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The Relationship Between Calcium Intake, Obesity, and Cardiovascular Disease Risk Factors: The Jackson Heart Study

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THE RELATIONSHIP BETWEEN CALCIUM INTAKE, OBESITY, AND CARDIOVASCULAR DISEASE RISK FACTORS: THE JACKSON HEART STUDY

by

Marjuyua Lartey-Rowser

A Dissertation
Submitted to the Graduate School
of The University of Southern Mississippi
in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy

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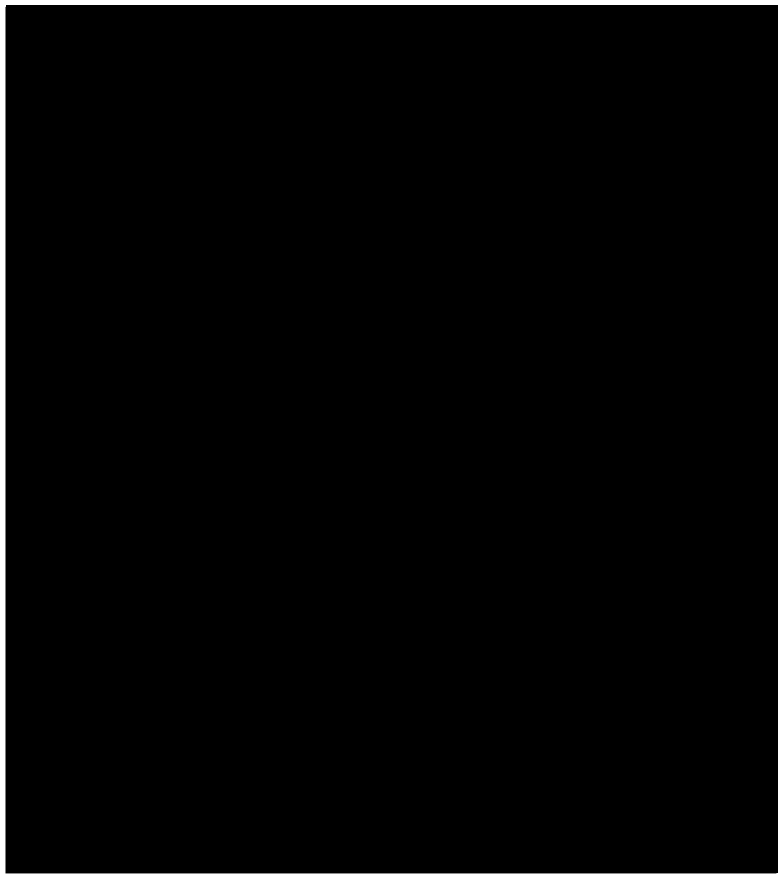

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ABSTRACT

THE RELATIONSHIP BETWEEN CALCIUM INTAKE, OBESITY, AND CARDIOVASCULAR DISEASE RISK FACTORS: THE JACKSON HEART STUDY

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Cardiovascular disease (CVD) is a major health risk in the United States. Major indicators of CVD risk include obesity, blood lipids, and blood pressure. Modifiable risk factors associated with CVD include body composition (body mass index and waist circumference), serum lipids, and blood pressure. Data suggest calcium intake may play a role in regulation of weight, serum lipids, and blood pressure. The purpose of this study was to assess relationships of dietary calcium intake with weight status, and cardiovascular disease risks in African American population participating in the Jackson Heart Study.

The subjects included 4,267 African American adults ages 21-95 years (mean = 55.1±12.6 years) in the Jackson Heart Study (JHS). Dependent variables included: body mass index (BMI) calculated from measured height/weight (stadiometer/balance scale), waist circumference (WC; measuring tape), serum lipids, and blood pressure (sphygmomanometer). A 158-item food frequency questionnaire (FFQ) was used to assess nutrient intake. Statistical analyses included multiple regression analysis and Pearson correlations using SPSS 16.0 (SPSS Inc. Chicago, IL, USA).

There was a significant positive relationship between calcium intake and the body composition measure BMI [$F\ (4, 3982) = 3.26, p = 0.019, \Delta R^2 = .003$] and a significant inverse relationship between calcium intake and WC [$F\ (4, 3982) = 2.43, p = 0.05, \Delta R^2 =$

.002]. These relationships were also observed in females only when data were analyzed by gender. There were significant inverse relationships between calcium intake and total cholesterol (TC) [F (4, 4259 = 5.46, p = 0.266, ΔR^2 = .002] and LDL-cholesterol (LDL) [F (4, 4225) = 3.218 p = 0.01, ΔR^2 = .003]. There were also significant inverse correlations between total cholesterol (TC) and LDL and calcium for males only. There was a significant relationship between calcium intake and HDL-cholesterol [F (4, 4259) = 13.31, p <0.001, ΔR^2 = .012], as well as significant a positive relationship between HDL and calcium from supplements and a significant negative relationship between HDL and non-dairy calcium consumption. There was a significant positive relationship between total calcium intake and systolic blood pressure (SBP) [F (4, 3986) = 4.74, p = 0.001, ΔR^2 = .004], as well as a significant relationship between calcium intake and diastolic blood pressure (DBP) [F (4, 3986) = 4.84, p = 0.01, ΔR^2 = .005]. The direction of this relationship varied with the calcium source. There was no association between calcium intake and triglycerides.

While significant negative associations were noted between dietary calcium intake and WC, TC, LDL, and SBP for JHS participants, and significant positive associations between dietary calcium and BMI, HDL, and DBP, the magnitude of the relationships was small. This can be related to several factors including the true predictive power of calcium for CVD risk factor measures (which may be highly multifactoral) and the large sample size. Data from this study suggest the need for additional research in African American populations on the potential relationship between calcium intake and BMI, WC, serum lipids, and blood pressure.

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LIST OF ABBREVIATIONS

ACC: American College of Cardiology

AHA: American Heart Association

BRFSS: Behavioral Risk Factor Surveillance System

BMI: Body mass index

BP: Blood pressure

Ca: Calcium

CDC: Centers for Disease Control and Prevention

CHOL: Cholesterol

CMR: Cancer mortality rates

CSFII: Continuing Survey of Food Intakes by Individuals

CVD: Cardiovascular Disease

DASH: Dietary Approaches to Stop Hypertension

DBP: Diastolic blood pressure

DPASS: Diet and Physical Activity Sub-Study

FDA: Food and Drug Administration

FFQ: Food Frequency Questionnaire

FOODS: Foods of Our Delta Study

HDL: High-density lipoprotein cholesterol

HDMR: Heart disease mortality rate

HEI: Healthy Eating Index

HTN: Hypertension

IMR: Infant mortality rate

JHS: Jackson Heart Study

LDL: Low-density lipoprotein cholesterol

LEF: Life expectancy figures for females

LEM: Life expectancy figures for males

LFFQ: Long Food Frequency Questionnaire

MR: All-cause mortality rate

NHANES: National Health and Nutrition Examination Survey

NHLBI: National Heart, Lung and Blood Institute

SBP: Systolic blood pressure

SES: Socioeconomic status

SFFQ: Short Food Frequency Questionnaire

TC: Total Cholesterol

TG: Triglycerides

US: United States

VLDL: Very low-density lipoprotein

WC: Waist circumference

WHO: World Health Organization

CHAPTER I

INTRODUCTION

Cardiovascular disease (CVD) is a major health risk in the United States (U.S.). CVD encompasses the first and third leading cause of death – heart disease and stroke. While nearly one-fourth of the American population lives with CVD, over 927,000 people die with CVD yearly (Centers for Disease Control and Prevention [CDC]- "Heart Disease,"n.d.; Grundy et al., 1998). African Americans suffer the greatest among ethnicities with the highest overall CVD mortality rates in the US ("Third Report", 2002). Of total deaths for African Americans, 33.4% are due to CVD. Not only that, in African American women rates of CVD-related death supersede rates of cancer-related deaths in every age group.

There are several major controllable risk factors for CVD including hypertension, high blood cholesterol, and obesity (CDC – "Heart Disease," n.d.; "Third Report", 2002). Blood pressure and blood lipids are major indicators of CVD. Hypertension (HTN) is defined as a systolic blood pressure greater than 140 mm Hg or diastolic blood pressure greater than 90 mm Hg. Elevated serum total cholesterol and low-density lipoprotein (LDL) cholesterol, defined as having a total cholesterol reading of greater than 240 mg/dL and LDL > 190 mg/dL, low serum high density lipoprotein cholesterol (HDL), defined as HDL < 40 mg/dL, and elevated triglycerides greater than 200 mg/dL are major independent risk factors for CVD (CDC – "Heart Disease," n.d.; "Third Report", 2002). Obesity and physical activity are labeled by the American Heart Association (AHA) and the American College of Cardiology (ACC) as predisposing risks or risks that will

exacerbate the independent risk factors. Because of this, the AHA has also designated both obesity and physical activity as major risk factors for heart disease (Grundy, Pasternak, Greenland, Smith, & Fuster, 1999).

Obesity and overweight are collectively a global epidemic. The World Health Organization (WHO) reports that 1.6 million people over the age of 15 are overweight and 400 million adults (defined by the WHO as age 15 or older) are obese (Centers for Disease Control and Prevention [CDC]– "Obesity and Overweight," n.d.). The prevalence of obesity in the US has risen three-fold in the last 20 years. In 1991, only 8% of the states reported obesity rates at or above 15% compared to 92% of states reporting obesity rates greater than 20% in 2005 (Centers for Disease Control and Prevention [CDC] – "US Obesity," n.d.) . More specifically, the National Health and Nutrition Examination Survey (NHANES) for 2003 – 2004 reported that the prevalence of overweight and obesity for adults ages 20 and over was 66.3% and 32.2%, respectively (Centers for Disease Control and Prevention [CDC] – "Prevalence of Overweight," n.d.).

Overweight in adults is defined as having a body mass index (BMI) of 25 – 29.9, and obesity as having a BMI of 30 or more (CDC – "Obesity and Overweight," n.d.). The prevalence of overweight and obesity is increasing among all ethnic backgrounds in the US. However, this increase is disproportionate in African American and Hispanic populations. Longitudinal data on the development of increased body mass index and the prevalence of obesity indicates that the increase in obesity rates in women has been greatest among African American women, followed by Hispanics, then Whites. Similar findings within that same data were indicated in African American men. African Americans also had the highest odds for obesity onset compared to other ethnic groups

(McTigue, Garrett, & Popkin, 2002). Similarly, NHANES data indicate that obesity prevalence has nearly doubled among African American men and women– from 16.5% in 1976-1980 to 31.2% in 2000-2004 for males and from 31.0% in 1976-1980 to 51.6% in 2000-2004 for females (Centers for Disease Control and Prevention [CDC} – "Table 68," n.d.).

The causes of obesity are related to hereditary, environmental, and psychosocial influences including genetics, behavior, culture, and socioeconomic status. Some of these causes associated with obesity and overweight can be addressed. Eating behaviors and physical activity are among the two causes associated with obesity and overweight that are modifiable. Obesity is also directly associated with an energy imbalance – energy consumed exceeds energy expended. Because of this core association, the increased prevalence of obesity in the US has been attributed to many factors including increased consumption of sweetened beverages, decreased physical activity, and increased consumption of high calorie, high fat foods (CDC – "Obesity and Overweight," n.d.).

Historically, an increase in weight is associated with increased macronutrient intake like lipids, proteins, carbohydrates. Klesges, Klesges, Haddock, and Eck (1992) conducted a longitudinal study that addressed the relationship between eating, physical activity, and changes in body weight among 294 Caucasian adult men and women. This study examined dietary intake, diet composition, physical activity, smoking and alcohol consumption in this population. In this study, higher fat intake as well as the percent of energy from fat was associated with increased body mass index among both men and women. Lahti-Koski, Pietinen, Heliövaara and Vartiainen (2002) examined similar variables in a 15 year longitudinal study. These data related obesity to specific types of

foods consumed rather than to the macronutrients. There were positive associations with the consumption of sausage, milk, and sour milk to obesity in both men and women. There were inverse associations noted with vegetable consumption and obesity in both groups. This may indicate that food items higher in fat had a greater association with obesity than those lower in fat. Another study identified predictors of weight gain among 826 women and 218 men. Among female participants, total energy intake was positively associated with body weight. In addition, there was an association between dietary intake of fat and weight gain among both men and women (Sherwood, Jeffery, French, Hannan, & Murray, 2000). In recent years, there has been a shift in the study of nutrients associated with weight increases. Micronutrients are now being considered as contributing factors for overweight and obesity (Rajpathak, Rimm, Rosner, Willett, & Hu, 2006). Calcium, in particular, has been a nutrient of interest in recent research.

Calcium is one of the most abundant minerals in the body and is essential to bone and teeth health, muscle and nerve activity and other body functions. While the chief functions of calcium have been clearly identified, there are additional functions that are still actively being investigated. Calcium is hypothesized to play a role in weight reduction and weight maintenance. Particularly, there has been an inverse association noted between calcium intake and weight in the literature. Emerging research in animal and human models has shown inverse associations between dietary calcium and dairy products intake and weight, and positive associations between dietary calcium and stimulated lipolysis (Heaney, 2006; Teegarden, 2003; Teegarden, 2005; Zemel, Richards, Milstead, & Campbell, 2005; Zemel, Shi, Greer, Dirienzo, & Zemel, 2000).

Calcium intake is thought to impact body weight (Heaney, 2006; Teegarden, 2003; Teegarden 2005) either by decreasing available energy or increasing energy utilization. Decreasing available energy is hypothesized to occur through two processes: by increasing satiety or decreasing the absorption of fatty acids (through the formation of calcium/fatty acid soaps in the intestine) (Heaney, 2006; Teegarden, 2003; Teegarden, 2005; Zemel, Thompson, Milstead, Morris, & Campbell, 2004). More data are available to support the fecal fat loss theory related to decreased energy availability than for the increased satiety theory. Studies that measure the effect of dietary calcium on fecal fatty acid excretion account for observed weight loss in human studies (Jacobsen, Lorenzen, Tourbo, Krog-Mikkelsen, & Astrup, 2005; Heaney, 2006; Teegarden, 2003; Teegarden, 2005; Zemel et al., 2004). Jacobsen et al. (2005) conducted an experimental study on 10 individuals using three isocaloric diets containing low calcium and normal protein intake (500 mg Ca, 15% of energy from protein), high calcium and normal protein intake (1,800 mg Ca, 15% of energy from protein), and high protein and high calcium intake (1800 mg calcium, 23% of energy from protein). The calcium and protein was obtained using mainly low-fat dairy products. The study used a randomized crossover administration of each diet for one week intervals for all participants. In this study, there was a positive correlation between calcium consumption and fecal fat excretion. Fecal fat content increased 2.5 fold during the consumption of the high calcium, normal protein phase as compared to the other diets (14.2 ± 6g versus 6.0± 2g and 5.9± 2g for low calcium/normal protein and high calcium/high protein respectively; $p=0.05$). The proportion of fat excreted while participants were on the low calcium, normal protein and high calcium, high protein diets was less than that from the high calcium, normal protein

diet (7.3 ±3%, 7.5 ±3%, and 18.0 ±8%, respectively). Fecal calcium excretion was also noted. High calcium, normal protein diets and high calcium, high protein diets had higher fecal calcium excretion than the other group (Jacobsen et al., 2005). In a similar study, where dietary calcium intake was compared to supplemental calcium intake (using calcium citrate malate fortification and supplementation), researchers designed the diets to include varied calcium levels and 11% of energy from protein. The low calcium diet consisted of 410 mg of calcium, 34% of energy from fat and the high calcium diet consisted of 2,200 mg of calcium from fortified food items and two supplement tablets. As seen in the Jacobsen study (2005), there was a two-fold increase in fatty acid excretion in the higher calcium diet period compared to the low calcium diet period. Excretion of dietary saturated fatty acids increased from 6% on the low calcium diet to 13% on the high calcium diet (Denke, Fox, & Schulte, 1993). These two studies indicate that higher calcium intakes, whether through calcium supplementation or increase in low fat dairy products increase fecal fatty acid excretion in humans and reflect changes in fatty acid metabolism.

The second proposed mechanism addresses energy utilization (metabolism). This concept explains that the impact of increased intakes of dietary calcium (about 400 to 1,000 mg/day) on energy utilization is related to increased lipolysis and lipid oxidation or the regulation of parathyroid hormone (PTH) and 1,25 dihydroxyvitamin D [1,25 $(OH)_2D$] by calcium (Heaney, 2006; Teegarden, 2003; Teegarden, 2005; Zemel et al., 2004). The most cited mechanism of the two explanations is the latter: calcium's regulation of the PTH and 1, 25 $(OH)_2D$ (Heaney, 2006; Rajpathak et al., 2006; Teegarden, 2003; Teegarden, 2005; Zemel et al., 2004).

Intracellular calcium is believed to be highly correlated with obesity. Calcium channel agonist and agouti protein, an obesity gene product expressed in human adipocytes, act to stimulate calcium influx and the expression of fatty acid synthase (a core enzyme in *de novo* lipogenesis) and inhibit lipolysis in human. This implies that intracellular calcium impacts adipocyte energy storage (Kim et al., 1997; Wang et al, 2004; Zemel, Shi, Greer, Dirienzo; Zemel, 2000; Zemel, 2001). PTH and 1,25 $(OH)_2D$, which act to increase serum calcium concentration and to maintain serum calcium homeostasis, work to increase the intracellular calcium in adipocytes. It is believed that increases in 1,25 $(OH)_2D$ and/or PTH due to decreases in dietary calcium can lead to the stimulation of lipogenesis, inhibition of lipolysis, and the storage of triglycerides in human adipocytes. (Heaney, 2006; Kim et al., 1997; Rajpathak et al., 2006; Teegarden, 2003; Teegarden, 2005; Zemel et al., 2000; Zemel, 2001; Zemel et al., 2004). If this process is indeed effective in human adipocytes, increases in dietary calcium should suppress the effects of PTH and 1,25 $(OH)_2D$. This leads to the conclusion that increased intake of calcium may have an "antiobesity effect" (Rajpathak et al., 2006; Zemel et al., 2004).

Although the initial report of the association between calcium and body weight was based on the first NHANES in the 1980s, only in the past 10 years has there been a greater concentration of research on the evaluation of this relationship in the literature (Azadbakht, Mirmiran, Esmailzadeh, & Azizi, 2005; Jacqmain, Doucet, Despres, Bouchard, & Tremblay, 2003; Teegarden, 2003; Teegarden, 2005). Inverse associations have been identified between calcium intake and weight status, calcium intake and lipoprotein-lipid concentration, and calcium intake and diastolic and systolic blood

pressure. This association is not only seen in dietary calcium intake and dairy foods but it is also evident in calcium supplementation (Azadbakht et al., 2005; Heaney, 2006; Jacqmain et al., 2003; Teegarden, 2003; Teegarden, 2005).

Recent studies have explored the relationship between dietary calcium, blood pressure levels, blood lipid concentrations and obesity to determine if there is a pattern of inverse associations between calcium intake and the major CVD risk factors. In a study conducted to examine the association between calcium intake, body composition and lipoprotein-lipid concentrations in 470 adults ages 20-65 years, participants in the Quebec Family Study were divided into three groups based on calcium reference intakes: group A (<600 mg/d), group B (600 – 1,000 mg/d), and group c (>1,000 mg/d). After adjusting for body composition, age, socioeconomic status (SES), dietary energy intake, percentage dietary fat, and dietary protein, women in the lowest calcium consumption group had higher body weights, BMI, percentage body fat, fat mass, waist circumference (WC), and abdominal adipose tissue than those in the other groups. Negative correlations were noted between calcium intake and percentage body fat, BMI, fatness, fat-free mass and WC in women. No significant associations were noted for men. There were inverse relationships noted between dietary calcium intake and plasma lipoprotein-lipid profile measures after controlling for other variables including fat mass and WC. (Jacqmain et al., 2003).

Azadbakht, Mirmiran, Esmailzadeh, and Azizi (2005) addressed dairy consumption and its association with metabolic syndrome in 827 Tehranian adults aged 18 – 74 years. Participants were grouped according to dairy intake into quartiles: quartile 1 (1.7 servings per day of dairy foods), quartile 2 (1.7 - < 2.3 servings per day), quartile 3 (2.3 - <3.1 servings per day), and quartile 4 (≥ 3.1 servings per day). Those in the highest

quartile for dairy were less likely to have enlarged WC and metabolic syndrome and had lower systolic and diastolic blood pressure, and lower BMI than the other groups. The prevalence of metabolic syndrome was greatest in those in quartile 1. Although there were no differences in serum triacylglycerol among groups, HDL was significantly lower in quartiles 1 through 3 than in quartile 4.

The studies reviewed here suggest an association of calcium/dairy intake with body composition, blood lipid concentrations, and metabolic health. The association between calcium intake and obesity is an important relationship to explore further in all populations but particularly in those with high rates of obesity such as African Americans. Identifying a connection between obesity and calcium intake may be pivotal in addressing the problem of obesity in this ethnic group. Only a few studies to date have examined the relationship between calcium and dairy consumption and body composition in African Americans. Lovejoy, Champagne, Smith, de Jonge, and Xie (2001) found an inverse relationship between body fat and dietary calcium intake in a sample of 52 middle-aged, premenopausal African American women. Zemel et al. (2005) conducted two randomized trials in obese African American adults. In a 24-week weight maintenance trial, subjects consuming a high dairy diet (1,200 mg Ca, 3 servings dairy/day) demonstrated decreased total body fat, trunk fat and blood pressure and increased lean mass compared to no changes in the low dairy (500 mg Ca, <1 serving dairy/day) diet group. In a weight loss trial with a caloric restriction (-500 kcal/day), both high dairy and low dairy groups lost weight and body fat, but weight and fat loss were significantly greater and lean loss significantly less for those on the high dairy diet.

Loos et al. (2004) conducted a study that included both African American and

white American males and females. The study examined the relationship between calcium intake and body composition. The results of this study indicated that African American males and females had significantly lower intakes of calcium than the white American participants. Additional results were based on the division of participants into energy-adjusted tertiles based on calcium consumption (low, intermediate, and high). African American participants' BMI, percent fat, skinfold, total abdominal fat, abdominal visceral fat, abdominal subcutaneous fat, and WC decreased as calcium intake increased. Among the white American participants, a decrease in percent fat was noted in males and a significantly inverse association was noted between calcium tertiles and BMI, percent fat, total abdominal fat, abdominal visceral fat and abdominal subcutaneous fat ($p=0.03$) for females.

This study showed that African American females with the highest calcium intake had a higher BMI and WC than those in the lower calcium groups as well as greater fat free mass than other groups. In African American males, the prevalence of obesity and overweight decreased significantly with increase in calcium intake ($p=0.018$). In white Americans, males exhibited similar trends in weight as seen in African American males for obesity only although not significant. For white American females, no significant associations were noted for overweight and obesity (Loos et al., 2004).

Cardiovascular disease is the number one killer of African Americans. Blacks are nearly twice as likely to die from heart disease as their white counterparts (American Heart Association [AHA], 2008). Minorities and low-income populations are disproportionately affected by CVD. Because of the significance of the impact of heart disease on the African American population and recent research suggesting that calcium

intake may affect factors related to heart disease, there is a need for research to evaluate the relationship in the African American population of calcium intake with body composition and cardiovascular disease risk factors. The purpose of this study is therefore to examine the relationship between calcium intake, and obesity, dyslipidemia, and hypertension in participants of the Jackson Heart Study.

The Jackson Heart Study (JHS) is an epidemiological study of CVD risks in an African American population in Mississippi. The JHS began its investigation in 2000. The JHS offers a unique opportunity to examine associations between diet and many health issues in a population of people who have been historically leery of research. The study design, protocols, and participation rates are described elsewhere (Taylor, 2005; Taylor et al., 2005).

Statement of the Problem

Relationships of calcium intake with obesity and cardiovascular disease risk factors have been observed in several different populations (Azadbakht et al., 2005; Lovejoy et al., 2001; Zemel et al., 2005). Research exploring these relationships in African American adults is limited. Because obesity is pandemic and cardiovascular disease is the leading cause of death and disability among African Americans, an investigation into the relationship of calcium intake with obesity and cardiovascular disease may add significantly to the body of knowledge related to these chronic diseases in this population, and offer insights related to future intervention and prevention efforts.

