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## **The Relationship Between Calcium Intake and Body Mass Index In the Participants of HUB City Steps**

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The University of Southern Mississippi

The relationship between calcium intake and body mass index in the participants of HUB  
City Steps

By

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Submitted to the Honors College of  
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## Abstract

**Background:** The social, economic, and health impacts of unhealthy dietary behaviors and sedentary lifestyles are quite significant and even more so in the rural South. The majority of individuals in the US do not adhere to the Dietary Guidelines for Americans, specifically fruits, vegetables, and calcium.

**Purpose:** The purpose of this study was to address the issue of calcium intake and obesity in a population of primarily African American women in south Mississippi and to determine if levels of calcium intake had a relationship with body mass index.

**Methods and Analysis:** Data for the current study was collected through the HUB City Steps- A Healthy "U" Begins with Steps program conducted by The University of Southern Mississippi, Department of Nutrition and Food Systems. The multi-component lifestyle intervention lasted 18 months and was divided into two parts: a six month active intervention quasi experimental phase and twelve month maintenance randomized controlled trial phase. The first phase consisted of an intervention that aimed to decrease systolic blood pressure by an increase in physical activity through walking. The second phase consisted of two treatment groups (low or high) of motivational interviewing via telephone over 12 months. Data on outcome measures of body mass index (BMI) and reported dietary calcium intake were analyzed. Both BMI and calcium values were evaluated categorically and continuously. Analyses included correlations between baseline and six month calcium and BMI to see if these variables exhibit significant relationships. Next, a multiple regression analysis was performed to determine if baseline calcium intake could predict baseline or six month BMI.

**Results:** When correlation between continuous calcium intake and BMI was assessed at zero and six months, results were not significant ( $p=0.467$ ,  $p=0.732$ , respectively). Multiple regression analyses revealed that calcium intake at baseline did not predict BMI at baseline or at six months. Lastly, using categorical calcium intake to predict BMI revealed no significant findings.

**Conclusion:** More research is needed to determine if a relationship exists between calcium intake and BMI, as well as calcium intake and body composition. Another factor to take into future consideration is the source of calcium in African American women's diets.

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## Chapter 1: Introduction

According to the Centers for Disease Control and Prevention (CDC, 2011), in 2010, 34% of people in Mississippi were obese and had a body mass index (BMI) of 30 or greater while a healthy BMI is thought to be between 18.5-24.9. Being overweight or obese can lead to a number of serious health problems, including diabetes, cardiovascular disease, and high blood pressure (National Heart Lung and Blood Institute, 2010). Additionally, being overweight or obese can affect the quality of a person's life by limiting everyday activities because of health problems or weight. Most dietitians believe that the best way to lose weight is through a healthy, balanced diet that meets the needs of the individual but is also conservative enough to lose weight (Nitzke & Freeland-Graves, 2007).

In Mississippi, a large percentage of the population is African American (U.S. Census Bureau, 2013). According to [statehealthfacts.org](http://statehealthfacts.org), in 2010, 75.1% of African Americans were overweight or obese in Mississippi. The U.S. Department of Health and Human Services (2011) stated that more African American women were overweight or obese than any other group in the US at 80% of that population. According to Hawkins (2007), one of the causes of obesity in African American women was genetics, although to what degree, researchers were not certain. Leptin, a protein correlated with total body fat, was found on a specific chromosome in African American and Mexican American populations. This protein hormone is known to regulate energy expenditure and intake. Currently, only insulin and leptin are known to act as adiposity signals. However, other issues that may have a more drastic impact on obesity risks are behavioral (i.e. physical activity levels) and lifestyle factors (i.e. socioeconomic status).

Hawkins (2007) stated that socioeconomic status can have an effect on the risk of obesity. Low socioeconomic status directly correlates with low education level and low levels of physical activity, which puts a person at higher risk for obesity. Hawkins (2007) also stated that African American women make up the most physically inactive group of people in the US despite the fact that there are proven preventive effects of physical activity in relation to cardiovascular and other chronic disease risk factors.

According to Buchowski, Semanya, and Johnson (2002), African Americans had a high prevalence and perceived prevalence of lactose intolerance which subsequently led to lower dairy and therefore calcium intake in their diets. Lactose maldigestion can be caused by a lack of the enzyme lactase in sufficient amounts. These authors also stated that in most cases, the cause of insufficient lactase is genetic and occurs in 70-75% of African Americans. For women, it is especially important to get an adequate amount of calcium through the diet, as women are at a higher risk for osteoporosis and bone disease than men (Mayo Clinic Staff, 2011). Because African Americans have a high prevalence of lactose intolerance (Fulgoni, Nicholls, Reed, Buckley, DiRienzo, & Miller, 2007), African American women must find other sources of calcium in which to fortify their diets.

