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THE IMPACT OF PHYSICAL ACTIVITY ON THE ASSOCIATION BETWEEN SMOKING AND HYPERTENSION

By

SOBHAN SOBY TADJALLI
B.A., UNIVERSITY OF DELAWARE

A Thesis Submitted to the Graduate Faculty
of Georgia State University in Partial Fulfillment
of the
Requirements for the Degree
MASTER OF PUBLIC HEALTH

ATLANTA, GEORGIA
20045

THE IMPACT OF PHYSICAL ACTIVITY ON THE ASSOCIATION BETWEEN SMOKING AND HYPERTENSION

by

SOBHAN SOBY TADJALLI

Approved:

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DEDICATION PAGE

The following thesis document is dedicated to my family and anyone who has had a positive influence in my life.

ACKNOWLEDGEMENTS

Thank you to my family for the guidance they have provided me guidance and joy throughout my academic, athletic, and personal life. My parents, Mehdi and Hoda, along with my siblings, Sal and Sonia, have been my supportive cast my whole life. I would also like to acknowledge the staff and faculty at Georgia State University: Miss Courtney Burton, Dr. Elizabeth Majestic, Dr. Frances McCarty, Dr. Richard Rothenberg, Professor John Steward, Dr. Sheryl Strasser, Dr. Christine Stauber, and Professor Russ Toal. Special thanks to my academic and thesis committee: Dr. Michael Eriksen, Dr. Rodney Lyn, and Dr. Okosun. In conjunction with Georgia State University, I am grateful to the Institute of Public Health for believing in me, and providing me the opportunity to pursue my education.

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Curriculum Vitae

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Georgia State University, Atlanta, GA August 2008 – Present

- Masters Degree in Public Health
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- Thesis Title: The Impact of Smoking on the Association Between Physical Activity and Hypertension

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- Bachelor of Arts in Biological Sciences
- NCAA Division I Athlete, Men's Soccer Team

Work Experience:

Centers for Disease Control and Prevention (CDC) 2010 - Present
Division of Nutrition, Physical Activity, and Obesity (DNPAO)
Atlanta, Georgia

- Perform literature reviews pertaining to active transportation as a mode of physical activity
- Pilot test Legislative Database Abstraction Tool; designed to abstract information from Bill's pertaining to physical activity, active transportation, recreation facilities, leisure time, built environment, urban design and land use policies, and funding
- Create and present PowerPoint's dealing with the latest global physical activity guidelines

National Association of Chronic Disease Directors (NACDD) 2010 - Present
Obesity Task Force Volunteer
Atlanta, Georgia

- Assessment of State and Local Public Health Program Needs Related to Obesity Prevention and Control and report to the CDC
- Providing technical assistance to practitioners engage in community-based participatory research and in obesity program implementation
- Support effective policy and environmental changes at local, state and national levels

The Davis Academy (K-8) 2010 - Present
Soccer Head Coach/Substitute Teacher
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Science and Health Educator
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- Demonstrate science modules on a variety of topics (Animal Diversity, Bio-technology, Chemistry, Geosciences, Heart Health, Environment/Water, DNA, Weather, and Microbes)
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TITLE OF THESIS:
The Impact of Physical Activity on the Association between Smoking and Hypertension.

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ABSTRACT

Background: Hypertension is synonymous with high blood pressure, where blood exerts a great force on the arterial walls. Smoking cigarettes is known to cause negative health outcomes, specifically increase blood pressure. Adversely, physical activity is known to provide many health benefits, including the reduction of blood pressure. This study examines the impact of physical activity on the association between smoking and hypertension.

Methods: Using secondary data from National Health and Nutrition Examination Survey (NHANES) 2007-2008, demographics of the population were described via descriptive statistics. Regressions were run using different models, controlling for various variables (age, ethnicity, sex, poverty to income ratio (PIR), body mass index (BMI), and interaction (smoking x physical activity)) to determine the association between smoking and hypertension. Odds ratios and 95% confidence intervals were used to determine statistical significance throughout all the analyses performed.

Results: In total, 10,149 cases were included in the study analysis. 10.9% of the cases were smokers, 48.1% were physically activity, and 28.6% were hypertensive. OR's for the various models observing smoking and hypertension were 1.48 (1.29, 1.69), 1.42 (1.22, 1.65), 1.37 (1.12, 1.67), and 1.36 (1.10, 1.68). In the final model which controlled for all variables including the interaction term, the OR was 1.12 (0.47, 2.67).

Conclusions: Smokers had significantly higher rates of hypertension in all the models. The final model which observed smokers who were physical active found that the relationship between smoking and hypertension was no longer significant. This study suggests physical activity as a mode of intervention to reduce blood pressure in smokers.

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CHAPTER I
INTRODUCTION

1a. Background

Regular physical activity can reduce the risk of several chronic diseases, such as diabetes, cancer, and hypertension (Warburton et al. 2006). The inverse relationship between physical activity and hypertension are well understood; as physical activity increases, risk of hypertension decreases. The CDC recommends 2.5 hours of moderate-intensity aerobic activity per week, accompanied by two days of muscle strengthening activities (CDC, 2010). By adhering to these recommendations, individuals reduce the risk of hypertension, as well as other conditions.

A 2006 study by Blair et al. concluded that the low levels of physical activity were associated with a 1.52 increased risk of developing hypertension when compared to highly physically active individuals (Blair et al. 2006). Hypertension can go fatally undetected unless an individual is proactive and visits their doctor regularly. Contrary to physical activity, smoking instills negative health impacts with several health repercussions. The negative impact smoking inflicts on blood pressure are also explicit. Smoking is the leading cause of preventable death in the world (Shafey et al. 2009). The baneful effects of smoking are well documented. Inhaling any foreign substance can cause severe harm to the human body, specifically the lungs. During inhalation of a cigarette, a smoker takes in over 4,000 chemicals via cigarette smoke (Shafey et al. 2009). This cigarette smoke is the genesis of most cases of lung cancer, respiratory illness, and hypertension. Hypertension is defined as the force blood exerts on arterial walls throughout the body (CDC, 2010). Blood pressure is interpreted using two values, systolic and diastolic. The systolic value represents the value of pressure blood exerts on arterial walls during a heartbeat. The diastolic value represents the value of pressure on arterial walls while the heart

is at rest (in between heartbeats). Cigarette smoke causes hypertension by constricting blood vessels, making a narrow path for blood to travel, resulting in extra exertion on arterial walls.