Using dietary data collected in the Jackson Heart Study, the researcher will assess relationships among three main factors: calcium intake, overweight/obesity status, and

cardiovascular disease risk factors (serum lipids and hypertension) in an African American population.

Research Objectives

In order to fully address the research objectives, the following research objectives were developed:

1. Describe JHS participants in terms of BMI and WC, serum lipid status and blood pressure.
2. Describe the nutrient intake of JHS participants, including macronutrient intake and calcium intake (total calcium and dietary calcium intakes).
3. Assess the association of calcium intake with body mass index and waist circumference measures.
4. Assess the association of calcium intake with serum lipids and blood pressure.

Assumptions

1. The Jackson Heart Study participants followed instructions for fasting prior to blood collection and measurement of blood pressure.
2. The Jackson Heart Study participants gave accurate accounts of their food consumption.
3. The Jackson Heart Study data collectors followed established protocols for data collection including height and weight measures, waist circumference measures, and dietary intake.
4. All biochemical analyses were accurate and precise.

Limitations

1. The dietary data collected are self-reported data from study participants.
2. Subjects in this study were recruited from a tri-county area in central Mississippi – Madison, Rankin, and Hinds Counties. The information collected may not be generalizable to other African American communities.

Significance of Study

There is very little literature available to assess the association of calcium intake with weight status and cardiovascular disease risk factors among African Americans. While the association between calcium intake and obesity has been observed in other populations, the African American population is one that suffers considerably from the disease. The last 20 years have shown an increased prevalence of adults with BMI >25. In the African American population, greater than 70% of adults are overweight or obese (BMI>24.9). This study would also be one of a few to address the role of dietary calcium intake as a predictor for cardiovascular disease in any population or cultural group. Healthy People 2010 addressed the problem of obesity as well as heart disease for Americans with a planned reduction rate of 15% for obesity for all Americans and of deaths from heart disease among African Americans by 30% (U.S. Department of Health and Human Services [USDHHS], 2000). As the prevalence of obesity increases and the prevalence of heart disease is still significantly high, meeting these goals may be difficult to attain without better understanding of preventable factors related to CVD.

The JHS presents a unique opportunity to study relationships between dietary intake and heart disease among an ethnic group that is so often underrepresented in research. The significant amount of health disparities experienced by this group is crucial

and should be addressed. This research may provide information that could improve healthcare for African Americans, as it explores the relationship between specific dietary components, overweight and obesity, and cardiovascular disease risks. The formulation of a link between calcium intake, obesity, and cardiovascular disease risk may lead to the development of theories and guidelines addressing eating behaviors in African American populations, similar to other population based studies as the Framingham Heart Study.

Definition of Terms

Jackson Heart Study – an observational epidemiological study investigating environmental and genetic factors that influence the progression of CVD in African Americans

Lipolysis – the hydrolysis of fats to glycerol and fatty acids

Lipogenesis - a collective name for the complex process of producing lipids from smaller precursor molecules

Metabolic Syndrome - a set of risk factors that includes: abdominal obesity, a decreased ability to process glucose (insulin resistance), dyslipidemia (unhealthy lipid concentrations), and hypertension

Milk Calcium – a sum of dietary calcium intake from milk only which had been consumed by an individual JHS participant and reported on the dietary intake record

Non-milk Dairy Calcium – a sum of dietary calcium intake from dairy sources other than milk which had been consumed by an individual JHS participant and reported on the dietary intake record

Non-dairy Calcium – a sum of dietary calcium intake from foods other than dairy foods that contain calcium, including vegetables, beans, fish, fortified foods and beverages, which had been consumed by an individual JHS participant and reported on the dietary intake record

Supplement Calcium – a sum of calcium intake from supplements including one-a-day type vitamins or a calcium supplement which had been consumed by an individual JHS participant and reported on the dietary intake record

Total Dietary Calcium – a sum of dietary calcium intake calculated from every food, beverage, and supplement source containing calcium which had been consumed by an individual JHS participant and reported on the dietary intake record

CHAPTER II

REVIEW OF LITERATURE

Health Status in America

Cardiovascular disease (CVD) is a major health risk in the United States (U.S.). CVD encompasses the first and third leading causes of death – heart disease and stroke. While nearly one-fourth of the American adult population lives with CVD, over 927,000 people die with CVD yearly (CDC – "Heart Disease," n.d.; Grundy et al., 1998). There are several key risk factors for CVD including hypertension, high blood cholesterol, and obesity. Recent studies show that during 1999–2000, nearly 30% of U.S. adults had hypertension, and of those with High blood cholesterol over 80% of them did not have it under control (Centers for Disease Control and Prevention [CDC] – "Fact Sheet," n.d.; Centers for Disease Control, 2005).

Approximately 105 million adults have high blood cholesterol. High blood cholesterol has long been identified as a major risk factor for CVD. Because of this, health care providers have endeavored to reduce the prevalence of high blood cholesterol through screening and by increasing public awareness. Healthy People 2010 objectives have established two national objectives to address high blood cholesterol to reduce to 17% the number of American adults with high total cholesterol and to increase to 80% the number of American adults who had their blood cholesterol checked in the preceding five years (USDHHS, 2000). The CDC has analyzed data from the Behavioral Risk Factor Surveillance System (BRFSS) collected during 1991—2003 (Centers for Disease

Control [CDC], 2005a). The data was analyzed to examine trends in the percentage of adults screened for high blood cholesterol and the percentage of those screened who were told they had high blood cholesterol. BRFSS participants were asked if they had ever had a blood cholesterol screening and, if so, how long it had been since their last screening. Approximately 73.1% of the participants in 2003 reported they were screened for high blood cholesterol in the last 5 years. The overall percentage of those participants who had been screened and were told they have high blood cholesterol was 31.1% (CDC, 2005a).

In 2005, BRFSS data were collected. The BRFSS data collection process included all 50 states; the District of Columbia, Commonwealth of Puerto Rico, and the US Virgin Island were represented. It included 153 selected metropolitan and micropolitan statistical areas (MMSA) and 232 selected counties. Those participants who noted that they had been informed by a healthcare professional that their blood cholesterol was elevated were classified as having high blood cholesterol. The prevalence of high blood cholesterol from the BRFSS data ranged from 30.9% in Louisiana to 40.6% in West Virginia. Those who had recently checked their cholesterol levels ranged from 55% to 85% (Chowdhury et al., 2007).

High blood pressure increases the risk for heart disease and stroke and affects approximately one in three American adults (CDC – "Fact Sheet," n.d.). In an effort to address the issue of hypertension (HTN), Healthy People 2010 includes reducing the proportion of adults with hypertension to 16%, increasing the proportion of adults with hypertension who are taking action to control it to 95%, and increasing the proportion of adults with controlled BP to 50% as objectives in the collective attempt to address health in the US (Centers for Disease Control, 2005b). The CDC analyzed data from National

Health and Nutrition Examination Survey (NHANES) collected for 1999 – 2002 which included data on HTN. The survey participants consisted of 7,000 U.S. adults aged ≥20 years and the 5,000 respondents who completed the health examination. In this study, HTN was defined as having an average blood pressure of 140/90 mm Hg (systolic over diastolic blood pressure) or taking blood pressure medication. People considered to have hypertension were "1) aware of their condition if they reported in the interview that a health-care professional had told them their blood pressure was high, 2) been treated if they reported using antihypertensive medication, and 3) controlled blood pressure if they were hypertensive but their BP measurements were <140/90 mm Hg" (CDC, 2005b). Of the participants in NHANES, 28% of participants had been diagnosed with high blood pressure. Of those diagnosed, 63.4% had been informed that they had high blood pressure (CDC, 2005b). The most recent BRFSS also looked at HTN from the stand point of those who had been informed that they had HTN by a healthcare professional (HTN during pregnancy was not included). In 2005, the percentage of BRFSS participants that had identified HTN ranged from19.2% in Utah to 34.8% in Mississippi. Among the MMSA, diagnosed HTN rates ranged from 13% to 39% (Chowdhury et al., 2007). According to the American Heart Association's Heart Disease and Stroke Statistics – 2005 Update, 42% of non-Hispanic black men and 45% of non-Hispanic black women were reported to have HTN (systolic blood pressure > 140 mm Hg or diastolic blood pressure > 90 mm Hg) (AHA, 2005).

Prevalence of Obesity

The prevalence of obesity in the US has greatly increased in the last 20 years. The prevalence of obesity changed from having only four of the fifty states with obesity rates

at 15 – 19 % in 1991 to having only four states with obesity rates less than 20% in 2005 (CDC – "US Obesity," n.d.) . Obesity not only impacts the US, but it has also become a global epidemic. The World Health Organization (WHO) reports that globally 1 billion adults are overweight and 300 million adults are obese (World Health Organization [WHO], n.d.). When we focus specifically on adults in the US, the change in weight status over the years is evident and significant. According to National Health and Nutritional Examination Survey (NHANES) data for 2003 – 2004, the prevalence of overweight and obesity for adults ages 20 and over is 66.3% and 32.2%, respectively (CDC – "Prevalence of Overweight," n.d.). The 2005 BRFSS data collected on people greater than 20 years of age shows similar statistics. With body mass index (BMI) calculated from self-reported heights and weights, overweight/obesity (BMI≥25) prevalence ranged from 53% in Hawaii to 67.3% in Mississippi and obesity (BMI≥30) prevalence ranged from 18.2% in Colorado to 31.8% in Louisiana (Chowdhury et al., , 2007). Obesity appears to be a link to the majority of the health conditions in Americans. It has been well documented that obesity is a key contributor to morbidity and mortality associated with such illnesses as coronary artery disease, hyperlipidemia, hypertension, diabetes mellitus, and cancer of the esophagus, pancreas, prostate and stomach. (Greenberg & Schneider, 1998; Young-Hyman, Herman, Scott, & Schlundt, 2000).

The prevalence of overweight and obesity is increasing among all ethnic backgrounds in the US. African American adults appear to be at greater risk for overweight and obesity compared to most other ethnic groups. Overweight and obesity in the US African American population has also increased significantly over the years. Overweight in this population increased from 51.3% in 1976-1980 to 66.8% in 2001-

2004 for males and from 62.6% in 1976-1980 to 79.5% in 2001-2004 for females. The prevalence of obesity in the same time periods increased from 16.5% to 31.2% for males and from 31.0% to 51.6% in females. When considering all race/ethnicity/sex groupings among Non-Hispanic whites, Non-Hispanic Blacks, and Mexican Americans, Non-Hispanic Black females appear to the most obese (CDC – "Table 68," n.d). Longitudinal data on the development of body mass and obesity indicates that the increase in obesity rates in women have been the greatest among African American women, followed by Hispanics then Whites. Similar findings within that same data were indicative in African American men. This study also found that African Americans had the highest odds for obesity onset than other ethnic groups (McTigue, Garrett, & Popkin, 2002).

In adults, obesity is defined as a BMI of 30 or greater and overweight is defined as 25 to 29.9 (CDC – "Overweight and Obesity, n.d.). Overweight is the excess of body weight in association with a set of standard references. Obesity is an excessively high proportion of body fat that is considered abnormal. Even though overweight and obesity are used interchangeably in the general public, these terns are not mutually exclusive. A person who is overweight may not be obese; however, a person who is obese is overweight (National Institutes of Health [NIH], 1998).

Obesity Measures

Body fat and obesity are assessed through physical measurements of an individual. These measures are in turn related back to an established standard that will reflect a classification of health. Body composition can be assessed by indirect and direct methods including: skin-fold thickness, circumference measurements – midarm circumference and WC (indirect measures), underwater weighing, total body potassium,

bioelectrical impedance analysis – dual-energy x-ray absorptiometry, air displacement plethysmogram (direct measures) (NIH, 1998; Engelen, Schols, Heidendal, & Wouters, 1998; Probst, Goris, Vandereycken, & Van Coppenolle, 2001; Sainz & Urlando, 2003). These methods are very effective in estimating body composition; however, the direct measures are expensive and not always readily available. Therefore, BMI and WC are more practical and affordable measurements of body composition and body fat (CDC – "Healthy Weight," n.d.).

BMI, which is defined as weight in kg divided by height in meters squared, is a validated nutrition status measure. It is easy to use and readily available. It is used to define adiposity in relation to height. BMI classifies health status where a BMI of 18.5 – 24.9 kg/m^2 identifies healthy weight, one of 25 to 29 kg/m^2 indicates overweight, and one of 30 kg/m^2 and above indicates obesity (NIH, 1998).

There are some disadvantages in using BMI to estimate adiposity (NIH, 1998; Shen et al., 2006; Stamler & Dolecek, 1997; Heiat, Vaccarino & Krumholz, 2001). The first is that BMI does not measure body fat directly and is limited in its ability to measure total adiposity. It does, however, correlate with direct measures of body fat in estimating adiposity in adults (Shen et al., 2006). The second disadvantage is that BMI does not differentiate between body fat and fat free mass (muscle). It will overestimate body fat where greater muscle mass is present and underestimate body fat where less muscle mass exists (NIH, 1998; Stamler & Dolecek, 1997; Heiat, Vaccarino & Krumholz, 2001). The third disadvantage of the BMI is that BMI values have a propensity to increase with age (NIH, 1998; Stamler & Dolecek, 1997; Heiat, Vaccarino & Krumholz, 2001). With that, BMI has been seen to vary by ethnicity and gender (Lev-Ran, 2001; Sanchez, Reed, &

Price, 2000; Tam et al., 1999). According to a study conducted by Beydoun and Wang (2008) which compared NHANES data collected during 1988 -1994 with data from 1999 – 2004, BMI increases were greater in women as compared to men. These researchers also noted that BMI increases were greater in African Americans as compared to whites, Mexican Americans, and other ethnic groups (1.8 units, 1.3 units, 1.1 units, and 1.4 units, respectively).

Waist circumference (WC) is a measure of body fat distribution in the central or abdominal area. It is measured by finding the smallest area below the rib cage and above the umbilicus and measuring the circumference of the waist using a stretchable tape measure. Waist circumference measures are related to abdominal fat only. Therefore, WC has its limitations in estimating obesity. It best denotes relative risk for abdominal fat and the development of obesity-related risks including type 2 diabetes, hypertension, CVD, and dyslipidemia. There are sex-specific values established to assess WC. Waist circumference measures greater than 102 cm or 40 inches in men and measures greater than 88 cm or 35 inches in women indicate high risk for obesity-related risk factors (NIH, 1998).

As observed in BMI interpretations, there are disadvantages to using WC to estimate adiposity and weight. Waist circumference may not be valid for those who have a BMI greater than 34.9 kg/m^2. In those with a BMI of 35 kg/m^2 or greater, WC has decreased predictive value of disease risk. For those with a BMI that falls between 25 and 34.9 kg/m^2, WC would be best interpreted if used in conjunction with BMI. Waist circumference also may not be valid as a predictive measure for those who are less than five feet tall. Thirdly, WC may be affected by ethnicity and age. For example, waist

circumference of older persons appears to have greater predictability for obesity-related disease (NIH, 1998; Gallagher et al., 1996; Perez et al., 2003; Shen et al., 2006). In addition to that, Beydoun and Wang (2008) identified that mean waist circumference was highest over time among African Americans compared to whites, Mexican Americans, and other ethnic groups (4.9 cm versus 4.6 cm, 3.2 cm, and 3.8 cm, respectively).

Shen and colleagues (2006) compared percent body fat, WC and BMI to determine which was better correlated to metabolic syndrome. The participants in this study were African American and white healthy adults ages 18 and over. Body composition was measured for all participants using calculated BMI, WC measure and DXA scan. Blood studies (glucose, lipids, and insulin) and blood pressure measurements (diastolic and systolic) were taken.

In white males, percent fat had the lowest correlation to blood results compared to WC and BMI. Both BMI and WC had significantly higher correlations to HDL (-0.342 and -0.335; $p<0.05$) than percent fat. In African American males, BMI had the lowest correlation to the blood measures compared to percent fat and WC. In this group, correlations with triglycerides were higher for percent fat and WC when compared to BMI (0.267 and 0.267 versus 0.125; $p<0.05$). Among white women, there were some differences in results. For blood glucose, WC had the lowest correlation. However, with HDL and triglycerides, WC had the highest correlation. In African American women, WC had the highest correlation to glucose, triglycerides, and HDL. The correlation for WC to blood results was significantly higher than that of percent fat among African American women., Percent fat had the lowest correlation with serum insulin among African American men and women and white women, and WC had the highest

correlation among all gender and ethnic groups. WC was significantly higher than percent fat among African American men and women and white women. WC reached significantly higher correlation to insulin than BMI in one group – white women. WC had significantly higher correlation to systolic and diastolic blood pressure than BMI and percent fat among white participants (0.373 and 0.404, respectively). Among African American males, percent fat had the highest correlation to diastolic blood pressure and WC had the highest correlation to systolic blood pressure. In African American females, BMI had higher correlation to systolic and diastolic blood pressure than other measures. BMI had a significantly higher correlation to systolic blood pressure than WC. In white females, BMI had a higher correlation to systolic blood pressure and WC had a higher correlation to diastolic blood pressure (Shen et al., 2006).

These findings indicate that WC is a better indicator of obesity related health risks than percent fat and BMI. BMI was also a better indicator of health risks than percent fat. These indicators of health are associated with adverse metabolic profiles that accompany excess fat. Although WC is the best indicator of obesity related health risks, referencing BMI with WC would be appropriate when considering obesity-related indicators of health.

Etiology of obesity

The causes of obesity are related to hereditary, environmental, and psychosocial influences including genetics, behavior, culture, and socioeconomic status. Some of these causes associated with obesity and overweight can be addressed. Eating behaviors and physical activity are among the two causes associated with obesity and overweight that are modifiable.

In the American Heart Association's scientific position statement, physical inactivity is a deemed a major risk factor for the development of cardiovascular disease (Haskell et al., 2007). There is substantial data available to support that position. It is also important to note that decreased physical activity is associated with weight increases and obesity risks (Hill & Peters, 1998; Sherwood et al., 2000). Sherwood et al. (2000) studied the relationship of diet, exercise and weight over a 3 year period of time among 828 women and 218 men. For men participating in this study, higher intensity physical activity was inversely associated with body weight. Among women, those who participated in moderate physical activity experienced smaller rates of weight gain over the three year period than those who did not participate in moderate physical activity and those who participated in high-intensity physical activity weighed less than others.

Poor nutrition intake is also associated with overweight and obesity. Obesity is present when there is an increase in energy intake that exceeds energy expenditure (Hill & Peters, 1998;) Obesity seems to increase in the presence of particular dietary makeup including high dietary fat intake and high energy dense dietary intake. Although the argument of whether or not dietary fat is the only factor that is associated with weight, researchers have shown increase in body fat with significant fat in the diet (Deshmukh-Taskar, Nicklas, Yang, & Berenson, 2007; Hill & Peters, 1998; Sherwood et al., 2000). Maskarinec and colleagues (2006) pooled data from 19 studies conducted at the Cancer Research Center of Hawaii, which included 156,920 subjects. Subjects were from six ethnic groups – Native Hawaiian, white, Japanese, Filipino, Chinese, and others. Those participants with the higher BMI consumed greater amounts of calories from fats than those with lower BMI. There was an inverse association noted for BMI and percent of

calories from fat (Maskarinec et al., 2006). In this same study, higher intakes of energy were associated with higher BMI – an additional 500 calories equated to 6% greater risk for excess weight in men and 14% greater risk for excess weight in women (Maskarinec et al., 2006). In another study, Sherwood and colleagues (2000) identified that men experienced a positive association between dietary fat intake and body weight as well as total energy intake and body weight. Higher intakes of fat and of total energy among women were positively associated with higher body weight.

Socioeconomic factors are influential on obesity and overweight. Maskarinec et al. (2006) found that some socioeconomic factors were associated with the nutritional determinants of overweight and obesity. In this study, older age and higher education were inversely associated with overweight and obesity. Other studies have observed associations between SES and obesity. Deshmukh-Taskar and colleagues (2007) reported that those individuals with reported education levels greater than 12 years seemed to consume healthier foods including breads and cereals, dairy products, fruits and 100% fruit juices, and vegetables. This may result in decreased risk for overweight and obesity. McMurray and colleagues (2000) noted that higher SES and being white decreased the relative risk of being overweight by 53% to 66%.

Health Status of Mississippi Residents

There is health status data available for residents who live in the lower Mississippi delta regions of the U.S. including Mississippi, Arkansas, and Louisiana. In a study that examined self-reported nutrition-related health problems for people living in the Lower Mississippi Delta Region, Smith et al. (1999) compared Delta and non-Delta counties in Arkansas, Louisiana, and Mississippi to the entire US population to identify

geographic associations in health risks. This group of researchers assessed health risks for a group of counties defined by a consortium of institutions established by the US government called the Lower Mississippi Delta Nutrition Intervention Initiative (Delta NIRI). The Delta NIRI was responsible for conducting nutrition research in the Lower Mississippi Delta region in 36 selected counties and parishes. The researchers used BRFSS data from years 1991 and 1993 to represent the U.S. population. The total number of participants was 4,586 and 5,001 for 1991 and 1993, respectively. The BRFSS uses self reported data on weight, height, and determinants of health. Respondents in BRFSS were asked specific questions about health, which included whether participants had ever been told by a health professional that they had diabetes, high blood pressure, or high cholesterol. Participants in 1993 also rated their health on a 5-point scale which included excellent, very good, good, fair, or poor as options to describe health status.

Smith et al. (1999) found a significantly higher proportion of African Americans or other ethnic minorities in the Delta NIRI counties, followed by non-Delta NIRI counties in these states, as compared to the other states represented in BRFSS. Delta NIRI county residents had the highest rates of informed chronic conditions including obesity, diabetes, high blood pressure, and high cholesterol. Further, rates in non-Delta NIRI counties of Arkansas, Louisiana, and Mississippi were higher than US rates in all instances except high cholesterol. While Delta NIRI counties showed trends for higher rates than non-Delta NIRI counties in the three states, only one category of informed health condition was significantly higher among Delta NIRI counties – hypertension. In addition to informed health conditions, Delta NIRI counties led the country in rating their health at poor to fair (Smith et al., 1999).

Smith et al. (1999) reported that for the Delta NIRI counties, obesity levels peaked between ages 35 - 64 for most groups regardless of race, sex, or SES, the exception being 65 and older African American women with high school or greater education. In addition, the prevalence of health conditions such as hypertension and diabetes increased with age.

The Delta region of Mississippi, Arkansas, and Louisiana has continued to be an area of interest for researchers. A key group of researchers investigating the health of residents in the Delta region was organized as the Lower Mississippi Delta Nutrition Intervention Research Consortium. This group analyzed self-reported health data of residents in the Mississippi Delta. Casey et al. (2004) compared data from the Foods of Our Delta Study (FOODS) 2000 with national data from the Continuing Survey of Food Intake of Individuals (CSFII) from the years 1994-1996 and 1998. This FOODS 2000 data was based on a random-digit dialing telephone survey.

The FOODS 2000 survey was designed to be comparable to the CSFII. In an effort to maintain consistency between the two surveys, the dietary information for FOODS 2000 was collected using the CSFII multiple-pass methodology. The basic premise of FOODS 2000 survey was to collect data on health and nutrition status of residents in the Delta. As to be expected, there were similarities and differences noted between the two studies. FOODS 2000 had a higher percentage of African Americans than CSFII, since both included representative population samples for their respective study areas (Casey et al., 2004).

