8-7-2012

# Body Mass Index as a Parameter to Evaluate the Prevalence of Hypertension in NH White, NH Black, and Hispanic Americans

Shaun Newsome
*Georgia State University*

*Institute of Public Health*

*Public Health Theses*

*Georgia State University* *Year 2012*

# Body Mass Index as a Parameter to Evaluate the Prevalence of Hypertension In NH White, NH Black, and Hispanic Americans

Shaun J. Newsome

Snewsome3@student.gsu.edu

# BODY MASS INDEX AS A PARAMETER TO EVALUATE THE PREVALENCE OF HYPERTENSION IN NH WHITE, NH BLACK, AND HISPANIC AMERICANS

by

SHAUN J. NEWSOME

B.S., MOREHOUSE COLLEGE

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

30303

BODY MASS INDEX AS A PARAMETER
TO EVALUATE THE PREVALENCE OF HYPERTENSION
IN WHITE, BLACK, AND HISPANIC AMERICANS

by

SHAUN J. NEWSOME

Approved:

____________________________________

Committee Chair

____________________________________

Committee Member

________________________

Date

# ABSTRACT

SHAUN J. NEWSOME

Body Mass Index as a Parameter to Evaluate the Prevalence of Hypertension in White, Black, and Hispanic Americans

Over the past 30 years, obesity has been primarily identified by the body mass index (BMI). Due to its ease of calculation, the BMI has become the most widely used diagnostic tool to identify weight problems. This study examined the association between hypertension and BMI in White, Black, and Hispanics in the United States. The study's hypothesis was that this relationship was weaker in Blacks than in the other groups. Data for the study came from the 2007-2008 and 2009-2010 National Health and Nutrition Examination Surveys. The association was weaker in Black men than in Whites or Hispanics on a univariate basis, and at most BMI levels on a multivariate basis. For females, it was also weaker in Blacks at most BMI levels on a univariate basis. However, multivariate logistic regression analysis did not indicate that the hypothesis held for Black women when adding covariates to the models.

INDEX WORDS: hypertension, obesity, body mass index, adiposity, bioelectrical impedance analysis, duel-energy X-ray absorptiometry, total body water, total body bone mineral mass, $^{40}$K counting, visceral body fat, anthropometric

AUTHOR'S STATEMENT PAGE

In presenting this thesis as a partial fulfillment of the requirements for an advanced degree from Georgia State University, I agree that the Library of the University shall make it available for inspection and circulation in accordance with its regulations governing materials of this type. I agree that permission to quote from, to copy from, or to publish this thesis may be granted by the author or, in his/her absence, by the professor under whose direction it was written, or in his/her absence, by the Associate Dean, College of Health and Human Sciences. Such quoting, copying, or publishing must be solely for scholarly purposes and will not involve potential financial gain. It is understood that any copying from publication of this dissertation which involves potential financial gain will not be allowed without written permission of the author.

______________________________

Name of Author

NOTICE TO BORROWERS

All theses deposited in the Georgia State University Library must be used in accordance with stipulations prescribed by the author in the preceding statement.

The author of this thesis is:

Student's Name: ______________________________

Street Address: ______________________________

City, State, and Zip Code: ______________________

The Chair of the committee for this thesis is:

Professor's Name: ______________________________

Department: ____________________________________

College: _______________________________________

Georgia State University
P.O. Box 4018
Atlanta, GA 30302-4018

Users of this thesis who are not regularly enrolled as students at Georgia State University are required to attest acceptance of the preceding stipulation by signing below. Libraries borrowing this thesis for the use of their patrons are required to see that each user records here the information requested.

| **Name of User** | **Address** | **Date** | **Type of Use** (Examination only Or copying) |
|---|---|---|---|
| | | | |
| | | | |

VITA

SHAUN J. NEWSOME
4809 Forestglade Circle
Stone Mountain, GA 30087-1309
404/386-1728; Snewsome3@student.gsu.edu

EDUCATION

BS Degree 2005
*Morehouse College, Atlanta, GA*
Major: Psychology Minor: Biology

RESEARCH EXPERIENCE

Graduate Student Researcher, Atlanta, GA 2010-Present
*GSU Institute of Public Health*

Communications Assistant, Atlanta, GA 2009-2010
*Morehouse School of Medicine*

Graduate Student Assistant, Atlanta, GA 2008-2010
*GSU Institute of Public Health*
*The Dirty Truth Campaign*

Project Coordinator, Atlanta, GA 2007-2008
*GSU Institute of Public Health*
*Everyone Deserves to Work Grant Project*

PROFESSIONAL EXPERIENCE

Research Associate, Atlanta, GA 2006-2007
*Morehouse School of Medicine*
*Physiology Department*

EXTRACURRICULAR ACTIVITIES

- Public Health Institute Student Association
- Boy Scouts of America
- Project Open Hand

TABLE OF CONTENTS

LIST OF TABLES

# CHAPTER I

# INTRODUCTION

The Centers for Disease Control and Prevention (CDC) defines blood pressure as the force blood applies to the arterial walls as it circulates throughout the body. It is measured while the heart beats, called systolic pressure, and while it rests, called diastolic pressure. Measurements are read as systolic pressure over diastolic pressure (SBP/DBP).[1] Hypertension, or *high* blood pressure, is a cardiac medical condition in which the systemic arterial blood pressure is elevated. It is defined as a systolic blood pressure $\geq$ 140 mg Hg and/or a diastolic blood pressure $\geq$ 90 mg Hg.[2]

According to the latest statistics from the CDC, about one out of three U.S. adults—31.3 percent—has hypertension. Hypertension is a major risk factor for heart disease, stroke, congestive heart failure, and kidney disease.[1] In 2006 hypertension was listed as a primary or contributing cause of death for 326,000 Americans. Hypertension is estimated to have cost the United States $76.6 billion in health care services, medications, and missed days of work in 2010.[3]

Obesity, on the other hand, is a medical condition in which excess adipose accumulates to the extent it is associated with an adverse effect on health, leading to reduced life expectancy and/or increased health problems, including hypertension.[4] Obesity has become a leading preventable cause of death worldwide, with increasing prevalence in adults and children, and authorities view it as one of the most serious public health problems of the 21st century.[5] One study published in 2010 estimates that 68 percent of the U.S. population greater than twenty years old is overweight or obese. When examined by gender and race/ethnicity separately, an estimated 72.6 percent of white men, 68.5 percent of African American men, and 79.3 percent of Hispanic men are overweight or obese. The corresponding estimates for women are 61.2 percent of white women, 78.2 percent of African American women, and 76.1 percent of Hispanic women[6].

Over the past 30 years, obesity has been primarily identified by using a body mass index (BMI).[7] Although the BMI does not actually measure the percentage of body adiposity directly, it is used to estimate a healthy body weight based on a person's height. Specifically, BMI is defined as an individual's body weight (in kg) divided by the square of his or her height (in $m^{2)}$.[8] BMI accounts for body mass and stature, and is a better predictor of body fat than measurements of mass or stature alone.[7] According to guidelines adopted by the World Health Organization (WHO) in 1997, $18.5 \leq BMI < 25.0$ is classified as normal, $25.0 \leq BMI < 30.0$ is overweight, and $BMI \geq 30.0$ is obese.[9]

Due to its ease of measurement and calculation, the BMI has become the most widely used diagnostic tool to identify weight problems within a population.[7] However, according to researchers, there are problems with using it; it does not take into account different body types, ignoring the difference between fat and fat-free mass like bone and muscle.[10] The BMI scale was created years ago and is based on Caucasians.[11] It assumes that the relationship between BMI and body fat is the same for all race/ethnic groups. It does not take into account differences in body composition between genders, race/ethnicity, and across the life span.[12] For example, one study concludes that BMI overstates the adiposity of African-Americans relative to whites because, on average, African-Americans have more non-fat mass.[11] Other studies have found that Asians have smaller frames than Caucasians, and therefore have higher levels of body fat at similar BMIs.[13] Therefore, the BMI may not be a reliable indicator of body fat for people who have body compositions that differ from Caucasians or who have lots of lean muscle.

The association between hypertension and obesity was first recognized through research undertaken in the Framingham Heart Study.[14] This landmark longitudinal research project, which has been ongoing since 1948, is a joint venture of the National Heart, Lung, and Blood Institute and Boston University. Over the years, one of the study's principle findings was the identification of the major risk factors for cardiovascular disease (CVD)—hypertension, high blood cholesterol, smoking, obesity, diabetes, and physical activity.[14] The link between hypertension and obesity has also been documented in large, cross-sectional studies sponsored by the National Institutes of Health (NIH), which additionally showed that African Americans had a higher risk of hypertension and its complications than other racial/ethnic groups in America.[15, 16, 17]

Since BMI is a predictor for obesity, and obesity is a risk factor for hypertension, BMI and hypertension are related. However, there are very few studies that test the diagnostic strength of this relationship. In fact, in reviewing the literature I could find no nationwide study that did this using a large, diverse adult population representing men and women of different age strata. Therefore, the aim of this study is to examine the relationship between BMI and hypertension in a large, representative multi-racial/ethnic sample of adults in the United States. It is the author's hypothesis that this association will be weaker in African Americans than in other racial/ethnic groups due to BMI's inability to discriminate between fat and lean mass.

# CHAPTER II

# REVIEW OF THE LITERATURE

The goal of this study was to investigate the racial and ethnic differences in the strength of the association between hypertension and BMI in African-American, Caucasian, and Hispanic adults in the United States. Specifically, the study's over-arching objective was to clarify whether or not obesity-related comorbid conditions such as hypertension occur at different levels of BMI in different racial and ethnic groups. To support this research, the author examined the historical background, development, and adoption of current guidelines on BMI. In addition, examinations of various studies comparing BMI and body adiposity across races/ethnicities are presented. Findings from research on differences in body composition by race/ethnicity and their impact on percentage body fat, and hence, BMI are presented as well. And finally, a review of two studies examining the association of BMI and hypertension by race/ethnicity is presented.

The formula for BMI, originally called the Quetelet index, was first developed in the 1800's.[18] The term "body mass index" became popular in 1972, after a paper published in the *Journal of Chronic Diseases* hypothesized that BMI was the best proxy for body fat percentage among ratios of weight and height. The paper's author explicitly cited that BMI was appropriate for population studies, and inappropriate for individual diagnosis.[19] Nevertheless, because of its simplicity, it has become widely used for individual diagnosis of a person's visceral adiposity.[7] World Health Organization (WHO) current cutoff points for BMI are as follows: $\text{BMI} < 18.5$ is classified as underweight, $18.5 \leq \text{BMI} < 25.0$ is normal, $25.0 \leq \text{BMI} < 30.0$ is overweight, $30.0 \leq \text{BMI} < 35.0$ is class I obesity, $35.0 \leq \text{BMI} < 40.0$ is class II obesity, and $\text{BMI} \geq 40.0$ is classified as class III obesity.[9]

The National Health and Nutrition Examination Survey (NHANES) of 1994 found that 59 percent of men and 49 percent of women had BMIs over 25.0. In that survey, morbid obesity—a BMI of 40 or more—was found in 2 percent of men and 4 percent of women.[15] The 2007-08 NHANES survey found a continuation of the increasing trend in BMI: 63 percent of Americans were overweight, with 26 percent classified as obese (a BMI or 30 or more).[6]

There are differences in the thresholds for BMI categories in some countries. In Japan, for example, BMI categories are as follows: $18.5 \leq \text{BMI} < 23.0$ is classified as normal, $23.0 \leq \text{BMI} < 25.0$ is overweight, and $\text{BMI} \geq 25.0$ is obese.[20] In Singapore, $18.5 \leq \text{BMI} < 23.0$ is normal, $23.0 \leq \text{BMI} < 27.5$ is overweight, and $\text{BMI} \geq 27.5$ is obese.[21] Between 1980 and the late 1990s in the U.S.A., national dietary guidelines defined overweight at a variety of levels ranging from 24.9 to 27.1. In 1985 an NIH conference recommended that overweight BMI be set at 27.8 for men and 27.3 for women.[4] The NIH brought U.S. definitions in line with WHO guidelines in 1998 and lowered the normal-overweight threshold from 27.8 to 25 and set the overweight-obese threshold at 30.[22, 23] Needless to say, these differences in guidelines by nationality make it difficult to conduct global studies on obesity.