Another reason calcium is essential is the noted negative correlation between calcium intake and BMI (Tidwell and Valliant, 2011). While Smith, Stephens, Smith, Clemens, & Polly, (2003) stated that there are many barriers to increasing calcium intake in the diet, including concern for health, lack of knowledge, limited food preferences, lack of food variety, concerns about food sanitation, and limited food availability, the fact remains that several researchers have illustrated the relationships between positive health

effects and dietary calcium intake. Low levels of dietary calcium and dairy products increase the risk of hypertension and insulin resistance syndrome (Zemel, 2000) and Heaney et al (2002) found a consistent effect of higher dietary calcium intake and lower body fat, body weight, or reduced midlife weight gain. Calcium contributes to maintenance of strong bones and may modulate weight gain in postmenopausal women. Unfortunately, not all calcium intake is equivalent, and Lorenzen et al. (2007) argued that a high intake of dietary calcium decreased the amount of postprandial fat in the blood, but the same was not true with a calcium supplement.

According to Hawkins (2007), the specific cause of obesity in African American women is unknown and is multifaceted. Tidwell and Valliant (2011) stated that a scientific explanation of the relationship between calcium and obesity is not clear. An important concept to remember is that calcium does not seem to be effective unless a calorie restriction is recommended, and replacing other sources of protein with low-fat dairy products may help augment weight loss. While Tidwell and Valliant did not take into account physical activity and lifestyle factors, which can influence a person's BMI, the relationship between calcium intake and these factors (BMI, physical activity and lifestyle) was not established in that research. Likewise, Buchowski, Semanya, & Johnson (2002) stated that in their study of dietary calcium intake in African American women, they did not control for eating habits or physical activity. These researchers proposed that a poor diet can lead to obesity, but the relationship between diet or eating habits and the effect of calcium intake on BMI is not known. While the relationship between calcium intake and body weight has been shown to be stronger when calcium intake was corrected for energy intake, the association between high BMI and low

calcium intake may be related to other nutritional factors. Researchers must recognize that body weight is a multi-factorial variable, and accounting for all of its variability with calcium is unlikely. However, it is important to assess this relationship as the amount of calcium in relation to total energy intake is of great value. The purpose of this research is to address the issue of low calcium intake and obesity in a population of primarily African American women in Mississippi. Specifically, researchers will determine if the intake of calcium is related to BMI.

## **Chapter 2: Literature Review**

According to Loos et al. (2004), much research has been done on the effect macronutrients have on diet and weight loss, but less research has been done to examine the effect that micronutrients have on diet and weight loss. Researchers also pointed out that dietary calcium intakes have been shown to be inversely related to adiposity in black men and white women (Carruth & Skinner, 2001). Similarly, Davies and colleagues (2000) showed that low calcium intake generally represents a poor diet, which could be a cause of overweight and obesity. Based on research by Davies and colleagues, to experience an 8 kg loss of body weight, a 1000 mg Calcium difference would be needed. Analysis of data from NHANES III supported this inference by showing a reduction in the odds of being in the highest quartile of adiposity with the increase in calcium and dairy product intake (Zemel et al., 2000).

### **Calcium**

According to Gropper, Smith, & Groff (2005), calcium makes up 1.5% to 2% of total body weight and is mostly found in bones and teeth. In the diet, calcium can be found in milk and dairy products, such as cheese and yogurt, as well as some seafood, vegetables, legumes, and dried fruits. Some foods, although they have calcium, can be poor sources because of high presence of acid that can bind calcium. Foods that are poor sources of calcium include meat, grains, nuts and vegetables like spinach and rhubarb. In addition to calcium coming from natural food sources, it is also found in many supplemental forms, including calcium carbonate, calcium acetate, calcium lactate, calcium gluconate, calcium citrate, calcium citratemalate, and calcium monophosphate.

Calcium plays important roles in the body and works to mineralize bone (99% total body calcium). Calcium is also found intracellularly and extracellularly (1% of total body calcium) where it performs functions such as blood clotting, nerve conduction, muscle contraction, enzyme regulation, and membrane permeability. Calcium is important in bones because bones require mineralization, in which calcium is a key component (Gropper, Smith, & Groff, 2005).

The calcium that is present in foods is in the form of insoluble salts, which is not the form that is absorbed by the body. Before calcium can be absorbed, it must be released from the insoluble salts. This release can occur in the acidic pH of the stomach, where the insoluble salts are solubilized; however, the solubilized calcium can complex with other minerals in the small intestine, causing poor absorption at times (Gropper et al., 2005).