Participants in FOODS 2000 were asked to report on whether or not they had been told by a physician that they had diabetes, high cholesterol, or hypertension. Delta

respondents were more likely than CSFII respondents to note that a physician had informed them that they had diabetes, high cholesterol, and hypertension. In the case of diabetes, Delta respondents were twice as likely as CSFII respondents to have been told they had diabetes (10.8% vs. 5.6%, respectively). Another disproportionate account of health status was noted for hypertension. One in three Delta respondents had been told they had hypertension compared to one in five CSFII respondents. There was also a significant difference between the number of Delta respondents and CSFII respondents who had been told by a doctor that they had high cholesterol (17.6% vs. 14.0%, respectively). Based on BMI calculated from self-reported height and weight, Delta respondents had nearly double the number of respondents who were obese in comparison to the CSFII respondents. The prevalence of obesity was significantly higher in the Delta respondents compared to CSFII for all race, gender, and age groups. In both the FOODS 2000 data and the CSFII data, the incidence of being told that one had a health condition increased as age increased. This was evident only between the ages 18 and 74. For FOODS 2000 participants, rates of respondents aged 75 or greater, having been told by a doctor that they had diabetes, high cholesterol, and hypertension were lower than for younger age groups. Ages 45-74 appeared to be the time when participants were most likely to be informed of chronic illnesses (Casey et al., 2004).

There were significant differences noted among the subgroups represented in the FOOD 2000 data. Among Delta respondents, African Americans had higher rates than whites of being told that they had diabetes, hypertension, and obesity. Women reported higher rates than men, and people who had lower incomes had higher rates compared to

higher income levels (Casey et al., 2004). The information gathered related to health in this study was similar to that identified by Smith and colleagues (1999).

Felix and Stewart (2005) also assessed the health status of Americans living in the Mississippi River Delta Region. Their examination encompassed eight states in this region including specifically designated Delta region counties and parishes based on Public Law 100-460 – Alabama (20 counties), Arkansas (42 counties), Illinois (16 counties), Kentucky (21 counties), Louisiana (46 parishes), Missouri (29 counties), Mississippi (45 counties), and Tennessee (21 counties). Every county in each state was a part of the analysis; however, Delta counties and non-Delta counties were classified separately. The data used in this research were not self-reported. Data were collected from several different sources including CDC WONDER Database, ICD-9 codes, and the Harvard Center for Populations and Development based on years 1994 to 1998. Felix and Stewart (2005) analyzed six mortality-related indicators to determine health status in the Mississippi River Delta Region - infant mortality rate (IMR), all-cause mortality rate (MR), cancer mortality rate (CMR), heart disease mortality-rate (HDMR), life expectancy figures for females (LEF), and life expectancy figures for males (LEM).

This study was designed to identify differences among counties in the Delta Region. Health disparities were noted between Delta and non-Delta counties in the Mississippi River Delta Region. The mean IMR among all Delta states was 8.35 (SD = 3.31), with Delta counties greater than non-Delta counties (9.56 compared to 7.74). Of the 720 counties represented in the Delta states, nine counties had statistically significantly lower IMR and twenty-five counties had significantly higher IMR than the mean IMR for the all counties represented. Of the 25 counties, 17 were Delta counties.

For MR, the mean age-adjusted mortality rates among the 720 counties in the eight states was 994.66 (SD = 98.25). There were 11 counties with a significantly lower MR and 22 counties with higher MR than the mean rate. Of the higher MR counties, 13 were Delta counties. The CMR for 719 counties was 223.99 (SD = 24.17). Of the 719 included in this analysis, 12 counties had a significantly lower CMR and 19 counties had a higher CMR than the mean rate. Those areas with with CMR higher than the mean were more likely to be non-Delta counties. The mean HDMR for 719 counties was 330.91 (SD = 53.45). There were 7 counties that had lower than the mean for HDMR and 23 that had a higher rate than the mean. Of the 23 counties, 15 were Delta counties. Even in life expectancy, the researchers reported significantly shorter life spans for those in Delta counties (males and females). The mean life expectancy for women was 78.01 years (SD = 1.36) and 70.28 years (SD = 1.88) for men. The Delta region counties were the counties which reported life expectancy rates to be statistically lower than the mean. For example, 29 out of 32 counties for LEF were Delta counties and 19 out of 20 counties for LEM were Delta counties (Felix & Stewart, 2005).

Eating Habits among Americans

Dietary habits are closely related to health conditions. A report card on America's diet quality called the Health Eating Index (HEI) reveals the quality of diets within different populations in the US. The data for the HEI were computed by the United States Department of Agriculture (USDA) from the Continuing Survey of Food Intakes by Individuals (CFSII) from 1989 to 2000 (Basiotis, Carlson, Gerrior, Juan, & Limo, 2002). Realizing that demographic and socioeconomic backgrounds are related to the quality of the diet, the HEI has identified specifically defined populations with good and poor diet

quality. The HEI includes ten categories which measure adherence to the USDA Food Guide Pyramid, including total fat consumption, saturated fat consumption, total cholesterol intake, sodium intake, and diet variety, with a maximum score of ten in each category. HEI scores are defined by USDA with 80 or greater implying "'good' diet", 51 – 80 implying "needs improvement" with dietary intake, and less than 51 implying a "'poor' diet" (Basiotis et al., 2002).

The most recent evaluation of HEI reports for 1999-2000 includes the most recent national nutrition data. The overall mean HEI score for Americans is 63.8, falling in the "need for improvements" category. Only 10% of the population had a good diet. African Americans had an overall mean score of 61.1, indicating the need for improvement in dietary quality. This score was considerably lower than the score for Whites and other racial groups including native-born Americans, US population born in Mexico, Mexican Americans or those from other countries at 64.2, 63.5, 64.5, 66, and 65.7, respectively. When the HEI was assessed according to age, children between the ages of two and three years appeared to have the highest mean HEI score at 75.7 (Basiotis et al., 2002).

As a part of the HEI scoring process, the five key food groups were analyzed based on recommended servings per group. The scores range from zero to ten with the maximum score of 10 assigned to the diets that reflect the recommendations of the Food Guide Pyramid and a score of 0 for a diet void of any item in a particular group. The five food groups represented in the HEI include grains (6 – 11 servings), vegetables (3 – 5 servings), fruits (2 – 4 servings), milk (2 – 3 servings), and meats (2 – 3 servings). For the entire US population, the scores for each group component were 6.7 for grains, 5.0 for vegetables, 3.8 for fruits, 5.9 for milk, and 6.6 for meat. Blacks scored lower than whites

on the HEI in two categories – milk (4.5 versus 6.4) and vegetables (5.2 versus 6.2). With the HEI, it is noted that with higher education level there is an increase in the consumption of each of the food groups. This was also evident in income levels (Basiotis et al., 2002).

Juan, Lino, and Basiotis (2004) took a look specifically at the diet qualities of older Americans using the HEI data. These data are based on the 1999-2000 National Health and Nutrition Examination Survey with the older American population extracted out of the entire group. Older Americans were defined as those aged 65 and up. Overall the majority of the older Americans had a poor diet or one that needed improvement during 1999- 2000: 14% of those aged 65 to 74 and 13 % of those aged 75 and above had a poor diet and 74% and 66% of those aged 65 to 74 and aged 75 and up, respectively, had a diet that needed improvement. The highest HEI component score was variety at 8.2, closely followed by the category of cholesterol at 8.1. Fifty-nine percent of the older American group scored a perfect 10 for variety and 73% scored a perfect 10 for cholesterol, which means they met the dietary recommendation for both categories. The five food group HEI scores were 6.4 for grains, 6.4 for vegetables, 5.5 for fruits, 5.9 for milk, and 6.4 for meat. While older Americans appeared to have better scores for fruit and vegetable consumption than did the US population ages 19-50 years, meat fell into the lower mean scores for older people. Of people 65 years and older, less than 30% of the population met the dietary recommendations for milk and fruit.

Deshmukh-Taskar, Nicklas, Yang, and Berenson (2007) examined food consumption by food groups of participants in the Bogalusa Heart Study as it related to socioeconomic, demographic and lifestyle factors. There were 1,266 participants aged 20

to 38 years participating in this research. The data was collected utilizing self-administered data collections tools. Food consumption patterns were assessed with the use of a 131-item validated self-administered youth and adolescent food frequency questionnaire. SES, demographics, and lifestyle characteristics were collected using a self-administered form. Heights and weights were measured on all participants using standardized procedures and calibrated instruments.

Of the 1,266 subjects, 74% were European Americans and 25.6% were African American. The mean age of participants was 29.7 years. There were nearly twice as many women participating as men: 61.3% women and 38.7% men. A higher percentage of African American participants had lower income levels than European Americans and a higher percentage of European Americans reported a greater than 12^{th} grade education. African American participants had a higher BMI than their European American counterparts. More specifically, African American women had the highest BMI compared to African American men, European American men, and European American women. African American men were more physically active than any other group (Deshmukh-Taskar et al., 2007).

This study evaluated consumption of 11 food group components from the youth and adolescent questionnaire – breads and cereal, dairy products, fruits and 100% fruit juices, vegetables, fats, meats, burgers and sandwiches, mixed dishes, snacks and desserts, sweetened beverages, and alcoholic beverages. This research looked at the association of characteristics of the participants with specific food group consumption. Participants who reported having a greater than a 12 year education level ate significantly more breads and cereals, cheese, yogurt, dairy products, fruits and 100% fruit juices, and

vegetables with and without French fries than those with less than or equal to a 12 year education level. Significant differences were noted in consumption of burgers and sandwiches and mixed dishes among income levels (Deshmukh-Taskar et al., 2007).

African Americans had significantly lower intakes of milk, cheese, dairy products, vegetables with and without French fries, fats, mixed dishes and sweetened beverages than the European American participants. In contrast, European Americans consumed less fruits and 100% fruit juices, snacks and desserts, and alcoholic beverages in comparison to the African American participants. Females consumed more yogurt, fruits and 100% fruit juices, vegetables with and without French fries, fats, and mixed dishes than males. Men, on the other hand, consumed more alcoholic beverages and burgers/sandwiches than women (Deshmukh-Taskar et al., 2007).

European Americans consumed significantly more dairy products than African American participants. European American males consumed more cheese than European American females, African American males, and African American females. African American females consumed more fruit and 100% fruit juices than any other ethnicity-gender group. European American females consumed more vegetables including French fries and fats than all other ethnicity-gender groups (Deshmukh-Taskar et al., 2007).

When comparing both articles, Basiotis et al. (2002) and Deshmukh-Taskar et al. (2007), similarities were identified. In the study of HEI for Americans based on CSFII data, African Americans had a lower intake of milk and vegetables in comparison to the white counterparts. In the Bogalusa Heart Study data, African Americans had decreased intake of milk and vegetables in comparison to the white counterparts. A look at

education level found similar results. Higher education in both studies was related to higher intakes in almost all categories of food.

Eating Habits among Mississippians

The Lower Mississippi Delta Nutrition Intervention Research Initiative was the research group responsible for the Foods of Our Delta Study (FOODS) 2000 research. One goal of this research group is to identify associations between diets of those living in the Mississippi Delta and create or identify effective nutrition interventions. FOODS (2000) was primarily designed to identify food sources for macronutrients and micronutrients in this population and use those foods in developing an FFQ. The FOODS 2000 study was conducted in 36 counties in the Lower Mississippi Delta (Louisiana, Mississippi, and Arkansas). The participants included 842 white Americans and 857 African Americans (ages 19 and older) and 485 children. The study design included a cross-sectional random-digit telephone survey. All participants in this study completed a 24-hour dietary recall (Champagne et al., 2004; Tucker et al., 2005).

Champagne and colleagues (2004) analyzed the FOODS 2000 data in order to compare the Lower Mississippi Delta Region resident to the US population. The US participants were drawn from the CSFII data 1994-1996, 1998. There were differences noted between the Mississippi Delta region participants and US participants. The results reported here were noted for adult participants. There was a considerably greater percentage of African American participants in the FOODS 2000 study than in the CSFII survey (43.8% versus 11.3%).

There was no significant difference in energy intake between Delta and CSFII participants. A significant difference was noted between Delta white Americans and

Delta African Americans (2,089 ± 34 kcal versus 1,926 ± 32, p=0.0009). Protein intakes were lower among Delta African Americans than US African Americans with no differences noted between Delta white Americans and the US population. In comparison, there no significant differences in carbohydrate consumption between the Delta and US populations, but there were differences between Delta white Americans and Delta African Americans (251.7 ± 4.2 g versus 233.4 ± 5.2, p=0.0094). With total fat intakes, there were no significant differences between Delta African Americans and US African Americans, but Delta white Americans consumed significantly more fat than US white Americans and Delta African Americans (Champagne et al., 2004).

When comparing fruit and vegetable consumption among Delta participants and CSFII participants, Delta African Americans consumed significantly more servings of fruit than Delta white Americans (1.3 ± 0.07 vs. 1.0 ± 0.05 servings, p=0.0005). There were no differences between Delta African Americans and US African Americans (1.3 ± 0.07 vs. 1.4 ± 0.06 servings, respectively). US white Americans consumed significantly more servings of fruits than Delta white Americans (1.5 ±0.03 and 1.0 ± 0.05, p=0.0001) (Champagne et al., 2004).

Delta white Americans consumed significantly more vegetables than Delta African Americans (3.0 ±0.08 vs. 2.3 ± 0.10, p=0.0001). Delta African Americans consumed significantly less vegetables than US African Americans (2.3 ± 0.10 vs. 3.2 ± 0.14, p=0.0001). This was also true for Delta white Americans compared to US white Americans (3.0 ± 0.08 vs. 3.5 ± 0.04, p=0.0001) (Champagne et al., 2004).

Calcium intake was also compared for the Delta and the US populations. Delta white Americans consumed significantly less calcium than US white Americans (735 ±

20 mg versus 797 ± 8 mg, p=0.0037). Delta African Americans consumed significantly less calcium than US African Americans (554 ± 15 mg versus 612 ± 21 mg, p=0.0243). Delta white Americans consumed significantly more calcium than Delta African Americans (735 ± 20 versus 554 ± 15 mg, p=0.0001) (Champagne et al., 2004).

Tucker and fellow researchers (2005) analyzed FOODS 2000 data; however, they did not compare it to other national or regional studies. They assessed food contributors to micronutrient and macronutrient intake among the Delta region residents. The top four contributors of energy for participants included soft drinks (7%), white bread (6%), burgers or meatloaf (4-5%), and salty snacks (3-4%). Within cultural groups, top contributors of energy did not vary much from what was identified for overall energy providers among the entire group of participants. For African American participants, the top four sources of energy were soft drinks (7.0%), white breads/rolls (6.0%), fried chicken (4.6%), and burgers/meatloaf (4.6%). For white American participants, the top for sources of energy were soft drinks (7%), white bread (5.8%), burgers or meatloaf (3.8%), and salty snacks (2.8%). The average calorie intake for white males and females was 2,450 ± 1,107 kcals and 1,791 ± 828 kcals, respectively. For African American males and females, the average calorie intake was 2,327 ± 1,215 kcals and 1,672 ± 925 kcals, respectively (Tucker et al., 2005).

Macronutrient intake contributors varied in all groups except in carbohydrates. Within both race groups, soft drinks (15%) and bread (9%) were the top sources of carbohydrates. Sweetened tea, cakes and muffins contributed more carbohydrates among whites and fruit drinks and candy surfaced as greater contributors of carbohydrates in African Americans. In both groups, salty snacks proved to be significant contributors to

carbohydrate intake. The top sources of protein within the two groups varied. For whites, the top contributors include burgers/meatloaf (7.1%), beefsteaks/roast (7.1%), fried chicken (5.4%), white breads/rolls (4.5%). A few of the foods identified as top contributors in whites were present in the top four list for African Americans – fried chicken (11.8%), burgers/meatloaf (8.4%), poultry, not fried (5.6%), and fried fish (5.0%). As identified in protein, the sources of fat varied among races. White participants consumed mayonnaise/salad dressing (6.2%), burgers/meatloaf (5.9%), salty snacks (chips) (3.9%), and fried fish (3.3%) as the primary sources of fat. African American participants consumed burgers/meatloaf (6.9%), sausage (6.4%), fried chicken (6.4%), and salty snacks (chips) (5.9%) as the primary sources of fat (Tucker et al., 2005).

The top contributors for calcium intake included milk, cheese, and breads. White participants consumed 26.2% of calcium from milk, 9.1% from cheese, and 6.0% from white breads/rolls. African American participants consumed 14.4% of calcium from milk, 10.2% from cheese, and 7.8% white bread/rolls, and 4.6% from cornbread. The mean intake of calcium among white males and females were 841 ± 633 mg and 662 ± 420 mg. The mean intake of calcium among black males and females were 643 ± 443 mg and 506 ± 407 mg (Tucker et al., 2005).

The information identified in the FOODS 2000 data is an indicator of eating habits among some residents in the Lower Mississippi Delta Region. While it may not necessarily be the same eating behaviors for those in central Mississippi, it is a good indication of dietary habits in this area of the country. In addition to identifying broad dietary behaviors, this data also give insight to specific foods that contribute to macronutrient and micronutrient consumption among some Mississippians.

Obesity is directly associated with an energy imbalance – energy consumed exceeds energy expended. Because of this core association, the increased prevalence of obesity in the US has been attributed to many factors including increased consumption of sweetened beverages, decreased physical activity, and increased consumption of high calorie, high fat foods (CDC – "Obesity and Overweight," n.d.). Past research linking diet with weight and obesity has emphasized aspects of macronutrient intake, including lipids and carbohydrate intake.

Historically, the increase in weight is associated with increased macronutrient intake like lipids, proteins, carbohydrates. Klesges and colleagues (1992) conducted a longitudinal study that addressed the relationship between eating, physical activity, and changes in body weight among 294 Caucasian adult men and women. This study examined dietary intake, diet composition, physical activity, smoking and alcohol consumption in this population. In this study, higher fat intake as well as the percent of energy from fat was associated with increased body mass index among both men and women. Lahti-Koski et al. (2002) examined similar variables in a 15 year longitudinal study. These data related obesity to specific types of foods consumed rather than to macronutrients. There were positive associations with the consumption of sausage, milk, and sour milk to obesity in both men and women. There were inverse associations noted with vegetable consumption and obesity in both groups. This may indicate that food items higher in fat had a greater association with obesity than those lower in fat. Another study identified predictors of weight gain among 826 women and 218 men. Among female participants, total energy intake was positively associated with body weight. In addition, there was an association between dietary intake of fat and weight gain among

both men and women (Sherwood et al., 2000). In recent years, there has been a shift in what is commonly associated with weight increases. Micronutrients are now being considered as contributing factors for overweight and obesity (Rajpathak et al., 2006). Calcium, in particular, has been a nutrient of interest in recent research. Because of that, exploring calcium as an independent micronutrient related to obesity and health is necessary.

Calcium and Calcium Metabolism

Calcium is one of the most abundant minerals in the body and is essential to bone and teeth health, muscle and nerve activity and other body functions. Ninety-nine percent of calcium in the body is found in the skeleton. The rest of the body's calcium is present in intra- and extra- cellular compartments in the blood, lymph, and other body fluids (Linder, 1991; Shils, Olson, Shike, & Ross, 1999).

Calcium absorption, reabsorption, and turnover in the body are regulated by several different hormones. The three most important calcium-regulating hormones are parathyroid hormone (PTH), calcitonin, and vitamin D. Collectively, these hormones act to maintain homeostasis for calcium amidst changing dietary requirements through the lifecycle. Calcium absorption takes place either in the small intestine or in the colon. In the intestine, there are two methods for calcium absorption. One method for calcium absorption occurs in the duodenum and proximal jejunum. This method of calcium regulation includes vitamin D and vitamin D dependent calcium-binding protein (CaBP or calbindin) and is considered the active method of calcium absorption. Calcium absorbed this way is affected by the host's calcium and vitamin D status, age, pregnancy, and lactation. The other method for calcium absorption is a passive route that occurs in

the entire length of the small intestine. This means for calcium absorption is independent of vitamin D regulation. Calcium absorbed this way relies on the amount and availability in the diet. The colon (in particular, the cecum and ascending colon) is where nearly four percent of dietary calcium is absorbed into the intestinal epithelial by ATP (Linder, 1991; Shils, Olson, Shike, & Ross, 1999.

Serum calcium is also closely regulated to safeguard calcium concentration and to shield neuromuscular and hormonal functions. Calcium is found in several forms in the plasma including as a free ion, bound to proteins like prealbumin, and bound to a citrate. Ionized calcium is readily accessible to the cell (Linder, 1991; Shils, Olson, Shike, & Ross, 1999).

The presence of ionized calcium in the blood is regulated mainly by PTH, calcitonin, and vitamin D, although a few other hormones serve in bone turnover and calcium metabolism. These hormones affect calcium transport within the body. The primary mechanism responsible for the release of PTH is a decrease in extracellular fluid calcium concentration. PTH causes an increase in the concentration of calcium in the extracellular fluid by stimulating bone resorption, stimulating renal tubular reabsorption, and by increasing intestinal absorption through 1, 25-dihydroxyvitamin D (1, 25 $(OH)_2D$). Calcitonin responds to a rise in serum calcium. It operates contrary to PTH. Calcitonin inhibits bone resorption and any hormone or agent that has a resorbent effect on bone resulting in lowered serum calcium. The most active vitamin D metabolite, 1, 25 $(OH)_2D_3$ is produced at higher rates during calcium deficiency. The secretion of 1, 25 $(OH)_2D_3$ causes enhanced intestinal absorption and renal reabsorption, and increased bone formation and resorption (Linder, 1991; Shils, Olson, Shike, & Ross, 1999).

Calcium and Obesity

Calcium has a significant role in bone and teeth development and maintenance. Calcium within the bone is relied upon for mineral homeostasis, particularly extracellular fluid calcium concentrations. While the main functions of calcium have been clearly identified, there are other functions that are still actively being investigated. Calcium is hypothesized to play a role in weight reduction and weight maintenance. Particularly, there has been an inverse association noted between calcium intake and weight in the literature. There are two proposed mechanisms for the association of body weight changes in conjunction with calcium intake (Heaney, 2006; Teegarden, 2003; Teegarden, 2005; Zemel et al., 2000).

The proposed mechanisms involve either a decrease in available energy or an increase in energy utilization. The decrease in available energy is proposed through two processes: increasing satiety or decreasing the absorption of fatty acids through the formation of calcium/fatty acid soaps in the intestine which reduces the absorption of energy related nutrients and increases fecal fatty acid loss (Heaney, 2006; Teegarden, 2003; Teegarden, 2005; Zemel et al., 2004). More data are available to support the fecal fat loss theory related to decreased energy availability than for increased satiety. Studies that measure the effect of dietary calcium on fecal fatty acid excretion account for observed weight loss in human studies (Jacobsen et al., 2005; Heaney, 2006; Teegarden, 2003; Teegarden, 2005; Zemel et al., 2004). Denke, Fox, and Schulte (1993) used calcium citrate malate fortification and supplementation to compare dietary calcium intake to supplemental calcium intake). The researchers designed the diets to include varied calcium levels and 11% of energy from protein. The low calcium diet consisted of

410 mg of calcium, 34% of energy from fat and the high calcium diet consisted of 2200mg of calcium from a fortified food items and two supplement tablets. Results indicated a two-fold increase in fatty acid excretion in the higher calcium diet period than the low calcium diet period. Excretion of dietary saturated fatty acids increased from 6% on the low calcium diet to 13% on the high calcium diet. In a similar study, Jacobsen et al. (2005) conducted an experimental study on 10 individuals using three isocaloric diets containing low calcium and normal protein intake (500 mg Ca, 15% of energy from protein), high calcium and normal protein intake (1,800 mg Ca, 15% of energy from protein), and high protein and high calcium intake (1,800 mg calcium, 23% of energy from protein). The calcium and protein were obtained using mainly low fat dairy products. Dietary fiber and vitamin D content were the same for each diet type. The study used a randomized crossover administration of each diet for one week intervals for all participants. In this study, there was a positive correlation between calcium consumption and fecal fat excretion. Fecal fat content increased 2.5 fold during the consumption of the high calcium, normal protein phase as compared to the other diets (14.2 ± 6g versus 6.0± 2g and 5.9± 2g for low calcium/normal protein and high calcium/high protein respectively; p=0.05). The proportion of fat excreted while participants were on the low calcium, normal protein and high calcium, high protein diets was less than that from the high calcium, normal protein diet (7.3 ±3%, 7.5 ±3%, and 18.0 ±8%, respectively). Fecal calcium excretion was also noted. High calcium, normal protein diets and high calcium, high protein diets had higher fecal calcium excretion than the other group. These two studies indicate that higher calcium intakes, whether through calcium supplementation or

an increase in low fat dairy products, increase fecal fatty acid excretion in humans and reflect changes in fatty acid metabolism.