Several studies have recognized the shortcomings of BMI to diagnose body adiposity accurately in all racial and ethnic groups. In one study, John Cawley et al. evaluated how obesity defined by BMI compared to body adiposity measured through Bioelectrical Impedance Analysis (BIA). Using BIA-measured adiposity, the researchers found that, on average, African American females had 3.56 kg more of fat-free mass (such as muscle, bone, and fluid) and 3.16 kg more of total body fat than white females, both of which were statistically significant ($p < 0.01$), for a total percent body fat of only 0.79 percentage points greater than that of white females, a difference that was not statistically significant. African American males had 1.33 kg more of fat-free mass on average and 2.33 kg less of total body fat compared to white males. As a result, their average percent body fat was 2.85 percentage points lower than that of white men, a statistically significant difference ($p < 0.01$). [24]

The Cawley research team found that when obesity was defined using BMI, the obesity rate among African American women was 11.46 percentage points higher than that among white women, a statistically significant difference ($p < 0.01$). However, when it was defined using BIA-measured percentage body fat, African American women's obesity rate fell to only 5.23 percentage points higher than that for white women. While that difference was still statistically significant, measuring obesity by BIA rather than BMI caused a 50 percent drop in the difference in obesity rates between black and white women. For men, the BMI-defined obesity rate among African Americans was 0.56 percentage points higher than that of white men, a difference that was not statistically significant. However, when BIA was used to measure obesity, white men had an obesity rate 16.26 points higher than African American men, which was statistically significant

($p < 0.01$).[24] John Cawley et al. demonstrated the benefits of measuring obesity by BIA rather than BMI by showing how BIA-measured obesity significantly impacts who is classified as obese.

Research undertaken using data from the *Black Pooling Project* found that obesity had a significantly stronger association with CHD, stroke, and CVD mortality among White individuals than among Black individuals. Specifically, the adjusted relative risk for CHD was 1.21 (95% confidence interval [CI] = 1.07, 1.36) for White participants versus 0.87 (95% CI = 0.69, 1.09) for Black subjects. For CVD, the adjusted relative risks were 1.18 (95% CI = 1.07, 1.29) and 0.91 (95% CI = 0.77, 1.05), respectively, for White and Black participants. The researchers also examined the risk of CVD associated with morbid obesity ($BMI \geq 35$), and found that among Black individuals, morbid obesity was not independently associated with CVD mortality (relative risk [RR] = 1.09; 95% CI = 0.89, 1.36). For Whites, however, the risk of CVD mortality increased further (RR = 1.51; 95% CI = 1.29, 1.76).[25]

In addition, research published in 2009 suggests that conventional methods of estimating body adiposity so inaccurately overestimate adiposity in African-Americans that they may need to become race-specific. In one study, Samuel Dagogo-Jack et al. investigated whether the relationship between BMI and body fat would differ by race by comparing how close BMI is to body fat when measured by dual-energy X-ray absorptiometry (DXA). The correlation between DXA-measured total fat and BMI was higher in Whites than in Blacks. The authors concluded that body adiposity is likely to be lower in Blacks than in Whites of the same weight and height, and suggested that muscle mass may be higher in Blacks. The authors also concluded that BMI is not a reliable indicator of body fat for people who have a large body frame or lots of lean muscle.[26]

Another study conducted by researchers at Baylor University corroborated this finding—that there are flaws in applying the same BMI guidelines to all people, regardless of their race/ethnicity. In this study, Andrew S. Jackson et al. also evaluated the capacity of BMI to estimate adiposity based on DXA in a racially/ethnically diverse sample of young men and women. Participants in this study were students aged 17-35 enrolled at the University of Houston. Based on their findings, the Baylor researchers showed that with age and BMI controlled, DXA-measured body fat percentage for African-American men and women, Asian-Indian men and women, Hispanic women, and Asian women differed significantly from non-Hispanic white men and women. For the same BMI of non-Hispanic white women, the body fat percentage of Black women was 1.76% lower, but 1.65% higher for Hispanic, 2.65% higher for Asian, and 5.98% higher for Asian-Indian women. For the same BMI as non-Hispanic white men, body fat percentage for Black men was 4.59% lower and 4.29% higher for Asian-Indian men. Using the customary BMI cut-off scores to define overweight and obesity systemically overestimated overweight and obesity prevalence in Black men and women and underestimated prevalence in Asian-Indian men and women, Asian women, and Hispanic women. The researchers concluded that even when the BMI formula indicates otherwise, African-American women may not be overweight or obese. As a result they recommended that Black women not be considered obese until they reach a BMI level of around 32.[27]

Furthermore, in a paper published in 2003, Jose Fernandez et al. expanded on earlier research comparing the association of BMI and percentage body fat when measured by DXA in Blacks and Whites to include Hispanic Americans. This study on a sample of roughly 1,500 individuals found that in women, there were significant differences in the relationship between Hispanics and Whites ($p < 0.002$) and between African-Americans and Hispanics ($p = 0.020$), but not between African-Americans and Whites ($p < 0.490$). In men, none of the racial/ethnic pairs exhibited significant differences in the BMI-DXA-measured body fat percentage relationship. When BMI was estimated on the basis of predicting equations, the trend in predicted percent body fat in women differed according to ethnic group and BMI category. At BMI < 30, Hispanics tended to have more body fat that did African-Americans and Whites, and at a BMI > 35, Whites tended to have more body fat than did other groups.[28]

Gallagher et al. also investigated whether Blacks and Whites had the same relative fatness regardless of age, sex, or race after adjusting for weight and stature. But in this study, total body fat percentage was assessed using a four-component model that required measurements of body volume, total body water, total body bone mineral mass, and body weight. In addition, no individuals with BMIs over 35.0 were included. These researchers found that when first controlling for age and gender, race did not significantly influence the relationship between BMI and body adiposity in Black and White adults.[29] This finding was contrary to those of other investigations reviewed in this thesis. One of the reasons could be that Gallagher et al. studied subjects with no BMI over 35. Another could be that Gallagher's group used a four-component model to measure body fat, whereas most of the other studies used dual-energy X-ray absorptiometry (DXA).

However, Gallagher and his colleagues' research did reveal one key finding: the ratio of tibia length-to-stature was significantly greater in Black men and women ($p = 0.020$ and $p = 0.001$ respectively) than in Whites of both genders.[29]

Differences in body composition by the race/ethnicity and their effect on percent body fat were also important in the literature review. Gallagher and his colleagues touched on these differences in their research as mentioned above. This author investigates them more thoroughly in this section. In addition, this section presents findings on fat-free body mass (water, mineral, and protein) and fat patterning in its comparative evaluations. In general, research findings revealed that Blacks have greater bone mineral density and body protein content than do whites, which results in greater fat-free body density. These findings were corroborated in cadaver analysis as well as through in vivo studies.[30, 31] In one study undertaken by Merz et al., radiographs of the femur were used to measure the bone mineral content of the skeletons of 203 Blacks and Whites of similar stature. The mean femur weight and skeletal weight of the Black men and women were greater than those of the white men and women, respectively. The circumference and amount of compact bone of the shaft of the femur were also greater in blacks than in whites. In addition, blacks had proportionally longer forearms and legs than the whites.[30]

In another study, Seale analyzed 100 dry, fat-free skeletons evenly divided into black and white men and women. Total skeletal weight was significantly greater in blacks than in whites (3,340 compared to 2,780 g; $p < 0.001$ after sexes were combined). Blacks also had significantly heavier upper and lower extremities than whites. And the percentage contribution of the upper limbs to total skeletal weight was greater in blacks than in whites (19.5 ±1.0% compared with 18.5 ± 1.2% in men, $p < 0.001$; 16.8 ± 0.7% compared to 16.2 ± 1.3% in women, $p < 0.001$).[31]

Trotter et al. extensively examined racial differences in bone as well. In research conducted in 1958, they reported that the densities of the humerus and femur were significantly greater in blacks than in whites, with the racial effect on bone density being more pronounced in the humerus ($p < 0.01$) than in the femur ($p < 0.05$).[32]

The findings from cadaver studies cited above were all confirmed through studies in vivo. In one study, Cohn et al. measured total body calcium and potassium contents of blacks and compared them to values for whites. After the data was normalized for body size and age, blacks had significantly higher mean calcium and potassium values than whites. Total body calcium was 21.9 ± 15.6% higher in black men ($p < 0.001$) and 16.7 ± 13.8% higher in black women ($p < 0.005$) than their white counterparts.[33]

In two other studies in vivo, Ortiz et al. and Cote and Adams used DXA to measure bone mineral content and bone mineral density between black and white women, and found racial differences in both.[34, 35] In 28 pairs of subjects matched for age, height, weight, and menstrual status, Ortiz et al. reported greater bone mineral content, bone mineral density, appendicular skeletal muscle mass (18.0 ± 3.0 compared to 15.7 ± 2,2 kg; $p < 0.001$), and total body potassium (2,703 ± 508 compared to 2,502 ± 403 mmol; $p < 0.05$) in blacks than in whites.[34] The Cote and Adams research team showed greater bone mineral density and bone mineral content as well, in addition to greater bone mineral content relative to the fat-free body (61.5 ± 3.3 compared to 58.1 ± 3.8 g/kg; $p < 0.001$) in black women than in white women.[35]

The research teams of Cohn et al., Ortiz et al., and Schutte et al. all have speculated about the reasons bone mineral content and bone mineral density are greater in blacks than whites. One theory is that blacks have genetically greater skeletal muscle mass than whites, and this greater mass causes added stress on the bone, thereby resulting in greater bone mineral contents and bone mineral densities.[33, 34, 36] Another research team of Hampton et al. suggested that blacks have a denser muscle mass and a greater total muscle weight than whites.[37]

In addition to the role that mineral plays relative to fat-free body density as mentioned in the studies cited thus far, research supports a prominent role for protein as well. Meneely et al. investigated the difference in lean body mass in 99 black and 360 white men ranging from age 7 to 79 using $^{40}K$ counting , a method of measuring lean body tissue using radioisotopes. At age 17, the black men were significantly heavier than the white men in the study, and most of the difference was attributable to greater lean body mass. Lean body mass in the black men was 5 – 7% greater than that of the white men throughout life. Although there was a decline in lean body mass in both races after the age of 40, the black men in the sample still had a greater lean body mass than did white men in their 60's.[38]

Although the total body water-to- fat free body ratio from research cited earlier by Ortiz et al. was nearly equal in black and white women, black women had a significantly greater total body potassium-to-fat free body ratio ($63.1 \pm 8.4$ compared to $56.6 \pm 7.4$; $p < 0.03$). The black females had greater skeletal muscle mass in the upper, lower, and combined extremities, as well. When total skeletal muscle mass was combined with total-body bone mass to provide an estimate of musculoskeletal mass, black females had a 24.7% higher value than the white females.[34]

In yet another study assessing the impact of potassium in male juveniles, Slaughter et al. found that total body potassium was 58% greater in blacks independent of height. Because increased total body potassium with increasing body height is a better marker of muscle growth than is increased total body water, the researchers speculated that there was a greater increase in the muscle mass of growing young, black males than in that of their white counterparts.[39] Using $^{40}K$ counting, Cohn et al. also reported a 16.8% higher total body potassium ($p < 0.001$), and consequently a higher lean body mass, in black men than in white men. Likewise, the total body potassium of black women was 15.3% greater than that of white women ($p < 0.001$).[33] The results were consistent with those of Meneely et al. cited earlier.[38]