1b. Purpose of Study

Current literature suggests that smoking can increase blood pressure, resulting in hypertension. This study will attempt to concur with previous studies, in addition, take physical activity into account. Being physically active is known to reduce blood pressure, however no current studies highlight the impact of physical activity on the association between smoking and hypertension. Physical activity, smoking, and hypertension have independently been studied extensively, this study will enhance the current literature by incorporating those factors in conjunction with other study variables, such as: age, race, gender, body mass index (BMI), and poverty-income ratio (PIR). These variables provide a snapshot of the demographics being studied. Demographic, examination, and questionnaire files were all retrieved from the National Health and Nutrition Examination Survey (NHANES) from 2007-2008. This study will provide further evidence pertaining to the inverse relationship between smoking and hypertension, as well as depict the influence physical activity has on this relationship. The results of this study may help prevent individuals from smoking given its effects on hypertension, and possibly depict physical activity as an intervention to reduce blood pressure in smokers.

1c. Research Questions

Question #1: Is there an association between smoking and hypertension?

Null Hypothesis: There is an association between smoking and hypertension.

Question #2: Is BMI an effect modifier between smoking and hypertension?

Null Hypothesis: BMI is not an effect modifier between smoking and hypertension.

Question #3: Does physical activity impact the association between smoking and hypertension?

Null Hypothesis: The association between smoking and hypertension will be decreased by physical activity and those who are physically active will have lower rates of hypertension.

CHAPTER II

REVIEW OF THE LITERATURE

The literature review will focus on dissecting each component of this study. It is important get a synopsis on the current understandings on the prevalence of physical activity, smoking, physical activity, and hypertension. Furthermore, a comprehensive review on the impact of physical activity on smoking, the impact of physical activity on hypertension, and the relationship between smoking and hypertension.

2a. Smoking

Smoking cigarettes are extremely harmful to one's health. The Third Edition of the Tobacco Atlas describes cigarettes as "shredded or reconstituted tobacco, processed with hundreds of chemicals and rolled into a paper-wrapped cylinder… they are lit at one end and inhaled through the other" (Shafey et al. 2009). Smoking comes in various forms including: manufactured cigarettes, roll-your-own cigarettes, cigars, hookahs/waterpipes, sticks, kreteks, or bidis (Shafey et al. 2009). Cigarette smoking is the most common form of smoking throughout the globe. With over 1 billion smokers worldwide, smoking has surpassed epidemic proportions.

With public health efforts to reduce smoking in developed countries, tobacco companies have targeted less developed countries, seizing them as untapped markets. For example, China has seen smoking rates elevate the past 40 years due to heavy marketing by tobacco companies (Jha 2009). As of 2008, China has the most number of males smokers with 311, 203,202, followed by India with 131,598,984 smokers. Amongst females, the U.S. has the most number of smokers with 23,671,860 (Shafey et al. 2009). Similar to China, Thailand has also witnessed an increase in cigarette consumption. In 1991, heavy marketing led to a smoking prevalence of

60% amongst Thai males (Levy et al. 2008). However Thailand's future, like the U.S., has been more promising than China's. With proper public health efforts to implement strict tobacco control policies, smoking prevalence in Thailand was reduced to 35% (Levy et al. 2008). Other countries that have high smoking prevalence rise include: Indonesia, Afghanistan, Yemen, Russian Federation, Ukraine, and Greece (Shafey et al. 2009). Well developed countries such as U.S.A., United Kingdom, and Japan have seen a decrease in smoking prevalence (Shafey et al. 2009). Public health efforts are aimed at reducing smoking rates throughout all countries.

In the United States, it is estimated that over 45 million people smoke, which equates to roughly 20% of the U.S. population (Shafey et al. 2009). Since 1965, smoking prevalence has been on a steady decline, going from 52% to 23% in males, and 34% to 18% in females (Shafey et al. 2009). Despite this steady decline, The U.S. is still one of the top 5 cigarette consuming countries, consuming 357 billion cigarettes in 2007 (Shafey et al. 2009). A fair portion of cigarette consumers in the U.S. are white males from lower socioeconomic status (SES) (Kaczynski et al. 2008). Those from a lower SES display less educational attainment, which is related to higher rates of smoking (Storr et al. 2009). Historically males have led women in smoking prevalence throughout the U.S., however there may be a shift in the near future. It is estimated that roughly 13.9% of girls between the ages of 13 and 15 are current cigarette smokers, 1.8% more than boys (Shafey et al. 2009). Adolescent females commonly start smoking over concerns of body image, glamorized cigarette use in movies and pop culture, and cigarette marketing campaigns targeting females (Shafey et al. 2009). If youth smoking trends continue, male and female smoking prevalence could become equivalent.

Despite smoking trends and prevalence, nobody is safe from the harm posed by smoking. It is known to affect multiple organs and body systems, as well as diminishing overall health. In

a systematic review by Kaczynski et al., smoking is cited as increasing the incidence of various cancers, coronary heart disease, stroke, and is the leading cause of chronic obstructive pulmonary disease. Inhaling any foreign substance is baneful, but given the thousand toxic substances found in cigarette smoke, smoking is the leading cause of lung cancer (Shafey et al. 2009). The pulmonary organs are extremely sensitive to smoke, hence the potential for multiple disorders, such as: chronic obstructive pulmonary disease (COPD), emphysema, chronic bronchitis, respiratory infection, asthma, and chronic cough. With current smoking trends, it is projected that between 2005 and 2030 smoking will kill 175.8 million individuals (cumulative tobacco-related deaths) (Shafey et al. 2009). Reducing the number of smokers is an essential step in reducing the burden of death and disease worldwide, as well as an economic burden. Smoking causes $193 billion in direct health-care expenditures and productivity losses each year (MMWR 2009). Reducing the number of smokers was explicitly mentioned in the Healthy People 2010. The primary target for HP 2010 was to reduce the adult smoking prevalence to 12%, however only Utah and U.S. Virgin Islands met the HP 2010 target goal (MMWR 2009).

It should be noted some studies suggest smokers avoid cessation because of potential weight gain associated with cessation (Parson et al. 2009). Cigarette smoking is negatively associated with body weight indicated by BMI, meaning smokers tend to be leaner (Xu et al. 2007). Smoking cessation may nonetheless be associated with a small increase in weight (Flegal et al. 1995). Nonetheless, the health benefits of cessation are irrefutable. Cessation improves overall health and enhances longevity and can reduce the risk of: certain cancers, pulmonary diseases, cardiovascular disease, and teeth discoloration (Samet 1990).