The second proposed mechanism addresses energy utilization (metabolism). This concept explains that the impact of increased intakes of dietary calcium (about 400 to 1,000 mg/day) on energy utilization is related to increased lipolysis and lipid oxidation or the regulation of parathyroid hormone (PTH) and 1,25 dihydroxyvitamin D [1,25 $(OH)_2D$] by calcium (Heaney, 2006; Teegarden, 2003; Teegarden, 2005; Zemel et al., 2004). The most cited mechanism of the two explanations is the latter: calcium's regulation of the PTH and 1, 25 $(OH)_2D$ (Heaney, 2006; Rajpathak et al., 2006; Teegarden, 2003; Teegarden, 2005; Zemel et al., 2004).

Intracellular calcium is believed to be highly correlated with obesity. Calcium channel agonist and agouti protein, an obesity gene product expressed in human adipocytes, act to stimulate calcium influx and the expression of fatty acid synthase (a core enzyme in *de novo* lipogenesis) and inhibits lipolysis in human. This implies that intracellular calcium impacts adipocyte energy storage. (Kim et al., 1997; Wang et al., 2004; Zemel et al., 2000; Zemel, 2001). PTH and 1,25 $(OH)_2D$, which acts to increase serum calcium concentration and to maintain serum calcium homeostasis, work to increase the intracellular calcium in adipocytes. It is believed that increases in 1,25 $(OH)_2D$ and/or PTH due to decreases in dietary calcium can lead to the stimulation of lipogenesis, inhibition of lipolysis, and the storage of triglycerides in human adipocytes. (Heaney, 2006; Kim et al., 1997; Rajpathak, et al., 2006; Teegarden, 2003; Teegarden, 2005; Zemel et al., 2000; Zemel, 2001; Zemel et al., 2004). If this process is indeed effective in human adipocytes, increases in dietary calcium should suppress the effects of

PTH and 1,25 $(OH)_2D$. This supports the hypothesis that increased intake of calcium may have an "antiobesity effect" (Rajpathak et al., 2006; Zemel et al., 2004).

Zemel and colleagues (2000) conducted specific research to test the effect of increasing dietary calcium on suppression of calcitrophic hormones (PTH and 1,25 $(OH)_2D$). Male aP2-agouti transgenic mice were used in this research. Mice were fed, at 6 weeks of age, a modified AIN-93GG (purified diet formulas designed to meet gestation, lactation, and growth requirements of rodents) with suboptimal calcium (0.4%), sucrose as the carbohydrate source, and fat provided 25% of calories. For the study, the mice were randomized into four groups – the basal group which remained on the standard diet, high calcium group which received an added supplementation of calcium carbonate to the basal diet to increase dietary calcium intake to 1.2%, medium dairy group with modified diets from basal to 25% of the protein being replaced with non-fat dairy milk and dietary calcium increased to 1.2%, and high dairy group with modified diets from basal to 50% of the protein being replaced with non-fat dairy milk and dietary calcium increased to 2.4%. These mice followed the diet prescribed for 6 weeks. After the six week period ended, mice were sacrificed. In addition, the calcitrophic hormones were observed using cultures of human adipocytes, and the effect of calcium on adiposity was evaluated using NHANESIII data (Zemel et al., 2000).

The results of this research supported Zemel's (2001) hypothesis that increased intracellular calcium results in inhibition of lipolysis and the prompting of lipogenesis. Nearly one quarter of the aP2-agouti mice on the basal diet had a weight gain of 24% body weight. However, those whose diets were changed to medium dairy, high dairy or high calcium experienced a reduction in weight by 29%, 39%, and 26% respectively

($p<0.04$). This decrease in weight was observed without a decrease in energy intake among the groups. The suggested effect on energy metabolism was exemplified in this group of transgenic mice by the measuring of the core temperature. Core temperatures increased by approximately 0.5° C in all three calcium modified diets, indicating thermogenesis and not energy storage. On the basal diet, a 2.6 fold increase in fatty acid synthase activity was noted. The modified calcium diets significantly reduced the increase in fatty acid synthase activity ($p<0.002$). The three calcium diets noted significant reductions in fatty acid synthase messenger RNA by 27% in the high calcium diet and 51% in both the medium and high dairy diets ($p = 0.01$). There was also an inverse association between high calcium diets and lipolysis. Lipolysis was increased by 3.4 to 5.2 fold in the three high calcium diets (Zemel et al., 2000).

Mice that were on calcium modified diets also had reductions in fat pad mass of the epidymal, abdominal, perirenal, and subscapular adipose tissue compartments at an average of 39% ($p<0.001$). More specifically, epidymal and subscapular fat pad mass was cut in half in all 3 diet types. Abdominal fat pad mass decreased to a greater degree on the dairy diets than on the high calcium diet. (Zemel et al., 2000).

Within this research, human subcutaneous adipose tissue was also observed through human cell cultures. It was noted in this assessment that both PTH and 1,25 (OH) $_2$D fueled significant increases in intracellular calcium. However, only in 1,25 (OH) $_2$D treatment was there a significant inhibition of lipolysis in human adipocytes (Zemel et al., 2000).

The impact of calcium intake on adiposity was further analyzed using NHANES III data. The result of the analysis of relative risk associated with calcium intake indicated

that there were inverse associations between calcium and dairy products intake and body fat noted in women. The regression model also showed a significant inverse relationship between calcium and dairy intakes and body weight. The odds ratio for women to be in the highest quartile for body fat decreased from 1.0 in the lowest quartile for calcium intake to 0.70, 0.40, and 0.16 for the second, third, and fourth quartiles, respectively (Zemel et al., 2000). This data is important evidence that one of the proposed mechanisms can explain how dietary calcium and dietary dairy intake could have an effect on adiposity.

Calcium on Weight Management and Weight Loss

Zemel and colleagues (2004) examined the effects of dietary calcium on body weight using energy restricted diets with obese adults. This examination is an extension to the study previously conducted by Zemel and colleagues in the year 2000. In the previous study, the subjects were mice being feed basal diets that had similar caloric value with calcium and dairy supplemented into the diet at different levels. In this instance, the subjects were obese adults with energy deficits of 500 calories per day.

The study included 32 otherwise healthy, obese individuals ages 18 to 60 years old. All participants in this study had an initial BMI of 30.0 to 39.9 kg/m^2 and a diet low in calcium at 500 to 600 mg/d, calculated from a food frequency questionnaire and a diet history. Participants in this study were placed on energy restricted (500 calorie per person per day deficit) outpatient diet regimens for 24 weeks. After the 24 week period, each participant was randomized to one of the three following diets: a low calcium diet (400 to 500 mg of dietary calcium/d, zero to one dairy product/day, and supplemented with placebo), a high-calcium diet (standard diet with 800 mg supplement of calcium

carbonate/d), or high-dairy diet (including supplemented with placebo, 3 daily servings of dairy products which brought daily calcium intake up to 1,200 to 1,300 mg/d). Participants in the low calcium group presented with greater initial body weight, body fat, trunk fat and WC than the other groups (Zemel et al., 2004).

The results noted body weight loss and body fat loss based on the individualized 500 calorie energy deficit. Each group experienced a significant loss of body weight from baseline. Those participants randomized to the high dairy group had the highest amount of weight loss, fat loss, and trunk fat loss. Percent weight loss in the low calcium group, the high calcium group and the high dairy group was 6.4 ± 2.5% ($p<0.01$), 8.6 ± 1.1% ($p<0.01$) , and 10.6 ± 1.6% ($p<0.01$), respectively. Fat mass loss was similar to that of percent body weight. Significant loss of body fat was noted in low calcium, high calcium, and high dairy groups at 8.1 ± 2.3%, 11.6 ± 2.2%, and 14.1 ± 2.4% of body fat, in that order ($p<0.01$). Each diet group also experienced a significant decrease in trunk fat. Trunk fat loss in this study represented 19.0 ± 7.9% of total fat loss on the low calcium diet, 50.1 ± 6.4% of total fat loss on the high calcium diet and 66.2 ± 3.0% of total fat loss on the high-dairy diet. This trunk fat loss corresponded with changes in WC: -4.5 cm in low calcium group, -7.0 cm in high calcium group, and -9.0 cm in high dairy group. There was also a significant decrease in systolic blood pressure noted in the high dairy group (a reduction of 4.8±mm Hg) (Zemel et al., 2004).

Zemel et al. (2000) and Zemel et al. (2004) studied relationships between calcium intake and weight by randomizing subjects to diets with specific prescriptions for calcium consumption. Other research has been conducted on the general population without intervening on the dietary intake (with calorie deficits or calcium/dairy prescriptions). In

a study conducted to examine the association between calcium intake, body composition and lipoprotein-lipid concentrations in adults ages 20-65 years, food habits were reviewed using a three day (3-d) dietary record (Jacqmain et al., 2003). The participants were divided into three groups based on an a priori decision to classify participants based on nutrient reference intakes: group A (<600 mg/d Ca), group B (600 – 1,000 mg/d Ca), group c (>1,000 mg/d Ca). After adjusting for body composition, age, SES, dietary energy intake, percentage dietary fat, and dietary protein, women in the lowest calcium consumption group had higher body weights, BMI, percentage body fat, fat mass, WC, and abdominal adipose tissue than those in the other groups. When simple correlations and adjusted correlations were performed (after adjusting for age, daily energy intake, percent dietary fat, dietary protein, and SES), negative correlations were noted between calcium intake and percentage body fat, BMI, fatness, fat-free mass and WC in women. No significant associations were noted for men. There were inverse relationships noted between dietary calcium intake and plasma lipoprotein-lipid profile measures after controlling for other variables including fat mass and WC.

While a number of research studies have been conducted to measure the association of dietary calcium to weight and fat mass, there have been few conducted with an African American population. One study analyzed the effects of dairy-rich diets on body weights and body fat in obese African American adults. The researchers studied these participants using a prescribed maintenance caloric intake diet and a prescribed energy-restricted caloric intake diet with varying dairy consumption for free-living African American participants (Zemel et al., 2005). This research was designed as two randomized trials with two sets of participants. The participants in Phase 1 (the

maintenance group) were comprised of 34 subjects who were either on a low calcium diet (low dairy) of 500 mg Ca/d including less than one serving of dairy products or a high calcium (high dairy) diet of 1,200 mg Ca/d including three servings of dairy products. There was no change for either group in the energy intake over the intervention timeframe of 24 weeks. Phase 2 (the weight loss group) included 29 subjects also randomized to low calcium or high calcium diets. This group, however, was placed on a calorie restricted regimen with a deficit of 500 calories per day (Zemel et al., 2005).

In Phase 1, there were no changes in body weight among the participants throughout the intervention. However, the high dairy group had significant decreases in total body fat (-2.158 kg, $p<0.01$), trunk fat (-1.026 kg, $p<0.01$), and WC (-3.9 cm, $p<0.01$) as compared to the low dairy group which had no significant changes. Circulating glycerol increased significantly in the high dairy group. There was also a significant decrease noted for the high dairy group in diastolic (-4.25mm HG, $p<0.01$) and systolic blood pressure (-6.25 mm HG, $p<0.01$), while there was no change noted in the low dairy group (Zemel et al., 2005).

In Phase 2, the caloric restriction of 500 calories per day produced weight loss and fat loss in all participants; nevertheless, the loss was about twice as much for the high dairy group as compared to the low dairy group (weight -, 11.02 kg to -5.954 kg; fat mass -9.08 kg to -3.97 kg, $p<0.01$). While significant lean body mass loss occurred in participants consuming the low dairy diets, participants in the high dairy intake group had a substantially smaller loss of lean body mass. As noted in Phase 1, trunk fat and WC loss was greater in the high dairy group. Circulating glycerol increased in both groups

significantly. A greater increase was noted in the high dairy group. No change in blood pressure was noted in either group (Zemel et al., 2005).

This study is an example of the observed effect of dairy consumption on body composition. The observed effects in this study have been found in other research. For example, Zemel and colleagues (2004) noted in a study they conducted with obese African American males that an increased intake of calcium from approximately 400 mg/day to 1000 mg per day for 1 year resulted in a 4.9 kg reduction in body fat.

Lovejoy and colleagues (2001) compared energy expenditure and dietary intakes between African American and white women. There were no differences noted among ethnic groups for 24-hour energy expenditure (EE), total exercise EE, or spontaneous physical activity EE. These researchers also found that African American women had higher measures of body composition (weight, body mass index, fat mass, lean mass, and percentage of body fat) than did white women. There were no significant differences between the two races in caloric, fat, or carbohydrate intakes. African American women had a significantly lower intake of calcium than white women (518 mg/d vs. 758 mg/d). In both races, inverse correlations were noted between body fat and calcium intakes (Lovejoy, Champagne, Smith, de Jonge, & Xie et al., 2001).

Calcium and Lipid Profiles

As noted earlier, CVD is the leading cause of death in the US. The American Heart Association has identified several risk factors and contributing factors for CVD, including modifiable and non-modifiable factors. Among the modifiable risk factors is high blood cholesterol (AHA, 2007). Serum cholesterol is made of three major components: low density lipoprotein (LDL) which makes up approximately 60-70

percent of the total serum cholesterol, high density lipoprotein (HDL) which makes up approximately 20-30 percent of the total serum cholesterol, and very low density lipoprotein (VLDL) which makes up approximately 10 – 15 percent of total serum cholesterol. Of the three, LDL has been identified as the most atherogenic lipoprotein and is usually the primary target for treatment of CVD. Elevated triglycerides and triglyceride-rich lipoproteins also play a significant roll in CVD and are implicated as risk factors ("Third Report," 2002).

In order to measure total cholesterol, HDL, LDL and triglycerides, lipid panels are completed. There are established optimal, borderline, and high levels for each component of serum cholesterol (Table 1). To be defined as high risk, LDL must be greater than 160, HDL must be less than 35, total cholesterol must be greater than 200, cholesterol to HDL ratio must be greater than 6, and HDL to LDL ratio must be greater than 23 for men and greater than 11 for women.

Table 1

Optimal, Borderline, and High Risk Lipid Profile

Component	Optimal	Borderline	High Risk	Male	Female
LDL Cholesterol	<100	130 – 159	>160		
HDL Cholesterol	≤60		>40		
Triglycerides	<150	150 - 190	>200		
Total Cholesterol	<200	200 – 239	>240		
Cholesterol:HDL	<4	5	>6		
HDL:LDL				Low Risk - 4.0 High Risk - >23	Low Risk – 3.8 High Risk - >11

Note: From "Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) Final Report," 2002, *Circulation*, 106, p. 3167, 3169, and 3172.

The association noted between increased calcium intake and increased lipolysis has led to the hypothesizing that calcium may also impact circulating lipid concentrations thus impacting CVD. Recent studies on calcium and dairy consumption have shown an association between increased calcium intake and healthier metabolic and lipid profiles. However, the available data is often contradictory. Jacqmain et al. (2003) studied calcium intake and obesity among adults aged 20-65 years. This study was a part of the second phase of a preexisting study, the Quebec Family Study. Participants in this study

were divided into three groups based on daily calcium consumption. In this analysis, plasma lipoprotein-lipid profile was also observed. There were inverse correlations noted between dietary calcium intake and plasma lipoprotein-lipid profile for women and men after adjusting for fat mass and WC, LDL cholesterol, total cholesterol, and the ratio of total to HDL cholesterol. In contrast, Zemel and colleagues (2004) found no significant effects of low calcium diets, high calcium diets, or high dairy diets on lipid profiles in adults.

Much of the research on calcium intake and lipid profiles addresses either dietary calcium intake, calcium supplement intake, or a combination of the two. Major, Alarie, Doré, Phouttama, and Trembly (2007) investigated the impact of calcium and vitamin D supplementation during a weight loss intervention on plasma lipids and lipoprotein concentrations. The participants in this study were 63 healthy, overweight or obese women. These women participated in a weight-loss intervention where they were instructed to follow a diet with a 700 kcal deficit. The participants in this study were also randomized to be in one of two groups: 2 tablets per day of calcium and vitamin D at 600 mg calcium and 200 IU vitamin D, or placebo. This intervention was complete after 15 weeks of participation. Because there was a 700 calorie decrease in consumption prescribed on an individual basis for all participants in this study, it was noted that there was a significant time effect on body weight, body mass index, WC, and fat mass. There were significant decreases noted between week 0 and week 15 in LDL cholesterol (in calcium plus vitamin D group), and in total: HDL and LDL: HDL ratios (in both groups). There was also a significant time x treatment interaction in these same groups. A significant effect of time on total, HDL, and LDL cholesterol, HDL:LDL, fasting blood

glucose and insulin, and blood pressure were noted as well. The differences noted between total:LDL and LDL:HDL were independent of the noted weight change among participants (Major et al., 2007).

Reid et al. (2002) also looked at the effects of calcium supplementation on lipid profiles in women. The participants in this study consisted of 223 women over the age of 55 years. Subjects were randomized to a treatment group (n = 111) and a placebo group (n= 112). The treatment group received 1 gram of elemental calcium citrate daily. The lipid measurements were conducted at baseline, 2 months, 6 months, and 1 year. Diet and physical activity was also assessed in this study.

There was no significant difference in baseline lipid data between calcium and placebo groups. A significant increase in HDL was noted in the calcium group compared to the placebo group (change at baseline to 12 months for HDL in calcium group and placebo group 0.12± 0.25 and 0.03 ± 0.20, respectively). HDL/LDL ratio also showed a significant between group difference (changes from baseline to 12 months in calcium and placebo groups were 0.07 ± 0.11 and 0.02 ± 0.35, respectively). There was also a non-significant decrease in triglycerides noted for either group. The researchers noted that there was a mean body weight decrease of 0.3 ± 1.8 kg in the calcium group and 0.09 ± 2.4 kg in the placebo group (p = 0.54) (Reid et al., 2002).

In studies conducted by Major et al. (2007) and Reid et al. (2002), there were significant time x treatment effects noted for HDL, and LDL:HDL ratio. It may be important to note an important difference between the two studies. Major and colleagues (2007) had an emphasis on weight loss with specific instruction to reduce total caloric intake by 700 calories. Reid et al. (2002) did not design the study to encourage weight

loss for its participants. Another difference between the two studies is the type of supplementation used and the dosage. Reid et al. (2002) used Citracal (calcium citrate) at 1,000 mg per day while Major et al. (2007) used Caltrate (elemental calcium plus vitamin D) at 1200 mg calcium and 400 IU of vitamin D per day. These differences may have impacted the differences observed between results.

Bostick and colleagues (2000) reported on the effect of calcium supplementation on lipid profiles in 193 men and women ages 30 – 74 years. This was a randomized, double-blinded clinical trial which was conducted over a four month period for cholesterol determinants (total cholesterol and HDL – cholesterol) and six months for blood pressure (diastolic and systolic). Participants in this study were assigned to one of three groups: placebo group, 1.0 gram elemental calcium supplement, or 2.0 gram elemental calcium supplement. Of the participants, 63% were men and 99% were white. Some of the participants presented with evidence of hypercholesterolemia and HTN. At baseline and at study's end, there were no significant differences among treatment groups in any area except for total daily fat intake for which that of the 2 gram calcium group was 3% higher than fat intake of the 1 gram calcium group.

Karanja et al. (1994) examined the impact of food derived calcium on plasma lipid and lipoproteins. A total of 236 participants were randomized into 3 intervention groups: diet group - counseled to increase dietary calcium through eating 1,500 mg calcium per day, supplement group - given a 1,000 mg per day calcium supplement, or placebo group. Participants were part of a 4 week baseline phase first and then were placed in an intervention group. Each intervention lasted for 12 weeks. Dietary intake data were measured using several different methods – 24 hour recalls at baseline and

during intervention and 3 day food records (for diet group only). There were no specific calorie intake requirements prescribed for participants.

Greater than 90% of the participants in each group were white. The majority of the participants were also professional people. Those participants who had hypertension had a significantly higher BMI that the normotensive participants. At baseline, triglycerides and total cholesterol did not differ among groups – hypertensive versus normotensive or male versus female. Normotensive females had significantly lower LDL than hypertensive subjects. Also, normotensive females had significantly higher HDL than males. Those participants that were hypertensive had significantly higher concentrations of LDL and significantly lower concentrations of HDL (Karanja et al., 1994). Normotensive females had a significantly higher intake of calcium than hypertensive female participants (894 mg and 783 mg, respectively). Normotensive women had significantly lower intake of calcium when compared to males (946 mg, 1,038 mg for hypertensive and normotensive males, respectively).

Calcium intake increased overall for the diet group from baseline to completion. Eighty-three percent of the diet group achieved the goal calcium intake of 1500 mg of food related calcium per day whereas 6% of both placebo and calcium supplement groups consumed 1,500 mg calcium per day from food sources. Males in the diet group increased their calcium intake from 1,023 ± 425 mg to 2,011± 421 mg per day. This increase was significantly greater than any other male group. Females in the diet group increased their calcium intake from 870 ± 289 mg to 1,754± 384 mg per day. For the women, this increase was significantly greater than any other female group. The effects of the different treatment groups on lipid profile for both male and female resulted in no

significant differences observed between baseline and 12 weeks. In addition to that, there were no significant weight change differences identified when comparing the diet group to the placebo group ($p>0.10$), which could potentially account for the lipid levels. Both males and females in the diet group gained weight (0.5±2.0 kg and 0.5±1.8 kg, respectively), while only females in the placebo group gained weight (0.48±1.6 kg). Males in the placebo group lost weight (0.02±2.8kg). As for the participants in the supplement group, supplement group males and females lost 0.2±1.6 kg and 0.2± 1.8 kg ($p<0.02$ (respectively) (Karanja et al., 1994).

Azadbakht et al. (2005) addressed dairy consumption and metabolic syndrome in 827 Tehranian adults aged 18 – 74 years. Participants were grouped according to dairy intake into quartiles: quartile 1 (1.7 servings per day of dairy foods), quartile 2 (1.7 - < 2.3 servings per day), quartile 3 (2.3 - <3.1 servings per day), and quartile 4 (≥ 3.1 servings per day). Those in the highest quartile for dairy were less likely to have enlarged WC and metabolic syndrome and had lower systolic and diastolic blood pressure, and lower BMI than the other groups. The prevalence of metabolic syndrome was greatest in those in quartile 1 of dairy consumption. In addition, HDL was significantly lower in quartiles 1 through 3 than in quartile 4.

Calcium Intake and Hypertension

High blood pressure is a major CVD risk factor that affects millions of adults in the US. Within the years 1999-2002, 30% of the adult population over the age 20 in the US had hypertension. African American men and women have a disproportionately higher prevalence of high blood pressure when compared to white and Mexican American men and women (40.6% African American men, 43.5% African American

women versus 27.6% white men, 28.5% white women and 26.8% Mexican men 27.9% Mexican women) (CDC – "Fact Sheet," n.d.). The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure has classified high blood pressure in two stages: Stage 1 Hypertension defined as systolic blood pressure ≥160 mmHg or diastolic blood pressure 80-89 mmHg and Stage 2 Hypertension defined as systolic blood pressure 140-159 mmHg or diastolic blood pressure ≥ 100 mmHg (National High Blood Pressure, 2004).

Because diet is an important determinant of blood pressure, it is understandable that national nutrition related guidelines would be established to treat or prevent HTN. The Dietary Guidelines for Americans suggest making specific changes in the diet that can impact blood pressure including 1) "maintain body weight in a healthy range, balance calories from foods and beverages with calories expended", 2) "to reduce the risk of chronic disease in adulthood: engage in at least 30 minutes of moderate-intensity physical activity, above usual activity, at work or home on most days of the week", 3)" Consume a sufficient amount of fruits and vegetables while staying within energy needs", 4) "Consume less than 2,300 mg (approximately 1 tsp of salt) of sodium per day", 5) "Choose and prepare foods with little salt. At the same time, consume potassium-rich foods, such as fruits and vegetables" (U.S. Department of Health and Human Services and U.S. Department of Agriculture [USDHHS USDA], 2005). These guidelines also suggest that individuals adopt a balanced diet by following guidelines established by the Food Guide Pyramid and the Dietary Approaches to Stop Hypertension (DASH) eating plan).