When calcium is absorbed, there are two main processes that transport calcium, both of which occur in the small intestine. The first process occurs mostly in the duodenum and proximal jejunum and is a calcitriol-dependent system which works during times of low calcium intake (<400mg). This process requires energy and calbindin and has three steps: transport across the brush border membrane, intracellular movement, and transport across the basolateral membrane. The second process occurs mostly in the jejunum and ileum. Unlike the first system, this one is non-saturable and passive and occurs during times of high calcium intake. Calcium is absorbed into the enterocytes and expelled across the basal lateral membrane. There are some substances that are known to inhibit or enhance calcium absorption. Substances that enhance calcium absorption include vitamin D, sugars, sugar alcohols, and protein. Substances that inhibit calcium

absorption are fiber, phytate, oxalate, excessive divalent cations, and unabsorbed fatty acids. Once calcium is absorbed in the body, it is transported in the blood (Gropper et al., 2005).

Calcium transport occurs in three ways. Calcium is either bound to proteins (mainly albumin and prealbumin), complexed with sulfate, phosphate, or citrate, or is free in the blood. The concentrations of calcium, both intracellular and extracellular, are controlled by three main hormones: parathyroid hormone (PTH), calcitriol, and calcitonin. PTH is released from the parathyroid gland when calcium concentration in the blood is low, and it works to increase calcium concentrations by interacting with the kidneys, intestines, and bones. Calcitriol also works in the intestines to increase calcium absorption. Calcitonin works in the bones to prevent mobilization of calcium ions out of the bones (Gropper et al., 2005).

### **Recommended and Current Intakes.**

Nelms, Sucher, Lacey, & Roth (2011) stated that calcium is needed throughout the lifecycle in adequate amounts in order to perform all of its functions in the body. If inadequate intakes occur during childhood and adolescence, the individual will have an increased risk for developing osteoporosis later in life. In adulthood, calcium works to decrease bone mineral loss. Because calcium works differently in different stages of life, various amounts of calcium are needed throughout the lifespan and also vary by gender.

The adequate intake of calcium, stated by Gropper et al. (2005), was set at 1000 mg per day for adult men and women aged 19-50 years. This recommended level includes women during pregnancy and lactation but increases for men and women aged

51 years and older to 1200 mg per day. In addition, the amount of calcium at which no more calcium could be physically retained is 1500 mg per day.

Inadequate calcium intake is associated with deficiency and certain disorders. In children, poor calcium intake can result in rickets, which occurs when bone does not form properly and cannot withstand the weight of the body. Poor calcium intake in adulthood can lead to osteopenia and osteoporosis, which is the loss of bone mass. Many individuals in the US do not consume their recommended amount of calcium each day, and some population groups have an increased need for calcium, including those with high fiber diets, fat malabsorption, decreased gastrointestinal transit time, and long term use of thiazide diuretics (Nelms et al., 2011).

### **Overweight and Obesity in U.S. Adults**

Statistics relating the prevalence of obesity throughout history have shown dramatic changes over different time periods. From 1960 to 1980, the percentage of the population that was classified as obese had very little change, with a small increase of about eight percent from 1976 to 2000. The National Health and Nutrition Examination Survey (NHANES) report even more current statistics on obesity. This report showed that 31.9 to 36 percent of women of all ethnic groups ages 20 to 59 had a BMI greater than or equal to 30 and 55.8 to 66 percent of women of all ethnic groups had a BMI greater than or equal to 25 (Flegal, Carroll, Kit, and Ogden, 2012).

Disparities of health exist in various geographical regions of the US and these disparities have been associated with dietary intake, excess calorie consumption, and energy expenditure. Newby et al. (2011) examined dietary intake to determine whether racial and regional differences existed among black and white men enrolled in the

Reasons for Geographic and Racial Differences in Stroke (REGARDS) study.

Participants in the “stroke buckle” and the “stroke belt” were compared to individuals living in other areas of the US and race was found to be a significant predictor of dietary intake. Both regions were associated with lower intakes of dietary fiber, saturated fat, potassium, calcium, sodium (Stroke Belt only), and magnesium (Stroke Buckle only) when compared to other regions of the country.

### **Body Mass Index.**

Many studies have been completed that examine the relationship between calcium intake and body fat percentage. Meeuwssen, Horgan, and Elia (2010) proposed that percent body fat is commonly used as an indicator of BMI, although the relationship can be erroneous because of the variability of muscle mass between individuals. BMI, according to Eliat-Adar et al. (2007), is calculated as weight in kg divided by height in meters squared. BMI is a ratio of weight to height so if an individual gains weight, his or her BMI will increase. While BMI does not take body composition into account, Chang-Hung (2011) states that BMI is very commonly used because it is simple, correlates with body fat, and is beneficial as a screener as well as research outcome because other methods to measure body fat are not readily used for large studies.