The relative distribution of subcutaneous fat—fat patterning—also contributes to differences in body composition that impact percentage body fat, and hence BMI, in blacks and whites. Relative to the fat deposition patterning of whites, blacks tend to have less subcutaneous fat in the extremities than in the trunk. Blacks also tend to carry relatively more fat on the back and lateral portions of their bodies, while whites have greater amounts of subcutaneous fat on the front of their bodies.[40, 41, 42] In related research by Malina, blacks consistently had smaller triceps skinfold thicknesses than whites, and a higher ratio of trunk-to-extremity skinfold thickness.[43] Also, in 242 youths ranging in age from 6 to 16, Harsha et al. found that black boys were 22 % thinner than white boys on the basis of measured skinfold thickness of the limbs, which was slightly greater at the subscapular site. Using multivariate regression analysis, they found a disproportionate deposition of fat at the subscapular skinfold site for black boys and girls at all levels of maturity.[44] Further, Zillikens and Conway made both skinfold thickness and total body water measurements in a biracial sample of 179 adults. The ratios of triceps- to-subscapular and of thigh-to-subscapular thickness were lower ($p < 0.001$) in black women ($1.04 \pm 0.28$ and $1.78 \pm 0.67$, respectively) than in white women ($1.45 \pm 0.33$ and $2.51 \pm 0.84$, respectively) which indicated that black women had relatively more subcutaneous fat on the trunk than on the extremities. In addition, both black men and women had lower ratios of suprailiac-to-subscapular skinfold thickness than their white counterparts (men: $1.21 \pm 0.42$ compared to $1.66 \pm 0.49$, $p < 0.001$; women: $1.01 \pm 0.32$ compared to $1.59 \pm 0.46$, $p < 0.001$). This finding indicates a tendency for blacks to carry relatively more fat on the upper rather than the lower part of the trunk compared to whites.[45]

Goren et al. expanded the literature on racial differences with regard to fat patterning beyond the scope of skinfold thickness measurements. They used DXA to measure total fat mass and computed tomography to assess intra-abdominal adipose tissue and subcutaneous abdominal adipose tissue in a sample of 65 black and 36 white prepubertal children. Black children had significantly less ($p < 0.05$) intra-abdominal adipose tissue (boys, $22 \pm 17$ $cm^2$; girls, $28 \pm 17$ $cm^2$) than white children (boys, $27 \pm 16$ $cm^2$; girls, $54 \pm 27$ $cm^2$), and black children deposited less intra-abdominal fat per unit of subcutaneous abdominal adipose tissue ($0.17 \pm 0.02$ compared to $0.23 \pm 0.02$ $cm^2$; $p < 0.05$).[46]

In addition to differences in body composition between races/ethnicities, this author also found evidence of differences in body proportions. In general, blacks have shorter trunks and longer extremities than whites.[43, 47] The cadaver analysis of Metz et al. and Seale verified that the bones of the extremities are relatively longer in blacks than in whites.[30, 31] Ortiz et al. reported significantly longer bone lengths (by ≈ 2 cm) in the upper ($p < 0.05$) and lower ($p < 0.01$) extremities in black females than in white females.[34] Trotter and Hixon showed that differences in extremity lengths exist even in fetal skeletons.[48]

Differences in physical make-up between blacks, whites, and other races/ethnicities could have a significant effect on the estimation of body fat percentage, and hence BMI, in the different racial/ethnic groups. Because most equations that predict relative body adiposity were derived from predominately white samples, variation in physical composition between races/ethnicities has practical significance. Systemic error can result in inaccuracies in the relative body fat and of definitions of obesity if these differences are ignored.

This author found many scientific studies that investigated the ability of BMI to accurately measure body adiposity in different racial/ethnic groups, as well as several that explored physiological differences in body compositions of various racial/ethnic groups and how they impact body fatness. However, he could find only two that examined the race/ethnic-specific association between hypertension and body fat distribution as measured by BMI directly. Both studies involved samples that used only Black and white subjects, and both were regional in scope. Hence, their results cannot be applied to the entire nation. In the first investigation, Lackland et al. conducted research on 3,175 black and white adults in Anderson and Florence, South Carolina. The researchers found that the age-adjusted prevalence of hypertension was disproportionately higher among blacks than whites, with 36.9% of black men and 39.6% of black women having hypertension compared to 29.4% of white men and 23.0% of white women. Hypertension was also more prevalent at earlier ages in blacks than whites, and blacks had a higher prevalence of more severe hypertension (160/95 mmHg) than whites. In addition, black females had significantly higher levels of BMI than white females ($p < 0.0001$), but the difference in male BMI levels was not statistically significant ($p = .1683$). Within each BMI quartile, blacks consistently had a higher prevalence of hypertension than whites. The researchers did not present odds ratios in their findings for the four quartiles of BMI by race-gender group, so this author could not evaluate them for the strength of BMI to predict hypertension by race. However, the ratios of prevalence rates of the upper quartile to the lowest quartile for each race-gender cohort, a proxy for race-gender odds ratios, were inconsistent. White males had the smaller ratio, 1.49, compared to black males' ratio of 2.38, while white females' ratio was 2.22 compared to 1.50 for black females.[49]

Margaret Harris et al. also studied the relationship of BMI to hypertension using a sample consisting of 15,063 African American and White men and women aged 45 to 64 living in Jackson, MS, Minneapolis, MN, Washington County, MD, and Forsyth County, NC. In that study, the age-adjusted prevalence of hypertension was also higher among African Americans than whites (55% for African American men vs. 29% for white men; 56% for African American women vs. 26% for white women). Even in the lowest quintile of BMI, the difference in the prevalence of hypertension between blacks and whites was significant—41% of African American women and 43% of African American men had hypertension compared to 14% of white women and 19% of white men.

Obesity and increased levels of BMI were associated with increased prevalence of hypertension in African American men, white men, and white women, but not African American women. Elevated levels of BMI were associated with increased odds of hypertension in African American and white women, although the odds ratios in white women were higher than in African American women. African American women in the highest quintile had a 2.77 (95% C.I.: 1.93, 3.97) times higher odds of hypertension than they did in the first quintile. In white women, the odds ratio was 5.40 (95% C.I.: 4.36, 6.69) for the same comparison. For men, elevated BMI was also associated with increased odds of hypertension in both African Americans and whites. However, this study showed no significant racial differences in associations between hypertension and BMI among African American and white men.[50]

In summary, all of the findings that were reviewed point to the possibility that the relationship between the BMI and the actual amount of visceral body fat may differ across race/ethnic lines. Although BMI is a convenient way to measure body fatness, its inability to distinguish lean mass from fat tissue may lead to actually misdiagnosing actual obesity. Moreover, differences in body composition of the various races/ethnicities may also play a role in determining whether an individual is at risk for complications of elevated BMI, including hypertension. In seeking to add to the scientific literature on the implications of adopting race/ethnic-specific cutoff points for BMI, this study will investigate the strength of BMI as a predictor of hypertension in African-, Caucasian-, and Hispanic-Americans by using a large national sample of adult residents of the United States.

# CHAPTER III

# METHODS AND PROCEDURES

The data for this study were obtained from the 2007-2008 and 2009-2010 National Health and Nutrition Examination Surveys (NHANES). Two two-year cycles were combined so as to achieve statistically reliable estimates for Hispanics as a separate category for analysis. The NHANES survey is a continuous, cross-sectional survey conducted on an ongoing basis by the National Center for Health Statistics (NCHS), a division of the CDC. Data from the survey are released for public use every two years. The survey's purpose is to assess the health and nutritional status of the civilian non-institutionalized population of the U.S. Data are collected through patient interviews, clinical tests, anthropometric measurements, and physical examinations.[51]

The NHANES survey uses a stratified, multi-stage probability cluster sampling design. Almost 20,700 individuals were selected to participate over both survey cycles, and their responses to the survey represent the general U.S. population. In order to produce reliable statistics, the 2007-2010 NHANES surveys over-sampled African-Americans and Hispanics, as well as persons aged 60 and over.[51]

This study investigates the strength of the relationship between BMI and hypertension in males and non-pregnant females ages 20 and over. In order to thoroughly assess the relationship, several types of measures—demographic, behavioral, anthropometric, and clinical—were included in the investigation. In addition to gender, demographic variables included race/ethnicity, age, education, and income. Race and/or ethnicity, which were self-reported in the NHANES survey, included the following classifications: non-Hispanic White, non-Hispanic Black, and Hispanic. All other race/ethnic groups were excluded from this study. Age, which was also self-reported in the NHANES survey, was the participant's age on his/her last birthday at the time of the NHANES interview. The ages of participating subjects were grouped into the following three categories: 20-39, 40-59, and ages 60 and above. Where appropriate, age adjustments were made using sampling weights based on the 2000 projected U.S. population.[52] Education levels that were evaluated include the following: Less than a HS diploma; HS diploma or GED; Some college, but no degree; and College degree or more. Income categories included the following annual household incomes: $0-$19,999; $20,000 -$44,999; $45,000 - $74,999, $75,000-$99,999, $100,000 and above, and unclassified. Each of these variables has been shown to have significant impact on BMI and hypertension in other studies.[53, 54]

Measures relative to behavior included variables of cigarette smoking and physical activity. A participant was classified as either "current smoker", "past smoker", or "never" having smoked according to his or her answers to the following two questions on the NHANES survey: (1) have you smoked at least 100 cigarettes in life and (2) do you now smoke cigarettes. Physical activity was based upon each subject self-reporting the number of days, the number of minutes per day, and the intensity of physical activity in a typical week. The NHANES survey uses the same physical activity classifications as the Global Physical Activity Questionnaire developed by the World Health

Organization.[55] The intensity of physical activity was based upon a respondent's participation in vigorous or moderate physical activity at work, during recreational activities, or traveling to and from places. Metabolic equivalents (METs), which compare a person's working metabolic rate to his or her rate when resting, were used to quantify the intensity and duration of the physical activities for classification as "high", "moderate", or "low".[55]

Anthropometric variables included in this study were weight, height, and body mass index (BMI). During the NHANES physical examination, weight was measured in kilograms with an electronic load scale. Participants wore only under-shorts and disposable paper shirts, pants, and foam slippers. Standing height was determined in centimeters using a fixed standiometer with a vertical backboard and moveable headboard.[51] Participants were excluded if their weight or height measurement included a comment indicating an enhancement, e.g. "medical appliance" or "clothing" included with weight, or "not straight" included with height on the NHANES survey.

This study excluded subjects with a BMI that was less than 18.5, as this writer was not interested in individuals who were underweight. For all other participants (those with BMIs $\geq$ 18.5), the respondents were divided into the four quartiles of BMI (25% within each). Male quartiles I – IV were as follows – Quartile I: $18.5 \leq BMI < 24.7$; Quartile II: $24.7 \leq BMI < 27.8$; Quartile III: $27.8 \leq BMI < 31.4$; and Quartile IV: $BMI \geq 31.4$. Quartiles for females were the following – Quartile I: $18.5 \leq BMI < 23.6$; Quartile II: $23.6 \leq BMI < 27.4$; Quartile III: $27.4 \leq BMI < 32.4$; and Quartile IV: $BMI \geq 32.4$.

Clinical measurements included both systolic and diastolic blood pressure. During the NHANES survey, three blood pressure measurements were taken on each participant's right arm using standard mercury sphygmomanometers with appropriate cuff sizes. Systolic blood pressure was measured at the first appearance of a pulse sound, and diastolic blood pressure at the disappearance of the pulse sound. The NHANES survey used the average of the three systolic and diastolic blood pressure measurements to calculate blood pressure.[51] Hypertension was defined as a systolic blood pressure greater than or equal to 140 mmHg, a diastolic blood pressure greater than or equal to 90 mmHg, or the use of anti-hypertension medication as reported in the survey.[2] Survey participants whose blood pressure readings were not complete or were enhanced with any additional equipment were omitted from this study.