Epidemiological and clinical data suggest that an effect on blood pressure can be achieved through manipulation of the diet. Svetkey and colleagues (1999) conducted a subgroup analysis of the DASH study to identify any effects of specific dietary patterns on blood pressure. Researchers with the DASH study used randomized controlled feeding environments as a part of their methodology. Participants were fed a controlled diet for 3 weeks. Subsequently, they were randomized to one of three diet types: the control diet, a diet rich in fruits and vegetables, and a combination diet rich in fruits and vegetables, low-fat dairy foods, and reduced in saturated fat, total fat, and cholesterol. As a part of participation, participants came into a feeding site once every week day and ate either lunch or dinner, and were given food to consume within the next 24-hour period of time (Svetkey et al., 1999).

Adherence to the diet was greater than 95% as evidenced by biochemical measures. Blood pressure changes were noted in participants eating the combination diet. In practically all subgroups (African Americans and whites, male and females, under 45 and over 45 years of age, various income levels, various levels of physical activity, hypertensive status, and genetic associations), a significant decrease in blood pressure (both diastolic and systolic) occurred. There was a statistically significant change in diastolic blood pressure for those with a high school education or less and for those who reported some alcohol consumption. Among all subjects, the reduction in blood pressure was significantly greater for those who presented with HTN. Among all participants, African Americans with HTN reduced blood pressure by 13.2/6.1 mm Hg (95% CI) compared to 4.3/2.6 mm Hg in normotensive African American participants. Whites with

HTN experienced a reduction of 6.9/3.7 mm Hg (95% CI) compared to 2.0/1.2 mm Hg (95% CI) in normotensive participants (Svetkey et al., 1999).

For those participants in the fruit and vegetable diet group, statistically significant decreases in blood pressure occurred for some subgroups including African Americans, males, obese females (systolic only), those with some college, the higher SES group, those who drank no alcohol, and those who were hypertensive from the beginning. The greatest impact of the fruit and vegetable diet was observed in those who presented with HTN. There was a 7.1/2.8 mm Hg decrease in blood pressure among hypertensive participants and a 0.9/0.4 mm Hg in the normotensive group. Hypertensive African American participants experienced the greatest effect with a 8.0/3.4 mm Hg decrease in blood pressure, compared to 5.9/3.1 mm Hg in hypertensive whites (Svetkey et al., 1999). In this study, the DASH combination diet had an effect in all groups represented. It was particularly successful in African Americans and hypertensive participants. This indicates that there is a response by hypertension to the diet.

Alonso, Beunza, Delgado-Rodriguez, Martinez, and Martinez-Gonzalez (2005) addressed the relationship of low-fat dairy consumption to hypertension in 5,880 university graduates in Spain. Participants in this study were over the age of 20, without documented HTN and CVD at baseline. Participants completed self-administered questionnaires that covered HTN diagnosis, food frequency, and demographic information including height and weight. The participants were followed up at 2 years following baseline assessment (Alonso et al., 2005).

Younger participants and female participants were more likely to have the highest consumption of total and low fat dairy products per day. A significant reduction in the

risk of HTN was noted for participants in the fourth quintile of dairy consumption compared to the lowest quintile. Those in the highest quintile for low-fat dairy product consumption also had a lower risk of HTN when compared to the lowest quintile (Alonso et al., 2005).

Zemel and colleagues (2004) found some effect on hypertension when the diet had increased amounts of calcium. In the study previously mentioned, there was also a significant decrease in systolic blood pressure noted in the high dairy group (a reduction of 4.8±mm Hg). There was no difference noted for diastolic blood pressure. In a study conducted by Bostick et al. (2000), changes in blood pressure were noted for all participants at six months into the intervention. However, those who were in the calcium supplementation group had blood pressures that seemed to decrease over time in comparison with the control group who had a small decrease in pressure and then a plateau. After six months, a non-significant decrease of 0.8 mm Hg in systolic blood pressure and 0.4 mm Hg in diastolic blood pressure was noted in calcium supplemental group.

In conclusion, studies suggest that there is an association between calcium intake and blood pressure in various populations. That association between calcium or more specifically dairy consumption has resulted in modest decreases in blood pressure. This is exemplified in the work of Zemel et al. (2004) where a modest reduction in systolic, but no reduction in diastolic blood pressure, was associated with increased calcium or dairy intake, as well as the work of Bostick et al. (2000), where a modest reduction in both systolic and diastolic BP was associated with increased calcium intake (trend not significant). Alonzo et al. (2005) found decreased risk for hypertension for those who

consumed the highest level of calcium in the study group, and Svetkey et al. (1999) found that increases in calcium intake with a combination diet resulted in decrease diastolic and systolic blood pressure for people from different ethnic, socioeconomic, and gender groups. While these inverse associations are of interest to the nutrition community, every study has not resulted in similar results. There are mixed results in the research for calcium's effect on blood pressure as there are mixed results for calcium's effect on CVD risk factors and obesity. The hypothesis that increased calcium intake can decrease blood pressure and blood lipid levels, and improve weight status is viable. The hypothesis is also worthy of further investigation.

The Jackson Heart Study

The JHS is a prospective, epidemiological study of CVD risks among African Americans in Mississippi sponsored by the National Heart, Lung, and Blood Institute and the National Center on Minority Health and Health Disparities. It is a collaboration of several Mississippi entities including the University of Mississippi Medical Center, Tougaloo College, and Jackson State University. The JHS began its investigation into CVD among African Americans in 2000. The study that began in 2000 represents what is considered the first phase of the JHS research process. Participants in the JHS underwent a broad examination during the initial visit that included a series of questionnaires on eating habits, lifestyle habits, medical history, medications intake, social interactions and cultural factors, physical assessments (height, weight, WC, blood pressure, electrocardiogram, ultrasound measurements of the heart and arteries in the neck, and pulmonary function) and laboratory measurements (including lipid panels, glucose, sodium, and DNA) (National Heart, Lung and Blood Institute [NHLBI], n.d.).

Currently, there has been little research conducted to assess the relationship between calcium intake, body composition measures including BMI and waist circumference, and serum lipids in the African American community. The data exists within the JHS to systematically investigate the hypothesis that increased calcium intake is associated with lower blood pressure, serum lipid levels, BMI, and waist circumference in an African American population.

CHAPTER III

METHODOLOGY

Design of Study

This study was a cross-sectional, secondary data analysis of calcium intakes and cardiovascular disease risks including obesity, serum cholesterol levels, and hypertension among African American adults age 21-84 years. Data from the Jackson Heart Study (JHS) were used in these analyses.

Participants

The men and women in this cross-sectional analysis were participants of the JHS. The JHS was a single-site prospective epidemiological investigation of cardiovascular disease among African-Americans from the urban and rural areas around the Jackson, Mississippi (MS), metropolitan statistical area (MSA) to encompass three specific counties (Hinds, Madison, and Rankin counties). The participants in the JHS were non-institutionalized African American males and females recruited from the Jackson MSA. There were 5, 302 participants (3,395 females and 1,907 males) ranging in age from 21 to 84 years who completed the baseline visit for the JHS. Participants in the JHS were taken from four main sample sources – Jackson Atherosclerosis Risk in Communities (ARIC) participants (ARIC was the foundation for JHS), random sampling, family component (from participants already recruited), and volunteers. A more detailed description of the original study has been published elsewhere ("Jackson Heart Study," 2001; Taylor, 2005; Taylor et al., 2005).

Exclusion Criteria: Exclusion criteria employed by other researchers working with the JHS data set were selected to determine valid dietary intake measures

(Talegawkar et al., 2007). All participants who reported total energy intakes <600 kcal or ≥4,000 kcal on the dietary assessment form were excluded from analysis. This method has been employed be previous researchers reporting on JHS data (n = 607) (Talegawkar et al., 2007; Carithers et al., 2009). Energy intakes below 600 calories per day or above 4, 000 calories per day were considered implausible. Participants without serum samples for total cholesterol, LDL, HDL, and triglycerides (collectively) (n = 430), BMI (n = 4), or WC (n = 3) were also eliminated from these analyses. Also excluded from the analysis were participants with implausible WC measures (n = 1). According to Fernandez et al. (2004), a waist circumference of 32 centimeters is below the 10^{th} percentile for boys and girls between the ages of 2-18.

Instruments and Data Collection

Data collection for the JHS began in late 2000 and ended in early 2004. Data pertaining to participants in JHS were obtained from the household interview component and from the clinic examinations, anthropometric and interview components were conducted at the examination center (EC). Household interview data were collected using the Home Induction Questionnaire conducted in the participants' home. The home interview established the potential participant's eligibility to participate and served as an instrument to enumerate other eligible household members. This interview ended with a scheduled JHS clinic appointment. Once each participant was in the EC, he or she was interviewed in a private setting where the participant completed the Delta NIRI/JHS Food Frequency Questionnaires administered by trained JHS staff.

The University of Mississippi Medical Center's institutional review board approved protocols for the JHS. All participants gave written informed consent prior to enrollment (Carithers et al., 2005).

Jackson Heart Study Data Collection Procedures

This research was a secondary data analysis of JHS data. Therefore, the data collection procedures were those followed by JHS staff. JHS data collection procedures discussed below included anthropometric assessment methods and dietary assessment methods. Procedures used to prepare the data for statistical analysis included exporting data into a SAS system file, identifying participants who had completed the six required data collections points and excluding those who did not, identifying participants who had blood samples available, and recoding extreme values reported in the FFQ. Further data analysis procedures included categorizing calcium containing food items and supplements and defining calcium intake patterns. The data analysis procedure for each objective will be discussed in the variable definition and statistical analysis sections that follow.

Physical and Biological Measures

Anthropometric Assessment methods. Height, weight, and WC were collected following standard procedures. All anthropometry was performed before participants consumed the clinic snack. Participants were dressed in light-weight, non-constricting clothing/underwear including either a scrub suit or an examination gown. If participants were wearing nylon hosiery or other constricting undergarments, they were asked to remove them. All anthropometric measures were either taken using a team approach where one technician took the body measurement and the other recorded the data or by

one technician using a full-length mirror to determine accuracy of measurement device placement.

1. Height. Standing height was measured on each participant once. All participants were measured without shoes. The height was measured with the heel and back of head touching a vertical centimeter ruler on the wall. Participants were instructed to stand erect with their head in the Frankfort Horizontal plane. The right angle was brought down snugly on the participant's head. A certified technician recorded the measurement for height in centimeters. Each measurement was rounded to the nearest centimeter.
2. Weight. Weight was measured on a balance scale (balanced before each participant was weighed to ensure that the indicator was on zero without any weight being applied to the scale). The scale was on a stable foundation (not carpet). Participants were instructed to stand in the middle of the platform on the balance scale with head erect and shoulders and eyes looking straight ahead. The scale used in this project was the Detector (model #437).The weights were adjusted on the beam balance until the scale was balanced. Weight was recorded in kilograms.
3. Waist Circumference. Prior to the measurement, participants were instructed to stand erect and place legs approximately 6 inches apart with their body weight evenly distributed on each leg. Abdominal girth was measured in the horizontal plane with the umbilicus as the

point of origin using an anthropometric tape. Upon measuring abdominal girth, participants were instructed to breathe quietly. The measurement was taken at the point of relaxation and exhalation. Each measurement was rounded to the nearest centimeter.

4. Body Mass Index. BMI was calculated using the standard formula of weight in kilograms divided by height in meters squared (kg/m^2). It was a derived variable provided by the Coordinating Center of the JHS.

Biological Measures. Biological data were collected on participants in the JHS using standard procedures. Participants were instructed to fast for at least 12 hours prior to appointment time with JHS ("Jackson Heart Study," 2001).

1. Blood Pressure. Sitting arm blood pressure was measured using a Hawksley random zero sphygmomanometer. Four cuff sizes were available and the appropriate one was selected based on measured arm circumference: small adult (<24 cm), adult (24-32 cm), large adult (33-41 cm), thigh (<41cm). Blood pressure was measured in the resting state. Two readings were taken on each participant, and an average of the two random zero readings were recorded for each patient.
2. Blood Samples. Blood samples were collected on the day of baseline interview and routed through a three step process. After blood samples were collected in vacutainer tubes, they were set-up for immediate processing which included holding tubes at room temperature for 30 minutes to allow the blood to clot, centrifugation of tubes at 3,000 x *g*

centrifugal force for 10 minutes at 4°C. After centrifugation, some of the serum was left in the local lab for testing. The rest was separated and held in -70°C freezer and sent to the JHS-Central Laboratory, Fairview-University Medical Center in Minneapolis, Minnesota. The JHS-Central Laboratory performed routine plasma lipid tests on specimens provided. After analysis, the Central Laboratory was responsible for reporting results to the JHS Coordinating Center.

Dietary Assessment

Food Frequency Questionnaires. The FFQ was used to ascertain the usual intake of the JHS cohort participants. The Delta NIRI-JHS FFQ (FFQ) is a 158 item questionnaire which was administered by trained JHS clinic staff to all participants of the JHS. As a part of the JHS requirement to limit participant burden, administration of FFQs was completed within a 20 minute time frame (Carithers et al., 2005; "Jackson Heart Study," 2001).

The FFQ used in the JHS was developed specifically for use in a southern population. Details about the development of the initial 283 item Delta-NIRI Long FFQ have been published elsewhere (Tucker et al., 2005). The FFQ, which was similar in design to a longer version of the food frequency questionnaire created for a validation study, was shortened to fit the time requirements of the JHS protocol by collapsing items. Quality control checks were performed on the FFQ to ensure completion of instrument administration. Five percent of all the FFQ administrations were audio-taped and reviewed by the registered dietitian on staff. Feedback was provided regarding any missing data or multiple marks indicated on the FFQ form, and interviewers were given

the opportunity to make any appropriate corrections. After completion of quality control procedures, FFQ data were sent to Tufts University for scanning. Outliers were identified and returned to JHS staff for editing. Once editing was complete, Tufts University created a data set in SAS (version 9) (Carithers et al., 2005; "Jackson Heart Study," 2001).

The JHS Delta NIRI FFQ was administered to participants in JHS as a part of the interview that took place during the examination. With the JHS cohort, subjects were asked to think about their usual dietary intake over the past 6 months. Participants were asked to respond with how often they usually consumed the FFQ items per day, per week, per month, or not at all. Frequencies of intake from the FFQ were converted twice: to per year level and finally converted to the per day level (P. Bakun, personal communication, September 5, 2008).

The FFQ included calcium-containing food categories, as listed in Table 2. The categories of FFQ calcium-containing items included milk and milk drinks (chocolate or regular); calcium fortified juices (citrus and non-citrus); dairy foods including cheese, yogurt, ice cream, frozen yogurt; beans including pinto beans and navy beans; fish including canned sardines with bone and canned salmon with bone; vegetables including turnip greens, mustard greens, broccoli, and okra; mixed dishes prepared with cheese including lasagna and pizza; and supplements including multivitamins (one-a-day types) and calcium supplements. An open-ended section of the FFQ allowed participants to provide a list of food items usually consumed, but not mentioned in the questionnaire. The researcher did not use this section of the food frequency in this study analysis.

Table 2

Calcium-Containing Food Categories and Subcategories Corresponding to Dairy Items of the JHS Delta NIRI Food Frequency Questionnaire (FFQ)

Calcium-Containing Food Categories & Subcategories	FFQ Item
1. Milk and milk drink, chocolate and regular	1a. When you eat cereal do you add milk? 1b. How often, on an average, do you drink milk? 1c. If you add milk or cream, is it usually milk…cream…non-dairy creamer? 1d. When you drink milk, it is usually…skim, 1%, 2%, whole? 1e. When you drink coffee, it is usually taken black, with some milk or cream, light, very light?
2. Citrus and non-citrus juices	2a. How often, on an average, do you drink fruit drinks – not 100% (including Hi-C, lemonade, Sunny Delight, Snapple) 2b. How often, on an average, do you drink powdered drink mixes (incl. Kool-Aid, Tang)?

Table 2. continued

3. Dairy foods – cheese, yogurt, and ice cream	3a. How often, on an average, do you eat cheese? 3b. How often, on an average, do you eat cottage cheese? 3c. How often, on an average, do you eat cheese spreads and dips? 3d. How often, on an average, do you eat yogurt (not frozen)? 3e. How often, on an average, do you eat ice cream? 3f. How often, on an average, do you eat frozen yogurt, ice milk? 3g. How often, on an average, do you eat pudding, custard, cheesecake?
4. Beans	4a. How often, on an average, do you eat other dried beans (other than baked, cooked in rice or chili)?
5. Fish	5a. How often, on an average, do you eat sardines, mackerel or canned salmon?
6. Vegetables, dark green leafy	6a. How often, on an average, do you eat broccoli? 6b. How often, on an average, do you eat mustard greens, turnip greens, collards,

Table 2, continued

	spinach, poke salat? 6c. How often, on an average, do you eat okra?
7. Mixed dishes with cheese	7a. How often, on an average, do you eat mixed dishes w/cheese (incl. macaroni & cheese, lasagna, broccoli & rice casserole)? 7b. How often, on an average, do you eat pizza?
8. Fruit	8a. How often, on an average, do you eat oranges, grapefruit (not juice)?
9. Supplement Use	9a. How often do you take a regular One-A-Day vitamin? For how long have you taken a regular One-A-Day vitamin? 96. Do you take calcium supplement regularly? For how long?

Variables

Table 3 shows all variables used in the analysis of the hypothesized relationship between dietary calcium intake, body mass index, waist circumference, serum lipids – total cholesterol, HDL cholesterol, LDL cholesterol, and triglycerides, and both diastolic

and systolic blood pressure. Dietary calcium intake of the participants was determined using the JHS food frequency questionnaire responses to the questions listed on Table 2. Macronutrient and calcium intakes based on the FFQ were calculated using the nutrient analyses program created by the University of Minnesota - Nutrition Data System (NDS) program (Version 5.0). Total calcium intake was calculated based on the sum of dietary calcium and calcium supplement intakes. Supplemental calcium intake was determined using standard supplement products on the market. A spreadsheet with reference medication portion sizes for all dietary supplements was created for the FFQ based on 24 hour recalls completed to create the original FFQ. This spreadsheet was merged with the current JHS FFQ (including the frequency and portion sizes eaten) into a database for nutrient composition of each food on the JHS FFQ. Median intakes from the original 24 hour recalls were recorded. The supplements were entered in the nutrient database from the FFQ at the reference quantities determined by mean intakes from the recalls. For multivitamin supplements, the nutrient make-up was based on a Centrum One-A-Day® vitamin. For individual calcium supplements, nutrient make-up of the supplement was calculated based on the nutrient make-up of a single nutrient supplement for calcium such as Oscal® (P. Bakun, personal communication, April 14, 2009). The FFQ was used to ascertain typical dietary calcium intake habits from foods and beverages and to determine the typical amount consumed at each intake. FFQ data were analyzed using NDS. Data was then entered into the NDS system for analyses. Energy presented in calories, macronutrients – carbohydrates, fats, proteins, saturated fat, and transfatty acid - presented in grams, and calcium intake presented in milligrams was derived from this process (J. Maris, personal communication, September 5, 2008).

Other variables included BMI, waist circumference, LDL and HDL cholesterol, total cholesterol, triglycerides, diastolic and systolic blood pressure, sociodemographic data, smoking data, and physical activity data. Of the weight-related variables, BMI was a derived variable, calculated from measured height and weight ("Jackson Heart Study," 2001). The sociodemographic data collected were gender, age, household income, and education level collected during the Home Induction Interview process. The data obtained on birth, education, and income was self-reported data. Data on smoking and physical activity were collected for JHS participants during the Home Induction Interview process. Both of these questions relied on self-reported data. The smoking status was a derived variable from questions regarding tobacco use by participants. Participants were classified, based on this derived variable, as never, former, or current smoker. The physical activity question was based on leisure time physical activity. Participants were asked, "During a usual week in the past year, about how many times a week did you do physical exercise in your free time for at least 20 minutes without stopping, which was hard enough to make your heart rate and breathing increase a large amount?" (JHS Manual, 2001). Participants responded to this question using zero to seven times per week.

Table 3

Variables, Units of Measurement, and Data Sources

Variables	Measurement Units	Variable Type	Data Source
Biological/Anthropometric			
Systolic Blood Pressure	mm Hg	Continuous	JHS Baseline Clinical Examination
Diastolic Blood Pressure	mm Hg	Continuous	JHS Baseline Clinical Examination
Chronological Age	Years	Continuous	
BMI	Kg/m^2	Continuous	JHS Baseline Clinical Examination
Waist Circumference	cm	Continuous	JHS Baseline Clinical Examination
Serum Cholesterol			
HDL	mg/dL	Continuous	JHS Baseline Clinical Examination
LDL	mg/dL	Continuous	JHS Baseline Clinical Examination
Total	mg/dL	Continuous	JHS Baseline

Table 3 (continued)

Cholesterol			Clinical Examination
Triglycerides	mg/dL	Continuous	JHS Baseline Clinical Examination
Socioeconomic			
Sex	Male/Female	Dichotomous (1/0)	Home Induction Interview
Education		Categorical	Home Induction Interview
Age	Years	Continuous	Home Induction Interview
Dietary Variables			
Calcium	mg	Continuous	FFQ
Milk	mg	Continuous	FFQ
Non-milk dairy	mg	Continuous	FFQ
Supplement	mg	Continuous	FFQ
Non-dairy	mg	Continuous	FFQ
Calories	Total kcal	Continuous	FFQ
Protein	gm	Continuous	FFQ
Carbohydrates	gm	Continuous	FFQ
Fats	gm	Continuous	FFQ
Saturated Fats	gm	Continuous	FFQ
Transfatty Acid	gm	Continuous	FFQ

Table 3 (continued)
Health Factors

Smoking Status	0, 1, or 2	Categorical	Home Induction Interview
Physical Activity	0, 1, 2, 3, 4, 5, 6, or 7	Categorical	Home Induction Interview

Data Management

The SAS system for windows was used to extract the data from the JHS file to a CD-ROM. Data were imported into SPSS for analyses. Descriptive statistics were used to identify outliers and implausible values, and data were cleaned based on these analyses.

Research Objectives

The researcher developed four research objectives to fully explore the problem of this study. The first research objective sought to describe participants in terms of BMI and WC, serum lipid status, and blood pressure. The second research objective described nutrient intake in terms of total caloric intake, total grams of carbohydrate, fat, and protein intake, total milligrams of calcium intake, total grams of saturated fat, total grams of trans fatty acid intake, and the milligrams of calcium based on dietary calcium and supplemental calcium intake (including milk, non-milk dairy, supplemental calcium, and non-dairy calcium intake). The third research objective was to assess possible association between (a) total calcium intake and BMI and (b) total calcium intake and WC within an African American population. The fourth research objective was to assess the possible association between (a) total calcium intake and TC, (b) total calcium intake and LDL cholesterol, (c) total calcium intake and HDL cholesterol, (d) total calcium intake and

triglycerides, (e) total calcium intake and systolic blood pressure, and (f) total calcium intake and diastolic blood pressure within an African American population.

Statistical Analyses

The current dissertation research was a correlational study using data from the JHS in a cross sectional analysis to examine the association between calcium intake and dairy product consumption and CVD risk factor: obesity (BMI and WC), HDL, LDL, total cholesterol, triglycerides, and diastolic and systolic blood pressures. Data were analyzed using SPSS for Windows, Version 16.0 (SPSS Inc. Chicago, IL, USA).

Regression analyses were used to evaluate the predictive value of calcium intake and components of calcium intake for dependent variables (DV) including BMI, waist circumference, LDL, HDL, total cholesterol, triglycerides, and systolic and diastolic blood pressure, while controlling for potential confounders. In multiple regression, the F-test was computed to determine if the relationship between the set of independent variables (IV) and the dependent variable (DV) was large enough to be meaningful. To assess differences by age, gender, education background, and family income, F-tests were used. The F-tests served to establish the presence of linearity and to determine if the model examined could significantly predict the dependent variable. Alpha for all analyses was set at 0.05 level.