### **Fat Mass and Percent Body Fat.**

BMI is not always the most accurate predictor of body fat. According to Shah and Braverman (2012), BMI misclassifies people by obesity and overweight, especially in women. They acknowledged that using BMI as an indicator of obesity significantly underestimated the number of obese individuals in their study and that using dual energy x-ray absorptiometry was a more accurate measure of obesity. The factors that cause this

misclassification the most were greater loss of muscle mass with age in women. It is important to remember that BMI is only one factor related to risk for disease yet evaluating its relationship with things like dietary and/or physical activity variables could be beneficial in uncovering or assessing risk for likelihood of developing obesity-related diseases.

### **Disease Risk.**

Being overweight or obese can lead to a number of health consequences.

According to Nelms et al. (2011), health consequences of obesity can be psychosocial and emotional or psychological. Psychosocial and emotional consequences include feelings of guilt and depression as well as having low self-confidence and anxiety.

Physiological consequences include type 2 diabetes, high blood pressure, lipid abnormalities, hepatobiliary disorders, cancers, reproductive disorders, and premature death. All of these health issues are chronic diseases that have to be managed throughout life and can lead to other, serious chronic diseases.

### **Calcium and Body Fat**

Other researchers have pointed out an overall decrease in percent body fat along with an increase in calcium intake. Loos and colleagues (2004) found a significant association between fat free mass and calcium intake in black women and also pointed out that lower calcium intake may be associated with higher adiposity. Loos et al. used baseline data from 362 men and 462 women that were participants in the HERITAGE Family Study. The Willett Food Frequency Questionnaire (FFQ) was used to gather information about subject's usual eating habits, dietary supplements, food items in 5 major food groups, food preparation, seasonings, and favorite foods, as well as

information about alcohol and caffeine intake. Interestingly, these researchers analyzed calcium intake relative to the total energy consumed and then intake was divided into tertiles. Adiposity measures were regressed on calcium tertiles to test for a linear relationship while accounting for age, generation, and height. Researchers reported that a significantly lower energy-adjusted calcium intake was seen in Blacks than Whites and men had a lower intake than women. Likewise, results of the analyses showed significant ( $p \leq .01$ ) inverse associations between the energy-adjusted calcium intake and adiposity and fat-free mass (FFM) tended to be lower ( $p = .05$ ) in the high energy-adjusted calcium intake group.

Contrary to Loos, a study conducted by Heiss, Shae, and Carothers (2008) examined a population of 49 postmenopausal Caucasian women aged 51-73 years. These researchers noted a significant inverse correlation between calcium intake and abdominal fat mass when diet was measured with a dietary history questionnaire and a three day food record. Diet records were computer analyzed using the Minnesota Nutrition Data System and calcium intake reflected food and supplemental calcium combined. A Pearson's correlation revealed significant inverse correlations between calcium intake and abdominal fat mass ( $r = -.25, p < .05$ ) and calcium intake and percent body fat ( $r = -.36, p < .01$ ). When calories were controlled, the only significant correlation between calcium intake and adiposity was calcium intake and percent body fat ( $r = -0.24, p < 0.05$ ). It is interesting to note that these researchers cited the shift in body fat from peripheral to central distribution that occurs in postmenopausal women as a possible explanation, and because intra-abdominal fat is more metabolically active than peripheral fat, different

relationships between adiposity and calcium intake may be seen in postmenopausal women.

The relationships that have been presented in the previous studies show that an increase of calcium in the diet may lead to a lower percentage of body fat as well as other adiposity markers. Chang-Hung (2011) stated that body fat can be used as an indicator for overweight and obese classifications in individuals. Studies have also been done that focus on African Americans and a relationship between calcium intake and percent body fat, which is especially important to the current study.

In the first part of a study completed by Zemel, Richards, Milstead, and Campbell (2005), a significant decrease in body fat and weight circumference occurred in the group that had high dairy intake compared to the groups with lower dairy intake when diets were assigned to participants. The two site study began with 338 participants that were randomized to either a low dairy or a recommended dairy group. Weight management clinics were conducted, and the weight loss phase (3 months) diet was a 1200-1500 kcal/day prescription using meal plans, prepackaged meals, shakes, and fruits and vegetables. The maintenance phase was from months 4-9 and participants were instructed to consume a diet using healthy eating strategies learned during the active intervention. In order to assess dietary intake, 3-day food records were collected at baseline, 3, 6, and 9 months. Researchers utilized the USDA National Nutrient Data Base for Standard Reference to estimate nutrient composition, energy intake, and servings of dairy products. Calcium intake was not significantly different at baseline for dairy group and low dairy groups,  $731 \pm 251$  mg/d and  $707 \pm 230$  mg/d, respectively. However, calcium intake was significantly higher for the recommended dairy group during follow-up,  $1325 \pm 254$  mg/d

for the recommended dairy group compared to  $579 \pm 166$  mg/d for the low dairy group ( $p < .0001$ ). Researchers stated that those in the recommended dairy group exhibited increased fat oxidation. Recommended dairy participants also consumed a greater amount of total energy with no additional weight gain when compared to participants who consumed less dairy products.

