedures were explained, questions were addressed and participants had signed the informed consent. Data were collected in order to evaluate their levels of physical activity, cardiovascular health and barriers to physical activity. Those assessments included:

1. Physical activity rating
2. Barriers to physical activity
3. Body mass index, BMI
4. Resting blood pressure
5. Waist circumference
6. Predicted VO2 max

Participants

Volunteers were recruited by announcing the study on posters that were displayed throughout the UWRF campus. Volunteers were excluded if; 1) they currently took any kind of medication; or 2) they smoked. Overall 30 faculty and staff participated in the study, 8 males (26.7%) and 22 females (73.3%), whose ages ranges from 30 to 65 years old. The mean age and standard deviation were 39.5±12.63 among males, 49.55±10.5 among females and 46.87±11.76 among all participants.

Measurements

Physical activity rating. The Physical Activity Rating (PAR) was used to evaluate a person's level of fitness as well as for the equations for the non-exercise VO2 max test. Participants' PAR score is determined by a self-selected number which best describes their overall level of physical activity for the previous 6 months. Scores ranged from 0 to 7; 0 point: Avoids walking or exercise (for example, always uses elevators, drives whenever possible instead of walking); 1 point: Walks for pleasure, routinely uses stairs, occasionally exercises sufficiently to cause heavy breathing or perspiration; 2 points: 10–60 minutes of walking; 3 points: Over 1 hour of walking per week; 4 points: Runs less than 1 mile per week or spends less than 30 minutes per week in comparable physical activity; 5 points: Runs 1-5 miles per week or spends 30–60 minutes per week in comparable physical activity; 6 points: Runs 5-10 miles per week or spends 1–3 hours per week in comparable physical activity; 7 points: Runs more than 10 miles per week or spends more than 3 hours per week in comparable physical activity.

Barriers to physical activity. A Barriers to Being Physically Active Questionnaire was used to examine participants' barriers to physical activity (Hoare et al., 2017). Six main barriers were listed in the questionnaire: 1. Lack of time, 2. Preference to do other things, 3. Lack of enjoyment, 4. Nobody to exercise with, 5. Lack of confidence, and 6. Lack of money. Participants were asked to choose only one barrier, their main barriers, that hindered them from engaging in physical activity the most.

Body mass index, BMI. The Doran Scales Inc Model DS5100 scale (Doran Scales Inc., Batavia, IL) was used to measure height, weight and BMI. Subjects were asked to remove their shoes and stand on the scale with legs straight, feet flat and heels together. Participants were also required to look straight ahead to ensure the line of sight was parallel with the floor. Then, the scale automatically displayed their height and weight and computed their BMI. The BMI is defined as per the equation kilograms of body mass divided by the square of the body height in meters. According to the World Health Organization (WHO) the BMI standard for body fat are as follows; normal is a BMI ranging from 18.5 to 24.9; overweight is a BMI ranging from 25.0 to 29.9; obesity is a BMI ranging from 30.0 or higher (Strazzullo, 2010).

Resting blood pressure. Before taking subjects' resting blood pressure, participants were asked to relax and sit in a chair peacefully with back support for at least 5 minutes. A standard sphygmomanometer and stethoscope were used to measure their resting blood pressure. The researcher placed a standard size cuff around participants' right upper arm, aligned with the brachial artery, at the level with their heart. The stethoscope was placed in the antecubital space over the brachial artery. The first Korotkoff sound heard by the researcher was noted as systolic blood pressure. The diastolic blood pressure was noted as the last Korotkoff sound heard by the researcher. According to new blood pressure guidelines issued by the American College of Cardiology and the American Heart Association, blood pressure was categorized into three levels: 1. Normal: systolic blood pressure (SBP) is less than 120 and diastolic blood pressure (DBP) is less than 80 mmHg; 2. Elevated blood pressure: SBP ranges from 120 to129 mmHg and DBP is less than 80 mmHg; 3. Hypertension: SBP is higher than 130 mmHg or DBP is higher than 80 mm Hg. Hypertension is divided into two categories, stage 1 and stage 2, based on level of elevation.

Waist circumference. Waist circumference was recorded by using a standard measurement procedure. Waist circumference was measured by placing the tape measure at the top of the participants' hip bone and then wrapping the tape all the way around the body. Participants ensured the tape was in line with their belly button and then the researcher ensured the tape was parallel to the ground. The measuring tape was wrapped around each participant's abdomen in a snug manner, but not so tightly that the tape compressed their skin. The American Heart Association defines that a person has high risk of CVD if their waist circumference is greater than 40 inches (102 cm) for men or 35 inches (88 cm) for women (Howard, 2006).

VO2 max. The assessment of VO2 max was calculated based on a regression equation developed by Jackson, et al. (1990). VO2 max = 56.363 + 1.921(PAR) – 0.381(A) – 0.754(BMI) + 10.987(G), where "PAR" represents physical activity rating scores from the physical activity questionnaire, "A" represents age (in years), "BMI" represents body mass index, and "G" represents gender (0 for women, 1 for men).

Data Analysis

The data analysis focused on the relationship between physical activity participation and cardiovascular health, examining whether or not physical activity level would influence university employees' risk of CVD. The Pearson's correlation coefficient was used to examine if there were significant correlations between physical activity rating scores and four risk factors of CVD, including BMI, blood pressure, waist circumference and predicted VO2 max. The Statistical Package for the Social Sciences (SPSS) (IBM Corporation, Armonk, New York, United States) version 24.0 was used for statistical analysis in this research. The strength of the correlation was specified by using published statistical research (Wuensch & Evans, 1996). The r value = 0.00 – 0.19 indicates a very weak correlation; r value = 0.20 – 0.39 indicates weak correlation; r value = 0.40 – 0.59 indicates moderate correlation; r value = 0.60 – 0.79 indicates strong correlation; r value = 0.80 – 1.0 indicates very strong correlation. The p value was set at < 0.05.

In addition, the Barrier to Being Physically Active Questionnaire were used to measure the primary factor for physical inactivity. The measurement allowed participants to choose only one single response in order to identify the most influential factor. The main barrier to being physically active was defined as the most cited barrier from participants.