2b. Hypertension

Hypertension is synonymous to high blood pressure. The term used to define the amount of resistance blood faces following each heart beat, hence narrow arteries lead to an increased blood pressure. ((MayoClinic.com, n.d.). High blood pressure generally does not express any visual symptoms, putting individuals at risk for hypertension unknowingly. For this reason, hypertension is known as the "silent killer". A simple blood pressure test using a sphygmomanometer is the lone test for hypertension. This test provides two readings, systolic blood pressure (SBP, the pressure of a heart beat) and diastolic blood pressure (DBP, the pressure of a heart at rest). Normal blood pressure readings are <120 mmHg SBP and <80 mmHg DBP. A systolic reading of 140-159 mmHg or a diastolic reading of 90-99 mmHg is considered stage 1 hypertension (CDC, 2010). SBP≥160 or DBP≥100 mmHg are considered stage 2 hypertension (JNC 2004). The "stages" are set up as a classification system of the severity of blood pressure readings. Despite the two stages, any elevated blood pressure reading should be treated and controlled before severe complication or death. Consistent high blood pressure can lead to heart disease, such as heart attack or stroke. Hypertension develops over time and several factors can contribute to it, including: lack of physical activity, poor diet (high in sodium), illicit drug use, over consumption of alcohol, tobacco use, certain medications (birth control, decongestants, OTC pain relievers, etc.), adrenal gland tumors, kidney problems, and/or race (MayoClinic.com, n.d.).

The World Health Organization (WHO) reports that the prevalence of people with hypertension worldwide is approximately 1 billion, with 7.1 million deaths per year attributable to hypertension (World Health Report 2002). Data from the National Health and Nutrition Examination Survey (NHANES) have indicated more than 50 million Americans have high BP

in need of some form of treatment (Macon et al. 2004). In 2006, hypertension contributed to over 326,000 U.S. deaths (Lloyd-Jones et al. 2010). As of 2010, about 1 in 3 U.S adults has high blood pressure. The Table below depicts the trends in awareness, treatment, and control of high blood pressure from 1976-2000.

Table 1. Trends in awareness, treatment, and control of high blood pressure, 1976-2000*

National Health and Nutrition Examination Survey (NHANES), Percent				
	1976-80[1]	1988-91[1]	1991-94[2]	1999-2003[3]
Awareness	51	73	68	70
Treatment	31	55	54	59
Control[t]	10	29	27	34

** Percentage of adults ages 18 to 74 years with SBP of 140 mmHg or greater, DBP of 90 mmHg or greater, or taking antihypertensive medication.*
† SBP below 140 mmHg and DBP below 90 mmHg, and on antihypertensive medication.
Sources: 1 Data from Burt VL, et al. Prevalence of hypertension in the US adult population. Results from the Third National Health and Nutrition Examination Survey, 1988–1991. Hypertension *1995;26:60–9.*
2 Data from The Sixth Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. Arch Intern Med *1997;157:2413–46.*
3 The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. JAMA *2003;289:2560–71.*

Awareness of hypertension is an essential factor in treating and controlling it. Between 1960 and 1991, median SBP for individuals aged 60-74 have declined by approximately 16 mmHg due to an increase of awareness, treatment, and control (Macon et al. 2004).

For individuals with a normal blood pressure at the age of 55 years, the risk of developing hypertension within their lifetime is approximately 90% (Vasan et al. 2001). Elevated blood pressure is associated with heart disease and stroke. Data from an observational study involving over 1 million individuals have indicated mortality from coronary heart disease (CHD) and stroke gradually increases linearly from levels as low as 115 mmHg SBP and 75

mmHg DBP upward (Lewington et al. 2002). Additionally, the Framingham Heart Study indicated BP values between 130-139/85-89 mmHg are associated with over a twofold increase in relative risk from heart disease when compared to those with normal BP (Vasan et al. 2001). Reducing blood pressure via proper exercise and diet can drastically reduce the risk of death from CHD or stroke. Decreasing diastolic blood pressure by 5 mmHg is associated with a 34% and 21% decrease in risk of CHD and stroke, respectively (MacMahon et al. 1990).

When stratified by race and gender, African American females have the highest percentage (44.1%) of hypertension; contrary to white women were only 28.3% having hypertension (Health, United States, 2008). However it should be noted that the gaps amongst race and gender are narrowing. High levels of sodium in daily American diet in conjunction with physical inactivity places everyone at risk for hypertension. Over 122 million Americans are considered overweight or obese (Flegal et al. 2002). Mean sodium intake for men and women are 4100 mg/day and 2750 mg/day, respectively (Cleveland et al. 1996). Similar to lifestyle, body mass index (BMI) is also predictor for hypertension. Table 2 describes this relationship. As BMI increase, risk of hypertension is greatly increased, as well as heart disease and stroke.

Table 2. Relative 10 year risk for hypertension, heart disease, and stroke over the next decade amongst men initially free of disease stratified by baseline BMI

BMI	Hypertension	Heart Disease	Stroke
18.5-21.9	1.0	1.0	1.0
22.0-24.9	1.5	1.1	1.1
25.0-29.9	2.4	1.7	1.3
30.0-34.9	3.8	2.2	2.1
>35.0	4.2	2.4	2.5

BMI, body mass index; Source: Field AE, et al. Impact of overweight on the risk of developing common chronic diseases during a 10-year period. Arch Intern Med *2001;161:1581–6.*

2c. Physical Activity (PA)

Physical activity is any type of body movement requiring energy and includes aerobic and muscle strengthening activity (CDC, 2010). The CDC's 2008 Physical Activity Guidelines for Americans recommends adults (ages 18-64) should engage in both aerobic activity and muscle-strengthening activity. Aerobic activity includes any form of endurance or fitness which increases heart rate and increases oxygen intake by an individual. Muscle strengthening physical activity is any activity that places resistance against muscles, therefore increasing muscle mass. Physical activity can be performed at two different intensities: moderate or vigorous. Moderate aerobic physical activity tends to be less strenuous and includes activities such as walking, golf, gardening, or dancing. Vigorous aerobic physical activity tends to be more strenuous and includes soccer, basketball, or intense cycling. However a dilemma lays in the definitions. Dancing, for example, is categorized as moderate physical activity, but can often be vigorous. A quick and easy test, known as the talk-test, is a simple way to measure intensity. According to the talk-test, if you can talk, but not sing during your activity, you are engaged in moderate intensity physical activity. Moreover, if you are unable sing or speak a few words, then you are engaged in vigorous intensity physical activity.