In the final analysis, 8,960 NH White, NH Black, and Hispanic men and women aged 20 and older met all requirements to be included in this study.

NHANES survey data were accessed from the CDC website at the following location: http://www.cdc.gov/nchs/nhanes.htm. All data were then downloaded into version 9.2 of SAS software (SAS Institute, Inc., Cary, NC) for statistical analysis.

All hypotheses were tested at the 5% level of statistical significance, and analyses are presented separately for male and female strata. Summary tables are provided for all the input variables—demographic, behavioral, and anthropometric. Tests for significant differences in all continuous exposure variables were undertaken using analysis of variance (ANOVA) by race/ethnicity. Tests for significant differences in categorical exposure variables were conducted using chi-square analysis, both for all study participants and for those with hypertension. Unadjusted (crude) and age-adjusted prevalence of hypertension were generated across race/ethnicity for each categorical exposure variable. And finally, prevalence odds ratios were calculated using logistic regression to test the strength of the relationship between BMI and hypertension on a univariate basis as well as on a multivariate basis after adjusting for age, education, income, smoking status, and physical activity.

CHAPTER IV

RESULTS

### 4.1 Basic Characteristics of the Study Population

Basic statistics for the continuous descriptive variables—age, weight, height, and body mass index (BMI)—are shown in Table 1 and Table 2, respectively, for all eligible male and female subjects and for men and women with hypertension. White, Black, and Hispanic subjects were significantly different in age, with White men and women being older and Hispanic men and women being younger. On average, Hispanic men weighed less ($p < .0001$) than White and Black men, while the average weight for all women differed significantly. Black women weighed more and Hispanic women weighed less ($p < .0001$). All three cohorts of men had different mean heights; White men were taller and Hispanic men were shorter. In women, Hispanics were significantly shorter ($p < .0001$) than both Whites and Blacks. All males had similar BMI ($p = .2318$); however, in females the opposite was the case. Women's average BMI differed in all three groups ($p = .0002$)—Black women had the largest and White women had the smallest.

For males with hypertension, Whites were significantly older ($p < .0001$) than both Blacks and Hispanic males. In women, however, the average age for those with hypertension was significantly different in each group ($p = .0159$)—White women were older and Black women were younger. The mean weight in both hypertensive males and females was different, but not as significantly different ($p = .0954$) in White males. In hypertensive males, Blacks weighed more and Hispanics weighed less; in females with hypertension, Whites weighed significantly more and Hispanics weighed less. Hypertensive Hispanic men and women were significantly shorter in stature than both Whites and Blacks ($p < .0001$). The average BMI for hypertensive White men was significantly less than for the two other groups ($p = .0429$); however, women with hypertension had statistically different average BMI ($p = .0075$)—Whites had lower BMI and Blacks had higher.

**Table 1**
**Characteristics of the Study Population (Mean ± SD) - Males**
**Continuous Variables**
**NHANES, 2007-2010**

| | NH White (n = 2,298) | NH Black (n = 891) | Hispanic (n = 1,302) | p-value* |
|---|---|---|---|---|
| **Age:** | | | | |
| All participants | 47±16 | 43±15 | 40±14 | <.0001 |
| Those with Hypertension | 58±14 | 54±13 | 53±14 | <.0001 |
| **Weight (kg):** | | | | |
| All participants | 90.5±18.8 | 90.2±22.6 | 84.6±18.8 | 0.0005 |
| Those with Hypertension | 95.8±20.7 | 97.9±26.6 | 91.5±21.2 | 0.0268 |
| **Height (cm):** | | | | |
| All participants | 177.6±6.9 | 176.4±7.0 | 170.5±7.5 | 0.0015 |
| Those with Hypertension | 176.6±7.0 | 176.1±7.5 | 170.7±7.0 | <.0001 |
| **BMI (kg/m²):** | | | | |
| All participants | 28.6±5.5 | 28.9±6.8 | 29.0±5.5 | 0.2318 |
| Those with Hypertension | 30.6±6.1 | 31.4±7.7 | 31.2±6.0 | 0.0429 |

*p-values are from ANOVA

**Table 2**
**Characteristics of the Study Population (Mean ± SD) - Females**
**Continuous Variables**
**NHANES, 2007-2010**

| | NH White (n = 2,215) | NH Black (n = 882) | Hispanic (n = 1,372) | p-value* |
|---|---|---|---|---|
| **Age:** | | | | |
| All participants | 49± 17 | 45± 15 | 42± 15 | 0.0013 |
| Hypertension | 62±13 | 56±13 | 59±12 | 0.0159 |
| **Weight (kg):** | | | | |
| All participants | 75.4±18.4 | 85.4±22.4 | 72.8±16.7 | 0.0007 |
| Hypertension | 99.3±19.9 | 87.3±22.4 | 75.2±16.4 | <.0001 |
| **Height (cm):** | | | | |
| All participants | 163.3±6.6 | 163.2±6.5 | 157.2±6.6 | <.0001 |
| Hypertension | 161.4±6.4 | 162.0±6.1 | 154.9±6.3 | <.0001 |
| **BMI (kg/m²):** | | | | |
| All participants | 28.3±6.6 | 32.0±7.9 | 29.4±6.4 | 0.0002 |
| Hypertension | 30.3±7.1 | 33.2±7.7 | 31.2±6.0 | 0.0075 |

*p-values are from ANOVA

Tables 3 and 4 present the frequency distribution percentages for all categorical exposure variables for male and female participants, respectively. Percentages were significantly different for all race/ethnic groups within each variable. Whites tended to be older, more highly educated, and had a higher economic status than did their Black and Hispanic counterparts ($p < .0001$). In contrast, Hispanic men and women were younger and had the least amount of education ($p < .0001$). Black women, but not Black men, had less income ($p < .0001$), but among men, Hispanics made less than both Whites and Blacks ($p < .0001$).

Results for the other three categorical exposure variables—smoking status, physical activity, and BMI—were mixed. Larger shares of Black men and women smoked at the time of the survey than did Whites and Hispanics ($p < .0001$). For subjects with a past history of smoking, White men and women had larger percentages ($p< .0001$). Hispanics had the largest share of participants who had never smoked at the time of the survey ($p < .0001$). Physical activity in men was highest among Hispanics and lowest among Blacks ($p = .0171$). In women, Whites were more physically active and Black women were least active ($p = .0003$).

The level of BMI was roughly evenly distributed among the four quartiles for White men and women ($p < .0001$). However, the distribution was not as evenly spread among the other racial/ethnic groups. Hispanics had approximately 50% fewer subjects with BMI in the first quartile than in the other three quartiles ($p < .0001$). In Black men, however, approximately 50% more participants had BMI within the first and last quartiles than in the middle two ($p < .0001$). The distribution of BMI was the most irregular among Black women. Almost four times more of them had BMI levels in the last quartile than in the first one ($p < .0001$).

**Table 3**
**Percentage Distribution of the Study Population - Males**
**Categorical Exposure Variables**
**NHANES, 2007-2010**

| | | White (n = 2,298) | Black (n = 891) | Hispanic (n = 1,302) | p-value* |
|---|---|---|---|---|---|
| Demographic Factors | **Age:** | | | | |
| | 20 - 39 | 34.2% | 43.6% | 55.5% | < .0001 |
| | 40 - 59 | 42.1% | 40.1% | 34.5% | |
| | 60 & above | 23.7% | 16.3% | 10.1% | |
| | **Education:** | | | | |
| | Less than HS Diploma | 12.0% | 26.3% | 46.4% | < .0001 |
| | HS Diploma or GED | 25.2% | 29.9% | 23.3% | |
| | Some College | 30.9% | 29.3% | 20.3% | |
| | College Degree or More | 31.8% | 14.5% | 9.9% | |
| | **Income[1]:** | | | | |
| | <$20,000 | 8.7% | 17.1% | 19.6% | < .0001 |
| | $20,000 - $44,999 | 20.5% | 32.7% | 37.8% | |
| | $45,000 - $74,999 | 24.1% | 22.7% | 19.9% | |
| | $75,000 - $99,999 | 15.3% | 10.1% | 7.4% | |
| | $100,000 & up | 27.8% | 10.6% | 9.1% | |
| | All Other | 3.7% | 6.8% | 6.3% | |
| Behavioral Factors | **Smoking Status[2]:** | | | | |
| | Current | 23.0% | 32.0% | 24.5% | < .0001 |
| | Past | 31.6% | 17.5% | 22.5% | |
| | Never | 45.4% | 50.5% | 53.0% | |
| | **Physical Activity[3]:** | | | | |
| | High | 45.9% | 46.3% | 48.5% | 0.0171 |
| | Moderate | 18.9% | 14.1% | 17.2% | |
| | Low | 35.2% | 39.6% | 34.3% | |
| Anthropometric Measurements | **BMI ($kg/m^2$):** | | | | |
| | $18.5 \leq BMI < 24.7$ | 23.5% | 29.1% | 18.7% | < .0001 |
| | $24.7 \leq BMI < 27.8$ | 25.4% | 20.1% | 27.6% | |
| | $27.8 \leq BMI < 31.4$ | 25.5% | 21.5% | 27.5% | |
| | $BMI \geq 31.4$ | 25.6% | 29.3% | 26.2% | |

*p-values are from chi-square analysis
[1, 2, 3] See appendix

**Table 4**
**Percentage Distribution of the Study Population - Females**
**Categorical Exposure Variables**
**NHANES, 2007-2010**

| | | White (n = 2,215) | Black (n = 882) | Hispanic (n = 1,372) | p-value* |
|---|---|---|---|---|---|
| Demographic Factors | **Age:** | | | | |
| | 20 - 39 | 31.9% | 40.0% | 48.3% | < .0001 |
| | 40 - 59 | 39.7% | 41.4% | 37.5% | |
| | 60 & above | 28.4% | 18.6% | 14.2% | |
| | **Education:** | | | | |
| | Less than HS Diploma | 13.1% | 22.8% | 44.1% | < .0001 |
| | HS Diploma or GED | 24.2% | 25.0% | 18.3% | |
| | Some College | 32.8% | 35.4% | 25.4% | |
| | College Degree or More | 29.9% | 16.7% | 12.2% | |
| | **Income[1]:** | | | | |
| | <$20,000 | 12.4% | 25.8% | 23.2% | < .0001 |
| | $20,000 - $44,999 | 25.2% | 30.3% | 36.3% | |
| | $45,000 - $74,999 | 22.5% | 21.1% | 18.4% | |
| | $75,000 - $99,999 | 14.4% | 9.6% | 6.9% | |
| | $100,000 & up | 22.4% | 7.7% | 8.2% | |
| | All Other | 3.1% | 5.5% | 7.1% | |
| Behavioral Factors | **Smoking Status[2]:** | | | | |
| | Current | 20.3% | 22.9% | 13.9% | < .0001 |
| | Past | 24.3% | 14.3% | 13.1% | |
| | Never | 55.4% | 62.7% | 73.1% | |
| | **Physical Activity[3]:** | | | | |
| | High | 28.4% | 22.3% | 22.0% | 0.0003 |
| | Moderate | 22.9% | 16.9% | 21.1% | |
| | Low | 48.6% | 60.7% | 56.9% | |
| Anthropometric Measurements | **BMI ($kg/m^2$):** | | | | |
| | $18.5 \leq BMI < 23.6$ (Ref) | 27.3% | 11.1% | 17.7% | < .0001 |
| | $23.6 \leq BMI < 27.4$ | 25.6% | 20.0% | 25.7% | |
| | $27.4 \leq BMI < 32.4$ | 23.9% | 28.2% | 28.9% | |
| | $BMI \geq 32.4$ | 23.3% | 40.7% | 27.7% | |

*p-values are from chi-square analysis
[1, 2, 3] See appendix

## 4.2 Characteristics of the Hypertensive Study Population

Distributions for all exposure variables for study participants with hypertension are displayed in table 5 for males and table 6 for females. With the exception of physical activity in females, all distributions differed significantly within each variable for each gender-race/ethnic cohort. As was the case with all subjects, White participants with hypertension were older, had a higher level of education, and earned more income than did their Black and Hispanic counterparts ($p < .0001$). Hypertensive Hispanics had less education and earned less money than the other two groups ($p < .0001$). Hispanic males with hypertension were younger ($p = .0008$), but in females, Black women had the largest share of young subjects with hypertension ($p < .0001$).