RESULTS

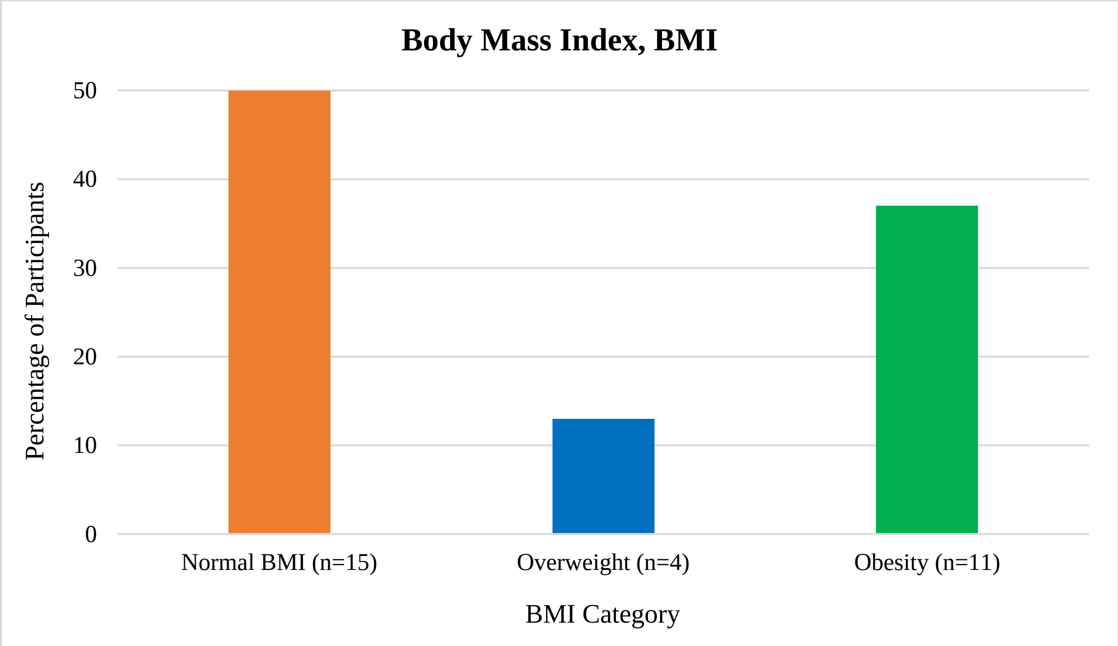
Physical Activity Rating

Data showed that twenty-five participants (83%) were classified as physical inactivity. Their physical activity participation was less than 150 minutes per week; five participants (17%) with physical activity participation of more than 150 minutes per week were classified as physically active.

Body Mass Index, BMI

Figure 1 illustrates participants' body composition categories. Results showed that half of the participants (n=15) had normal BMI, ranging from 18.5 to 24.9 and the other half had BMI of 25.0 or higher. These participants were either overweight (n=4) with BMI ranging from 25.0 to 29.9, or obese (n=11) with BMI ranging from 30.0 or higher. Pearson's correlation coefficient showed that there was a very strong correlation between physical inactivity and BMI higher than 25.0 ($r = 0.89$). However, no significance was found among the data ($p = 0.638$).

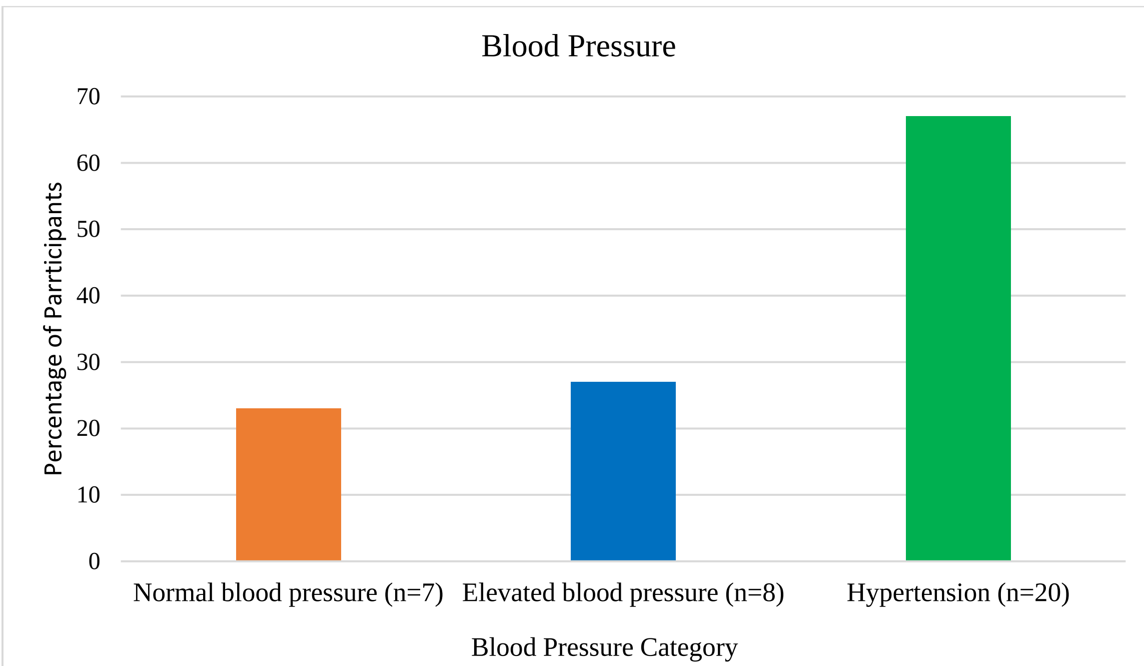
Figure 1. Percentage of participants by BMI categories



Blood Pressure

Figure 2 illustrates participants' blood pressure categories. The data show that seven participants (23%) had normal blood pressure, three participants (10%) had elevated blood pressure, and twenty participants (67%) had hypertension. Moreover, among those who were hypertensive, eight participants (27%) had stage 1 hypertension and twelve participants (40%) had stage 2 hypertension. Pearson's correlation coefficient showed that there was a moderate statistical correlation between physical inactivity and hypertension, ($r = 0.599$, $p < 0.01$).

Figure 2. Percentage of participants by blood pressure categories

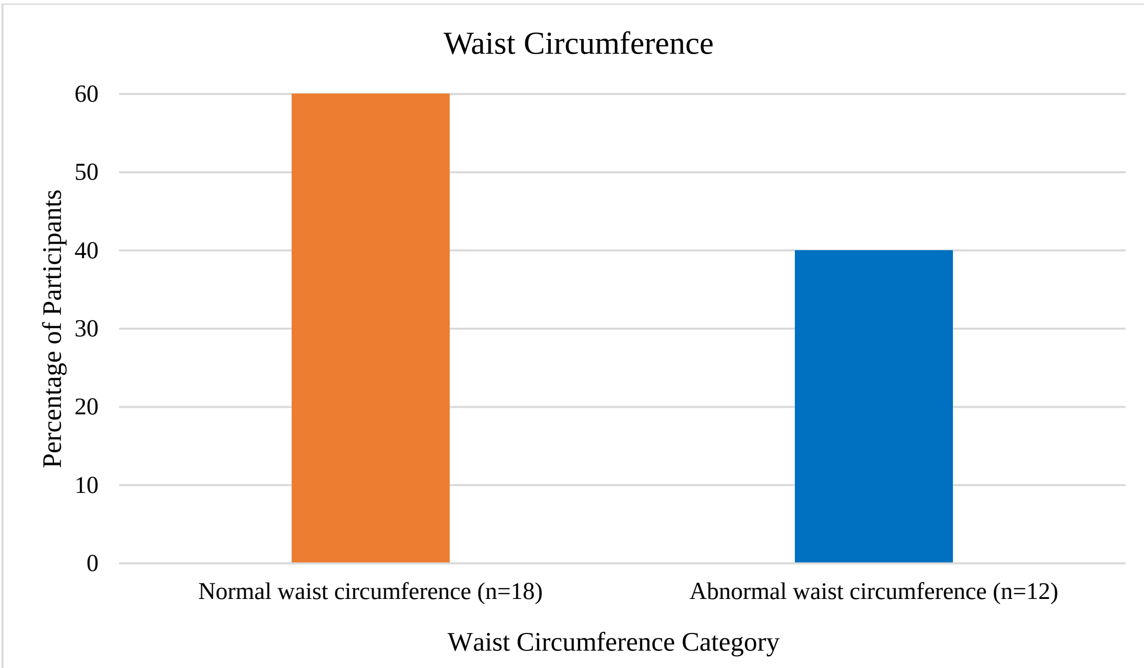


Pearson's correlation coefficient showed that there was a moderate statistical correlation between physical inactivity and hypertension, ($r = 0.599$, $p < 0.01$).