Research Objective One -- Describe JHS participants in terms of BMI and WC, Serum lipid status and blood pressure.

Descriptive statistics, including means, SDs, and number of participants who were at a normal weight, overweight, underweight, or obese; normotensive or hypertensive;

and with or without the presence of dyslipidemia, were computed to respond to this research question.

Research Objective Two -- Describe the nutrient intake of JHS participants, including macronutrient intake and calcium intake (total calcium and dietary calcium intakes).

Descriptive statistics, including means and SDs, and mg and gm of consumption, were computed to respond to this research question. The FFQ data were used to derive calcium intakes for each category of intake, including milk, non-milk dairy, calcium supplements, and non-dairy calcium. Nine main types and 27 subtypes of dairy and non-dairy calcium containing foods were examined. The FFQ items corresponding to each calcium-containing food group are listed in Table 2.

Research Objective Three -- Assess the association of calcium intake with body mass index and waist circumference measures.

Multiple linear regression models were used to evaluate the contribution of calcium intake to variation in BMI and WC. BMI and WC were the dependent variables for the multiple regression analysis. These analyses were controlled for education, age, energy, physical activity, and smoking.

Correlations and partial correlations were calculated to evaluate relationships between total calcium intakes (calcium from milk, non-milk dairy, supplements, and non-dairy foods and beverages) and BMI and WC. Adjustments were made to control for potential confounders including education, age, energy, physical activity, and smoking. For each regression model, potential confounders were first entered in the model, followed by the dietary calcium measures. The R squared change resulting from the

addition of the calcium measures is reported for each model. For all analyses, an α value of 0.05 was considered statistically significant.

Research Objective Four-- Assess the association of calcium intake with serum lipids and blood pressure.

Multiple linear regression models were used to evaluate the contribution of calcium intake to variations in total cholesterol, LDL and HDL cholesterol, triglycerides, and systolic and diastolic blood pressure. Blood lipid and blood pressure measures were the dependent variables for the multiple regression analyses. The analyses for serum lipids were controlled for waist circumference and BMI. The analyses re were controlled for physical activity, smoking, and age. Correlation and partial correlation analyses were conducted to evaluate relationships between calcium intakes, specifically milk calcium, non-milk dairy calcium, non-dairy calcium, calcium in supplements, and BMI and WC. For each regression model, potential confounders were first entered in the model, followed by the total calcium measures. The R squared change resulting from the addition of the calcium measures is reported for each model. For all analysis, an α value of 0.05 was considered statistically significant.

CHAPTER IV

RESULTS

The purpose of this study was to examine the relationship between calcium intake and cardiovascular disease risk factors including obesity, dyslipidemia, and hypertension in the Jackson Heart Study (JHS). This research used data from the JHS cohort food frequency data file, laboratory data file, and examination 1 data file to address the research objectives of the study. Multiple regression analysis was used to predict linear relationships among calcium intake, specifically total calcium intake and calcium intake types, and cardiovascular disease risk factors in this population.

Selection criteria for this study included participants who completed the JHS Food Frequency Questionnaire (FFQ) and had complete data for the specified biological and anthropometric measures that were chosen for this study. The initial sample which met these criteria included 5, 311 participants. Participants excluded from the dataset were those who had 1) energy intake less than 600 kcal or greater than 4,000 kcal (n=607), 2) missing lab data on all of the lipid profile: triglycerides (TG), high density lipoprotein (HDL), low density lipoprotein (LDL), and total cholesterol (TC) collectively (n=430), 3) missing body mass index (BMI) measures (n=4), 4) missing waist circumference measures (WC) (n=2), or 5) implausible WC (n=1).

The measured dependent variables were selected from the JHS dataset. These study variables are listed in Appendix A. The dependent variables body mass index (BMI), waist circumference (WC), systolic blood pressure (SBP), diastolic blood pressure (DBP), fasting low density lipoprotein cholesterol (LDL), fasting high density

lipoprotein cholesterol (HDL), fasting total cholesterol (TC), and fasting triglyceride (TG) were taken directly from the JHS laboratory dataset.

The measured independent variables were selected from the JHS dataset. These study variables are listed in Appendix A. The independent variables included total dietary calcium, calcium from milk (milk calcium), calcium from non-milk dairy (non-milk dairy calcium), calcium from supplements (supplement calcium), and calcium from other foods (non-dairy calcium).

After excluding subjects as described above, there were 4,267 African American adults included in the analyses for this study, ages 21-95 years (mean 55.1±12.6 years). The subjects consisted of 2,767 females (64.8%) and 1,500 males (35.2%). The mean age did not differ significantly between males and females (54.5±12.6 years and 55.6±12.5 years, respectively). Smoking status data of 4,243 JHS participants reporting smoking status showed that 69.1% of the participants were never smokers, 19.1% were former smokers, and 11.2% were current smokers. Among females, 9.0% were current smokers compared to 15.4% of males. Education demographic data of 4,256 JHS participants showed that 17.1% of the study sample reported less than a twelfth grade education, 19.7% a high school diploma or GED, 28.3% a vocational degree or some college, and 34.6% reported that they had an associate, bachelor's or professional degree.

A total of 4,022 participants responded to questions concerning physical activity. The physical activity question used in this data analysis was, "During a usual week in the past year, about how many times a week did you do physical exercise in your free time for at least 20 minutes without stopping…" ("Jackson Heart Study," 2001). Greater than

fifty percent (50%) of the participants reported no physical exercise during a usual week. Sample demographics by gender are displayed in Table 4.

Table 4

Characteristics of Male and Female Jackson Heart Study Participants

Variables	Males (n = 1,500)	Females (n=,2767)	Total (n=4,267)
Age, y	54.5±12.6	55.6±12.5	55.1±12. 6
Smoking Status[a], %			
Never	58.6	75.5	69.1
Former	26.1	15.5	19.1
Current	15.4	9.0	11.2
Education[b], %			
<12y	17.5	17.0	17.1
High school Diploma or GED	18.4	20.4	19.7
Vocational Degree Or some college	28.7	28.2	28.3
Associates/ bachelor's/ professional degree	35.4	34.4	34.6

Table 4 (continued)

Variables	Males (n = 1,501)	Females (n=2,769)	Total (n=4,270)
Physical Activity[c], %			
0 times per week	50.4	55.0	50.4
1 time per week	10.7	9.0	9.0
2 times per week	9.9	8.1	8.2
3 times per week	12.9	12.2	11.7
4 times per week	5.2	5.4	5.0
5 times per week	7.5	7.4	7.0
6 times per week	1.6	1.1	1.2
7 times per week	1.9	1.7	1.6

Values are means ± SD.
Values are means ± SD.
[a] n = 1,489 (males) and 2,751 (females)
[b] n = 1,496 (males) and 2,760 (females)
[c] n= 708 (males) and 1,441 (females)

Research Objective 1

Research Objective One was to describe JHS participants in terms of weight status and cardiovascular disease risk factors.

Obesity Measures. The mean BMI and WC by gender are provided in Table 5. BMI ranged from 14.6 to 75.1 kg/m^2 (mean = 31.7 kg/m^2). WC ranged from 56 cm – 244 cm (mean = 100.4 cm). BMI was significantly higher in females than in males (32.8±7.5 and 29.8± 6.1 kg/ m^2, p<0.001, respectively). There was no significant difference in WC between genders (100.1±16.6 cm female and 101.1±14.8 cm male).

JHS participants were represented in each weight category by measured BMI although 85.9% of the participants were classified as either overweight or obese. More

males than females were classified as overweight (BMI 25-29.9), and more females than males were classified as obese by BMI ≥ 30 (42.1 % overweight versus 28.0% overweight and 59.8% obese and 40.3% obese, respectively) (Table 6).

Table 5

Mean Body Mass Index (BMI) and Waist Circumference (WC) by Gender

	Male (n= 1,500)	Female (n = 2,767)	Total (n = 4,267)
Obesity Variables			
BMI	29.8±6.1[a]	32.8±7.5[b]	31.7±7.2
WC (cm)	101.1±14.8	100.1±16.6	100.4±15.9
	Male	*Female*	*Total*

Note. BMI ≥24.9 is considered overweight/obese. WC >102 cm for males and >88 cm for females is considered obese. Values are means ± SD. Means by gender in the same row that do not share superscripts are significantly different at $p<.001$.

Table 6

Percent of Subjects in Each Body Mass Index (BMI)Category by Gender

	Male (n =1,500)	Female (n= 2,767)	Total (n = 4,267)
BMI			
Underweight	0.8	0.4	0.5
Normal Weight	16.7	11.8	13.5
Overweight	42.1	28.0	33.0
Obese	40.3	59.8	52.9

Hypertensive Status. Blood pressure measurements by gender are provided in Table 7. The mean SBP for all participants was 126.9±18.1 mm Hg (range of 73-222 mm Hg). There was a small but significant difference in SBP between females and males (126.4±18.3 mm Hg and 127.9±17.6 mm Hg, $p = 0.008$; respectively). The mean DBP

was 78.9±10.4 mm Hg (range of 31-129 mm Hg). There was a 4 mm Hg difference between male and female participants. Males had significantly higher DBP than females (81.7 and 77.4 mm Hg; $p<0.001$; respectively).

Table 7

Mean Systolic Blood Pressure (SBP) and Diastolic Blood Pressure (DBP) by Gender

	Male (n=1,500)	Female (n=2,763)	Total (n=4,263)
SBP	127.9±17.6 mm Hg[a]	126.4±18.3 mm Hg[b]	126.9±18.1 mm Hg
DBP	81.7±10.4 mm Hg[a]	77.4±10.1 mm Hg[b]	78.9±10.4 mm Hg

Note. Values are means ± SD. Means by gender in the SBP row that do not share superscripts are significantly different at p=0.008. Means by gender in the DBP row that do not share superscripts are significantly different at $p<0.001$. SBP = Systolic Blood Pressure; DBP = Diastolic Blood Pressure

Dyslipidemia. Serum lipid concentrations are reported in Table 8. The mean TC for JHS participants was 199.7±39.8 mg/dL (range of 76-470 mg/dL). Females had a significantly higher TC than males (201.1 ±39.6 mg/dL versus 197.2±39.9 mg/dL; p = .002, respectively). The mean LDL for the entire sample was 126.9±36.6 mg/dL, and there were significant differences in LDL readings between females and males (125.9±36.3 and 128.9±37.2 mg/dL; p = .01, respectively). The mean HDL in the JHS study sample was 51.9±14.6 mg/dL. There was a significant difference noted between females and males for HDL (55.2±14.6 mg/dL versus 45.9±12.6 mg/dL; $p < .0001$ respectively). The mean triglyceride reading in JHS was 106.2±76.2 mg/dL. Males had significantly higher triglycerides than females (115.1±92.0 mg/dL versus 101.3±65.6 mg/dL; $p <.001$, respectively).

Table 8

Mean Serum Lipid Profile Data for Jackson Heart Study Participants by Gender (n = 4266)

	Male n=1,499	Female n=2,767	Total n=4,266
LDL	128.9±37.2[a] mg/dL	125.9±36.3[b] mg/dL	126.9±36.6 mg/dL
HDL	45.9±12.6[a] mg/dL	55.2±14.6[b] mg/dL	51.9±1.6 mg/dL
Total Cholesterol	197.2±39.9[a] mg/dL	201.1±39.6[b] mg/dL	199.7±39.8 mg/dL
Triglycerides	115.1±92.0[a] mg/dL	101.3±65.5[b] mg/dL	106.2±76.2mg/dL

Note. Values are means ± SD. n=4,266 (2,767 females and 1,499 males) for all measures except LDL, with n= 4,235 (2,750 females and 1,479 males). Means by gender in the LDL row that do not share superscripts are significantly different at p<.01. Means by gender in the HDL row that do not share superscripts are significantly different at p<.001.Means by gender in the Total Cholesterol row that do not share superscripts are significantly different at p=.002. Means by gender in the Triglyceride row that do not share superscripts are significantly different at p<.001. LDL = low density lipoprotein; HDL = high density lipoprotein

Research Objective 2

Research Objective Two was to describe the dietary intake of JHS participants, including macronutrient and calcium intake (total dietary calcium, calcium from milk, calcium from non-milk dairy, calcium from supplements, and calcium from other foods).

Macronutrient and micronutrient analysis was performed on the dataset. The mean energy intake for all participants was 1,960.3±785.4 kcal. Males (2,189.7±795.2 kcal) consumed significantly higher calories than females (1,835.1±750.8 kcal) (p<0.001). Males also consumed significantly more total fat, saturated fat, carbohydrate (CHO), protein, and cholesterol than females. The average reported intake of fat was 85.8±37.3 g for males and 72.4±35.1 g for females. The mean intake of CHO for the total sample was 246.2±103.8 g; males reported 268.2±103.2g while females reported

234.2±102.3 g (p = 0.001). The average consumption of protein for JHS participants was 70.8±32.9 g. Males consumed more protein than females (80.3±34.9g and 65.6±30.5g; p>0.001, respectively). The total dietary calcium intake ranged from 139.9 to 3660.4 mg. The mean total dietary calcium intake was 803.2±432.2 mg. There was no significant difference in consumption of total dietary calcium between males and females (797.3±386.6 mg and 806.9±454.8 mg, respectively) (Table 9).

Table 9

Dietary Intake of JHS Participants, Macronutrients and Micronutrients

Dietary Nutrient	Male n = 1,500	Female n = 2,767	Total n = 4,267
Energy, Kcal	2,189.7±795.2[a]	1,835.1±750.9[b]	1,960.3±785.4
Total Fat, g	85.8±37.4[a]	72.4±35.1 [b]	77.1±36.5
Total Carbohydrate (CHO), g	268.2±103.2[a]	234.3±102.3 [b]	246.2±103.9
Total Protein, g	80.4±34.9[a]	65.6±30.6 [b]	70.8±32.9
Cholesterol, mg	394.9±223.9[a]	289.8±177.2 [b]	326.8±201.2
Saturated Fat, g	26.8±12.8[a]	22.7±11.9 [b]	24.1±12.4
Trans Fatty Acid, g	4.9±2.6[a]	3.9±2.3 [b]	4.3±2.4
Calcium, mg	796.5±386.6	806.9±454.9	803.5±432.4

Note. Values are means ± SD. Means by gender in the same row that do not share superscripts are significantly different at p< 0.001.

Calcium intake from milk products ranged from 0.0 to 2083.4 mg (mean= 103.2±187.7 mg). Males consumed significantly more calcium from milk than females (119.9±205.9 and 94.1±176.4 mg) (p<.001). Calcium intake from non-milk dairy foods ranged from 0.00 to 1090.8 mg (mean = 111.4±129.0 mg). Females consumed

significantly more calcium from non-milk dairy foods than males (120.4±137.6 versus 94.91±109.6, respectively) ($p<.001$). The mean intake of calcium from supplements was 111.6±287.9 mg (range of 0.00 to 2,232.0 mg) (Table 10). Females consumed significantly more calcium from supplements than did males (141.4±327.1 mg compared to 56.8±184.4 mg, respectively) ($p<.001$). The amount of calcium consumed from dietary sources other than dairy and supplements was 483.7±203.1 mg (range of 99.9 to 2,103.2 mg). Males consumed significantly more calcium than females from foods other than dairy products and supplements containing calcium (532.6±210.3 mg versus 457.2±193.9 mg, respectively) ($p<.001$).

Table 10

Mean Calcium Intake by Gender

	Male n = 1,500	Female n = 2,767	Total n = 4,267
Total Dietary Calcium (mg)	797.3±387.6[a]	806.9±454.8[b]	803.2±432.2
Milk Calcium (mg)	119.9±205.9[a]	94.1±176.4[b]	103.2±187.7
Non-Milk Dairy Calcium (mg)	95.1±109.9[a]	120.37±137.5[b]	111.50±129.0
Supplement Calcium (mg)	56.8±184.4[a]	141.3±326.9[b]	111.6±287.9
Non-Dairy Calcium (mg)	533.2±211.2[a]	457.3±193.9[b]	483.9±203.5

Note. Values are means ± SD. Means by gender in the same row that do not share superscripts are significantly different at $p< 0.001$.

Calcium consumption was analyzed based on BMI weight categories (Table 11). Total dietary calcium intake was 806.4±379.4 mg, 808.7±425.7 mg, 796.1±432.2 mg, and 806.7±434.4 mg for underweight, normal weight, overweight, and obese, respectively. Calcium intake from milk was 86.5±167.1 mg for underweight participants, 109.9±194.2 mg for normal weight participants, 100.3±179.8 mg for overweight participants, and

103.5±191.2 mg for obese participants. Consumption of calcium from non-milk dairy foods was 118.4±121.1 mg for underweight participants, 103.4±110.2 mg for normal weight participants, 105.9±126.91 mg overweight participants, and 116.9±134.5 mg obese participants. Calcium consumption from supplements was 25.5±48.8 mg for underweight, 129.1±312.4 mg for normal weight, 111.9±281.6 mg for overweight, 108.1±286.8 mg for obese. Calcium consumption from calcium containing foods other than dairy foods was 580.5±230.3 mg for underweight participants, 474.9±191.3 mg for normal weight participants, 483.9±204.6 mg for overweight participants, and 485.0±204.5 mg for obese participants.

Table 11

Total Dietary Calcium Intake by BMI Category

	Underweight (n = 23)	Normal Weight (n = 577)	Overweight (n = 1,408)	Obese (n = 2,260)
Total Calcium	806.4±379.4 mg	808.7±425.7 mg	796.1±432.2 mg	806.7±434.4 mg
Milk Calcium	86.4±167.1 mg	109.9±194.2 mg	100.3±179.8 mg	103.5±191.2 mg
Non-Milk Dairy Calcium	118.4±121.1 mg	103.4±110.2 mg	105.8±126.9 mg	116.9±134.5 mg
Supplement Calcium	25.5±48.8 mg	129.1±312.4 mg	111.9±281.6 mg	108.1±286.8 mg
Non-Dairy Calcium	580.5±230.3 mg	474.9±191.3 mg	483.8±204.6 mg	485.0±204.5 mg

Research Objective 3

Multiple regression analysis was used to assess the association between calcium intake and weight status using BMI and WC (Table 12). Calcium intake includes the

measures total dietary calcium (mg), calcium from milk (mg), calcium from non-milk dairy (mg), calcium from supplements (mg), and calcium from other food sources (mg). Adjustments were made to control for potential confounders including smoking status, physical activity, age, energy intake, and education. For each regression model, potential confounders were first entered in the model, followed by the dietary calcium measures. The R square change resulting from the addition of the calcium measures is reported for each model.

There was a significant positive relationship noted between BMI and dietary calcium intake [F (4, 3982) = 3.26, $p = 0.019$, $\Delta R^2 = .003$] (Table 12). Total calcium intake accounted for 0.3 percent (change R square) of the variance in BMI. After analyzing by gender, a significant positive association between BMI and total dietary calcium intake in females was still present [F (4, 2590) = 2.22, $p = 0.02$, $\Delta R^2 = .004$] (Table 13 and 14). However, there was no significant relationship between BMI and total calcium intake for males [F (4, 1382) = 0.359, $p = 0.84$, $\Delta R^2 = .001$]. There was a significant negative relationship between WC and dietary calcium intake [F (4, 3982) = 2.43, $p = 0.05$, $\Delta R^2 = .002$]. After analyzing data by gender groups, there was a significant negative association between WC and dietary calcium intake for females only [Females - F (4, 2590) = 2.85, $p = 0.02$, $\Delta R^2 = .004$; Males - F (4, 1382) = .903, $p = 0.46$, $\Delta R^2 = .003$] (Table 15 and 16).

Table 12

Summary of Multiple Regression Analysis for the Relationship between Dietary Calcium, BMI and WC (n=4,267)

Variable	B	SE B	β	*p*
BMI				
Milk Calcium	.000	.001	-.019	.243
Non-Milk Dairy Calcium	.003	.001	.052	.002
Supplement Calcium	.000	.000	-.010	.540
Non-Dairy Calcium	.001	.001	.035	.111
WC				
Milk Calcium	.000	.001	-.011	.498
Non-Milk Dairy	\			
Calcium	-.001	.002	-.008	.620
Supplement Calcium	-.002	.001	-.036	.025
Non-Dairy Calcium	.003	.003	.042	.060

Note. Adjusted R^2 = .028 for BMI; ΔR^2 = .003 for BMI. Adjusted R^2 = .019; ΔR^2 =.002 for WC.

Table 13

Summary of Multiple Regression Analysis for the Relationship between Dietary Calcium and BMI in Females (n=2,767)

Variable	B	SE B	β	*p*
Milk Calcium	-.001	.001	-.034	.090
Non-Milk Dairy Calcium	.001	.001	.019	.371
Supplement Calcium	.000	.000	-.032	.101
Non-Dairy Calcium	.002	.001	.057	.034

Note. Adjusted R^2 = .029 for BMI; ΔR^2 = .004

Table 14

Summary of Multiple Regression Analysis for the Relationship between Dietary Calcium and BMI in Males (n=1,500)

Variable	B	SE B	β	*p*
Milk Calcium	.001	.001	.026	.336
Non-Milk Dairy Calcium	.001	.002	.014	.623
Supplement Calcium	.000	.001	-.014	.607
Non-Dairy Calcium	.000	.001	.016	.675

Note. Adjusted R^2 = .029; ΔR^2 = .004

Table 15

Summary of Multiple Regression Analysis for the Relationship between Dietary Calcium and WC in Females (n=2,767)

Variable	B	SE B	β	*p*
Milk Calcium	-.003	.002	-.035	.086
Non-Milk Dairy Calcium	-.001	.003	-.010	.647
Supplement Calcium	-.002	.001	-.044	.024
Non-Dairy Calcium	.004	.002	.043	.107

Note. Adjusted $R^2 = .034$; $\Delta R^2 = .004$

Table 16

Summary of Multiple Regression Analysis for the Relationship between Dietary Calcium Intake and WC in Males (n=1,500)

Variable	B	SE B	β	*p*
Milk Calcium	.002	.002	.034	.216
Non-Milk Dairy Calcium	.002	.004	.015	.609
Supplement Calcium	.002	.002	.023	.402
Non-Dairy Calcium	.003	.003	.042	.268

Note. Adjusted $R^2 = .014$; $\Delta R^2 = .003$

Simple correlations and adjusted correlations between total dietary calcium intake and body composition variables in females and males were determined. Within the entire study sample, there was a significant correlation noted between body composition measures and total calcium intake. After controlling for education, age, physical activity, smoking and total calorie intake, there was a significance positive relationship noted between BMI and calcium from non-milk dairy foods ($r = .046$, $p = .01$). There was a significant inverse relationship between WC and calcium intake from supplements ($r = -.035$, $p = .05$). When this analysis was conducted based on gender, there was no significant relationship noted between calcium intake and BMI or WC for either gender group after correction for confounding variables such as age, daily energy intake, education, physical activity, and smoking (See Table 17).

Research Objective 4

Serum Lipids. A multiple regression analysis was used to assess the prediction of serum lipids by calcium intake. Calcium intake includes the measures total dietary calcium (mg), calcium from milk (mg), calcium from non-milk dairy (mg), calcium from supplements (mg), and calcium from other food sources (mg). Adjustments were made to address the confounders for this analysis; analysis was controlled for WC and BMI. For each regression model, potential confounders were first entered in the model, followed by the dietary calcium measures. The R square change resulting from the addition of the calcium measures is reported for each model.

There was a small but significant inverse relationship between LDL and dietary calcium intake [$F (4, 4225) = 3.18$, $p = 0.01$, $\Delta R^2 = .003$] (Tables 18). A separate analysis by gender found no relationship for females and a weak but significant relationship for

males [Females - F (4, 2746) = 1.22, $p = 0.30$, $\Delta R^2 = .002$ and Males - F (4, 1472) = 2.61, $p = 0.03$, $\Delta R^2 = .007$, respectively] (Table 19 and 20).