In evaluating smoking status, Whites had the larger share of persons with hypertension who smoked in the past, but Black men and women had the larger share who smoked at the time of the survey ($p < .0001$). Hispanics males and females had the largest share who indicated they had never smoked ($p = .0001$). In males, Whites had the larger percentage of participants with hypertension who were very active physically, while Blacks had the larger share that were the least physically active ($p = .0246$). Differences in physical activity among females were not significant ($p = .4734$).

With the exception of Black males, the share of hypertensive participants increased with each BMI quartile in all gender-racial/ethnic groups ($p < .0001$). For Black men, the share in the first quartile exceeded that in the second. Hypertensive Black men and White women had larger proportions of persons in the first quartile of BMI; Hispanic men and Black women had the smallest ($p < .0001$). In the highest quartile, Black men and women had the largest proportions and White men and women had the smallest ($p = .0001$).

**Table 5**
**Percentage Distribution of the Hypertensive Study Population - Males**
**NHANES, 2007-2010**

| | | White (n = 864) | Black (n = 394) | Hispanic (n = 364) | p-value* |
|---|---|---|---|---|---|
| Demographic Factors | **Age:** 20 - 39 | 10.4% | 15.1% | 19.0% | <.0001 |
| | 40 - 59 | 43.4% | 50.7% | 49.2% | |
| | 60 & above | 46.2% | 34.3% | 31.7% | |
| | **Education:** | | | | |
| | Less than HS Diploma | 14.1% | 28.7% | 48.1% | <.0001 |
| | HS Diploma or GED | 28.8% | 27.8% | 24.5% | |
| | Some College | 29.8% | 28.6% | 15.5% | |
| | College Degree or More | 27.3% | 14.8% | 12.0% | |
| | **Income[1]:** | | | | |
| | <$20,000 | 9.9% | 19.4% | 19.8% | 0.0471 |
| | $20,000 - $44,999 | 24.6% | 31.0% | 35.0% | |
| | $45,000 - $74,999 | 21.9% | 26.6% | 21.2% | |
| | $75,000 - $99,999 | 14.2% | 9.7% | 8.1% | |
| | $100,000 & up | 25.7% | 8.9% | 9.2% | |
| | All Other Income | 3.7% | 4.4% | 6.8% | |
| Behavioral Factors | **Smoking Status[2]:** | | | | |
| | Current | 16.4% | 26.1% | 20.6% | <.0001 |
| | Past | 40.8% | 24.7% | 30.0% | |
| | Never | 42.8% | 49.2% | 49.4% | |
| | **Physical Activity[3]:** | | | | |
| | High | 36.2% | 32.7% | 35.2% | 0.0249 |
| | Moderate | 20.6% | 15.1% | 14.8% | |
| | Low | 43.2% | 52.2% | 49.9% | |
| Anthropometric Measurements | **BMI (kg/m²):** | | | | |
| | $18.5 \leq BMI < 24.7$ | 12.0% | 18.6% | 9.0% | <.0001 |
| | $24.7 \leq BMI < 27.8$ | 21.7% | 15.9% | 22.5% | |
| | $27.8 \leq BMI < 31.4$ | 28.7% | 21.5% | 24.9% | |
| | $BMI \geq 31.4$ | 37.6% | 44.1% | 43.6% | |

*p-values are from chi-square analysis
[1, 2, 3]See appendix

**Table 6**
**Percentage Distribution of the Hypertensive Study Population - Females**
**NHANES, 2007-2010**

| | | | White (n = 819) | Black (n = 427) | Hispanic (n = 414) | p-value* |
|---|---|---|---|---|---|---|
| Demographic | Factors | **Age:** 20 - 39 | 6.4% | 9.6% | 5.9% | <.0001 |
| | | 40 - 59 | 34.3% | 52.1% | 42.1% | |
| | | 60 & above | 59.4% | 38.3% | 52.0% | |
| | | **Education:** | | | | |
| | | Less than HS Diploma | 17.3% | 28.3% | 59.8% | <.0001 |
| | | HS Diploma or GED | 29.3% | 23.4% | 14.5% | |
| | | Some College | 31.7% | 34.2% | 17.4% | |
| | | College Degree or More | 21.7% | 14.1% | 8.3% | |
| | | **Income[1]:** | | | | |
| | | <$20,000 | 16.7% | 28.4% | 32.3% | <.0001 |
| | | $20,000 - $44,999 | 31.0% | 30.3% | 31.3% | |
| | | $45,000 - $74,999 | 22.7% | 20.6% | 15.4% | |
| | | $75,000 - $99,999 | 9.1% | 9.0% | 5.9% | |
| | | $100,000 & up | 16.6% | 6.0% | 5.2% | |
| | | All Other Income | 4.0% | 5.8% | 9.9% | |
| Behavioral | Factors | **Smoking Status[2]:** | | | | |
| | | Current | 14.0% | 22.3% | 11.8% | 0.0216 |
| | | Past | 30.6% | 22.1% | 18.6% | |
| | | Never | 55.3% | 55.6% | 69.7% | |
| | | **Physical Activity[3]:** | | | | |
| | | High | 17.3% | 15.4% | 16.5% | 0.0389 |
| | | Moderate | 20.1% | 14.8% | 14.3% | |
| | | Low | 62.5% | 69.8% | 69.3% | |
| Anthropometric | Measurements | **BMI ($kg/m^2$):** | | | | |
| | | $18.5 \leq BMI < 24.7$ | 17.3% | 6.9% | 7.5% | <.0001 |
| | | $24.7 \leq BMI < 27.8$ | 22.6% | 15.1% | 19.4% | |
| | | $27.8 \leq BMI < 31.4$ | 27.1% | 31.2% | 36.3% | |
| | | $BMI \geq 31.4$ | 33.0% | 46.8% | 36.7% | |

*p-values are from chi-square analysis
[1, 2, 3] See appendix

**4.3 Prevalence of Hypertension**

Prevalence rates of hypertension are given in tables 7 and 8 for men and women, respectively. The overall unadjusted prevalence (crude) and age-adjusted prevalence of hypertension were statistically significantly different for White, Black, and Hispanic study participants for both genders ($p < .0001$). Overall age-adjusted prevalence of hypertension differed by 7.5% in Hispanic men and 6.0% in Hispanic women over crude prevalence estimates. Prevalence rates also increased for Black subjects when comparing crude rates to age-adjusted rates, although the increases were smaller than for Hispanics. In comparing White and Hispanic men, the difference in hypertension prevalence decreased from 11.4% to 2.2% when using age-adjusted prevalence estimates versus crude estimates. In comparing White and Hispanic women, prevalence rates differed by only 1.7% for age-adjusted estimates versus 11.4% for unadjusted estimates. Black men and women had the higher hypertension prevalence rates, both on a crude basis as well as on an age-adjusted basis.

At the level of individual covariates, the prevalence of hypertension generally increased with the age of participants. Hispanics were less prone to being hypertensive in both young adults (ages 20-39) and in middle-age adults (ages 40-59). However, in seniors (ages 60 and above), Whites were less likely to be hypertensive. Black males and females were more prone to hypertension in all three age groups.

The trend in hypertension prevalence from one smoking status to the next was not monotonic. While prevalence increased in each sex-race/ethnic cohort when moving from current smokers to those who smoked in the past, it generally decreased when going from past smokers to subjects who had never smoked. At all categories of smoking status, hypertension was most prevalent among Blacks and least prevalent among

Hispanics. In both genders, prevalence was the highest in participants who had a past history of smoking—50.4% in Black men and 63.7% in Black women.

In general, the rate of hypertension decreased with each increase in level and intensity of physical activity. On a race/ethnic basis, hypertension was most prevalent in Black men and women and least prevalent in Hispanics. In the most physically active study participants, hypertension was 3.3% more prevalent in Black men than in White men and 76.9% more prevalent than in Hispanic men. In the most inactive group of men, the numbers were 24.1% and 65.2%, respectively. Similarly, in physically active Black females, hypertension was 47.7% more prevalent than in White females, and 88.7% more than in Hispanic females. For inactive women, Black women were 16.4% more prone to being hypertensive than White women and almost twice as prone (92.3%) as Hispanic women.

Hypertension prevalence increased with each increasing quartile of BMI for all gender-race/ethnicity strata. As with the other covariates, prevalence was highest among Blacks and lowest among Hispanics. In the first quartile of BMI, Black men were hypertensive at a rate that was 44.0% higher than in White men and more than twice the rate for Hispanic men (243.6%). In the BMI quartile with the largest subjects, Black men were 18.2% more likely to have hypertension than White men and 64.8% more likely than Hispanic men. In the first quartile of BMI, Black women were 28.4% more likely to be hypertensive than White women and three times as likely as Hispanic women. In women with BMI in the fourth quartile, hypertension was 5.5% higher in Black women than in White women, and 77.6% higher than in Hispanic women.

Prevalence of hypertension generally decreased with increasing educational attainment in women, and to a lesser extent, in men. While White men experienced less hypertension as they attained more education, Black men and Hispanic men initially experienced a drop in hypertension before seeing levels rise again as they received more education. Hispanics were less prone to being hypertensive at each level of education and Blacks were the most prone (the exception being in White men with a high school diploma/GED).

As was the case with education, the unadjusted prevalence of hypertension generally decreased with each increment in economic status. Hispanics had the smallest prevalence of hypertension at each level of income and Blacks had the highest.

**Table 7**
**Prevalence of Hypertension by Categorical Variable - Males**
**NHANES, 2007-2010**

| | | | White (n = 2,298) | Black (n = 891) | Hispanic (n = 1,302) |
|---|---|---|---|---|---|
| Overall | | **Hypertension:** | | | |
| | | Unadjusted Prevalence | 31.1% | 35.9% | 19.7% |
| | | Age-adjusted Prevalence | 29.4% | 39.5% | 27.2% |
| Demographic | Factors | **Age:** | | | |
| | | 20 - 39 | 9.5% | 12.4% | 6.8% |
| | | 40 - 59 | 32.0% | 45.5% | 28.0% |
| | | 60 & above | 60.6% | 75.3% | 62.3% |
| | | **Education:** | | | |
| | | Less than HS Diploma | 36.5% | 39.4% | 20.4% |
| | | HS Diploma or GED | 35.5% | 33.4% | 20.6% |
| | | Some College | 29.9% | 35.0% | 15.1% |
| | | College Degree or More | 26.7% | 36.6% | 23.7% |
| | | **Income[1]:** | | | |
| | | <$20,000 | 35.5% | 41.0% | 19.4% |
| | | $20,000 - $44,999 | 37.5% | 34.0% | 18.2% |
| | | $45,000 - $74,999 | 28.2% | 42.1% | 21.0% |
| | | $75,000 - $99,999 | 28.9% | 34.2% | 21.6% |
| | | $100,000 & up | 28.8% | 30.0% | 20.0% |
| | | All Other Income | 30.9% | 23.1% | 22.6% |
| Behavioral | Factors | **Smoking Status[2]:** | | | |
| | | Past | 40.1% | 50.4% | 26.3% |
| | | Never | 29.3% | 35.0% | 18.3% |
| | | **Physical Activity[3]:** | | | |
| | | High | 24.5% | 25.3% | 14.3% |
| | | Moderate | 33.9% | 38.3% | 16.9% |
| | | Low | 38.2% | 47.4% | 28.7% |
| Anthropometric | Measurements | **BMI (kg/m²):** | | | |
| | | $18.5 \leq$ BMI $< 24.7$ | 15.9% | 22.9% | 9.4% |
| | | $24.7 \leq$ BMI $< 27.8$ | 26.5% | 28.4% | 16.1% |
| | | $27.8 \leq$ BMI $< 31.4$ | 35.1% | 36.0% | 17.8% |
| | | BMI $\geq 31.4$ | 45.6% | 53.9% | 32.7% |