Waist Circumference

Figure 3 illustrates participants' waist circumference categories. The results indicated that eighteen participants (60%) had normal waist circumferences and twelve participants (40%) had waist circumferences above 40 and 35 inches for males and females, respectively. Pearson's correlation coefficient showed that there was a weak statistical correlation between physical inactivity and central obesity, (r = 0.365, $p < 0.05$).

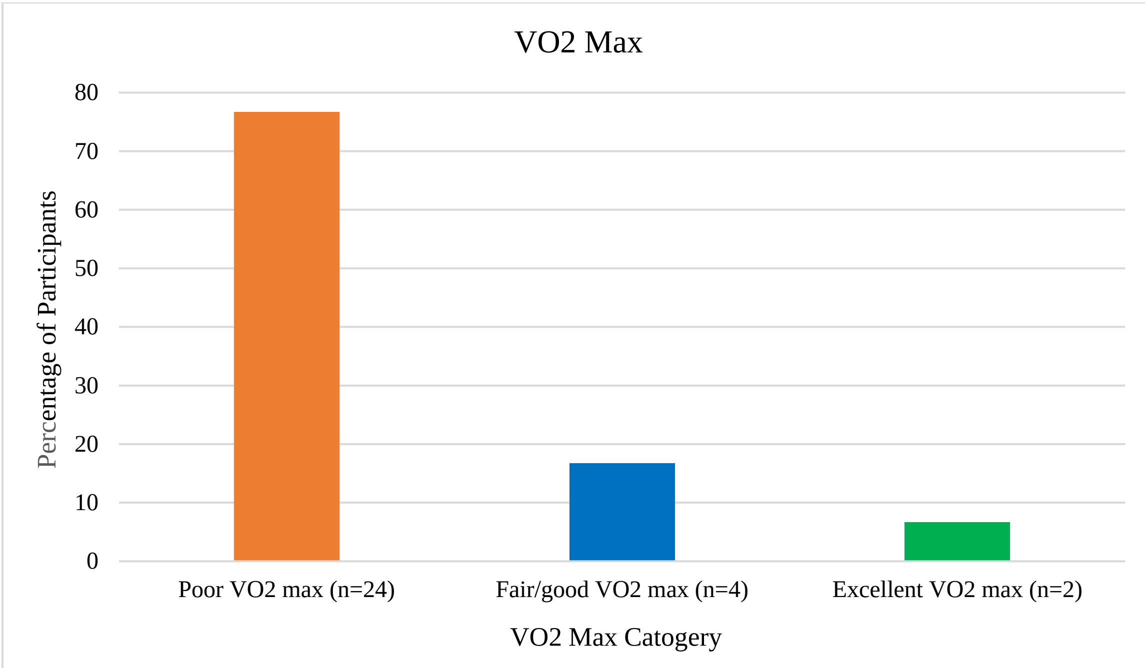
Figure 3. Percentage of participants by waist circumference categories



VO2 Max

Figure 4 illustrates participants' VO2 max categories. The data shows that, with regard to predicted VO2max, twenty-three participants (76.7%) had poor VO2max, five participants (16.7%) had fair to good VO2max, and two participants (6.7%) had excellent VO2max in their classifications. Pearson's correlation coefficient showed that there was a moderate negative statistical correlation between physical inactivity and VO2 max, (r = -0.539, $p < 0.05$).

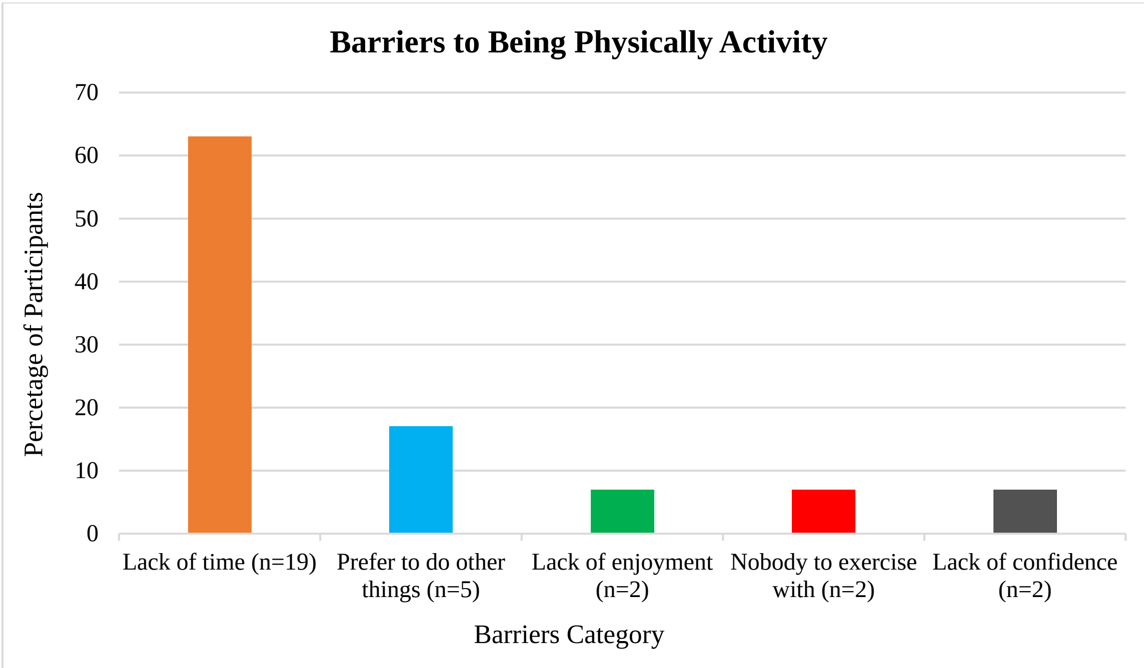
Figure 4. Percentage of participants by VO2 max categories



Barriers to Being Physically Active

Figure 5 illustrates the prevalence of barriers to physical activity. Data showed that lack of time (63%) was the main barrier to being physically active. Other barriers reported as the main deterrents of physical activity included preference to do other things (17%), lack of enjoyment (7%), nobody to exercise with (7%), and lack of confidence (7%). No one thought lack of money (0%) was the most influential barrier to physical activity.