For HDL, there was a small but significant association with dietary calcium intake [F (4, 4259) = 13.31, $p < 0.001$, $\Delta R^2 = .012$] (Table 21). This significance was not seen when data were analyzed by gender (Female – [F (4, 2760) = 2.04, $p = 0.09$, $\Delta R^2 = .003$]; Males – [F (4, 1492) = 1.39, $p = 0.23$, $\Delta R^2 = .003$]) (Table 22 and 23).

The analysis of TG and total calcium intake showed no overall significant relationship between the two for the total sample (Table 24) [F (4, 4259) = 0.99, $p = 0.41$, $\Delta R^2 = 0.001$]. There was also no relationship noted by gender [Females - F (4, 2760) = 0.533, $p = 0.71$, $\Delta R^2 = .001$; Males - F (4, 1492) = 1.092, $p = 0.36$, $\Delta R^2 = .003$] (Tables 25 and 26).

There was a small but significant inverse relationship noted between TC and dietary calcium intake [F (4, 4259) = 5.426, $p < 0.001$, $\Delta R^2 = .005$] (Table 27). The analysis by gender found no relationship for females, and a small but significant relationship for males [Female- F (4, 2760) = 1.30, $p = 0.266$, $\Delta R^2 = .002$; Males - F (4, 1492) = 3.56, $p = 0.007$, $\Delta R^2 = .009$] (Table 28 and 29).

Table 17

Partial Correlations between Calcium Intake and Body Composition Measures for All Participants (n=4,267)

Variable	R
BMI Total	
Milk Calcium	-.020
Non-Milk Dairy Calcium	.046[b]
Supplement Calcium	-.005
Non-Dairy Calcium	.023
BMI Female	
Milk Calcium	-.030
Non-Milk Dairy Calcium	.221
Supplement Calcium	-.028
Non-Dairy Calcium	.071
BMI Male	
Milk Calcium	.020
Non-Milk Dairy Calcium	.018
Supplement Calcium	-.021
Non-Dairy Calcium	.014
WC Total	
Milk Calcium	-.014
Non-Milk Dairy Calcium	-.013
Supplement Calcium	-.035[a]

Table 17 (continued)

Non-Dairy Calcium	.031
WC Female	
Milk Calcium	-.038
Non-Milk Dairy Calcium	-.013
Supplement Calcium	-.046
Non-Dairy Calcium	.033
WC Male	
Milk Calcium	.032
Non-Milk Dairy Calcium	.013
Supplement Calcium	.026
Non-Dairy Calcium	.026

Note. $^{a}p = 0.05$; $^{b}p = 0.01$

Table 18

Summary of Multiple Regression Analysis for the Relationship between Calcium Intake and LDL for All Participants (n=4,232)

Variable	B	SE B	B	*p*
Milk Calcium	-.003	.003	-.017	.261
Non-Milk Dairy Calcium	-.004	.004	-.015	.351
Supplement Calcium	-.003	.002	-.023	.144
Non-Dairy Calcium	-.007	.003	-.040	.011

Note. Adjusted $R^2 = .004$ for LDL; $\Delta R^2 = .003$ for LDL.

Table 19

Summary of Multiple Regression Analysis for the Relationship between Calcium Intake and LDL in Females (n=2,753)

Variable	B	SE B	B	*p*
Milk Calcium	-.002	.004	-.012	.532
Non-Milk Dairy Calcium	-.002	.005	-.007	.705
Supplement Calcium	-.002	.002	-.020	.291
Non-Dairy Calcium	-.006	.004	-.032	.109

Note. Adjusted R^2 = .003 for LDL; ΔR^2 = .002 for LDL.

Table 20

Summary of Multiple Regression Analysis for the Relationship between Calcium Intake and LDL in Males (n=1,479)

Variable	B	SE B	B	*p*
Milk Calcium	-.006	.005	-.030	.244
Non-Milk Dairy Calcium	-.007	.009	-.022	.408
Supplement Calcium	-.002	.005	-.009	.722
Non-Dairy Calcium	-.012	.005	-.068	.011

Note. Adjusted R^2 = .006 for LDL; ΔR^2 = .007 for LDL.

Table 21

Summary of Multiple Regression Analysis for the Relationship between Calcium Intake and HDL for All Participants (n= 4,266)

Variable	B	SE B	B	*p*
Milk Calcium	-.002	.001	-.020	.173
Non-Milk Dairy Calcium	.002	.002	.020	.184
Supplement Calcium	.004	.001	.079	<.001
Non-Dairy Calcium	-.005	.001	-.066	<.001

Note. Adjusted R^2 = .065 for HDL; ΔR^2 = .012 for HDL.

Table 22

Summary of Multiple Regression Analysis the Relationship between Calcium Intake and HDL in Females (n=2,767)

Variable	B	SE B	B	*p*
Milk Calcium	.000	.002	-.001	.942
Non-Milk Dairy Calcium	.000	.002	-.008	.668
Supplement Calcium	.002	.001	.052	.005
Non-Dairy Calcium	.000	.001	-.004	.820

Note. Adjusted R^2 = .043 for HDL; ΔR^2 = .003 for HDL.

Table 23

Summary of Multiple Regression Analysis for the Relationship between Calcium Intake and HDL in Males (n=1,499)

Variable	B	SE B	B	*p*
Milk Calcium	-.001	.002	-.019	.444
Non-Milk Dairy Calcium	.000	.003	-.009	.734
Supplement Calcium	.002	.002	.035	.163
Non-Dairy Calcium	-.002	.002	-.040	.118

Note. Adjusted R^2 = .075 for HDL; ΔR^2 = .003 for HDL.

Table 24

Summary Multiple Regression Analysis for the Relationship between Calcium Intake and Triglycerides for All Participants (n=4,266)

Variable	B	SE B	B	*p*
Milk Calcium	.007	.006	.018	.228
Non-Milk Dairy Calcium	-.013	.009	-.022	.168
Supplement Calcium	-.003	.004	-.012	.432
Non-Dairy Calcium	.003	.006	.008	.602

Note. Adjusted R^2 = .027 for Triglycerides; ΔR^2 = .001 for Triglycerides.

Table 25

Summary Multiple Regression Analysis for the Relationship between Calcium Intake and Triglycerides for Females (n=2,767)

Variable	B	SE B	B	*p*
Milk Calcium	.008	.007	.022	.236
Non-Milk Dairy Calcium	-.007	.009	-.015	.455
Supplement Calcium	.002	.004	.010	.577
Non-Dairy Calcium	-.002	.007	-.005	.801

Note. Adjusted R^2 = .028 for Triglycerides; ΔR^2 = .001 for Triglycerides.

Table 26

Summary Multiple Regression Analysis for the Relationship between Calcium Intake and Triglyceride in Males (n=1,499)

Variable	B	SE B	B	*p*
Milk Calcium	.004	.012	.010	.704
Non-Milk Dairy Calcium	-.018	.022	-.022	.403
Supplement Calcium	-.024	.013	-.048	.063
Non-Dairy Calcium	.002	.011	.005	.861

Note. Adjusted R^2 = .017 for Triglycerides; ΔR^2 = .003 for Triglycerides.

Table 27

Summary Multiple Regression Analysis for the Relationship between Calcium Intake and Total Cholesterol (n=4,266)

Variable	B	SE B	B	*p*
Milk Calcium	-.004	.003	-.017	.269
Non-Milk Dairy Calcium	-.003	.005	011	.491
Supplement Calcium	.001	.002	.006	.701
Non-Dairy Calcium	-.012	.003	-.064	<.001

Note. Adjusted R^2 = .005 for Triglycerides; ΔR^2 = .005 for Triglycerides.

Table 28

Summary Multiple Regression Analysis for the Relationship between Calcium Intake and Total Cholesterol for Females (n=2,767)

Variable	B	SE B	B	*p*
Milk Calcium	-.001	.004	-.005	.815
Non-Milk Dairy Calcium	-.003	.006	-.011	.569
Supplement Calcium	.001	.002	.006	.770
Non-Dairy Calcium	-.008	.004	-.038	.052

Note. Adjusted R^2 = .006 for Triglycerides; ΔR^2 = .002 for Triglycerides.

Table 29

Summary Multiple Regression Analysis for the Relationship between Calcium Intake and Total Cholesterol for Males (n=1,499)

Variable	B	SE B	B	*p*
Milk Calcium	-.006	.005	-.030	.244
Non-Milk Dairy Calcium	-.011	.010	-.030	.250
Supplement Calcium	-.004	.006	-.017	.523
Non-Dairy Calcium	-.015	.005	-.077	.004

Note. Adjusted R^2 = .006 for Triglycerides; ΔR^2 = .009 for Triglycerides.

Partial correlations were conducted to assess relationships between calcium intake and serum lipid variables (Table 29). After controlling for BMI and WC, there were significant inverse correlations in the entire study sample noted between TC and non-dairy calcium (r = -.068, p = .05), for HDL and non-dairy calcium (r = -.069, p = .05), and for LDL and non-dairy calcium (r = -.044, p = .05) for the entire study sample. There was also a significant positive correlation noted for HDL and calcium from supplements for the entire study sample. When this analysis was conducted based on gender, there was a significant inverse correlation noted between TC and LDL and total calcium for males only. This association was noted between TC and LDL and non-dairy calcium sources. HDL and calcium from non-dairy food sources were positively correlated (p <0.001) in females. This was not observed in males (see Table 30).

Hypertensive Status. A multiple regression analysis was used to assess the prediction of systolic and diastolic blood pressure by calcium intake. Calcium intake includes the measures total dietary calcium (mg), calcium from milk (mg), calcium from non-milk dairy (mg), calcium from supplements (mg), and calcium from other food sources (mg). These analyses were controlled for physical activity, smoking, and age.

There was a significant inverse relationship noted between calcium intake and systolic blood pressure for the entire study sample [F (4, 3986) = 4.74, $p = 0.001$, $\Delta R^2 = .004$] (Table 31). No relationship was noted when data were assessed by gender [Females - F (4, 2592) = 1.97, p = 0.09, $\Delta R^2 = .003$; Males - F (4, 1385) = 1.45, $p = .22$, $\Delta R^2 = .004$] (Table 32 and 33).

There was a significant relationship between dietary calcium intake and diastolic blood pressure for the entire study sample [F (4, 3986) = 4.84, p = .001, $\Delta R^2 = .005$] (Table 34). When data were analyzed by gender, no relationship was identified [Females – F (4, 2592) = .692, p = .59, $\Delta R^2 = .001$; Males – F (4, 1385) = .490, p = .74, $\Delta R^2 = .001$] (Table 35 and 36).

Table 30

Partial Correlation of Calcium Intake and Serum Lipids

Variables	R
TC	
Milk Calcium	-.025
Non-Milk Dairy Calcium	-.026
Supplement Calcium	.009
Non-Dairy Calcium	-.068[b]
TC Female	
Milk Calcium	-.010
Non-Milk Dairy Calcium	-.020
Supplement Calcium	.007
Non-Dairy Calcium	-.041[a]
TC Male	
Milk Calcium	-.038
Non-Milk Dairy Calcium	-.050
Supplement Calcium	-.018
Non-Dairy Calcium	-.085[a]
LDL	
Milk Calcium	-.022
Non-Milk Dairy Calcium	-.026
Supplement Calcium	-.021
Non-Dairy Calcium	-.044[b]

Table 30 (continued)

LDL Female	
Milk Calcium	-.016
Non-Milk Dairy Calcium	-.017
Supplement Calcium	-.019
Non-Dairy Calcium	-.034
LDL Male	
Milk Calcium	-.036
Non-Milk Dairy Calcium	-.039
Supplement Calcium	-.010
Non-Dairy Calcium	-.074[b]
HDL	
Milk Calcium	-.027
Non-Milk Dairy Calcium	.008
Supplement Calcium	.086[b]
Non-Dairy Calcium	-.069[b]
HDL Female	
Milk Calcium	-.005
Non-Milk Dairy Calcium	-.008
Supplement Calcium	.053[b]
Non-Dairy Calcium	-.008
HDL Male	
Milk Calcium	-.022
Non-Milk Dairy Calcium	-.018

Table 30 (continued)

Supplement Calcium	.036
Non-Dairy Calcium	-.045
TG	
Milk Calcium	.017
Non-Milk Dairy Calcium	-.018
Supplement Calcium	-.014
Non-Dairy Calcium	.006
TG Female	
Milk Calcium	.020
Non-Milk Dairy Calcium	-.013
Supplement Calcium	.010
Non-Dairy Calcium	-.006
TG Male	
Milk Calcium	.007
Non-Milk Dairy Calcium	-.022
Supplement Calcium	-.049
Non-Dairy Calcium	.001

Note. [a]$p = .05$; [b]$p = .01$

Table 31

Summary Multiple Regression Analysis for the Relationship between Calcium Intake SBP (n=4,263)

Variable	B	SE B	β	*p*
Milk Calcium	.001	.001	.015	.322
Non-Milk Dairy Calcium	-.006	.002	-.039	.011
Supplement Calcium	-.003	.001	-.043	.004
Non-Dairy Calcium	.002	.001	.027	.078

Note. Adjusted $R^2 = .137$; $\Delta R^2 = .004$.

Table 32

Summary Multiple Regression Analysis for the Relationship between Calcium Intake and SBP for Females (n=2,763)

Variable	B	SE B	β	*p*
Milk Calcium	.001	.002	.011	.533
Non-Milk Dairy Calcium	-.004	.003	-.028	.127
Supplement Calcium	-.002	.001	-.040	.028
Non-Dairy Calcium	.001	.002	.007	.691

Note. Adjusted $R^2 = .172$; $\Delta R^2 = .003$.

Table 33

Summary Multiple Regression Analysis for the Relationship between Calcium Intake and SBP for Males (n=1,500)

Variable	B	SE B	β	*p*
Milk Calcium	.001	.002	.015	.552
Non-Milk Dairy Calcium	-.005	.004	-.033	.208
Supplement Calcium	-.004	.002	-.041	.111
Non-Dairy Calcium	.003	.002	.035	.179

Note. Adjusted $R^2 = .084$; $\Delta R^2 = .004$.

Table 34

Summary Multiple Regression Analysis for the Relationship between Calcium Intake and DBP (n=4,263)

Variable	B	SE B	β	*p*
Milk Calcium	-.004	.001	-.001	.940
Non-Milk Dairy Calcium	-.004	.001	-.049	.002
Supplement Calcium	-.001	.001	-.035	.026
Non-Dairy Calcium	.002	.001	.041	.010

Note. Adjusted $R^2 = .016$; $\Delta R^2 = .005$.

Table 35

Summary Multiple Regression Analysis for the Relationship between Calcium Intake and DBP in Females (n=2,763)

Variable	B	SE B	β	*p*
Milk Calcium	.000	.001	-.006	.776
Non-Milk Dairy Calcium	-.002	.002	-.026	.206
Supplement Calcium	.000	.001	-.019	.340
Non-Dairy Calcium	.000	.001	.004	.840

Note. Adjusted $R^2 = .008$; $\Delta R^2 = .001$.

Table 36

Summary Multiple Regression Analysis for the Relationship between Calcium Intake and DBP in Males (n=1,500)

Variable	B	SE B	β	*p*
Milk Calcium	-.001	.001	-.025	.342
Non-Milk Dairy Calcium	-.002	.003	024	387
Supplement Calcium	.001	.002	.010	.706
Non-Dairy Calcium	.001	.001	.011	.686

Note. Adjusted $R^2 = .029$; $\Delta R^2 = .001$.

Simple correlations and adjusted correlations of calcium intake with systolic blood pressure and diastolic blood pressure variables for the entire sample are presented in Table 37. After adjusting for BMI and WC, there were significant negative relationships noted for non-milk dairy calcium and supplement calcium with both systolic and diastolic blood pressure. After analyzing by gender, there was a significant inverse association between calcium intake from supplements and systolic blood pressure in females only (see Table 37).

Table 37

Partial Correlation of Total Dietary Calcium Intake and Blood Pressure

Variables	R
SBP	
Milk Calcium	.016
Non-Milk Dairy Calcium	-.036[a]
Supplement Calcium	-.050[b]
Non-Dairy Calcium	.024
SBP Female	
Milk Calcium	.012
Non-Milk Dairy Calcium	-.029
Supplement Calcium	-.045[a]
Non-Dairy Calcium	.003
SBP Male	
Milk Calcium	.013
Non-Milk Dairy Calcium	-.027
Supplement Calcium	-.044
Non-Dairy Calcium	.030
DBP	
Milk Calcium	-.001
Non-Milk Dairy Calcium	-.043[b]
Supplement Calcium	-.039[a]
Non-Dairy Calcium	.033[a]

Table 37 (continued)

DBP Female	
Milk Calcium	.-.007
Non-Milk Dairy Calcium	-.026
Supplement Calcium	-.020
Non-Dairy Calcium	-.002
DBP Male	
Milk Calcium	-.027
Non-Milk Dairy Calcium	-.024
Supplement Calcium	.008
Non-Dairy Calcium	.005

Note. [a]$p = .05$; [b]$p = .01$

CHAPTER V

DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

Discussion

The present study used data from an epidemiological study of African Americans in central Mississippi to examine the relationship between calcium intake and cardiovascular disease (CVD) risk factors including obesity, dyslipidemia, and hypertension. Research on calcium intake and CVD risk factors offers a range of outcomes, from identifying significant relationships between these variables to determining that no relationships exist. Data from this analysis has shown comparable results to other studies that address some or all of the components investigated.

Research Question 1. In this study, more than half of the participants were classified as overweight or obese by body mass index (BMI) and waist circumference (WC). Females had a higher mean BMI than males and a higher percentage of females than males were overweight and obese. The percentages of overweight and obesity are comparable to the American population over all and by ethnicity (CDC, 2007; Deshmukh-Taskar et al., 2007; McTigue et al., 2002; "Prevalence of Overweight", n.d.; CDC – "US Obesity," n.d.; CDC – "Obesity and Overweight," n.d.). The mean BMI for males in this study fell in the overweight category, whereas, the mean BMI for females fell in the Grade I obesity category.

Mean male systolic blood pressure was 127.9±17.6 mmHg, slightly higher (+1.5 mm Hg) than mean female systolic blood pressure (SBP) of 126.4±18.3 mmHg. Mean diastolic blood pressure (DBP) for males was 81.7±10.4 mmHg, +4.3 mm Hg higher than the mean for females of 77.4±10.1 mmHg. This margin of difference for diastolic blood

pressure is clinically meaningful. Prehypertension is defined as SBP of 120 – 139 mmHg and DBP of 80-89 mmHg (CDC, 2006). The mean SBPs for males and females were categorized as prehypertension, while the mean DBPs would be considered prehypertension for males only. Females in this study had DBPs that were normal.

As for serum lipid measures, mean total cholesterol (TC) and high density lipoprotein (HDL) levels were significantly higher in females than in males. The mean TC for females of 201.1±39.6 mg/dL was greater than the desirable range of <200 mg/dL ("Third Report," 2002). As for HDL in the present study sample, similar findings were noted for HDL profiles among females. Karanja et al. (1994) also found higher HDL levels in females at baseline in an intervention study, which included 326 hypertensive and non-hypertensive participants. Similar to the Karanja study, males in the present study had significantly higher low density lipoprotein (LDL) and triglycerides (TG) than females (Karanja et al., 1994). Although in the present study the mean subfractions of cholesterol were higher among males than females, mean total cholesterol was in the normal range for males according to national standards ("Third Report," 2002).

Research Objective 2. Macronutrient and micronutrient intake was analyzed in this population. Males consumed significantly more calories, fat, carbohydrate, protein, and cholesterol than females. These findings appear to indicate that African Americans participating in the Jackson Heart Study consumed comparable amounts of energy, fat, carbohydrates, protein, saturated fat, and cholesterol to other reported intakes for this ethnic group in the same geographic region.

Champagne et al. (2004) compared the estimated energy intake of African Americans in a 36-county area of LMD with those in a nationally representative sample,

based on multiple pass 24-hr recalls. The LMD participants included 1,751 adults, of which 43.8% were African American. For the nationally representative population included in the Continuing Survey of Food Intakes of Individuals (CSFII), 11.3% were adult African Americans. Champagne et al. (2004) reported a mean energy intake of 1,926 ±32 kcal for Delta region African Americans and 2,000±44 kcal for US African Americans. The Champagne et al. (2004) study did not compare genders.

In a study conducted by Tucker et al. (2005) in the Lower Mississippi Delta (LMD) region of Arkansas, Louisiana, and Mississippi which included 857 African American adults, estimated energy intake for males was 2,327±1,215 kcal and for females was 1,672 ±925 kcal, based on a single 24-hr recall, compared to 2,189.7±795.2 for males and 1,825.1±750.9 for females in this study.

Macronutrient and micronutrient intake was also assessed in the present study and the studies of LMD residents. This study found significant differences in grams of total fat, protein, carbohydrates, cholesterol, and saturated fat between genders. Tucker et al. (2005) found that African American males consumed 273±151 grams of carbohydrate, 89±50 grams of protein, and 94±61 grams of fat, and females consumed 205±116 grams of carbohydrates, 63±38 grams of protein, and 67±47 grams of fat. Champagne et al. (2004) found that a representative sample of LMD African Americans adults consumed 223.4±5.2 grams of carbohydrates, 71.4±1.0 grams of protein, and 76.3±1.5 grams of fat and US African Americans adults consumed 242.1±5.8 grams of carbohydrate, 77.6.7±1.5 grams of protein, and 78.7±2.1 grams of fat. Generally nutrient intakes of males in this study were slightly lower than those of LMD males, whereas intakes of carbohydrate and fat were somewhat higher for females in this study compared to Tucker

et al. (2005). Use of a food frequency questionnaire in this study versus a 24-hr recall in the other studies could account for some differences (Champagne et al., 2004; Tucker et al., 2005).

As for calcium consumption, the present study identified no significant difference between the genders for calcium consumption. Females consumed 806.9±454.9 milligrams and males consumed 796.6±386.6 milligrams of total dietary calcium. Tucker et al. (2005), in contrast, found that African American males in the LMD consumed more calcium than females. A national study designed to assess dietary intake data collected in CSFII 1994-1996, 1998 found that African American males in every adult age group consumed significantly more calcium than African American females in related age groups (ages 19-30 years - 732.9±71.6 and 561.6±108.8 mg, respectively; ages 31 – 50 years – 763.4±117.8 and 509.9±28.2 mg, respectively; ages 51 years and older - 629.9±30.6 and 494.9±17.5 mg, respectively) (Fulgoni et al., 2007).

The mean calcium intake for all adults in this study, 804±432 mg, was higher than that of a representative sample of LMD African Americans, who consumed an average of 554±15 mg calcium, and also higher than that of U.S. African Americans, who averaged 612±21 mg calcium (Champagne et al., 2004). Champagne et al. (2004), Fulgoni et al. (2007), and Tucker et al. (2005), however, did not consider supplemental calcium intake.

The mean dietary calcium intake of 804±432 mg in the present study was below the DRI recommendations for adequate intake levels for adults the age of those in this study, which range from 1,000 – 1,200 mg per day (Standing Committee, 1997). This finding appears to be comparable to results of other studies of calcium intake in the American population (Basiotis et al., 2002; Champagne et al., 2004; Juan, Lino, &

Basiotis, 2004; Wooten & Price, 2004; Tucker et al., 2005). In consumer-based research on dairy consumption conducted in 2004 that included 2,016 African American adults, this group only consumed about 66% of the established DRI for calcium (Wooten & Price, 2004).

Daily intake of calcium varies depending on the sources of dietary calcium. In this study of JHS adults, the largest amount of calcium was from non-dairy foods. With a mean intake of 483.9±203.5 mg, non-dairy foods provided nearly three times the amount of calcium as did milk, non-milk dairy foods, or supplements. This finding in its simplest form is not unique to this study sample. In the Tucker et al. (2005) study of LMD adults, white bread and cornbread provided nearly one-third of the calcium consumed by African Americans at 12.5% collectively (7.8% from white bread and rolls and 4.6% from cornbread), while milk and cheese provided the other two thirds (14.4% and 10.2%, respectively). In a study that included 50 lactose maldigesting postmenopausal African American females (26 lactose intolerant and 24 lactose tolerant), the primary sources of calcium for lactose tolerant participants were milk, yogurt, and dairy products (comprising approximately 45% of calcium sources), whereas the major sources for lactose intolerant participants were mixed dishes which included breads, noodles, salad dressings, meat and meat products, and eggs and egg products. Fruits and vegetables provided smaller amounts of calcium to both groups; no more than 12% of total calcium consumed came from fruits and vegetables (Buchowski, Semeya, and Johnson, 2002).