Loos and colleagues (2004) found a positive association in black women between the amount of fat free mass and calcium intake, and Tidwell and Valliant (2011) found a significant relationship between calcium intake and percent body fat in African American women. Tidwell and Valliant reported a cross-sectional study with 100 premenopausal African American women participants. One 24-hour recall was collected and reported diets were analyzed for total energy, macronutrients, calcium, vitamin D, and other nutrients using Nutritionist software. The mean age was  $26.4 \pm 6.4$  years and the mean BMI for all women was  $29.8 \pm 6.9$  kg/m<sup>2</sup>. Independent *t* tests determined that women with higher percent body fat had lower ( $p < .001$ ) calcium and vitamin D intakes and women who consumed more than 35.0% of kilojoules as fat ( $n = 20$ ) had a low mean calcium intake of  $478.3 \pm 176.4$  mg/d. Unfortunately, only 20% of participants obtained or exceeded their calcium RDA (1300 mg for 18 years old, 1000 mg for 19-50 years old). The researchers concluded that African American women with higher calcium and vitamin D intakes had lower body fat compared with women with lower calcium and vitamin D intakes. It is interesting that dietary calcium intake differed significantly where women with less than 38% body fat had higher intakes of calcium and vitamin D, and also carbohydrate, and lower amounts of energy and fat compared with women with at least 37.9% body fat ( $p < .001$ ).

## **Calcium and Body Mass Index**

Frakenfield, Rowe, Cooney, Smith, and Becker (2001) showed that percent body fat correlates with BMI but have also pointed out that BMI is commonly used in many studies to identify obesity; therefore, it is imperative to the current study to examine research that addresses the relationship between BMI and calcium intake. According to Mirmiran, Esmailzadeh, and Azizi (2005), it is also important to study this relationship in order to decrease the number of chronic diseases that are caused by obesity.

In a study of Chinese women completed by Huang et al. (2011), BMI and other measures of body composition were studied against dairy calcium and supplemental calcium. The authors concluded that dairy calcium was inversely associated with BMI, weight change, waist to height ratio, and fat mass. They also found that with an increase in dairy calcium, the risk for abdominal obesity was significantly decreased; however, no significant relationships were found between calcium supplement intake and body composition. A similar relationship was found in a study of a group of Tehranians where Mirmiran et al. (2005) found an increase in calcium intake as dairy consumption increased, which led to participants having lower BMIs than the participants who had lower dairy consumption. They did not find any differences between men and women regarding dairy consumption.

The relationship between BMI and calcium intake as it concerns health problems is important to study. Varena and colleagues (2007) found a significant inverse association between BMI and the prevalence of overweight individuals and dairy intake in a population of women. The researchers stated that when overweight was considered as a factor, women who had the lowest calcium intake were more likely to have

osteoporosis than women with high calcium intake. In addition, these researchers also found that low bone mineral density increases the risk of fracture especially in women, and increased calcium can not only reduce this risk, but can also decrease the risk of overweight and obesity.

### **Source of Calcium and Body Mass Index**

Although research has shown that there is in fact an effect of calcium on adiposity, dairy sources of calcium appear to be more influential and produce greater effects than does calcium supplementation alone. Researchers hypothesized that there must be additional mechanisms mediated by the complete dairy product, possibly components like whey-derived bioactive compounds or branched chain amino acids. Several researchers have examined this possibility and Zemel, Thompson, Milstead, Morris, and Campbell (2004) found that dietary calcium provided a greater effect on weight loss than supplementary calcium, and they found a significant difference in initial body fat in the high calcium and high dairy groups of their study. Similarly, Lorenzen and colleagues (2007) found that a high intake of dietary calcium decreases the amount of postprandial fat in the blood, but the same was not true with a calcium supplement. By increasing dietary calcium intake in a population of American Indians, Eliat-Adar and colleagues (2007) showed that a decrease of body fat percentage occurred, and when other variables were controlled, percent body fat and BMI decreased as calcium intake increased.