Figure 5. Percentage of participants by barrier to physical activity



Barriers to Being Physically Activity
70
60
50
40
30
20
10
0
Percetage of Participants
Lack of time (n=19)
Prefer to do other things (n=5)
Lack of enjoyment (n=2)
Nobody to exercise with (n=2)
Lack of confidence (n=2)
Barriers Category

Discussion

Cardiovascular Risk Factors

Findings from this research indicated that 83% of participants were physically inactive which is consistent with previous studies (Fountaine, Piacentini, & Liguoril, 2014; Alzeidan, Rabiee, Mandil, Hersi, & Fayed, 2016). University employees tended to have a sedentary lifestyle. Fountaine et al. (2014) conducted an on-line survey to evaluate university employees' sitting, standing, walking and laboring time during their workdays. The results showed that university employees (n = 593) spent 75% of their working time seated. University employees sat in an office at least 6 hours every day they worked. In addition, an epidemiological study collected data from 4500 subjects to assess non-communicable disease (NCD) risk factors among university employees (Alzeidan et al., 2016). That study found that 3443 subjects (77%) had a sedentary lifestyle, which was similar to the results of the current study. According to those research findings, it was reasonable to draw a conclusion that a prevalence of sedentary lifestyle exists in the university workplace.

In addition, many studies showed that cardiovascular risk factors, like obesity, hypertension, abnormal waist circumference, and poor cardiovascular capacity existed in university employees who were sedentary and had an extremely low energy expenditure during the work day (< 1.5 METs) (Fountaine et al., 2014; Alzeidan et al., 2016; Alkhatib, 2015; Schumann et al., 2010). Alkhatib (2015) argued that there was a high prevalence of sedentary lifestyle as well as undesirable health concerns among employees in a campus workplace. In the current research, university employees, regardless of job role, had high risk of CVD in terms of excess body fat, hypertension and lower cardiorespiratory capacity. These health issues could negatively impact healthcare cost and work productivity. Many studies showed that physical inactivity was significantly associated with excess healthcare cost among office workers (Garret, Brasure, Schmitz, Schultz, & Huber, 2004; Wilkerson, Boer, Smith, & Heath, 2008; Hill, Thompson, Shaw, Pinidiya, & Card-Higginson, 2009). The medical cost was 11.7% higher among people who were physically inactive compared to those who were physically active. Heart disease, due to physical inactivity, accounted for up to 25.3% of extra medical cost (Min & Min, 2016). In addition, Williden, Schofield, & Duncan (2012) found a relationship between physical inactivity and reduced work productivity. Workers who were physically inactive had significantly lower work productivity because of higher psychological stress ($p < 0.001$) and additional sickness absence from work ($p = 0.038$). Physically inactive individuals tended to have higher frequency of sickness absence and longer duration of time off from work (Høgsbro, Davidsen, & Sørensen, 2018). Furthermore, Asay, Roy, Lang, Payne, & Howard (2016) argued that CVD risk factors such as physical inactivity, obesity, and hypertension substantially increased absenteeism and employer costs in the US workforce. Therefore, health issue could have a tremendous impact on the workplace. Although physical activity participation is a personal behavior, office administrators or human resource personnel should establish policies or programs to promote physical activity in order to reduce those CVD risk factors.

Main barriers to Physical Activity

Results from the current study showed that lack of time (63%) was the main barrier to being physically active among these university employees. Similarly, time availability was widely discussed in previous sedentary lifestyle studies, and those findings are consistent with the current study (Sequeira, Cruz, Pinto, Santos, & Marques, 2015; Booth, Bauman, Owen, & Gore, 1997; Justine, Azizan, Hassan, Salleh, & Manaf, 2013; Dias, Loch, & Ronque, 2015). Sequeira et al. (2015) examined barriers to physical activity based on different socioeconomic status and gender. Results from 2236 participants (927 males; 1309 females) showed that lack of time (55%), lack of money (20%) and preference to do other things (15%) were the three most common barriers to physical activity (72). Lack of time was the most prevalent barrier to physical activity regardless of gender and socioeconomic status. Another study that focused on a sedentary population recruited 1,232 subjects who were physically inactive (energy expenditure < 1.8 kcal/kg/day). The findings showed that lack of time was the most prevailing barrier to physical activity among those aged from 18 to 39 years (Booth, et al., 1997). Justine et al. (2013) classified 120 subjects into two different age groups; middle age (aged from 45 to 59 years, mean age 51.7±4.15 years) and elderly (aged older than 60 years, mean age 67.82±6.62 years) respectively, in order to examine if there was a significant difference between barriers by age. There was no significant difference found between age and barriers, research data showed that lack of time was the most cited barrier in both groups (46.7% & 48.4%).

In summary, our research results indicated university employees are physically inactive and have multiple risk factors for CVD. In addition, physical activity participation can have a positive impact on CVD risk factors; unfortunately, time appears to be the biggest barrier. Hence, researchers, health professionals, and university administrators should focus on developing time management strategies to manipulate small bouts of time throughout their work day to overcome the barrier and increase physical activity. There are three ways to become physically active. First, university employees can take the stairs instead of using the elevator or park on the far side of the parking lot. This is a simple way office workers can increase their physical activity without spending extra time or money. They could take a 10-minute walk before and after work to walk or over lunch, which would significantly improve their physical activity level and cardiovascular health. Secondly, university employees can switch a regular desk to an adjustable standing desk in their office. Mummery, Schofield, Steele, Eakin, & Brown (2005) found that the average sitting time among white-collar workers was 207.1±169.1 minutes per work day and 60.6% of all employees reported more than 360 minutes of daily occupational sitting time. Office workers spend the majority of time sitting every work day; however, investing in an adjustable standing desk would help them to increase their passive energy expenditure while working. Office workers can still work in their office for long periods of time and avoid being physically inactive. Lastly, university employees can have walking meetings instead of meeting in a room. Oppezzo & Schwartz, (2014) found that walking meetings were more efficient than traditional sit-down meeting in terms of creative thinking. Office workers could discuss projects they are working on with co-workers through walking meetings, which helps them yield new solutions to problems more easily. Furthermore, walking meetings allow employees to exercise during their workday, which enhances health advantage and work productivity due to lower risk of CVD and number of sick days. Therefore, university administration could consider those suggestions to establish policies that benefit both university employees and the university system.

Future Research

Future research should evaluate the effectiveness of interventions that can be implemented when lack of time is the biggest barrier. Based on current literature, three recommendations can be given for future research. First, randomized controlled trials are needed to evaluate diverse interventions to physical activity behavior among university employees. By assigning subjects to different groups randomly, researchers can evaluate the impact of a specific intervention and thus obtain further information about the effectiveness of different interventional strategies that deal with physical inactivity and its impact on CVD risk factors.

Additionally, randomized controlled trials assist with the development and implementation of interventions at the university. Researchers can assess more than one exercise intervention in a study. For example, interventions such as an adjustable standing desk, walking meetings, and a combination of aerobic and resistance exercises can be conducted in the same time. This would enable researchers to assess multicomponent of experimental designs simultaneously. Furthermore, the application of randomized controlled trials help reach a conclusion which would be more comparable and reliable statistically. A specific intervention is directly compared with another intervention or control group to determine if particular benefits could be found in one intervention over the other. A randomized research design is fundamental in identifying relevant variables. For instance, explanatory variables such as diet, cardiovascular capacity or education may influence the effect of target variables on exercise intervention. Furthermore, a randomized controlled trial minimizes potential errors, including allocation bias and selection bias. By implementing randomization procedures, investigators can avoid assigning participants who have superior or inferior physical fitness to either experimental group or control group, which strengthen the research findings generalizability to the target population.