The CDC's physical activity recommendations for adults include 150-300 minutes/week of moderate-intensity aerobic activity, or 75 minutes/week of vigorous-intensity, in conjunction with 2 days/week of muscle strengthening activities (working major muscle groups: legs, hips, back, abdomen, chest, shoulders, and arms)(CDC, 2010). For children and adolescents, 60+ minutes/day of moderate to vigorous-intensity aerobic activity, and 3+ days of muscle and bone strengthening activities. Meeting the CDC's recommended physical activity requirements can

prevent several health outcomes, included diabetes, cardiovascular disease, cancer, and other obesity related complications (Kaczynski et al. 2008).

In a systematic review in 2008, an estimated 25% of the US population actually engages in the recommended amount of physical activity (Kaczynski et al. 2008). State Indicator Reports from the CDC for 2010 show a different picture. Amongst adults, 64.5% of American adults are physically active (CDC 2010). Tennessee had the lowest percentage of physically activity individuals with 51.8%, and Vermont leads the nation with 73.3% (CDC 2010). The CDC's value depicts a giant discrepancy from Kaczynski's review. The difficulty in measuring physical activity levels in the US lies within reporting. Activity cannot be measure by healthcare professionals, therefore self reporting physical activity levels is the most feasible way to determine if individuals are meeting the CDC's physical activity recommendations. However, those who are physically active tend to have reduced risk of cardiovascular disease, reduced risk for type 2 diabetes and metabolic syndrome, reduced risk of some cancers, strengthened bones and muscles, improved mental health, improved ability to do daily activities, better weight control, and increased life expectancy (CDC, 2010).

2d. Smoking and Hypertension

Smoking cigarettes constricts blood vessels giving blood a narrow pathway to flow, which gives insight for why smokers generally have higher rates of hypertension (Omvik, 1996). This is due to the fact that nicotine acts as a stimulant, which increasing heart rate and exerts greater pressure on the arterial walls. Smoking also diminishes oxygen supply to the body,

which leads to an increase heart rate to compensate for the lack of oxygen reaching major organs and muscles. Literature suggests male and female smokers have higher rates of systolic and diastolic blood pressure (Al-Safi 2007). Several studies have reported smoking as a risk factor for hypertension amongst several other health factors. In a 14 year longitudinal study by Dochi (2009) and colleagues, hypertension was studied amongst smokers via systolic and diastolic blood pressure readings. Smokers were identified via self reported questionnaires. The cohort consisted of 8251 male Japanese workers at a steel company. After adjusting for age, body mass index, drinking, habitual exercise, job schedule type, hemoglobin A1c, total cholesterol, creatinine, aspartic aminotransferase, gamma-glutamyl transpeptidase, and uric acid, a logistic regression analysis found a significant association between smoking and hypertension (OR = 1.13, 95%CI = 1.03, 1.23). The study revealed that smoking is independently related to the onset of hypertension (Dochi et al. 2009). Smoking is also known to increase arterial stiffness, in addition to blood pressure, amongst hypertensive males (Rhee et al. 2007). Similarly, Halperin (2008) and colleagues performed a study on middle aged and older men examining smoking and the incidence of hypertension. A cohort of 13529 males were divided into three smoking categories: non-smokers, former smokers, and current smokers. Hypertension was measure via systolic and diastolic blood pressure. A Cox proportional hazards model found relative risks of developing hypertension 1.08 and 1.15 for former and current smokers (compared to non-smokers). The authors concluded smoking is a modest but significant risk factor for developing hypertension (Halperin et al. 2008).

The relationship between smoking and hypertension is affiliated with body mass index (BMI). Increased BMI is significantly associated with an increased risk of developing hypertension (Zhao et al. 2009). In a 10 year prospective cohort study between 1992 and 2002,

subjects with normal BMI's had an accumulative incidence rate of hypertension of 22.0%; subjects indentified as obese had a rate of 56.3% (Zhao et al. 2009). Similarly to hypertension, smoking is inversely related to BMI; as smoking increases, BMI decreases (Chatkin et al. 2010). However, this relationship is reversed in those with obese BMI's. Obese smokers do not experience the same weight loss effect as their normal or overweight counterparts (Chatkin et al. 2010). This is possibly due to the sedentary lifestyle lived amongst obese individuals. The perception of smoking promotes weight loss is widely popular, especially amongst young adults (Bean 2008). This perception lures in new smokers on a regular basis, even though smoking is clearly accompanied with numerous health consequences.

It should be noted, the primary method to reduce the harm brought upon from smoking is cessation. Over 60% of smokers quit smoking to improve their general health, while 70% quit for at least one health reason (Shafey et al. 2008). Smoking cessation reduces the risks of heart disease, stroke, and some cancers. Given these benefits, it should be noted that the literature on smoking cessation and hypertension is less promising. A study on the effects of smoking cessation and changes in blood pressure and incidence of hypertension concluded that individuals who quit smoking developed elevated blood pressures, increasing the risk of hypertension. The adjusted relative risks of hypertension amongst those who had quit smoking for ≥ 3 years was 3.5 (95% CI 1.7 to 7.4), relative to current smokers (Lee et al. 2001). Although smoking is known to elevate blood pressure, this study implies that smoking cessation may result in an additional increase in blood pressure, hypertension, or both. Similarly, another study observing changes in blood pressure following smoking cessation in women concluded that incidence of hypertension was enhanced with cessation. Systolic and diastolic blood pressures were measured at baseline and re-assessed during a nine year follow up. The odds ratios for

quitters and current smokers were 1.8 (1.4 – 2.5) and 1.3 (1.07-1.6), respectively (Janzozn et al. 2004). The mechanism resulting in elevated blood pressure amongst quitters is unknown and requires further study (Lee et al. 2001). Abstaining from smoking in the first place is the paramount mode of harm reduction.

2e. Physical Activity and Hypertension

Several studies provide indisputable evidence that increasing physical activity levels meeting the proper duration and intensity lowers blood pressure significantly (Chase et al. 2009). Physical activity decreases stress levels, improves psychological well-being, and helps maintain a proper weight, all in which decrease blood pressure (Johnson et al. 1996).

Epidemiological studies find a clear connection between physical activity and hypertension. A 12 year cohort study observing physical activity and hypertension amongst adult males and females by Blair et al. concluded that "persons with low levels of physical activity had a relative risk of 1.52 for the development of hypertension when compared with highly fit persons" (Blair et al. 1984), although their study did not control for smoking. Similarly, in young adults (18-26 yrs) the odds of overweight and obese individuals reporting a diagnosis for high blood pressure are 1.5 to two times higher than normal-weight individuals while controlling for gender, age, race, use of healthcare, tobacco use, physical activity/inactivity, and BMI (Ford et al. 2008). Cross-sectional and large-scale longitudinal population studies reported that the relative risk for developing hypertension in sedentary men and women with normal BP at rest is approximately 35% to 70% higher when compared to their physically active peers (Kokkinos et al. 2009). In a study solely observing middle-aged women,

those who were classified as having moderate and high-fitness, based on their peak exercise time during a treadmill test, had significantly lower diastolic BP (5 and 7 mmHg, respectively) when compared to women of low fitness level (Kokkinos et al. 1995).