[1, 2, 3] See appendix

**Table 8**
**Prevalence of Hypertension by Categorical Variable - Females**
**NHANES, 2007-2010**

| | | White (n = 2,215) | Black (n = 882) | Hispanic (n = 1,372) |
|---|---|---|---|---|
| Overall | **Hypertension:** | | | |
| | Unadjusted Prevalence | 31.7% | 41.4% | 20.3% |
| | Age-adjusted Prevalence | 28.0% | 42.8% | 26.3% |
| Demographic Factors | **Age:** | | | |
| | 20 - 39 | 6.3% | 9.9% | 2.5% |
| | 40 - 59 | 27.4% | 52.1% | 22.8% |
| | 60 & above | 66.3% | 85.1% | 74.0% |
| | **Education:** | | | |
| | Less than HS Diploma | 41.9% | 51.4% | 27.6% |
| | HS Diploma or GED | 38.3% | 38.7% | 16.1% |
| | Some College | 30.6% | 39.9% | 13.8% |
| | College Degree or More | 23.1% | 34.8% | 13.8% |
| | **Income[1]:** | | | |
| | <$20,000 | 42.8% | 45.6% | 28.3% |
| | $20,000 - $44,999 | 38.9% | 41.4% | 17.5% |
| | $45,000 - $74,999 | 32.0% | 40.2% | 17.0% |
| | $75,000 - $99,999 | 20.1% | 38.8% | 17.4% |
| | $100,000 & up | 23.4% | 32.0% | 12.7% |
| | All Other Income | 41.0% | 43.2% | 28.4% |
| Behavioral Factors | **Smoking Status[2]:** | | | |
| | Current | 21.9% | 40.2% | 17.1% |
| | Past | 39.9% | 63.7% | 28.9% |
| | Never | 31.7% | 36.7% | 19.3% |
| | **Physical Activity[3]:** | | | |
| | High | 19.3% | 28.5% | 15.1% |
| | Moderate | 27.9% | 36.2% | 13.8% |
| | Low | 40.8% | 47.5% | 24.7% |
| Anthropometric Measurements | **BMI (kg/m²):** | | | |
| | $18.5 \leq BMI < 24.7$ | 20.1% | 25.8% | 8.6% |
| | $24.7 \leq BMI < 27.8$ | 28.0% | 31.2% | 15.3% |
| | $27.8 \leq BMI < 31.4$ | 36.0% | 45.8% | 25.5% |
| | $BMI \geq 31.4$ | 45.1% | 47.6% | 26.8% |

[1, 2, 3] See appendix

**4.4 Univariate Prevalence Odds Ratios**

The focus of this research is on the relationship between BMI and hypertension, and whether the relationship differs within gender by race/ethnicity. Toward that end, a thorough investigation into this association on a univariate basis as well as on a multivariate basis is in order. Tables 9 and 10 show the results of logistic regression on a univariate basis of hypertension and BMI split by gender. In men, the odds of hypertension in the second quartile of BMI were 1.34 times the odds in the reference quartile ($18.5 \leq BMI < 24.7$) in Blacks, 1.85 in Hispanics, and 1.91 in White men. The odds ratio of the third quartile ($27.8 \leq BMI < 31.4$) to the reference quartile was 1.90 in Black males, 2.09 in Hispanics and 2.85 in White males. Similarly, the odds of hypertension for men with BMI in the last quartile to the reference quartile was 3.94 in Blacks, 4.70 in Hispanics, and 4.42 in White men. Hence, odds ratios were lower in Black men than in Hispanic or White men in every quartile. With the exception of Black men in the second quartile ($24.7 \leq BMI < 27.8$), the results were significant at all levels of BMI. Odds ratios in two of three quartiles of BMI in females were lower for Blacks than for Whites or Hispanics. In the second BMI category ($23.6 \leq BMI < 27.4$), odds ratios were 1.31, 1.54, and 1.91 in Black, White, and Hispanic women, respectively; in the largest BMI quartile ($BMI \geq 32.4$), they were 2.61, 3.27, and 3.88 in Black, White, and Hispanic females, respectively. The third quartile of BMI ($27.4 \leq BMI < 32.4$) had Black women's odds ratios in between those of White and Hispanic women. Except for Black women with BMI in the second quartile, the results were significant for all categories of BMI in females.

**Table 9**
**Odds Ratios of Hypertension across BMI - Males**
**NHANES, 2007-2010**

| | NH White | | NH Black | | Hispanic | |
|---|---|---|---|---|---|---|
| | Odds Ratio | 95% C.I. | Odds Ratio | 95% C.I. | Odds Ratio | 95% C.I. |
| **BMI(kg/m²):** | | | | | | |
| 18.5 ≤ BMI < 24.7 (Ref) | 1.00 | | 1.00 | | 1.00 | |
| 24.7 ≤ BMI < 27.8 | 1.91 | 1.37 - 2.65 | 1.34 | 0.84 -2.14 | 1.85 | 1.12 - 3.04 |
| 27.8 ≤ BMI < 31.4 | 2.85 | 2.08 - 3.91 | 1.90 | 1.23 - 2.93 | 2.09 | 1.29 - 3.41 |
| BMI ≥ 31.4 | 4.42 | 3.19 - 6.14 | 3.94 | 2.67 - 5.81 | 4.70 | 2.75 - 8.01 |

Odds ratios and 95% C.I.'s were calculated using univariate logistic regression

**Table 10**
**Odds Ratios of Hypertension across BMI - Females**
**NHANES, 2007-2010**

| | NH White | | NH Black | | Hispanic | |
|---|---|---|---|---|---|---|
| | Odds Ratio | 95% C.I. | Odds Ratio | 95% C.I. | Odds Ratio | 95% C.I. |
| **BMI(kg/m²):** | | | | | | |
| 18.5 ≤ BMI < 23.6 (Ref) | 1.00 | | 1.00 | | 1.00 | |
| 23.6 ≤ BMI < 27.4 | 1.54 | 1.15 - 2.07 | 1.31 | 0.78 - 2.19 | 1.91 | 1.18 - 3.11 |
| 27.4 ≤ BMI < 32.4 | 2.24 | 1.66 - 3.01 | 2.43 | 1.46 - 4.06 | 3.63 | 2.26 - 5.81 |
| BMI ≥ 32.4 | 3.27 | 2.37 - 4.51 | 2.61 | 1.60 - 4.26 | 3.88 | 2.36 - 6.39 |

Odds ratios and 95% C.I.'s were calculated using univariate logistic regression

**4.5 Multivariate Prevalence Odds Ratios**

This section extends the research further by using multivariate logistic regression to determine whether the association differed by race/ethnicity after adjusting for confounding effects of age, education, income, smoking status, and physical activity. Table 11 and table 12 display these results for males and females, respectively.

In men, hypertension and BMI were significantly associated when comparing almost all BMI quartiles to the reference BMI category ($18.5 \leq \text{BMI} < 24.7$), after adjusting for the other covariates. Prevalence odds ratios in the second quartile compared to the first quartile were lower in Black men (1.13) than in White (1.47) and Hispanic men (1.71). Hence, the association of hypertension to BMI in the second quartile in Black men was weaker than in the other two groups. Likewise, the odds ratios of hypertension for men in the third quartile to men of the same race/ethnicity in the reference quartile were 1.57 in Black men, 2.24 in Whites, and 1.87 in Hispanics, which meant that hypertension was not as strongly associated with BMI in Black men in this quartile as in the White or Hispanic men either. The 5.1 odds ratio in Black men in the fourth quartile ($\text{BMI} \geq 31.4$) to those in the first quartile ($18.5 \leq \text{BMI} < 24.7$) was the only category where the hypertension-BMI association was not the weakest in Black males. With the exception of the second quartile in Blacks and Hispanics, BMI contributed significantly to the prevalence of hypertension in males at all levels of BMI.

After controlling for the covariates, the odds of hypertension in females having BMI in the second quartile ($23.6 \leq \text{BMI} < 27.4$), to those in the reference quartile ($18.5 \leq \text{BMI} < 23.6$) were 1.19 in Whites, 1.32 in Blacks, and 1.53 in Hispanics. Odds ratios for the third and fourth quartile were lower for White females and higher for Hispanic women than for Black women, as well. The results indicate that hypertension was not as strongly associated with BMI in White women as in the other two groups, and not as strong in Black women as in Hispanics. Although none of the relationships were significant in the second quartile for any of the female racial/ethnic groups, all of them were significant in the third and fourth quartiles.

The only other covariates where the odds of hypertension were lower in Blacks than in Whites or Hispanics were in smoking history in Black men and educational attainment in Black females. However, none of those associations were significant.

**Table 11**

**Odds Ratios of Hypertension across Covariates - Males**

**NHANES, 2007-2010**

| | NH White | | NH Black | | Hispanic | |
|---|---|---|---|---|---|---|
| | Odds Ratio | 95% C.I. | Odds Ratio | 95% C.I. | Odds Ratio | 95% C.I. |
| **BMI (kg/m²):** | | | | | | |
| 18.5 ≤ BMI < 24.7 (Ref) | 1.00 | | 1.00 | | 1.00 | |
| 24.7 ≤ BMI < 27.8 | 1.47 | 1.01 - 2.15 | 1.13 | 0.67 - 1.93 | 1.71 | 0.97 - 3.04 |
| 27.8 ≤ BMI < 31.4 | 2.24 | 1.53 - 3.27 | 1.57 | 1.01 - 2.45 | 1.87 | 1.10 - 3.19 |
| BMI ≥ 31.4 | 3.85 | 2.67 - 5.54 | 5.10 | 2.98 - 8.73 | 4.62 | 2.26 - 9.48 |
| **Age:** | | | | | | |
| 20 - 39 (Ref) | 1.00 | | 1.00 | | 1.00 | |
| 40 - 59 | 4.15 | 3.01 - 5.70 | 7.63 | 5.17 - 10.21 | 5.26 | 3.52 - 7.85 |
| 60 & above | 13.60 | 9.63 - 19.20 | 28.23 | 16.40 - 48.58 | 25.10 | 16.18 - 38.95 |
| **Education:** | | | | | | |
| College Deg or More (Ref) | 1.00 | | 1.00 | | 1.00 | |
| Some College | 1.24 | 0.92 - 1.68 | 1.07 | 0.63 - 1.81 | 0.65 | 0.32 - 1.35 |
| HS Diploma or GED | 1.51 | 1.11-2.06 | 1.04 | 0.62 - 1.73 | 1.24 | 0.61 - 2.52 |
| Less than HS Diploma | 1.47 | 0.94 - 2.31 | 1.00 | 0.55 - 1.83 | 0.90 | 0.56 - 1.44 |
| **Income[1]:** | | | | | | |
| $100,000 & up (Ref) | 1.00 | | 1.00 | | 1.00 | |
| $75,000 - $99,999 | 0.97 | 0.64 - 1.46 | 1.20 | 0.66 - 2.19 | 1.07 | 0.5 - 2.28 |
| $45,000 - $74,999 | 0.88 | 0.59 - 1.32 | 2.29 | 0.95 - 3.35 | 0.98 | 0.48 - 2.02 |
| $20,000 - $44,999 | 1.10 | 0.77 - 1.57 | 1.79 | 1.47 - 4.25 | 0.87 | 0.40 - 1.87 |
| < $20,000 | 1.34 | 0.88 - 2.82 | 2.50 | 1.09 - 4.84 | 1.02 | 0.55 - 1.87 |
| Unclassified Income | 0.81 | 0.47 - 1.41 | 1.07 | 0.43 - 2.68 | 0.93 | 0.42 - 2.08 |
| **Smoking Status[2]:** | | | | | | |
| Never (Ref) | 1.00 | | 1.00 | | 1.00 | |
| Past | 0.98 | 0.74 - 1.29 | 0.65 | 0.38 - 1.10 | 0.80 | 0.59 - 1.09 |
| Current | 0.83 | 0.63 - 1.11 | 0.71 | 0.47 - 1.06 | 0.92 | 0.59 - 1.44 |
| **Physical Activity[3]:** | | | | | | |
| High (Ref) | 1.00 | | 1.00 | | 1.00 | |
| Moderate | 1.12 | 0.83 - 1.50 | 1.03 | 0.61 - 1.74 | 0.88 | 0.57 - 1.36 |
| Low | 1.15 | 0.93 - 1.43 | 1.55 | 1.16 - 2.07 | 1.35 | 0.91 - 2.01 |