Secondly, a large or diverse sample should be used in future research concerning the influences of exercise interventions on occupational sedentary behavior. Researchers should recruit participants from more than one university to augment reliability and generalizability of research findings. A larger collection of data depicting regional and national university employees allow investigators to examine other potential factors that cause long periods of occupational sitting time, which may exist in one university but not the other. Data from multiple educational settings can also assist investigators with evaluating the social-ecological level of influence on physical activity participation. In addition to demographics, like age, gender, education and marital status, environmental attributes could possibly affect physical activity behavior and motivation to exercise, including access to fitness facilities, spatial layout of workplaces, cost of health club, and distance to sports/fitness center (Trinh et al., 2015).

Lastly, a counseling intervention may be another strategy to cope with physical inactivity. Studies showed that a counseling intervention has been established effectively to promote physical activity at the workplace (Hoecke et al., 2012; Arrogi et al., 2017). Arrogi et al. (2017) conducted a 3-month physical activity counseling intervention focused on applying self-determination theory to boost employees' motivations for engaging in physical activity, in a large pharmaceutical company. The results showed a significant improvement of physical activity participation in terms of increased daily step. Future studies could manipulate the counseling strategy to not only support employees' psychological needs, but also educate them how to apply small bouts of time to increase their physical activity throughout their work day. Since many studies showed that accumulated short bouts of physical activity were significantly associated with lower risk of CVD as long as they reached 150 minutes of physical activity per week (Glazer et al., 2013; Loprinzi, 2015; Jefferis et al., 2016), future studies are needed to strengthen the hypothesis that counselling intervention and short duration of physical activity can be implemented as effective strategies to overcome physical inactivity at the workplace.

Conclusion

The results of the current study indicated a prevalent phenomenon of physical inactivity among university employees. Physical inactivity resulted in higher risk factors of CVD such as excess body fat, hypertension, central obesity and poor VO2 max. Additionally, several significant correlations between physical inactivity and CVD risk factors were found in this study, including hypertension, central obesity, and poor VO2 max. Although there was a strong correlation between physical inactivity and excess BMI, no statistical significance was found. Moreover, lack of time was the most cited barrier to physical activity among university employees compared with other barriers, including preference to do other things, lack of enjoyment, nobody to exercise with, lack of confidence and lack of money.

Based on findings from present and previous studies, future studies should focus on interventions that can be woven into the workplace. An adjustable standing desk and walking meeting might be feasible and instrumental to increase physical activity. Additionally, a counseling intervention could be applied to enhance employees' motives for physical activity as well as teach office workers how to incorporate short bouts of physical activity throughout their work day.

Reference

Adegbija, O., Hoy, W., & Wang, Z. (2015). Prediction of cardiovascular disease risk using waist circumference among Aboriginals in a remote Australian community. *BMC Public Health, 15*(1). doi:10.1186/s12889-015-1406-1

Ahmed, S., Ware, P., Visca, R., Bareil, C., Chouinard, M., Desforges, J., Gogovor, A. (2015). The prevention and management of chronic disease in primary care: Recommendations from a knowledge translation meeting. *BMC Research Notes, 8*(1). doi:10.1186/s13104-015-1514-0

Alharbi, M., Gallagher, R., Neubeck, L., Bauman, A., Prebill, G., Kirkness, A., & Randall, S. (2016). Exercise barriers and the relationship to self-efficacy for exercise over 12 months of a lifestyle-change program for people with heart disease and/or diabetes. *European Journal of Cardiovascular Nursing, 16*(4), 309-317. doi:10.1177/1474515116666475

Al-Mallah, M. H., Sakr, S., & Al-Qunaibet, A. (2018). Cardiorespiratory Fitness and Cardiovascular Disease Prevention: An Update. *Current Atherosclerosis Reports, 20*(1). doi:10.1007/s11883-018-0711-4

Alkhatib, A. (2013). Sedentary Risk Factors across Genders and Job Roles within a University Campus Workplace: Preliminary Study. *Journal of Occupational Health, 55*(3), 218-224. doi:10.1539/joh.12-0158-oa

Alkhatib, A. (2015). High prevalence of sedentary risk factors amongst university employees and potential health benefits of campus workplace exercise intervention. *Work, 52*(3), 589-595. doi:10.3233/wor-152182

Alzeidan, R., Rabiee, F., Mandil, A., Hersi, A., & Fayed, A. (2016). Non-Communicable Disease Risk Factors among Employees and Their Families of a Saudi University: An Epidemiological Study. *Plos One, 11*(11). doi:10.1371/journal.pone.0165036

Araújo, R., Serpeloni, E., R Vaz, E., Borges, R. S., Silva, A. M., Minderico, C. S., Sardinha, L. B. (2012). Cardiovascular fitness and cardiovascular risk factors among obese men and women aged 58 years and older, in Portugal. *Revista Médica De Chile, 140*(9), 1164-1169. doi:10.4067/s0034-98872012000900009

Arrogi, A., Schotte, A., Bogaerts, A., Boen, F., & Seghers, J. (2017). Short- and long-term effectiveness of a three-month individualized need-supportive physical activity counseling intervention at the workplace. *BMC Public Health, 17*(1). doi:10.1186/s12889-016-3965-1

Arroyo, L. (1999). Mechanisms of plaque rupture mechanical and biologic interactions. *Cardiovascular Research, 41*(2), 369-375. doi:10.1016/s0008-6363(98)00308-3

Asay, G. R., Roy, K., Lang, J. E., Payne, R. L., & Howard, D. H. (2016). Absenteeism and Employer Costs Associated With Chronic Diseases and Health Risk Factors in the US Workforce. *Preventing Chronic Disease, 13*. doi:10.5888/pcd13.150503

Backer, G. D. (2007). Prevention Guidelines: Management of the Coronary Patient. *Cardiovascular Prevention and Rehabilitation*, 26-29. doi:10.1007/978-1-84628-502-8_4

Balakumar, P., Maung-U, K., & Jagadeesh, G. (2016). Prevalence and prevention of cardiovascular disease and diabetes mellitus. *Pharmacological Research*, 113, 600-609. doi:10.1016/j.phrs.2016.09.040

Beltz, N. M., Gibson, A. L., Janot, J. M., Kravitz, L., Mermier, C. M., & Dalleck, L. C. (2016). Graded Exercise Testing Protocols for the Determination of VO2max: Historical

Perspectives, Progress, and Future Considerations. *Journal of Sports Medicine, 2016,* 1-12. doi:10.1155/2016/3968393

Berlin, J. A., & Colditz, G. A. (1990). A Meta-Analysis Of Physical Activity In The Prevention Of Coronary Heart Disease. *American Journal of Epidemiology, 132*(4), 612-628. doi:10.1093/oxfordjournals.aje.a115704

Brown, M. M. (2002). Brain attack: A new approach to stroke. *Clinical Medicine, 2*(1), 60-65. doi:10.7861/clinmedicine.2-1-60

Bogers, R. P. (2007). Association of Overweight With Increased Risk of Coronary Heart Disease Partly Independent of Blood Pressure and Cholesterol LevelsA Meta-analysis of 21 Cohort Studies Including More Than 300 000 Persons. *Archives of Internal Medicine, 167*(16), 1720. doi:10.1001/archinte.167.16.1720