Interventional studies concur with epidemiological findings. In a review examining physical activity interventions for hypertensive individuals, the average exercise-related intervention reduced systolic blood pressure by 10.5 mmHg and diastolic blood pressure by 7.6 mmHg. The control group experienced a 3.8 mmHg and 1.3 mmHg reduction for systolic and diastolic blood pressure, respectively (Kokkinos et al. 2001). Similarly, in a separate review, SBP and DPB were reduced by 6.9 mmHg and 4.9 mmHg in the active intervention group (Cornelissen et al. 2005).

Physicians prescribing physical activity is crucial in increasing physical activity amongst individuals. In a study by Halm et al. 2008, prescribing physical activity via physician advice was studied. Doctors prescribed physically activity roughly 30% of the time to patients, a further 71% of patients adhere to their doctor's advice, resulting in increased physical activity and decreased systolic blood pressure by 3-4 mmHg (Halm et al. 2008). For those with fatal levels of hypertension, physical activity and prescription medication are critically imperative. Physical activity attenuates BMI, which in turn can reduce the risk of hypertension (Rankinen et al. 2007). Kokkinos et al. reported after a 16-week moderate-intensity exercise training program accompanied with prescription meds, resting systolic BP was lowered by 7 mmHg and diastolic by 5 mmHg (Kokkinos et al. 2009).

2f. Smoking and Physical Activity

In 2008, the USA had over 32 million male smokers, and over 23 million female smokers (Shafey et al. 2008). Although smoking trends have been declining since the mid 1960's, the prevalence of smoking is still maliciously impacting millions of Americans lives. According to the Tobacco Atlas 3rd Edition, tobacco is projected to kill 6 million people in the year 2010. It is well understood that nonsmokers live an average of 15 years longer than smokers (Shafey et al. 2008). It should also be noted that smokers tend to be less physically active (Kaczynski et al. 2008). A study by deRuiter et al. examined the prevalence of physically active smokers in Canada via surveys from the Canadian Community Health Survey (CCHS). Their study found a prevalence of 5441 physically active smokers and 17218 physically inactive smokers, translating to 22.6% of smokers being physically active (deRuiter et al. 2008). In another study by Nguyen et al. observing exercise patterns amongst 30-60 year old male smokers (N=671), approximately 54% of smokers exercised less than once a week. A further 16.7% actually engaged in exercise at least twice a week (Nguyen et al. 1996). This study is in unison with implications suggesting smokers are less physically active. Even amongst those who are physically active, chronic smokers have significantly reduced cardiovascular fitness. Smoking reduces the capacity of the circulatory system, which diminishes exercise duration, increases blood pressure, and elevates heart rate (Papathanasiou et al. 2007). In a treadmill fitness test measuring oxygen uptake and heart rate, researchers found that smoking significantly reduced the fitness capability in healthy males regardless of age (Bernaard et al. 2003). In a systematic review by Kaczynski et al., 61% of studies performed on adult populations indicated a negative association between smoking and physical activity. Some potential reasons for this relationship include: smokers engage in risky behavior versus physical activity, less capable of being physically active due to decrease lung

performance, higher rates of depression, suppressed desire to engage in physical activity (Kaczynski et al. 2008). Contrary to these studies, de Bourdeaudhuij and van Oost found no association between smoking and physical activity in adults. In their study of 2390 Belgians aged 16-65 years, the bivariate correlation between leisure time physical activity (LTPA) and smoking was 0.02 in 16-65years (de Bourdeaudhuij et al. 1999).

Studies have consistently proven that smokers tend to weigh less than their non-smoking counterparts. A study amongst Thai adults found that smokers had significantly lower BMI's than non-smokers (22.6 kg/m2 vs. 24.8 kg/m2). However smoking should not be used for weight management, the negative health outcomes of smoking clearly outweigh potential negative health outcomes of being overweight (Jitnarin et al. 2008). Several studies also examine the ability of physical activity to reduce harm amongst smokers. It is well understood the best harm reduction method for smokers is cessation or abstinence. However, amongst those who cannot abstain from smoking, various forms of harm reduction are beneficial. Heavy smokers and/or those who are heavily dependent on nicotine are often unable to quit smoking, and often suffer the consequences of smoking (Trofor et al. 2008). This study may provide implications physical activity is a potential harm reduction agent amongst smokers who chose to continue to smoke.

CHAPTER III

METHODOLOGY

3a. Data Sources

Data for this study was obtained from the National Health and Nutrition Examination Survey (NHANES) for the years 2007-2008. NHANES is a national survey which is unique in the sense that it combines interviews with physical examinations. Since the 1960's, this survey includes about 5,000 persons each year from across the country. It is designed to assess the health and nutritional status of adults and children in the United States available to the public through the CDC (CDC, 2009). Findings from the surveys will assist professionals in research to improve public welfare. NHANES surveys encompass all variables of interest in this study relating to smoking, age, race, gender, and physical activity. For the present study, data from demographics, questionnaire, and examination files were used for the NHANES years 2007-2008.

3b. Study Population

Eligibility criteria: adults aged 20y+ who participated in NHANES 2007-2008.

3c. Study Measures

The study measures that were considered in the study were obtained from the demographic file. These included age, race, education, family income and poverty income ratio. Any participant who did not have complete information on the demographic characters was eliminated from the study.

a. Age

Age was reported at the time of screening. Three different age categories were developed: 20-39y, 40-59y, and 60y+. The categories were designed to depict young adults, adults, and older adults.

b. Race

Race was categorized in to the following groups: Non-Hispanic Whites, Hispanics, Non-Hispanic Blacks and other multiracial. Statistical results for the other multiracial are not discussed as there is a wide variation within this group and it cannot be meaningfully interpreted.

c. Sex

Participants were classified as males or females based on self reported data.

d. Body Mass Index (BMI)

BMI was calculated: [weight (kg)] / [height (m^2)]. BMI was categorized into three groups: normal (BMI $\leq$ 24.9), overweight (25.0 $\leq$ BMI $\leq$ 29.9), and obese (BMI $\geq$ 30.0).

e. Poverty Income Ratio (PIR)