Odds ratios and 95% C.I.'s were calculated using multivariate logistic regression after adjusting for confounding in the covariates

**Table 12**

**Odds Ratios of Hypertension across Covariates - Females**

**NHANES, 2007-2010**

| | NH White | | NH Black | | Hispanic | |
|---|---|---|---|---|---|---|
| | Odds Ratio | 95% C.I. | Odds Ratio | 95% C.I. | Odds Ratio | 95% C.I. |
| **BMI (kg/m²):** | | | | | | |
| 18.5 ≤ BMI < 23.6 (Ref) | 1.00 | | 1.00 | | 1.00 | |
| 23.6 ≤ BMI < 27.4 | 1.19 | 0.84 - 1.68 | 1.32 | 0.77 - 2.28 | 1.53 | 0.80 - 2.91 |
| 27.4 ≤ BMI < 32.4 | 1.70 | 1.16 - 2.48 | 2.20 | 1.26 - 3.83 | 2.21 | 1.15 - 4.24 |
| BMI ≥ 32.4 | 3.22 | 2.30 - 4.52 | 3.79 | 2.28 - 6.29 | 4.02 | 1.94 - 8.33 |
| **Age:** | | | | | | |
| 20 - 39 (Ref) | 1.00 | | 1.00 | | 1.00 | |
| 40 - 59 | 5.54 | 3.78 - 8.14 | 10.53 | 6.64 - 16.69 | 11.20 | 5.79 - 21.67 |
| 60 & above | 27.60 | 19.12 - 39.55 | 57.64 | 34.91 - 95.16 | 114.68 | 60.06 - 218.96 |
| **Education:** | | | | | | |
| College Degree or More (Ref) | 1.00 | | 1.00 | | 1.00 | |
| Some College | 1.55 | 1.15 - 2.09 | 0.89 | 0.51 - 1.58 | 1.11 | 0.69 - 1.79 |
| HS Diploma or GED | 1.49 | 1.07 - 2.06 | 0.71 | 0.39 - 1.27 | 1.33 | 0.78 - 2.26 |
| Less than HS Diploma | 1.58 | 1.17 - 2.13 | 0.91 | 0.47 - 1.76 | 1.49 | 0.92 - 2.40 |
| **Income[1]:** | | | | | | |
| $100,000 & up (Ref) | 1.00 | | 1.00 | | 1.00 | |
| $75,000 - $99,999 | 0.78 | 0.47 - 1.31 | 1.46 | 0.77 - 2.77 | 1.28 | 0.44- 3.72 |
| $45,000 - $74,999 | 1.23 | 0.77 - 1.96 | 1.81 | 0.86 - 3.83 | 1.42 | 0.71 - 2.88 |
| $20,000 - $44,999 | 1.16 | 0.71 - 1.89 | 1.61 | 0.77 - 3.37 | 1.21 | 0.61 - 2.39 |
| < $20,000 | 1.48 | 0.81 - 2.69 | 2.36 | 1.10 - 5.05 | 1.79 | 0.83 - 3.84 |
| Unclassified Income | 1.03 | 0.47 - 2.23 | 1.59 | 0.60 - 4.22 | 1.48 | 0.71 -3.10 |
| **Smoking Status[2]:** | | | | | | |
| Never Ref) | 1.00 | | 1.00 | | 1.00 | |
| Past | 1.16 | 0.86 - 1.56 | 1.15 | 0.66 - 2.01 | 0.94 | 0.66 - 1.34 |
| Current | 0.94 | 0.70 - 1.27 | 1.16 | 0.69 - 1.95 | 1.09 | 0.67 - 1.77 |
| **Physical Activity[3]:** | | | | | | |
| High (Ref) | 1.00 | | 1.00 | | 1.00 | |
| Moderate | 1.10 | 0.74 - 1.64 | 1.05 | 0.53 - 2.06 | 0.58 | 0.36 - 0.92 |
| Low | 1.49 | 1.10 - 202 | 1.47 | 0.77 - 2.78 | 0.90 | 0.58 - 1.40 |

Odds ratios and 95% C.I.'s were calculated using multivariate logistic regression after adjusting for confounding in the covariates

# CHAPTER V

# DISCUSSION AND CONCLUSION

The purpose of this study was to investigate the strength of the association between BMI and hypertension in White, Black, and Hispanic Americans in the United States. If the relationship between BMI and hypertension were equivalent in these groups, it seems reasonable to expect that similar levels of BMI would be associated with similar prevalence rates of hypertension. The results of this research, however, show this not to be the case. While there was a small, insignificant difference in average BMI among the men, the prevalence of hypertension differed significantly between them. On an unadjusted basis, the overall prevalence of hypertension in African-American men was 35.9%, almost five points higher than in Whites, and nearly twice the 19.7% prevalence of hypertension in Hispanics. On an age-adjusted basis, it was even higher—39.5% for Blacks, versus 29.4% and 27.2% for Whites and Hispanics, respectively.

Small (but significant) differences existed in average BMI in women as well. But much more substantial differences in the prevalence of hypertension were apparent between them. The overall unadjusted prevalence of hypertension was 41.4% in Blacks, almost ten points higher than in Whites, and more than twice the rate in Hispanic females. The 42.8% age-adjusted prevalence in Black females was 52.9% higher than in Whites, and 62.7% higher than in Hispanic females.

When study participants were stratified into four BMI quartiles with an equal number of participants within each group, differences in the prevalence of hypertension were even more apparent. The age-adjusted prevalence of hypertension among Black men in the first quartile was 44.0% higher than in Whites, and 143.6% higher than in Hispanics. Similarly, women in the first quartile had an age-adjusted prevalence that was 28.4% higher than Whites and three times higher than Hispanics. The large differences in the prevalence disappeared in both men and women at higher levels of BMI, however. For example, in the fourth quartile of BMI in men, the difference in the prevalence of hypertension between Blacks and Whites was only 18.2%, considerably lower than the 44.0% prevalence difference in the first quartile.

Reasons for the sizable differences in hypertension are not clear. One reason could be that the body fatness reflected in BMI in Whites and Hispanics is greater than that at comparable levels of BMI in Blacks. If actual body adiposity (as measured with DXA, for example) were used to compare hypertension prevalence between groups, rates of hypertension would be much closer. The work of research teams headed by Crawley, Dagogo-Jack, Jackson, and Fernandez all support this idea.[24, 26, 27, 28]

In an effort to investigate this phenomenon further, logistic regression was used in models that compared the odds of hypertension in successively larger BMI quartiles to its odds in the first quartile. Univariate models that regressed hypertension on BMI, as well as multivariate models that included several covariables—age, education, income, smoking status, and physical activity—were developed to examine the hypertension-BMI relationship. In the univariate models, odds ratios in men were smaller for Blacks than for White men or Hispanics in all BMI quartiles. Thus, hypertension and BMI were associated in all three groups, but the association was weaker in Black men than in Whites or Hispanics. The results were not as consistently favorable in women, however. Univariate odds ratios were smaller for African-American women than for Whites or Hispanics in the second and fourth quartile, but not in the third, where Whites had the lower odds ratios. Hence, the association was weaker, in fact, in the second quartile ($26.3 \leq BMI < 27.4$) and the fourth ($BMI \geq 32.4$) for Black females, but White females had the weaker BMI-hypertension association in the third quartile ($27.4 \leq BMI < 32.4$). With the exception of one BMI quartile for males and one for females, all the associations were significant.

This writer has no doubt that differences in the physical anatomy of Whites, Blacks, and Hispanics played a role in these relationships. The literature reviewed for this study revealed that, in general, Blacks have more fat-free body mass, greater bone mineral density, more skeletal weight, and greater skeletal muscle mass than Whites or Hispanics.[30,31,34] These disparities could significantly affect BMI in the three racial/ethnic groups, as BMI equations are based on predominately white populations. As such, variations in body composition between White and non-White groups have practical significance. If these differences are ignored, significant errors could result in inaccuracies in relative body fat. Hence, the relationship between hypertension and the inadequately measured body fat parameter, in this case BMI, would be weak.

When age, education, income, smoking status, and physical activity were controlled for, odds ratios produced by multivariate logistic regression revealed that the BMI-hypertension association was weaker in Black men in the second and third quartiles than in Whites or Hispanics. Although it was not significant in the second quartile, the association was significant in the third. In females, the association *was* weaker in Black women than in Hispanics; however, it was weaker for Whites than for Black or Hispanic women overall.

As is normally the case, the multivariate models generally attenuated the results produced with the univariate models. In males, odds ratios decreased in all but one of the BMI quartiles when comparing univariate models to the analogous full, multivariate models. Reductions for female models were not as consistent as in men, where five of the nine odds ratios saw a decrease from univariate to full, adjusted model in women. As is evident from the odds ratios, age had the strongest impact on hypertension in both men and women in the multivariate models.

The results of this investigation were mixed. In men, BMI and hypertension had a weaker association at all BMI levels in Black men than in Whites or Hispanics when considering the unadjusted models with no covariables. When the models were adjusted for the effects of confounding in related variables, BMI and hypertension were more weakly associated in Black men than in White or Hispanic men at two different levels of BMI. In women, the assessment of the univariate models revealed that the BMI-hypertension relationship was weaker in Blacks than in Whites or Hispanics in the second and fourth BMI quartiles. Unfortunately, multivariate logistic regression that used all of the covariates indicated that the relationship was weaker in White women at all BMI levels after adjusting for confounding.

This study generally supports the author's hypothesis that the association of BMI and hypertension is weaker in African-American men than in other comparable groups.

In females, it corroborates the hypothesis on a univariate basis; however, it could not be proven on a multivariate basis.

This study does have some limitations. The findings cannot be generalized to the entire U.S. population because the NHANES surveys on which they were based oversampled both Black Americans and Hispanics. Second, they did not include any other racial/ethnic groups besides Whites, Blacks, and Hispanics. In addition, the subjects did not include participants who were under age 20. Still, given the high rate of hypertension and the potential of weight control to reduce prevalence, reduction in levels of BMI should be considered an important public health priority for Black, White, and Hispanic Americans.

## REFERENCES


1. CDC. Health, United States, 2008 (http://www.cdc.gov/nchs/hs.htm). Hyattsville, MD: National Center for Health Statistics; 2008.

2. National Institutes of Health. National Heart, Lung, and Blood Institute. Disease and Conditions Index. High Blood Pressure. http://www.nhlbi.nih.gov/health/dci/Diseases/Hbp.

3. Lloyd-Jones D, Adams RJ, Brown TM et al. Heart Disease and Stroke Statistics –2010 Update. A Report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. Circulation. 2010; 121:e1-e170.