Booth, F. W., Roberts, C. K., & Laye, M. J. (2012). Lack of Exercise Is a Major Cause of Chronic Diseases. *Comprehensive Physiology*. doi:10.1002/cphy.c110025

Booth, M. L., Bauman, A., Owen, N., & Gore, C. J. (1997). Physical Activity Preferences, Preferred Sources of Assistance, and Perceived Barriers to Increased Activity among Physically Inactive Australians. *Preventive Medicine, 26*(1), 131-137. doi:10.1006/pmed.1996.9982

Cornelissen, V. A., & Fagard, R. H. (2005). Effects of Endurance Training on Blood Pressure, Blood Pressure-Regulating Mechanisms, and Cardiovascular Risk Factors. *Hypertension, 46*(4), 667-675. doi:10.1161/01.hyp.0000184225.05629.51

Correction to: Heart Disease and Stroke Statistics—2018 Update: A Report From the American Heart Association. (2018). *Circulation, 137*(12). doi:10.1161/cir.0000000000000573

Dlugosz, E. M., Chappell, M. A., Meek, T. H., Szafranska, P. A., Zub, K., Konarzewski, M., Garland, T. (2013). Phylogenetic analysis of mammalian maximal oxygen consumption during exercise. *Journal of Experimental Biology*, *216*(24), 4712-4721. doi:10.1242/jeb.088914

Dias, D. F., Loch, M. R., & Ronque, E. R. (2015). Perceived Barriers to Leisure-Time Physical Activity and Associated Factors in Adolescents. *Ciencia & Saude Coletiva, 20*(11), 3339–3350. doi:10.1590/1413-812320152011.00592014

Dobler, L. C., & Ecker, K. R. (2017). Risk Factors for Cardiovascular Disease Among University Employees. *Medicine & Science in Sports & Exercise*, *49*, 281. doi:10.1249/01.mss.0000517627.56272.d0

Flegal, K. M., Kit, B. K., Orpana, H., Graubard, B. I. (2013) Association of All-Cause Mortality With Overweight and Obesity Using Standard Body Mass Index Categories A Systematic Review and Meta-analysis. *JAMA.309*(1):71–82. doi:10.1001/jama.2012.113905

Fountaine, C. J., Piacentini, M., & Liguoril, G. A. (2014). Occupational Sitting and Physical Activity Among University Employees. *International Journal of Exercise Science*, *7*(4), 295–301.

Gander, J. C., Sui, X., Hébert, J. R., Hazlett, L. J., Cai, B., Lavie, C. J., & Blair, S. N. (2015). Association of Cardiorespiratory Fitness With Coronary Heart Disease in Asymptomatic Men. *Mayo Clinic Proceedings*, *90*(10), 1372-1379. doi:10.1016/j.mayocp.2015.07.017

Garrett, N. A., Brasure, M., Schmitz, K. H., Schultz, M. M., Huber, M. R. (2004). Physical inactivity: Direct cost to a health plan. *American Journal of Preventive Medicine, 27*(4), 304-309. doi:10.1016/j.amepre.2004.07.014

Gaziano, T. A., & Gaziano, J. M. (2012). Global Burden of Cardiovascular Disease. Braunwalds Heart Disease: *A Textbook of Cardiovascular Medicine,* 1-20. doi:10.1016/b978-1-4377-0398-6.00001-9

Gersh, B. (2012). National, regional, and global trends in body-mass index since 1980: Systematic analysis of health examination surveys and epidemiological studies with 960 country-years and 9·1 million participants. *Yearbook of Cardiology,* 2012, 252-254. doi:10.1016/j.ycar.2012.01.086

Gersh, B. J., Sliwa, K., Mayosi, B. M., & Yusuf, S. (2010). Novel therapeutic concepts * The epidemic of cardiovascular disease in the developing world: Global implications. *European Heart Journal, 31*(6), 642-648. doi:10.1093/eurheartj/ehq030

Gibson, A. L., Wagner, D. R., & Heyward, V. H. (2006). *Advanced fitness assessment and exercise prescription*. Champaign, IL: Human Kinetics.

Glazer, N. L., Lyass, A., Esliger, D. W., Blease, S. J., Freedson, P. S., Massaro, J. M., Vasan, R. S. (2013). Sustained and Shorter Bouts of Physical Activity Are Related to Cardiovascular Health. *Medicine & Science in Sports & Exercise, 45*(1), 109-115. doi:10.1249/mss.0b013e31826beae5

Gu, Z., Li, D., He, H., Wang, J., Hu, X., Zhang, P., . . . Ji, G. (2018). Body mass index, waist circumference, and waist-to-height ratio for prediction of multiple metabolic risk factors in Chinese elderly population. *Scientific Reports, 8*(1). doi:10.1038/s41598-017-18854-1

Hill, R. K., Thompson, J. W., Shaw, J. L., Pinidiya, S. D., & Card-Higginson, P. (2009). Self-Reported Health Risks Linked to Health Plan Cost and Age Group. *American Journal of Preventive Medicine, 36*(6), 468-474. doi:10.1016/j.amepre.2009.01.034

Hoare, E., Stavreski, B., Jennings, G., & Kingwell, B. (2017). Exploring Motivation and Barriers to Physical Activity among Active and Inactive Australian Adults. *Sports*, *5*(3), 47. doi:10.3390/sports5030047

Hoecke, A. V., Delecluse, C., Opdenacker, J., Lipkens, L., Martien, S., & Boen, F. (2012). Long-term effectiveness and mediators of a need-supportive physical activity coaching among Flemish sedentary employees. *Health Promotion International, 28*(3), 407-417. doi:10.1093/heapro/das025

Høgsbro, C., Davidsen, M., & Sørensen, J. (2018). Long-term sickness absence from work due to physical inactivity: A registry-based study. *Scandinavian Journal of Public Health, 46*(3), 306-313. doi:10.1177/1403494817751328

Howard, W. (2006). Diagnosis and Management of the Metabolic Syndrome: An American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement. *Yearbook of Endocrinology, 2006*, 113-114. doi:10.1016/s0084-3741(08)70316-0

Hu, F. B. (2008). Measurements of Adiposity and Body Composition. *Obesity Epidemiology*, 53-83. doi:10.1093/acprof:oso/9780195312911.003.0005

Jackson, A. S., Blair, S. N., Mahar, M. T., Wier, L. T., Ross, R. M., & Stuteville, J. E. (1990). Prediction of functional aerobic capacity without exercise testing. *Medicine & Science in Sports & Exercise, 22*(6), 863. doi:10.1249/00005768-199012000-00021

Jacobson, D. M., Strohecker, L., Compton, M. T., & Katz, D. L. (2005). Physical Activity Counseling in the Adult Primary Care Setting. *American Journal of Preventive Medicine, 29*(2), 158-162. doi:10.1016/j.amepre.2005.04.009

James, P. (2010). The Current State of the Obesity Pandemic. *Obesity Prevention*, 445-462. doi:10.1016/b978-0-12-374387-9.00036-2