For this study, PIR was used as a measure of socio-economic status. PIR represents the ratio of an individual's income to the poverty threshold. A ratio below 1.00 indicates means income is below poverty. A ratio of 1.00 or greater indicates income above the poverty level. For example, if individuals PIR is 1.95, that indicates their income is 195% above the poverty level. PIR was calculated via family income and family size. In this study, participant PIR was divided into three categories: <1.00 (low income), 1.00-1.85 (middle income), and >1.86 (high income); this was based on the standards recommended by the US Census Bureau (CDC, 2002).

f. Smoking (Smoke)

The smoking variable was dichotomized into "smokers" and "nonsmokers". Smokers were considered those who answered yes to both of the following NHANES questions: "Smoked at least 100 cigarettes in entire life?" and "Do you now smoke cigarettes?" (Pechacek, 2010). Respondents who responded "no" to either or both questions were considered nonsmokers.

g. Hypertension (HTN)

Participants were categorized as either being "hypertensive" or "nonhypertensive". To be considered hypertensive, individuals had to meet the following criteria: systolic blood pressure (sbp) ≥ 140 mmHg or a diastolic blood pressure (dbp) ≥ 90 mmHg, and answered "yes" to "Taking prescription for hypertension". If individuals did not meet all the criteria, they were considered "nonhypertensive".

h. Physical Activity (PA)

The physical activity component was split into two groups: physically active vs. physically inactive. To qualify for the physically active group, individuals must have answered "yes" to either of the following questions in the NHANES questionnaire: "Do any vigorous-intensity sports, fitness, or recreational activities that cause large increases in breathing or heart rate like running or basketball for at least 10 minutes continuously?" or "Do any moderate-intensity sports, fitness, or recreational activities that cause a small increase in breathing or heart rate such as brisk walking, bicycling, swimming, or golf for at least 10 minutes continuously?". Those who answered "no" to both of those questions were considered physically inactive.

i. Interaction PA

This interaction term was introduced to provide a better description between our dependent variable and covariates. We calculated our interaction term by multiplying two covariates: Smoke x Physical Activity.

3d. Data Analysis

The Statistical Package for the Social Sciences (SPSS) R version 17.0 was used for the data analysis portion of this study. Individuals who refused to answer any questions on the dataset were considered missing. To depict the study population, frequency tables were produced to determine the representation of all variables such as age, ethnicity, sex, BMI, PIR, smoking, physical activity, and hypertension. Next, numerous binary regressions were run, odds ratios and confidence intervals were included to determine statistical significance. Table 3 depicts a binary logistic regression ran between Hypertension (Dependent Variable) and Smoking (Covariate). This represents the crude association between hypertension and smoking. Table 4 introduced physical activity to see if it is a confounder on the association. For Table 5 we wanted to adjust for other factors that may be potential confounders in addition to smoking and physical activity, such as age, race, sex, and PIR. Table 5 excluded BMI because it was a potential intermediary variable between smoking and hypertension and we therefore conducted a separate regression for sensitivity analysis comparing adjusted models without BMI and with BMI (Table 6). Table 7 ran the same regression where hypertension remained the dependent variable, and all other covariates were included: age, race, sex, PIR, BMI, and Interaction PA. In table 8 we ran a separate logistic regression asking whether physical activity modifies the association between smoking and hypertension by including an interaction term between physical activity and

smoking (smoking x physical activity) and applying the Wald test. OR's and 95 % CI were provided for all regressions to determine statistical significance.

CHAPTER IV

RESULTS

4a. Sample Demographics

When merging NHANES data, an initial 10,149 respondents were gathered. Participant demographics with respect to age, ethnicity, gender, BMI and PIR are depicted in Table 3. The three subgroups of ages (20-39y, 40-59y, and 60+y) were represented fairly evenly. Whites were represented the most in this study making up 40.5% of the study population. Hispanics made up a third of the study population, and blacks made up 21.8%. Males and females were fairly evenly represented. Slightly fewer than 50% of respondents were in the normal BMI range, while the remaining participants were split equally as either overweight or obese. 40% of the population had a high school diploma, some college, or college degree. Majority of the respondents were classified in the upper tertile of the PIR (>1.85). In regards to smoking status, a majority of participants were non-smokers (almost 90%). Slightly more than half the population was considered physically inactive. And a little less than 30% of the population was considered hypertensive.

Table 3. Demographic Profile of Participants from NHANES 2007-2008 Sample (n=10,149)

Variables	N	%
Age		
20-39	1910	32.2
40-59	1871	31.5
60+	2154	36.3
Race		
Non-Hispanic White	4115	40.5
Non-Hispanic Black	2211	21.8
Hispanic	3358	33.1
Other	465	4.6
Sex		
Male	5096	50.2
Female	5053	49.8
BMI		
Normal	4337	49.1
Overweight	2228	25.2
Obese	2261	25.6
PIR		
<1	2442	26.4
1-1.85	2238	24.2
>1.85	4575	49.5
Smoke		
No	9044	89.1
Yes	1105	10.9
PA		
No	3690	51.9
Yes	3415	48.1
HTN		
No	7243	71.4
Yes	2906	28.6

In table 4, the OR between Hypertension (dependent variable) and Smoking (covariate) was 1.48. The 95% confident interval indicates a significant relationship between the two

(95%CI = 1.29, 1.69). This crude value confirms that smokers significantly have greater odds of hypertension than non-smokers.

Table 4. Binary regression of Hypertension and Smoking Status; Adjusted Odds Ratios and 95% CI

	HTN OR (95% CI)
Covariates	
Smoke	
No	Reference
Yes	1.48 (1.29, 1.69)

In Table 5, where we adjusted for smoking and physical activity, the odds ratio slightly dropped to 1.42. The 95% CI indicates the relationship remained statistically significant (95% CI = 1.22, 1.65). The minimal decrease in odds ratio between Table 4 and Table 5 indicates that physical activity is not a confounder.

Table 5. Binary regression of Hypertension, adjusting for Smoking and Physical Activity; Adjusted Odds Ratios and 95% CI

	HTN OR (95% CI)
Covariates	
Smoke	
No	Reference
Yes	1.42 (1.22, 1.65)
PA	
No	Reference
Yes	0.95 (0.86, 1.05)

In table 6, we adjusted for smoking, physical activity, age race, sex, and poverty-to-income ratio (PIR). Hypertension and smoking kept their significant relationship with an OR of

1.37 (95% CI = 1.12, 1.67). This OR is a slight reduction compared to the previous two tables. Table 4 for did not include body mass index (BMI).