Research Objective 3. There was a weak but significant positive relationship identified between calcium intake and BMI in this study and a weak but significant inverse relationships between calcium intake and WC. A weak relationship was also

identified when the data were analyzed by gender; calcium intake was positively associated with BMI and negatively associated with WC in females.

In other studies where African Americans were research participants, similar relationships were identified for body composition measures. Loos et al. (2004) assessed African American and White Americans participating in the HERITAGE Family Study to identify the role calcium plays on body composition measures. In this study, the researchers found that African-American females (n = 201) who reportedly consumed higher amounts of calcium (low - 568±60 mg Ca, intermediate - 737±59 mg Ca, and high - 1171±76 mg Ca) had significantly higher BMI and waist circumference and significantly more fat free mass than those African American female participants who were in the lower calcium intake groups. Also, the prevalence of obesity increased significantly with higher intakes of calcium ($p = 0.003$). On the other hand, African American males' (n = 109) calcium intake (low - 517±40 mg Ca, intermediate - 748±69 mg Ca, and high - 1025±107 mg Ca) in this study resulted in a significant inverse relationship to BMI, percent body fat, skinfold measures, and waist circumference. The prevalence of overweight decreased significantly with increased intake of calcium ($p = 0.018$) (Loos et al., 2004). In another study by Kamycheva, Joakimsen, and Jorde (2002), 9252 males and 9662 females over the age of 24 were assessed to identify relationships between body mass index and lifestyle factors. These researchers found a significant positive association between calcium intake and BMI in males ($R^2 = 0.038$, $p = 0.001$). The R^2 observed in the Kamycheva et al. (2002) study was larger than the one observed in the current study. Loos et al. (2004) did not report an R^2 for their data.

Other observational studies have found no relationship between calcium intake and body composition in African American participants (Brooks, Rajeshwari, Nicklas, Yang, & Berenson, 2006). Brooks et al. (2006) assessed calcium intake and dairy product consumption in participants in the Bogalusa Heart Study. The study sample included 1306 adults (African American and White American) between the ages of 19 and 38 years. Among the African American participants there was no association identified between calcium intake or dairy product consumption with BMI or waist circumference.

Buchowski and colleagues (2002) also found an inverse relationship between calcium intake and weight status. These researchers identified a relationship between calcium intake and body mass index in an African American population of females. Participants were classified as lactose tolerant or lactose intolerant. Calcium intake was significantly higher in the lactose tolerant group than in the lactose intolerant group (780±305 mg versus 388±151 mg). Researchers found that inverse associations to BMI were observed with calcium intake in the lactose tolerant group ($R^2 = 0.470$) (Buchowski et al., 2002). R^2 values in the Buchowski et al. study (2002) were higher than those for the present study.

Several studies have found an association between calcium intake and BMI in populations other than African American groups (Azadbakht et al., 2005; Jacqmain et al., 2003; Rosell, Hakansson, & Wolk, 2006). In a study of 10,066 Women's Health Study participants 45 years of age or older, median calcium intake, assessed by a 131-item FFQ, was 857 mg per day. Females in the highest quartile of calcium intake were leaner than females in the lower quartiles (Liu et al., 2005).

Jacqmain et al. (2003) assessed 470 males and females ages 20-65 years participating in the Quebec Family Study. Dietary data were collected using a 3-day diet record, and participants were categorized based on daily calcium consumption. Body mass index, body weight, percent body fat, fat mass, waist circumference, and abdominal adipose tissue were significantly lower in participants who consumed the highest levels of calcium (>1,000 mg/day) compared to those who consumed the lowest (<600 mg/day). No difference was noted between the middle calcium group (600-1,000 mg) and the highest calcium group for these body composition measures. The researcher also identified significant negative correlations between calcium intake and percent body fat (r=-0.19), fat mass (r=-0.17), BMI (r=-0.14), and waist circumference (r=-0.15) in females only (Jacqmain et al., 2003). Azadbakht et al. (2005) studied dairy consumption and metabolic syndrome in 827 Tehranian adults (ages 18-74). A 168-item FFQ was used to assess dietary intake. Participants in this study were divided into quartiles based on the number of daily servings of dairy foods - quartile (Q) 1 - <1.7 servings/day (mean calcium intake = 829±9 mg), Q 2 - 1.7-<2.3 servings/day (mean calcium intake = 931±10mg), Q3 – 2.3 - <3.1 servings per day (mean calcium intake = 958±11 mg), and Q 4 - ≥ 3.1 servings/day (mean calcium intake = 989±13 mg). Those participants who were in the highest quartile for calcium consumption had significantly lower BMI and WC than other quartiles.

Zemel et al. (2005) demonstrated effects of dairy product consumption on weight status of African Americans in a dairy foods weight intervention. Researchers (2005) observed 34 obese adult African Americans in a maintenance phase in a 24-week study and 29 obese, adult African Americans in a 24-week weight loss phase (500 kcal energy

deficit) of a randomized trial addressing the effects of dairy consumption on body composition and other biological markers. In both the maintenance group and the weight loss group, there was significantly greater loss of trunk fat, body fat, waist circumference, and weight in the groups consuming the higher amounts of dairy products (higher calcium intake; maintenance phase – mean calcium intake of 1,124±53 mg; weight loss phase - mean calcium intake of 1,037±27 mg) than in the participants in the lower dairy (lower calcium group; maintenance phase – mean calcium intake of 458±96 mg; weight loss phase – mean calcium intake of 468±23 mg).

Despite the fact that the present research found statistically significant relationships between calcium intake and BMI and WC, there was no clinical relevance to the findings because the amount of variance attributable to calcium intake was very small (less than 0.5%).

In other epidemiological studies of calcium intake and BMI, similar findings were reported. Kamycheva et al. (2002) assessed 9,252 males and 9,662 females over the age of 24. Although this study identified a significant positive association between calcium intake and BMI in males, calcium consumption explained only about 3.8 % of the variance in BMI. Davies et al. (2000) reanalyzed five clinical studies on calcium intake and osteoporosis to assess the possible relationship between calcium intake and BMI. The subjects in this study were 780 females between the ages of 18 and 89 years. Davies et al. reported a significant negative association between calcium intake and BMI, but noted that estimated calcium intake explained only 3% of the variability in BMI. In a study conducted with Portuguese children, Moreira, Padex, Mourao, and Rosado (2005) found a significant inverse association between calcium-to-protein ratio and BMI in girls only

($\beta = -0.052$; $R^2 = 0.006$). The variance to explain calcium's impact on BMI was similar to that reported in the present study.

These studies have speculated regarding explanations for the small amount of variability of body weight attributable to calcium intake. All of the researchers suggest that self-reported dietary data collection lends itself to under-reporting of energy and nutrient consumption thus causing underestimation of nutrient intake. The researchers also note that body weight is a highly multifactoral variable and cannot be explained to a great degree by any one factor.

Other dietary predictors of BMI and weight status have been identified in multiethnic groups including African Americans. Lovejoy et al. (2001) assessed dietary intake and energy expenditure in premenopausal African American and White American females. The authors reported positive correlations between body fat or BMI and intakes of total fat, saturated fat, monounsaturated fat, and dietary cholesterol. This study also identified inverse correlations between percent body fat and intakes of fiber, calcium, magnesium, and eicosapentanoic acid and docosahexanoic acids. The researchers indicated that the greatest predictors of body fat in this population (accounting for 21% of the variance) included fiber, saturated fat, exercise, and flights of stairs climbed per day, collectively.

Maskarinec et al. (2006) described the nutrient and food intake trends related to BMI among different ethnic groups in Hawaii (including African Americans), using data from 19 studies conducted over a 25 year period. Dietary data were collected using the FFQ (three studies used the same instrument). Increases in fat consumption by 1g/100 kcal, increases in energy consumption of 500 kcal/d, increases protein intake of 1g/100

kcal, and increases of carbohydrate intake of 1g/100 kcal resulted in a higher odds ratio for excess weight among females and males. This study also found that increased dietary fiber intake of 1g/200 kcal resulted in decreased risk for overweight and obesity (Maskarinec et al., 2006). In the Pound of Prevention study, researchers studied the relationship between nutrient intake, physical activity, and body weight (Sherwood et al., 2000). Participants in this study were males and females ages 21 to 45 years. Inverse associations were noted between high intensity physical activity and body weight in males and females. This study also identified that the percent of calories from fat was positively associated with body weight for males and females. For the JHS study participants, there was a general trend toward little to no physical activity and the mean fat intake for this population was approximately 35% of the total caloric intake.

The absence of relationships of any magnitude between calcium intake and weight status in this study may be related to a number of factors. First, while mean calcium intakes of the study sample were comparable to intakes in other assessments of African Americans, they did not meet the Adequate Intake recommendations of 1000-1200 mg per day (Standing Committee, 1997). Effects of calcium on weight status measures have primarily been shown when intakes of calcium were within recommended ranges. It is possible that intakes for the present study participants were not sufficient to warrant a dose response reduction in BMI or WC. Secondly, the principal sources of calcium intake for the present study were non-dairy food sources. It is possible that the source of dietary calcium may be directly related to the impact or effect of calcium on weight status.

Another factor that may have contributed to the absence of any clinically significant findings related to calcium intake and weight status is possible overestimation or underestimation of energy and nutrient intake. It is also plausible that calcium alone cannot predict weight change or relationships with weight alone in this study sample. Factors such as physical activity, energy intake, and fat intake may be stronger predictors for weight than calcium consumption for the participants in this research.

Research Question 4. Analysis of the data related to serum lipids found only a weak relationship for dietary calcium with TC, LDL, and HDL. Inverse correlations were observed between calcium intake and TC and LDL in the entire group. When the data were analyzed by gender groups, a relationship was identified between calcium and TC and between calcium and LDL for males only. As seen for BMI and WC, the variance attributable to calcium intake was small (LDL – $\Delta R^2 = .005$, $p<0.001$ total group and LDL – $\Delta R^2 = .007$, $p = 0.03$ males; TC –$\Delta R^2 = .005$, $p<0.001$ total and TC – $\Delta R^2 = .009$, $p = 0.007$ males). Calcium significantly predicted HDL ($\Delta R^2 = .010$, $p<.001$), but in all instances, calcium intake explained less than 1.2% of the variance for serum lipids. There was no identified relationship between calcium intake and triglycerides.

Relationships between calcium intake and serum lipids have been identified in the literature, many of which have been associated with calcium supplementation. In this study, supplemental calcium intake was significantly associated with HDL, but not with other lipid measures, in the total study sample, and in females when data were analyzed by gender.

An intervention study on the impact of elemental calcium consumption on serum lipid concentration in postmenopausal females, prescribed 223 females either 1 gram

elemental calcium supplement, or a placebo, to be taken daily (Reid et al., 2002). At baseline, all participants in the study had a comparable calcium intake of 910±400 mg for the placebo group and 910±440 for the supplement group ($p = 0.99$). In the supplement group, mean HDL ($p = 0.009$) and HDL/LDL ratio ($p = .001$) increased significantly from baseline to 12 months in the supplement group, and LDL decreased significantly in the calcium group($p = 0.04$). Major et al. (2007) conducted an intervention study on healthy overweight/obese females who typically consumed less than 800 mg of calcium per day. Participants were randomized to either a placebo group or an experimental group, who received a supplement of 1,200 mg calcium/400 mg vitamin D per day for 15 weeks. All participants were also placed on a 700 kcal/day energy deficit diet. At the 15-week mark, a significant time and treatment interaction was noted for total cholesterol:HDL, LDL, and LDL:HDL in the calcium group when compared to the placebo group (Major et al., 2007).

Jacqmain et al. (2003) found significant negative correlations between dietary calcium intake and LDL and TC, but no significant relationship identified for a HDL, in a cross sectional study of 827 male and female subjects. Azadbakht et al. (2005) found that participants in the highest dairy intake quartile had a significantly higher HDL than participants in other calcium quartiles as well as a lower percentage of subjects with low serum HDL cholesterol.

Analysis of the data related to blood pressure found that there was a significant relationship between calcium intake and both systolic and diastolic blood pressure. This significance was not present when observed by gender. Other researchers have identified relationships like those identified in this present study. Azadbakht et al. (2005) found that

those consuming 3.1 servings of dairy or more (approximately 989±13 mg calcium/day) had lower SBP and DBP than those who consumed less. Snijder et al. (2007) studied the relationship of dairy consumption and metabolic syndrome in 2,484 elderly, white male and female participants in the Hoorn Study, in which a 92-item FFQ was used to assess food intake. Participants were categorized based on calcium intake by dairy product intake. The mean calcium consumption in each quartile was as follows: quartile 1 - 646±164 mg calcium, quartile 2 - 927±124 mg calcium, quartile 3- 1,150±123 mg calcium, and quartile 4- 1,630±330 mg calcium. Participants in the highest quartile had significantly lower systolic and diastolic blood pressure measure than the other three groups at baseline. After adjusting for potential confounders, total dairy consumption was inversely associated with DBP but that effect was not present for SBP. Liu et al. (2005), like Snijder et al. (2007), assessed the association between calcium intake and metabolic syndrome components. Liu et al. (2005) found that fewer participants in the higher quartile for calcium consumption had high blood pressure as compared to the other calcium quartiles ($p<0.0001$).

Some researchers have found opposing views to the relationship between calcium consumption and blood pressure. In an intervention study for African American adolescents, Dwyer et al. (1998) found positive correlations between calcium intake and SBP but inverse correlations between calcium intake and DBP. There are also studies that show no relationship between calcium intake and blood pressure. Bostick et al. (2000) assessed the impact of calcium supplementation on blood pressure in a randomized, double-blind study. Participants in this study were either randomized to a placebo group or one of two experimental groups (1 gram elemental calcium or 2 gram elemental

calcium supplement). Groups experienced some decreases in mean systolic and diastolic blood pressures, but decreases were not significant when compared to the placebo group.

Several studies have looked at identified predictors of hypertension. Studies addressing the dietary changes like those in the DASH study are exemplary of the impact we may expected to see when diet alterations include multifaceted changes. In a review of the DASH diet studies by Champagne et al. (2006), the authors examined the relationships between the dietary changes required in the DASH trial and blood pressure and blood lipid level changes. The DASH trial included 459 participants (African Americans included) with a mean age of 45 and mean BMI of 28.7 for females and 27.7 for males. About one-third of the study sample had hypertension. Participants were placed in either a control group or one of two experimental groups: fruit and vegetable (37% kcal from fat; 16% kcal from saturated fat; 15% kcal from protein; 48% kcal from carbohydrates; including 450 mg of Ca/2,000 kcal; additional fruit and vegetables) or DASH/combination diet (27% kcal from fat; 6% kcal from saturated fat; 18% kcal from protein – mainly from dairy products; 55% kcal from carbohydrates; including 1240 mg/2,000 kcal for calcium). Participants followed these diets for 8 weeks. Those consuming the DASH diet experienced greater decreases in both systolic and diastolic blood pressure than participants in the fruit and vegetable group (although both experimental groups experienced significant decreased in systolic blood pressure when compared to the control group). For hypertensive participants, systolic blood pressure decreased three times as much as that of normotensive participants (although both groups experienced significant decreases with the DASH diet) (Champagne, 2006).

In this study of JHS participants, calcium intake explained a very small but statistically significant percentage (1.2% or less) of the variance in BMI, WC, TC, LDL, HDL, SBP, and DBP. There are several reasons why this may be so. The significant associations between calcium intake and these measures, with very small R^2 changes, can be attributed to the large sample size of 4,267. In addition, the large sample size may influence the true predictive power of calcium over obesity measures, serum lipid concentrations, and blood pressure. Just as described under BMI and WC, there is the potential that serum lipids and blood pressure measures are highly multifactoral variables making it difficult to attribute a large portion of the predictability to an individual factor.

Limitations

This present study had several limitations that should be acknowledged. First, the method used to assess calcium intake was an FFQ, which provided self-reported dietary intake. Self-reported data can result in overestimation or underestimation of nutrient intake (Hill & Davies, 2001). Weight status measures included BMI calculated from measured height and weight, and waist circumference. There were only a small percentage of the participants who were either underweight or normal weight based on BMI. Therefore, there are limitations to the representation of every weight category in the present study thus limitations on the ability to compare the effects of dietary calcium intake across weight categories. In addition, assessing fat free mass and fat mass could have offered a more comprehensive look at the impact of calcium on weight status. Another limitation in this research is the size of standard deviations for calcium intake. In many instances, the standard deviation is half the size of the mean or greater. This was true for total calcium intake (803 ± 432 mg), calcium from milk (103 ± 188 mg), calcium

from non-milk dairy foods (111 ± 129 mg), calcium from supplements (112 ± 288 mg), and nearly true for calcium from other calcium containing foods (484 ± 203 mg). This may be an indication that the data are highly skewed. No data transformations were performed. Further, the sample size was large, creating the potential for a Type II error. Finally, subjects in this study were recruited from a tri-county area in central Mississippi. Therefore, the information collected may not be generalizable to other African American communities.

Future Research and Application

In this study, a relationship of calcium with waist circumference, total cholesterol, low density lipoprotein, triglycerides, diastolic and systolic blood pressure was present but weak. Obesity, as well as other diseases like diabetes, coronary heart disease, and metabolic syndrome which are closely linked to obesity, is extensively impacting the African American population. For this reason, there is a need to understand any potential causal relationships between macronutrients, micronutrients, and obesity development.

A preponderance of the studies designed to assess the relationship between dietary calcium, body composition, and CVD have been retrospective analyses and observational studies. Possible ideas for future research in African Americans could include additional observational studies of an African American population as well as intervention studies. At present, very few studies that address the impact of calcium intake on weight status, dyslipidemia, and hypertension on the African American ethnic group are available. Those that are available have conflicting results including positive association between calcium intake and BMI or no relationship at all. Intervention studies examining the impact of calcium intake on weight changes in African Americans found

significant inverse correlations between dietary calcium intake and percent body fat, lean mass measures, systolic blood pressure, LDL, and total cholesterol. The current study addressed calcium intakes' impact on weight status using BMI and WC and CVD risk factors including serum lipids and blood pressure. For weight status, the present study found significant positive associations between calcium intake and BMI and significant inverse associations between calcium intake and WC. Therefore, future investigations into calcium intake and body composition in African American populations should include the use of dual energy x-ray absorptiometry (DXA) total body scan or bioelectrical impedance analysis so that associations of calcium intake with body composition beyond BMI and WC could be analyzed. An intervention study that explores improved dietary calcium intake and body composition or CVD risk factors may also be an ideal method of assessing the impact of calcium on CVD risk factors in this population. The planned study should incorporate subjects representative of all BMI categories - underweight, normal weight, overweight, and obese; thus, facilitating the identification of the effect of calcium intake on body composition and CVD risks factors on various weight levels and ages. Furthermore, the intervention could establish control and treatment groups that are prescribed various levels of calcium in milligrams to include foods from dairy and non-dairy sources. These specified amounts can be based on Dietary Reference Intake recommendations.

At present, data available on the relationship between dietary calcium consumption, obesity and CVD risks factors in the African American population is conflicting (Brooks et al., 2006; Dwyer et al., 1998; Loos et al., 2004; Lovejoy et al., 2001; Zemel et al., 2005). African Americans in Mississippi, Arkansas, and Louisiana

have high rates overweight and obesity, as well as diabetes, hypertension, and heart disease (Casey et al., 2004; Felix & Stewart, 2005; Smith et al., 1999). This population also has similar food intake to individuals of the same ethnic background in the southern region of the United States, particularly the Delta region which includes Arkansas and Louisiana (Champagne et al., 2004). The Jackson Heart Study consists of African-Americans living in Mississippi. While JHS was a large, epidemiological study, it was not designed specifically to examine the calcium intake and weight status, serum lipid concentration, or blood pressure relationship. The establishment of a causal relationship between calcium, BMI, WC, and CVD risk factors like dyslipidemia and hypertension could allow for the development of culturally sensitive nutrition education materials designed to address the importance of calcium consumption, recommend guidelines for dairy consumption, recommend sources for other calcium rich foods (including those with lower amounts of lactose), and recommend other guidelines to address eating behaviors in this population that complement calcium intake. In addition, finding a relationship between calcium intake, body composition, and CVD risk factors would be beneficial in the battle to reduce the obesity epidemic and CVD in this population.

APPENDIX A

Table of Study Measured Dependent and Independent Variables

Variable	Abbreviation	Units	Variable	Coded
DEPENDENT				
Body Composition				
Body Mass Index	BMI	kg/m^2	Continuous	N/A
Waist Circumference	WC	cm	Continuous	N/A
Dyslipidemia				
Serum Cholesterol	TC	mg/dL	Continuous	N/A
Serum LDL Cholesterol	LDL	mg/dL	Continuous	N/A
Serum HDL Cholesterol	HDL	mg/dL	Continuous	N/A
Serum Triglycerides	TG	mg/dL	Continuous	N/A
Hypertension				
Serum Systolic Blood Pressure	SBP	mmHg	Continuous	N/A
Serum Diastolic Blood Pressure	DBP	mmHg	Continuous	N/A
INDEPENDENT				
Total Dietary Calcium	Total Calcium	Mg	Continuous	N/A
Total Calcium from Milk	Milk Calcium	Mg	Continuous	N/A
Total Calcium from Non-Milk Dairy	Non-Milk Dairy	Mg	Continuous	N/A
Total Calcium from Supplement	Supplement Calcium	Mg	Continuous	N/A
Total Calcium Non-Dairy Foods	Non-Dairy Calcium	Mg	Continuous	N/A

APPENDIX B

HUMAN SUBJECTS REVIEW COMMITTEE APPROVAL

THE UNIVERSITY OF SOUTHERN MISSISSIPPI

Institutional Review Board

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HUMAN SUBJECTS PROTECTION REVIEW COMMITTEE
NOTICE OF COMMITTEE ACTION

The project has been reviewed by The University of Southern Mississippi Human Subjects Protection Review Committee in accordance with Federal Drug Administration regulations (21 CFR 26, 111), Department of Health and Human Services (45 CFR Part 46), and university guidelines to ensure adherence to the following criteria:

- The risks to subjects are minimized.
- The risks to subjects are reasonable in relation to the anticipated benefits.
- The selection of subjects is equitable.
- Informed consent is adequate and appropriately documented.
- Where appropriate, the research plan makes adequate provisions for monitoring the data collected to ensure the safety of the subjects.
- Where appropriate, there are adequate provisions to protect the privacy of subjects and to maintain the confidentiality of all data.
- Appropriate additional safeguards have been included to protect vulnerable subjects.
- Any unanticipated, serious, or continuing problems encountered regarding risks to subjects must be reported immediately, but not later than 10 days following the event. This should be reported to the IRB Office via the "Adverse Effect Report Form".
- If approved, the maximum period of approval is limited to twelve months. Projects that exceed this period must submit an application for renewal or continuation.

PROTOCOL NUMBER: **29033003**
PROJECT TITLE: **Calcium Intakes and CVD Risk Factors of Jackson Heart Study Participants**
PROPOSED PROJECT DATES: **02/20/09 to 03/15/09**
PROJECT TYPE: **Dissertation or Thesis**
PRINCIPAL INVESTIGATORS: **Marjuyua Etherline Lartey-Rowser**
COLLEGE/DIVISION: **College of Health**
DEPARTMENT: **Nutrition and Food Systems**
FUNDING AGENCY: **National Heart, Lung, and Blood Institute (NHLBI) and National Center on Minority Health & Health Disparities (NCMHD)**
HSPRC COMMITTEE ACTION: **Exempt Approval**
PERIOD OF APPROVAL: **04/07/09 to 04/06/10**

Lawrence A. Hosman

Lawrence A. Hosman, Ph.D.
HSPRC Chair

4-13-09
Date

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