Jefferis, B. J., Parsons, T. J., Sartini, C., Ash, S., Lennon, L. T., Wannamethee, S. G., . . . Whincup, P. H. (2016). Does duration of physical activity bouts matter for adiposity and metabolic syndrome? A cross-sectional study of older British men. *International Journal of Behavioral Nutrition and Physical Activity, 13*(1). doi:10.1186/s12966-016-0361-2

Justine, M., Azizan, A., Hassan, V., Salleh, Z., & Manaf, H. (2013). Barriers to participation in physical activity and exercise among middle-aged and elderly individuals. *Singapore Medical Journal, 54*(10), 581-586. doi:10.11622/smedj.2013203

Kearns, K., Dee, A., Fitzgerald, A. P., Doherty, E., & Perry, I. J. (2014). Chronic disease burden associated with overweight and obesity in Ireland: The effects of a small BMI reduction at population level. *BMC Public Health, 14*(1). doi:10.1186/1471-2458-14-143

Khan, S. S., Ning, H., Wilkins, J. T., Allen, N., Carnethon, M., Berry, J. D., . . . Lloyd-Jones, D. M. (2018). Association of Body Mass Index With Lifetime Risk of Cardiovascular Disease and Compression of Morbidity. *JAMA Cardiology, 3*(4), 280. doi:10.1001/jamacardio.2018.0022

Koning, L. D., Merchant, A. T., Pogue, J., & Anand, S. S. (2007). Waist circumference and waist-to-hip ratio as predictors of cardiovascular events: Meta-regression analysis of prospective studies. *European Heart Journal*, *28*(7), 850-856. doi:10.1093/eurheartj/ehm026

Lamberti, J. (2006). Prevalence of the Metabolic Syndrome Among Patients Receiving Clozapine. *American Journal of Psychiatry*, *163*(7), 1273. doi:10.1176/appi.ajp.163.7.1273

Lamonte, M. J., Eisenman, P. A., Adams, T. D., Shultz, B. B., Ainsworth, B. E., & Yanowitz, F. G. (2000). Cardiorespiratory Fitness and Coronary Heart Disease Risk

Factors : The LDS Hospital Fitness Institute Cohort. *Circulation, 102*(14), 1623-1628. doi:10.1161/01.cir.102.14.1623

Linden, B. (2011). The link between body mass index and cardiovascular diseaseDudina A, Cooney MT, De Bacquer D on behalf of the SCORE investigators (2011) Relationships between body mass index, cardiovascular mortality, and risk factors: A report from the SCORE investigators. Eur J Cardiovasc Prev Rehabil 18(5): 731–42. *British Journal of Cardiac Nursing, 6*(12), 616-617. doi:10.12968/bjca.2011.6.12.616b

Loprinzi, P. D. (2015). Accumulated Short Bouts of Physical Activity Are Associated With Reduced Premature All-Cause Mortality: Implications for Physician Promotion of Physical Activity and Revision of Current US Government Physical Activity Guidelines. *Mayo Clinic Proceedings, 90*(8), 1168-1169. doi:10.1016/j.mayocp.2015.06.008

Mcmurray, R. G., Ainsworth, B. E., Harrell, J. S., Griggs, T. R., & Williams, O. D. (1998). Is physical activity or aerobic power more influential on reducing cardiovascular disease risk factors? *Medicine & Science in Sports & Exercise, 30*(10), 1521-1529. doi:10.1097/00005768-199810000-00009

Mendis, S., Puska, P., & Norrving, B. (2011). *Global atlas on cardiovascular disease prevention and control.* Geneva: World Health Organization in collaboration with the World Heart Federation and the World Stroke Organization.

Min, J., & Min, K. (2016). Excess Medical Care Costs Associated with Physical Inactivity among Korean Adults: Retrospective Cohort Study. *International Journal of Environmental Research and Public Health, 13*(1), 136. doi:10.3390/ijerph13010136

Mummery, W. K., Schofield, G. M., Steele, R., Eakin, E. G., Brown, W. J. (2005) Occupational sitting time and overweight and obesity in Australian workers. *American Journal of Preventive Medicine, 29*(2), 91-97. doi:10.1016/j.amepre.2005.04.003

Nabi, T., Rafiq, N., & Qayoom, O. (2015). Assessment of cardiovascular fitness among medical students by Queens College step test. *International Journal of Biomedical and Advance Research*, 6(5), 418-421.

Oja, P., & Titze, S. (2011). Physical activity recommendations for public health: Development and policy context. *EPMA Journal*, *2*(3), 253-259. doi:10.1007/s13167-011-0090-1

Oppezzo, M., & Schwartz, D. L. (2014). Give your ideas some legs: The positive effect of walking on creative thinking. Journal of Experimental Psychology: *Learning, Memory, and Cognition, 40*(4), 1142-1152. doi:10.1037/a0036577

Ostchega, Y., Zhang, G., Kit, B. K., & Nwankwo, T. (2017). Factors Associated With Home Blood Pressure Monitoring Among US Adults: National Health and Nutrition Examination Survey, 2011–2014. *American Journal of Hypertension, 30*(11), 1126-1132. doi:10.1093/ajh/hpx101

Peterson, J. A., & Cheng, A. (2012). Physical activity counseling intervention to promote weight loss in overweight rural women. *Journal of the American Association of Nurse Practitioners, 25*(7), 385-394. doi:10.1111/j.1745-7599.2012.00794.x

Pronk, N. P., Boyle, R. B., & Oconnor, P. J. (1998). The Association between Physical Fitness and Diagnosed Chronic Disease in Health Maintenance Organization Members. *American Journal of Health Promotion, 12*(5), 300-306. doi:10.4278/0890-1171-12.5.300

Purnamasari, D., Badarsono, S., Moersadik, N., Sukardji, K., & Tahapary, D. (2011). Identification, Evaluation and Treatment of Overweight and Obesity in Adults: Clinical Practice Guidelines of the Obesity Clinic, Wellness Cluster, Cipto Mangunkusumo Hospital, Jakarta, Indonesia. *Journal of the ASEAN Federation of Endocrine Societies, 2011*(2), 117-121. doi:10.15605/jafes.026.2.06

Redon, J., Tellez-Plaza, M., Orozco-Beltran, D., Gil-Guillen, V., Fernandez, S. P., Navarro-Pérez, J., Martin-Moreno, J. M. (2016). Impact of hypertension on mortality and cardiovascular disease burden in patients with cardiovascular risk factors from a general practice setting. *Journal of Hypertension, 34*(6), 1075-1083. doi:10.1097/hjh.0000000000000930

Riebe, D., Ehrman, J. K., Liguori, G., & Magal, M. (2018). *ACSMs guidelines for exercise testing and prescription.* Philadelphia: Wolters Kluwer.