Table 6. Binary regression of Hypertension, adjusting for Smoking, Physical Activity, Age, Race, Sex, and Poverty-to-Income Ratio; Adjusted Odds Ratios and 95% CI

	HTN OR (95% CI)
Covariates	
Smoke	
No	Reference
Yes	1.37 (1.12, 1.67)
PA	
No	Reference
Yes	0.97 (0.84, 1.11)
Age	
20-39	Reference
40-59	1.15 (0.97, 1.36)
60+	0.96 (0.81, 1.14)
Race	
W	Reference
B	1.02 (0.85, 1.23)
H	1.08 (0.92, 1.28)
O	1.26 (0.89, 1.79)
Sex	
M	Reference
F	0.96 (0.83, 1.10)
PIR	
<1	Reference
1-1.85	1.02 (0.83, 1.25)
>1.85	0.92 (0.77, 1.10)

In table 7 we included BMI as a covariate and ran the same regression. The OR was barely reduced to 1.36, keeping a statistically significant relationship between smoking and hypertension after adjusting for all covariates (95% CI = 1.10, 1.68).

Table 7. Binary regression of Hypertension, adjusting for Smoking, Physical Activity, Age, Race, Sex, Poverty-to-Income Ratio, and Body Mass Index; Adjusted Odds Ratios and 95% CI

	HTN OR (95% CI)
Covariates	
Smoke	
No	Reference
Yes	1.36 (1.10, 1.68)
PA	
No	Reference
Yes	1.01 (0.87, 1.16)
Age	
20-39	Reference
40-59	1.16 (0.97, 1.39)
60+	0.96 (0.79, 1.14)
Race	
W	Reference
B	1.02 (0.85, 1.24)
H	1.10 (0.92, 1.31)
O	1.19 (0.82, 1.72)
Sex	
M	Reference
F	0.93 (0.81, 1.08)
PIR	
<1	Reference
1-1.85	0.99 (0.81, 1.24)
>1.85	0.94 (0.78, 1.13)
BMI	
Normal	Reference
Overweight	1.39 (1.17, 1.67)
Obese	1.71 (1.44, 2.03)

Table 6 included all covariates as well as the new covariate Interaction PA. The interaction term was (Smoke x Physical Activity). This resulted in a high OR of 1.74 with statistical significant (95% CI = 1.30, 2.34).

Table 8. Binary regression of Hypertension, adjusting for Smoking, Physical Activity, Age, Race, Sex, Poverty-to-Income Ratio (PIR), Body Mass Index (BMI), and our Interaction term (Interaction PA = smoke x PA); Adjusted Odds Ratios and 95% CI

	HTN OR (95% CI)
Covariates	
Smoke	
No	Reference
Yes	1.74 (1.30, 2.34)
PA	
No	Reference
Yes	1.07 (0.92, 1.25)
Age	
20-39	Reference
40-59	1.16 (0.97, 1.39)
60+	0.95 (0.79, 1.14)
Race	
W	Reference
B	1.02 (0.84, 1.23)
H	1.10 (0.92, 1.31)
O	1.17 (0.81, 1.70)
Sex	
M	Reference
F	0.93 (0.81, 1.08)
PIR	
<1	Reference
1-1.85	0.99 (0.80, 1.24)
>1.85	0.93 (0.77, 1.12)
BMI	
Normal	Reference
Overweight	1.39 (1.17, 1.67)
Obese	1.71 (1.44, 2.03)
Interaction PA	0.60 (0.40, 0.92)

In table 9, we ran a logistic regression asking whether physical activity modifies the association between smoking and hypertension by including an interaction term between physical activity and smoking and applying the Wald test. OR's and 95 % CI were again used to determine statistical significance. We present the adjusted OR for the association between smoking and hypertension stratified by physical activity. Physical activity significantly modifies the association between smoking and hypertension ($p = 0.018$). Amongst physically inactive individuals, the odd of hypertension amongst smokers is 1.74 times greater than non-smokers. Amongst physically active individuals, the odds of hypertension amongst smokers are 1.12 times greater than non-smokers, but this is no longer statistically significant.

Table 9. Adjusted Odds Ratios and 95% CI for the Association between Smoking and Hypertension, Including an Interaction Term (smoke x PA)

	PA			
	No		Yes	
Smoke	OR	95%CI	OR	95%CI
	1.74*	(1.29, 2.33)	1.12**	(0.47, 2.67)

*Hypertension (dependent variable) vs. Smoking, PA, age, ethnicity, sex, PIR, BMI, Interaction term (smoke x PA) (covariates)
** Exponentiation [(B for smoke) + (B for interaction PA) + (B for PA)]

Chapter V
DISCUSSION AND CONCLUSION

5a. Discussion

As previously mentioned, smoking, hypertension, and physical inactivity kills millions of people annually. Adversely, smoking, hypertension, and physical activity are very prevalent in the United States. The death and disease associated with them can be prevented. Abstaining from smoking is the essential step in reducing or eliminating harm. Avoiding tobacco and eating healthy, in conjunction with physical activity are crucial to a long and healthy life. Smoking's capacity to elevate blood pressure to hazardous levels is serious alarm to smokers. Cessation provides relief from many potential diseases and complications, however, according to Janzon et al. and Lee et al., does not offer relief from hypertension. For smokers who cannot or will not quit, a physical activity intervention may be necessary. Physical activity can significantly reduce blood pressure amongst smokers (and nonsmokers).

This study concurs with previous studies in regards to smoking and hypertension. Similar to the Dochi et al. study, we found that smokers have greater odds of hypertension than non-smokers. In the crude model, the regression indicates a statistically significant relationship between smoking and hypertension, prior to adjusting. Our OR was slightly higher than Halperin's et al., however both were statistically significant (Halperin et al. 2008). Smoking clearly impacts blood pressure, elevating it to hypertensive levels. Similar to table 4, table 5

indicated a relationship between smoking and hypertension after controlling for physical activity. Although the OR was faintly reduced after adjusting for physical activity, the relationship remained significant. In table 4, the OR continued to remain significant after controlling for physical activity, age, ethnicity, sex, and PIR. Table 5 was similar to table 4, except we included BMI as a covariate. There was minimal change in the OR between tables 5, 6, and 7; BMI did not appear to confound the relationship between smoking and hypertension. Also, BMI did not reduce the precision in our estimates and therefore unlikely to be an intermediary variable. Our interaction term is what provides our results with strength and validity. Neglecting to account for an interaction term will not provide an accurate estimation between our dependent variable and covariates.