4. National Institutes of Health Consensus Development Panel. Health Implications of Obesity: National Institutes of Health Consensus Conference Statement. Ann Intern Med. 1985; 103:1073-1077.

5. Haslam DW, James WP. Obesity. Lancet. 2005; 366:1197-1209.

6. Flegal KM, Carroll MD, Ogden CL, Curtin LR. Prevalence and Trends in Obesity among U.S. Adults, 1999-2008. JAMA. 2010; 303(3):235-241.

7. Romero-Corral A, Somers VK, Sierra-Johnson J, et al. Accuracy of Body Mass Index to Diagnose Obesity in the US Adult Population. Int J Obes. 2008; 32(6):959-966.

8. Garrow JS and Webster J. Quetelet's Index as a Measure of Fatness. Int J Obesity. 1985; 9:147-153.

9. Obesity: Preventing and Managing the Global Epidemic. Report of a WHO Consultation on Obesity, 3-5 June 1997. Geneva, Switzerland: World Health Organization, 1998.

10. Wellens RI, Roche AF, Khamis HJ, Jackson AS, Pollock ML, and Siervogel RM. Relationships between the Body Mass Index and Body Composition. Obesity Res. 1996; 4:35-44.

11. The Endocrine Society (2009, June22). Widely Used Body Fat Measurements Overestimate fatness in African-Americans, Study Finds. Science Daily. Retrieved February 3, 2011, from http://www.sciencedaily.com/releases/2009/06/090611142407.htm.

12. Flegal KM, Shepherd JA, Looker AC, et al. Comparisons of Percent Body Fat, Body Mass Index, Waist Circumference, and Waist-Stature Ratio in Adults. Am J Clin Nutr. 2009; 89:500-508.

13. Deurenberg P, Yap M, and van Staveren, WA. Body Mass Index and Percent Body Fat: A Meta Analysis among Different Ethnic Groups. Int J Obes Rel Metab Disord. 1998; 22:1164-1171.

14. Kannel WB, Brand N, Skinner JJ, et al. The Relation of Adiposity to Blood Pressure and Development of Hypertension: The Framingham Study. Ann Intern Med. 1967; 67:48-59.

15. Flegal KM, Carroll MD, Kuczmarski RJ, et al. Overweight and Obesity in the United States: Prevalence and Trends, 1960-1994. Int J Obesity. 1998; 22:39-47.

16. Stamler MA, Stamler J, Reidlinger WF, et al. Weight and Blood Pressure: Findings in Hypertension Screening of One Million Americans. JAMA. 1978; 240:1607-1610.

17. Dustan HP, Roccella EJ, and Garrison HH. Controlling Hypertension: A Research Success Story. Arch Intern Med. 1996; 156 (17):1926-35.

18. Quetelet A. A Treatise on Man and the Development of His Faculties. Burt Franklin; New York: Originally published in 1842. Reprinted in 1968.

19. Keys A, Fidanza F, Karvonen, MJ, Taylor, L. Indices of Relative Weight and Obesity. J Chronic Dis. 1972; 25(6):329-343.

20. Overweight Japanese with Body Mass Indexes of 23.0 – 24.9 Have Higher Risks for Obesity-Associated Disorders: A Comparison of Japanese and Mongolians. (http://cat.inist.fr/?aModele=afficheN&cpsidt=15705967).

21. Revision of Body Mass Index (BMI) Cutoffs in Singapore. (http://wwwhpb.gov.sg/hpb/default.asp?)

22. National Institutes of Health. National Heart, Lung, and Blood Institute. Clinical Guidelines on the Identification and Treatment of Overweight and Obesity in Adults: The Evidence Report. NIH Publication no. 98-4083. September 1998.

23. Are You Overweight? Using the New NIH Guidelines. (http://www.righthealth.com/topic/BMI_Guideslines/overview/).

24. Cawley, J and Burkhauser, RV. Beyond BMI: The Value of More Accurate Measures of Fatness and Obesity in Social Science Research. Journal of Health Economics. 2008; 27(2):519-529.

25. Abell JE, Egan BM, Wilson PWF, Lipsitz S, Woolson RF, and Lackland DT. Differences in Cardiovascular Disease Mortality Associated with Body Mass Between Black and White Persons. Am J Pub Hlth. 2008; 98(1):63-66.

26. Dagogo-Jack S and Ionica N. Widely Used Body Fat Measurements Overestimate Fatness in African-Americans, Study Finds. The Endocrine Society. 2009. (http://www.sciencedaily.com/releases/2009/06/090611142407.htm).

27. Jackson AS, Ellis KJ, McFarlin BK, Sailors MH, and Bray MS. Body Mass Index Bias in Defining Obesity of Diverse Young Adults: The Training Intervention and Genetics of Exercise Response (TIGER) Study. Br J Nutr. 2009; 102(7):1084-1090.

28. Fernandez JR, Moonseong H, Heymsfield SB, et al. Is Percentage Body Fat Differentially Related to Body Mass Index in Hispanic Americans, African Americans, and European Americans? Am J Clin Nutr. 2003; 77(1):71-75.

29. Gallagher D, Vissar M, Sepulveda D, et al. How Useful Is Body mass Index for Comparison of Body Fatness across Age, Sex, and Ethnic Groups? Am J Epidemiol. 1996; 143(3):228-239.

30. Merz AL, Trotter M, and Peterson RR. Estimation of Skeleton Weight in the Living. Am J Phys Anthropol. 1956; 14:589-609.

31. Seale RU. The Weight of the Dry Fat-free Skeleton of American Whites and Negroes. Am J Phys Anthropol. 1959; 17:37-48.

32. Trotter M, Broman GE, and Peterson RR. The Density of the Humeri of American Whites and Negroes. Leech. 1958; 28:139-143.

33. Cohn SH, Abesamis C, Zanzi I, Aloia JF, Yasumura S, and Ellis KJ. Body Elemental Composition: Comparison between Black and White Adults. Am J Physiol 1977; 232:E419-422.

34. Ortiz O, Russell M, Daley TL, et al. Differences in Skeletal Muscle and Bone Mineral Mass between Black and White Females and their Relevance to Estimates of Body Composition. Am J Clin Nutr. 1992; 55:8-13.

35. Cote K, and Adams WC. Effect of Bone Density on Body Composition Estimates in Young Adult Black and White Women. Med ci Sports Exerc. 1993; 25:290-296.

36. Schutte JE, Townsend EJ, Hugg J, Shoup RF, Malina RM, and Blomqvist CG. Density of Lean Body Mass Is Greater in Blacks than in Whites. J Appl Physiol. 1984; 56:1647-1649.

37. Hampton MC, Huenemann RL, Schapiro LR, Mitchell BW, and Behnke AR. A Longitudinal Study of Gross Body Composition and Body Conformation and their Association with Food and Activity in a Teen-age Population: Anhropometric Evaluation of Body Build. Am J Clin Nutr. 1966; 19:422-435.

38. Meneely GR, Heyssel RM, Ball COT, et al. Analysis of Factors Affecting Body Composition Determined by Potassium Content in 915 Normal Subjects. Ann N Y Acad Sci. 1963; 110:271-281.

39. Slaughter MH, Lohman TG, Boileau RA, Christ CB, and Stillman RJ. Differences in the Subcomponents of Fat-free Body in Relation to Height between Black and White Children. Am J Hum Biol. 1990; 2:209-217.

40. Harsha DW, Voors AW, and Berenson GS. Racial Differences in Subcutaneous Fat Patterns in Children Aged 7-15 Years. Am J Phys Anthropol. 1980; 53:333-337.

41. Hortobagyi T, Israel RG, Houmard JA, et al. Comparison of Four Methods to Assess Body Composition in Black and White Athletes. Int J Sport Nutr. 1992; 2:60-74.

42. Vickery SR, Cureton KJ, and Collins MA. Prediction of Body Density from Skinfolds in Black and White Young Men. Hum Biol. 1988; 60:135-149.

43. Malina RM. Regional Body Composition: Age, Sex, and Ethnic Variation. Human Kinetics. 1996; 217-255.

44. Harsha DW, Frerichs RR, and Berenson GS. Densitometry and Anthropometry of Black and White Children. Hum Biol. 1978; 50:261-280.

45. Zillikens, MC and Conway JM. Anthropometry in Blacks: Applicability of Generalized Skinfold Equations and Differences in Fat Patterning between Blacks and Whites. Am J Clin Nutr. 1990; 52:45-51.

46. Goran MI, Nagy TR, Treuth MS, et al. Visceral Fat in White and African American Prepubertal Children. Am J Clin Nutr. 1997; 65:1703-1708.

47. Himes JH. Racial Variation in Physique and Body Composition. Can J Sports Sci. 1988; 13:117-126.

48. Trotter, M and Hixon BB. Sequential Changes in Weight, Density and Percentage Ash Weight of Human Skeletons from Early Fetal Period through Old Age. Anat Rec. 1974; 179:1-18.

49. Lackland DT, Orchard TJ, Keil JE, et al. Are Race Differences in the Prevalence of Hypertension Explained by Body Mass and Fat Distribution? A Survey in a Biracial Population. Int J Epidemiol. 1992; 21(2):236-245.

50. Harris, MM, Stevens J, Thomas N, Schreiner P, and Folsom AR. Associations of Fat Distribution and Obesity with Hypertension in a Bi-ethnic Population: The ARIC Study.

51. CDC. National Center for Health Statistics. National Health and Nutrition Examination Survey. (http://www.cdc.gov/nchs/nhanes.htm). Hyattsville, MD: National Center for Health Statistics; 2011.

52. Klein RJ and Schoenborn CA. CDC Statistical Notes: Age Adjustment Using the 2000 Projected U.S. Population. CDC/National Center for Health Statistics. 2001; 20:1-9.

53. Seidell J. Environmental Influences on Regional Fat Distribution. Int J Obes. 1991; 15:31-35.

54. Duncan B, Chambless L, Schmidt M., et al. Correlates of Body Fat Distribution: Variations across Categories of Race, Sex, and Body Mass Index in the Atherosclerosis Risk in Communities Study. Ann Epidemiol. 1995; 5:192-200.

55. World Health Organization. Global Physical Activity Questionnaire Analysis Guide. Surveillance and Population-Based Prevention. Department of Chronic Diseases and Health Promotion. www.who.int/chp/steps

APPENDIX

**[1]Income:**

All other – Aggregated income that could not be classified into one of the other five categories

**[2]Smoking Status:**

Current – Participants indicated that they had smoked at least 100 cigarettes in life and that they smoked at the time of the survey.

Past – Participants answered that they had smoked at least 100 cigarettes in life, but that they did not currently smoke

Never – Participants indicated that they had not smoked at least 100 cigarettes in life and that they do not currently smoke

**[3]Physical Activity:**

- Based on metabolic equivalents (METs)
- One MET is defined as the energy cost of sitting quietly, and is equivalent to a caloric consumption of 1kcal/kg/hour
- Each minute spent during vigorous physical activity consumes eight (8) times as much energy as sitting quietly
- Each minute spent during moderate physical activity consumes four (4) times as much energy as sitting quietly

High – a person reaching either of the following:

➢ vigorous intensity activity on at least 3 days, achieving a minimum of at least 1,500 MET-minutes/week

➢ 7 or more days of any combination of walking, moderate, or vigorous intensity activities, achieving a minimum of at least 3,000 MET-minutes per week

Moderate – a person not meeting the standard for the "high" category, but meeting either of the following criteria:

- 3 or more days of vigorous intensity activity of at least 20 minutes per day
- 5 or more days of moderate intensity activity, walking, or bicycling at least 30 minutes per day
- 5 or more days of any combination of walking, bicycling, moderate or vigorous intensity activities, achieving a minimum of at least 600 MET-minutes per week

Low- a person not meeting any of the criteria above for "high" or "moderate"