Ross, R., Blair, S. N., Arena, R., Church, T. S., Després, J., Franklin, B. A., . . . Wisløff, U. (2016). Importance of Assessing Cardiorespiratory Fitness in Clinical Practice: A Case for Fitness as a Clinical Vital Sign: A Scientific Statement From the American Heart Association. *Circulation, 134*(24). doi:10.1161/cir.0000000000000461

Sadasivan, C., Fiorella, D. J., Woo, H. H., & Lieber, B. B. (2013). Physical Factors Effecting Cerebral Aneurysm Pathophysiology. *Annals of Biomedical Engineering, 41*(7), 1347-1365. doi:10.1007/s10439-013-0800-z

Salmon, J., Owen, N., Crawford, D., Bauman, A., & Sallis, J. F. (2003). Physical activity and sedentary behavior: A population-based study of barriers, enjoyment, and preference. *Health Psychology, 22*(2), 178-188. doi:10.1037//0278-6133.22.2.178

Salvi, S. (2016). Faculty of 1000 evaluation for Global, regional, and national age-sex specific all-cause and cause-specific mortality for 240 causes of death, 1990-2013: A systematic analysis for the Global Burden of Disease Study 2013. F1000 - *Post-publication Peer Review of the Biomedical Literature.* doi:10.3410/f.725286838.793523287

Schembre, S. M., & Riebe, D. A. (2011). Non-Exercise Estimation of VO2max Using the International Physical Activity Questionnaire. *Measurement in Physical Education and Exercise Science, 15*(3), 168-181. doi:10.1080/1091367x.2011.568369

Schmitz, G., & Torzewski, M. (2001). Atherosclerosis: An Inflammatory Disease. *Inflammatory and Infectious Basis of Atherosclerosis*, 1-21. doi:10.1007/978-3-0348-8239-2_1

Schumann, B., Seidler, A., Kluttig, A., Werdan, K., Haerting, J., & Greiser, K. H. (2010). Association of occupation with prevalent hypertension in an elderly East German population: An exploratory cross-sectional analysis. *International Archives of Occupational and Environmental Health, 84*(4), 361-369. doi:10.1007/s00420-010-0584-5

Semplicini, A. (2014). Faculty of 1000 evaluation for Blood pressure and incidence of twelve cardiovascular diseases: Lifetime risks, healthy life-years lost, and age-specific associations in 1·25 million people. *F1000 - Post-publication Peer Review of the Biomedical Literature.* doi:10.3410/f.718429942.793497724

Sequeira, S., Cruz, C., Pinto, D., Santos, L., & Marques, A. (2011). Prevalence of barriers for physical activity in adults according to gender and socioeconomic status. *British Journal of Sports Medicine, 45*(15). doi:10.1136/bjsports-2011-090606.59

Shephard, R. (2008). Maximal Oxygen Uptake as a Parametric Measure of Cardiorespiratory Capacity. *Yearbook of Sports Medicine, 2008*, 103-104. doi:10.1016/s0162-0908(08)79148-7

Stamatakis, E., Hamer, M., Odonovan, G., Batty, G. D., & Kivimaki, M. (2012). A non-exercise testing method for estimating cardiorespiratory fitness: Associations with all-cause and cardiovascular mortality in a pooled analysis of eight population-based cohorts. *European Heart Journal, 34*(10), 750-758. doi:10.1093/eurheartj/ehs097

Strazzullo, P., Delia, L., Cairella, G., Garbagnati, F., Cappuccio, F. P., & Scalfi, L. (2010). Excess Body Weight and Incidence of Stroke: Meta-Analysis of Prospective Studies With 2 Million Participants. *Stroke, 41*(5). doi:10.1161/strokeaha.109.576967

Sweeting, J., Ingles, J., Ball, K., & Semsarian, C. (2015). Physical activity in hypertrophic cardiomyopathy: Prevalence of inactivity and perceived barriers. *Heart, Lung and Circulation, 24.* doi:10.1016/j.hlc.2015.06.644

Trinh, L., Larsen, K., Faulkner, G. E., Plotnikoff, R. C., Rhodes, R. E., North, S., & Courneya, K. S. (2015). Social-ecological correlates of physical activity in kidney cancer survivors. *Journal of Cancer Survivorship, 10*(1), 164-175. doi:10.1007/s11764-015-0462-y

Vischer, A. S., & Burkard, T. (2016). Principles of Blood Pressure Measurement – Current Techniques, Office vs Ambulatory Blood Pressure Measurement. Advances in Experimental Medicine and Biology Hypertension: From Basic Research to Clinical Practice, 85-96. doi:10.1007/5584_2016_49

Wang, C., Li, W., Yin, L., Bo, J., Peng, Y., & Wang, Y. (2017). Comparison of healthy lifestyle behaviors among individuals with and without cardiovascular diseases from urban and rural areas in China: A cross-sectional study. *Plos One, 12*(8). doi:10.1371/journal.pone.0181981

Watanabe, K., Kawakami, N., Otsuka, Y., & Inoue, S. (2018). Associations among workplace environment, self-regulation, and domain-specific physical activities among white-collar workers: A multilevel longitudinal study. *International Journal of Behavioral Nutrition and Physical Activity, 15*(1). doi:10.1186/s12966-018-0681-5

Wilkerson, G. B., Boer, N. F., Smith, C. B., & Heath, G. W. (2008). Health-Related Factors Associated With the Healthcare Costs of Office Workers. *Journal of Occupational and Environmental Medicine, 50*(5), 593-601. doi:10.1097/jom.0b013e318162f5ad

Williden, M., Schofield, G., & Duncan, S. (2012). Establishing Links Between Health and Productivity in the New Zealand Workforce. *Journal of Occupational and Environmental Medicine, 54*(5), 545-550. doi:10.1097/jom.0b013e31824fe0c8

Wuensch, K. L., & Evans, J. D. (1996). Straightforward Statistics for the Behavioral Sciences. *Journal of the American Statistical Association, 91*(436), 1750. doi:10.2307/2291607

Zanesco, A., & Antunes, E. (2007). Effects of exercise training on the cardiovascular system: Pharmacological approaches. *Pharmacology & Therapeutics, 114*(3), 307-317. doi:10.1016/j.pharmthera.2007.03.010

Appendix

Physical Activity Rating Questionnaire

Name ________________________ Date __________________

Determine Your Physical Activity Rating (PAR)

Give yourself the appropriate PAR score (0–7) based on the following scale:

I. Does not participate regularly in programmed recreation, sport, or physical activity.

0 points: Avoids walking or exercise (for example, always uses elevators, drives whenever possible instead of walking).

1 point: Walks for pleasure, routinely uses stairs, occasionally exercises sufficiently to cause heavy breathing or perspiration.

II. Participates regularly in recreation or work requiring modest physical activity (such as golf, horseback riding, gymnastics, table tennis, bowling, weight lifting, or yard work).

2 points: 10–60 minutes per week

3 points: Over 1 hour per week

III. Participates regularly in heavy physical exercise (such as running or jogging, swimming, cycling, rowing, skipping rope, running in place) or engages in vigorous aerobic type activity (such as tennis, basketball, or handball).

4 points: Runs less than 1 mile per week or spends less than 30 minutes per week in comparable physical activity.

5 points: Runs 1-5 miles per week or spends 30–60 minutes per week in comparable physical activity.

6 points: Runs 5-10 miles per week or spends 1–3 hours per week in comparable physical activity.

7 points: Runs more than 10 miles per week or spends more than 3 hours per week in comparable physical activity.

Barrier to Being Physically Active Questionnaire

Which One of the Following Is Your Main Barrier to Being Physically Active?

1. Lack of time
2. Prefer to do other things
3. Lack of enjoyment
4. Nobody to exercise with
5. Lack of confidence
6. Lack of money