In a study by Lin et al. (2000), the ratio of dietary calcium to energy and the ratio of dairy calcium to energy were significant negative predictors of changes in both body weight and body fat. Subjects were from a two year exercise study and were Caucasian

females aged 18-31 years. Participants reported dietary intake at baseline and every 6 months for 30 months using 3-day diet records with information regarding mineral and vitamin supplement use. Using CompuTrition to analyze dietary records, total calcium included all sources, non-dairy and dairy while non-dairy calcium was calculated as the difference between total calcium intake and dairy calcium intake. While the current recommendation of 1000 mg/day, the mean intake of calcium was below the recommendation at  $781 \pm 212$  mg/day. However, calcium intake was significant in predicting changes in weight ( $p = .01$ ) and fat mass ( $p = .01$ ). The reported effects of calcium appeared to be specific to dairy sources, because both total calcium and dairy calcium predicted changes in body weight and fat, whereas nondairy calcium did not.

### **Lactose Intolerance and Body Mass Index**

Some research, such as a study done by Buchowski and colleagues (2002), showed that an individual's BMI is a predictor of the amount of calcium intake he or she gets and suggests that lactose intolerance can affect calcium intake. Because lactose intolerance can cause a low calcium intake, studies have been conducted to determine how severe symptoms can become on high dairy diets. Pribila and colleagues (2000) studied a group of African American girls who were lactose maldigesting and found a significant decrease in bloating and flatulence after they adapted to a high calcium diet, and when they were given a high amount of lactose, they reported a small amount of symptoms. Buchowski (2002) found that the lactose intolerant group of their study had a higher average weight and BMI than the lactose tolerant group, and there was a higher average daily calcium intake in the lactose tolerant group.

It is important, according to Buchoski and colleagues (2002), to note the obstacle of obtaining enough calcium when lactose intolerance is a factor, because the amount of dairy intake in individuals with lactose intolerance will significantly decrease if gastrointestinal symptoms are present. Smith and colleagues (2003) found that as a group, African Americans have a lower dairy intake than white men and women, and a high number of African American individuals suffer from lactose insufficiency, which causes them to have a small dairy intake. However, Suarez and colleagues (1998) showed that their subjects could intake 1500 mg of calcium per day through dairy products and have no significant difference in the amount of gastrointestinal symptoms when subjects were given 12.5 g lactose per day and 2 g lactose per day.

### **Conflicting Research**

Although the majority of research has found that calcium intake decreases body fat percentage, body composition, or BMI, there has been some research to suggest otherwise. Yanovski et al. (2009) completed a study in which participants were given either a calcium supplement or a placebo for two years. The main outcome measure was body fat mass and body weight. The researchers found no significant difference between calcium supplementation and the placebo group in change in body weight or body fat mass. Another study done by Harvey-Berino, Gold, Lauber, and Starinski (2005) focused on overweight or obese adults that were divided into three diet groups: calorie restricted, low dairy calcium, or high dairy calcium. The participants were studied over a twelve month period and participated in a weight loss program using eating, exercise habits, and self-management skills. The researchers found that there was no significant increase in the amount of body weight loss or fat loss in a diet restricted in kilocalories with high

calcium intake other than what can be achieved using a behavioral weight loss intervention.

Eliat-Adar et al. (2007) hypothesized ethnic differences, previously not examined in American Indians, and could play a role in the relationship between adiposity and calcium intake. The analysis included 3638 subjects from 13 different Indian tribes. A 24-hour dietary recall was used and analyzed using the Minnesota Nutrition Data System. In this study, calcium intake was categorized into quintiles and variables in the regression equation included gender, age, study center, education, income, alcohol consumption, smoking, diabetes status, and energy intake. A significant trend of decreasing percent body fat was observed with increasing quintile of calcium intake, but this association was not observed for BMI.

Heaney and Rafferty (2008) stated that a clear scientific consensus on the subject of calcium's role in obesity is lacking. These researchers stated that lack of consensus is probably due to several factors including a large amount of null findings, small effect sizes, and investigator bias. The authors noted that calcium is a micronutrient and therefore has a smaller effect within the body when compared to other nutrients. Because of the micronutrient nature of calcium and the fact that dietary intake, obesity, and the two combined introduce a great deal of variability in measurement, finding small and significant effects can be difficult.

### **Research Purpose**

Because of the conflicting findings in the current research, it is important to continue studies on the effects that calcium has on weight, fat mass, and BMI. It is especially relevant to study specific population groups because of the findings that some

groups have disparities in calcium intake, such as African Americans with lactose intolerance. This condition may prevent African Americans from getting a sufficient amount of calcium or dairy in the diet. Likewise, research has shown disparities of the effect of calcium on adiposity between men and women, as well as various ethnicities. It is important to examine the impact macronutrients and micronutrients have on adiposity so that the relationships between diet and obesity can be further elucidated. Likewise, these relationships are important so that individuals undergoing medical nutrition therapy can be given the best evidence based recommendations possible and so that the number of secondary chronic diseases related to obesity can be decreased. The current study examined a population of primarily African American women in south Mississippi to determine if the intake of dietary calcium was related to or could predict BMI.