Considering the current epidemic of smoking, the concept of harm reduction is crucial. Many smokers try new methods to reduce the harm caused by smoking, such as using snus or smokeless tobacco. However, other forms of tobacco are also very potent and carcinogenic. Most U.S. smokers claim they want to quit for health purposes, however the potent chemical nicotine keeps their addiction alive (Cook et al. 1997). Early intervention and smoking cessation provide solutions to harm reduction amongst smokers. However, the results of this study suggest physical activity significantly reduces the association between smoking and hypertension. Based on results, the advice we would give to smokers would be to take part in physical activity to reduce odds of developing hypertension. Quitting smoking should always be a priority even though this study did not find an association between smoking and hypertension among physically active people. This study provides evidence for harm reduction in terms of blood pressure. No other studies have examined the influence of physical activity in reducing blood pressure amongst smokers. Physical activity is currently used as an intervention to help reduce

the risk of several diseases cardiovascular disease, reduced risk for type 2 diabetes and metabolic syndrome, reduced risk of some cancers, strengthened bones and muscles, improved mental health, control weight, improved ability to do daily activities, and increase life expectancy (CDC, 2010). This study suggests that reducing blood pressure amongst smokers may be added to the list. Though we found a direct association between smoking and hypertension, this study did not discover an association between physical activity and hypertension. Previous literature suggests physical activity significantly decreases the risk of developing hypertension (Blair et al. 1984). These discrepancies may be due to the definition we used for physical activity (See limitations).

This study offers a promising potential for harm reduction amongst current smokers. Although smoking cessation may possibly be associated with weight gain, physical activity can help offset potentially fatal blood pressure. Similar to smoking, physical activity requires plentiful attention. Future communication efforts of the CDC's physical activity guidelines should broadcasted on a national level. There is a need for more effective campaigns to promote physical activity among the American public (Bennett et al. 2009). In addition to campaigns, physician advice can increase motivation to increase physical activity and quit smoking. Individuals who receive a verbal prescription to engage in more physical activity are more likely to increase activity levels (Balde et al. 2003). Future programs need to focus on increasing awareness of physical activity guidelines and benefits to meeting them.

Increasing physical activity amongst smokers and nonsmokers should be a primary objective regardless of hypertensive status. Although, those with elevated blood pressure should immediate begin a physically active lifestyle, in conjunction with other healthy behaviors. Awareness of the physical activity guidelines and its benefits has shown to increase adherence to the guidelines (Ferney et al. 2009). This implicates the need to disseminate the CDC's physical

activity guidelines to a widespread audience to increase adherence. Physical activity can be increase via several methods, joining sports teams, walking, biking, running, or swimming. Walking is the most common form of physical activity and can help individuals meet the recommended levels of physical activity (Booth et al. 1997). Traveling via walking, cycling, or running is a form of physical activity called active transportation. This concept of active transportation is the disengagement of motorized transportation, and the engagement of physical activity as a mode of transportation. By incorporating active transportation in their lifestyles, individuals can potentially reach the CDC's physical activity guidelines. Active transportation could provide smokers with a new form of intervention. As long as smokers can meet the minimum minutes of physical activity via active transportation, their risk of hypertension can significantly decrease.

Reducing the number of smokers is a tall task and will require abundant public health campaigns. Television, internet, and media already play a crucial role, however these efforts need to be exacerbated. Smoking prevention and cessation are not possible without help from the government and leading organizations. Nonprofit organizations such as the American Heart Association and American Cancer Society are active in the fight against tobacco. For example, the American Cancer Society holds an annual "Great American Smoke-Out" event which encourages current smokers to quit (America Cancer Society 2010). When the FDA received the authority over tobacco earlier in 2009, there was no doubt that things would change for big tobacco. Already, the FDA has regulated flavored tobacco and is currently pushing for a regulation of ingredient in tobacco products (U.S. FDA 2009). An ingredient label would let users know what exactly they are putting into their body and potentially discourage current tobacco users to quit.

The objective of this study was to find the impact of physical activity on the association between smoking and hypertension using the NHANES 2007-2008 data. NHANES is a nationally represented dataset which provided measurements of all variables of interest. NHANES was the best tool given this study focused on the adult population. The percentages of smokers and hypertensive individuals in this study were consistent with the national representation. Having a large sample size and all variables of interest clearly defined add to the strengths of this study. Lifestyle decisions influence ones health on a daily bases. By being physically active and not smoking are great ways to reduce ones risk for hypertension. Unfortunately smoking, physical inactivity, and hypertension are all largely prevalent in the U.S. Further research needs to be done to reduce the prevalence of all unhealthy risk factors.

5b. Study Limitations

Our data has a few discrepancies between national data. The representative data suggests that about 11% of individuals smoke, where as the national hovers around 20%. Similarly, there is a difference in physical activity prevalence. We found roughly 48% of the study population is physically active, while the national average is approximately 25%. Despite our large sample size, they did not thoroughly represent the nation. We excluded adults under the age of 20 year, which may have affected the data.

Although NHANES is a resourceful source of data, error in the physical activity portion could have hindered the output. Ideally, using minutes and days of physical activity would be used for the physical activity variable, however data from NHANES 2007-2008 displayed errors in data collection. For example, some individuals reported over 400 minutes of vigorous

physical activity per day, while others reported over 7 days of physical activity per week. Another limitation, which relates to physical activity, is the chance of self-report bias. There is no way to ensure full truth from respondents. This may lead to incorrect data or missing data. Several respondents were missing in various categories (age, race, gender, etc.).

5c. Recommendations

Future research could split data up by age, race, gender, and/or other variables. It is important to examine if physical activity impacts smoking and hypertension for different ages, races, SES, and genders. For example, future research could study the impact of physical activity on the association of smoking and hypertension in African American young adults. This study depicts a broad picture of physical activities impacts and should encourage further studies. Future studies could also examine the impact of physical activity on hypertension amongst various categories of smokers, such as: current smokers, former smokers, light smokers, etc.. Stratifying our categories would provide more detailed results.

Our definition of physical activity could have been better for this study. Due to error in self-reported data in NHANES 2007-2008, our definition of physical activity does not match the CDC's recommendations for individuals meeting the physical activity guidelines. Had we have used the CDC's definition of physical activity for NHANES 2007-2008, the prevalence of physically active individuals would have provided incorrect data. Using different dataset or different definitions for variables of interest will also be beneficial and add to current literature.

5d. Conclusion

This study is important because it depicts physical activity, smoking, and hypertension as real health issues in America. Large percentages of individuals are either physically inactive, smokers, or hypertensive. Hypertension already affects a high proportion of Americans, any form of intervention to reduce these rates should be endorsed. Reducing the burden of hypertension amongst smokers is crucial to harm reduction and improving public welfare. Being physically active comes with many benefits, ranging from mental well-being to physical well-being. By incorporating physical activity into their routine, smokers can significantly reduce their odds of developing hypertension.

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