## **Chapter 3: Methods**

Data for the current study was collected through the HUB City Steps- A Healthy "U" Begins with Steps program conducted by The University of Southern Mississippi Department of Nutrition and Food Systems. According to Zoellner et al. (2011), The HUB City Steps program sought to assess changes in physical, dietary, and psychosocial measures in participants and to improve health of these participants, the majority of which were African American women, in Hattiesburg, MS, by involving participants in regular walking activity. Participants were recruited for six months prior to beginning the program using word of mouth, brochures, and personal contact. The program lasted 18 months and was divided into two parts: a six month active intervention quasi experimental phase and twelve month maintenance randomized controlled trial phase. The first phase consisted of an intervention that aimed to decrease systolic blood pressure by an increase in physical activity through walking. All participants were provided with walking group leaders, or volunteer "coaches," motivational interviewing by staff, pedometer self-monitoring, and five education sessions. In the second phase, participants were divided into two groups: a low treatment and a high treatment of motivational interviewing via telephone. The low group was contacted four times and the high group was contacted twelve times over the course of twelve months for similar motivational interviewing sessions.

### **Sample Selection**

Participant data from the HUB City Steps multi-component lifestyle intervention was used in these analyses. HUB City Steps was collaboration between the City of Hattiesburg, Mississippi, and The University of Southern Mississippi (USM) that focused

on improving health in the greater Hattiesburg area by involvement of residents in regular walking activity. The study was funded by the National Institutes of Health (NIH) Center for Minority Health and Health Disparities (5R24MD002787-03); therefore, the primary recruitment efforts were directed toward African American residents experiencing health disparities.

Zoellner et al. (2011) stated that walking coaches were recruited before the intervention began, and individuals were allowed to apply for the position. When the intervention began, 24 walking coaches participated in 16 hours of training about the intervention, after which, they were instructed to recruit members of their community for the groups. The study limited recruitment to the Hattiesburg city limits; therefore, participants with home addresses outside the city were excluded.

Participants of the study were targeted due to the high incidence of death among non-whites in Hattiesburg due to heart disease, cerebrovascular disease, and stroke. The main race/ethnic group that was recruited was African Americans, but race/ethnicity was not used as an exclusion factor. Participants had to be 18 years of age or older, speak English, be non-institutionalized, and reside in the Hattiesburg area. Participants were excluded and advised to seek medical attention if blood pressure was over 180/110. The data collection criteria did not exclude individuals with hypertension or other chronic diseases from participating in the program.

In order to be considered a participant of the HUB City Steps, individuals had to receive a contact form from their coaches, which they would fill out and return, make an appointment for their enrollment health assessment, and complete their enrollment health assessment. In addition, participants had to fill out a pre-enrollment screening/registration

form and return them to the intervention staff, which would enter the participant information into the database. If a participant answered yes to any of six screening questions about poor or adverse health status, he or she was required to have a release from a physician to participate in the enrollment health assessment. At the end of enrollment, a total of 269 participants were consented and enrolled in the intervention.

### **Procedures**

Health assessments were completed as participants cycled through a series of stations, including but not limited to reception, informed consent, blood pressure, finger stick, motivational interviewing, and questionnaires where data was collected. Further procedures are laid out in the HUB City Steps Outcome Data Collection Manual (*HUB City Steps*, 2009).

### **Measures**

Researchers for HUB City Steps assessed changes in physical, dietary, and psychosocial outcome measures in program participants at multiple time points. Complete outcome data were collected every three months following baseline data collection and up to the point of randomization for the maintenance phase (0, 3, and 6 Months).

#### **Body Mass Index.**

Among other things, but pertinent to the current study, height and weight were measured with a stadiometer and a Tanita scale, respectively. From this data, BMI was calculated, as cited in the literature by Eliat-Adar (2007), through the formula weight in kilograms divided by height in meters squared.

## **Dietary Intake.**

Dietary intake was assessed using a NCI Screener. The NCI Screener is a 16-item FFQ that estimates the percent of energy intake from fat, grams of fiber, dairy, calcium, and fruits and vegetables (NCI, 2003); however, the NCI Screener was slightly adapted for the intervention. It was adapted to include 20 interviewer administered items that included responses from “never” to “5 or more times per day.” Questions regarding portion size were not included, and interviewers did not attempt to assess the entire diet of participants. The validity of the Five-Factor Screener has been assessed in two studies: NCI’s Observing Protein and Energy (OPEN) Study and the Eating at America’s Table Study (EATS). While the Five-Factor Screener may not be useful in estimating more ethnic diets, such as Latino or Asian, these two studies support the use of the Five-Factor Screener and suggest its usefulness in estimating dietary intake among populations consuming the average American diet (National Cancer Institute, 2007).

For this study, the amount of calcium intake was determined from the NCI Screener. The objective of this study was not to measure total dietary intake; however, dietary changes were an important part of evaluation to measure the success of the behavior changes through the intervention education sessions. The NCI Screener was helpful for dietary changes because of its estimation of usual intake, although it is not as accurate as other methods (i.e. food diaries; Greene et al., 2008). In addition, the NCI Screener is short and easily administered, which was beneficial to the intervention because of the numerous measures that were used to collect data. Finally, research suggests that the NCI Screener estimates can help distinguish individuals with high and low intakes among foods and also show interrelationships between diet and other variables (Peterson, 2008).

In the analysis, participant responses were used from the questionnaire and entered into formulas from the NCI that are used to calculate the intake estimates (NCI, 2003). The estimates are intended to show what the participant would have reported on a 24-hour recall.

### **Psychosocial Measures.**

The psychosocial measures included Social Support, Self-Efficacy, and Processes of Change. The data on these measures was collected using various instruments. Social support was assessed by an interviewer using an adapted work, Social Provisions Scale of Russell and Cutrona (1984). Processes of change were also assessed by an interviewer using an instrument developed by Nigg et al. (2001). Finally, self-efficacy was assessed using an instrument developed by Ryan and Connell (1989).

### **Physical Activity.**

Physical activity was measured by participants completing a weekly walking log, which was measured by a Yamax pedometer (Yamax, Tokyo, Japan). When completing the walking log, participants included goals and physical activity performed each week. Participants submitted walking logs by mail or through the website, and research staff entered the data into the database.

## **Data Management and Quality Control**

All raw data obtained from participants was entered into an Access database, and IBM SPSS version 20, was used to analyze data. Screening was conducted for inappropriate or missing values and outliers. In order to perform a secondary data analysis, the researcher selected pertinent variables (BMI, dietary intake, age, weight, and other health characteristics) and created a subset of data.

### **Analysis**

The researcher performed descriptive and frequency statistics in order to describe the sample. The researcher further analyzed data to evaluate relationships related to BMI and calcium. Both BMI and calcium values were evaluated categorically and continuously. The researcher hypothesized that categorizing calcium and BMI might uncover relationships not seen with the continuous data analyses because there is evidence that a threshold concentration of calcium may need to be achieved to see linear relationships between calcium and adiposity measures.

Standards defined by the World Health Organization (2012) were used by the researcher to define individuals as underweight (BMI less than 18.5), normal (BMI of 18.5 to 24.9), overweight (greater than or equal to 25), and obese (greater than or equal to 30). The researcher also used values based on the EAR and RDA to categorize reported calcium intake. Reported intakes below the EAR were classified as a low intake and values above the RDA were classified as a high intake (Table 1; Ross et al., 2011).

The researcher conducted analyses that included correlations between baseline and six month calcium and BMI to see if these variables exhibited any significant

relationships. Next, a multiple regression analysis was performed to determine if baseline calcium intake predicted baseline or 6 month BMI.

Table 1

*Calcium Intake Ranges based on EAR and RDA*

Age range	Low intake (mg/d)	Adequate intake (mg/d)	High intake (mg/d)
18	<1100	1100-1300	>1300
19-50	<800	800-1000	>1000
51+	<1000	1000-1200	>1200

## Chapter 4: Research Findings

Of the 345 participants who expressed interest and were screened for the study, 269 (78%) were enrolled, of whom 24 were coaches. The majority of participants were African American (94.4%) and female (85.1%) with a mean age of 44.3 (SD=12.2) years. Less than half (42%) of the participants were married, over three-fourths (80.4%) had some post-secondary education, while approximately one-fourth (26.5%) reported a household income greater than \$50,000 per year (Table 2). According to BMI classification, over 90% of the participants were either overweight (19.3%), obese (28.6%), or morbidly obese (42.4%). The enrolled sample was generally well representative of the targeted population, with the exception of males.

Reported mean calcium intake at baseline was 719 mg/d and 582 mg/d at 6 months. Reported dairy intake was 1 cup/d at baseline and 6 months. Likewise, reported sugar intake was 17.3 teaspoons/d at baseline and 14.5 teaspoons/d at 6 months.

Table 2

### *Characteristics of Study Sample*

	Frequency	Percentage
Sex		
Male	40	15.0%
Female	227	85.0%
Race		
Black or African American	252	94.4%
White	14	5.2%
American India or Alaska native	1	0.4%
Education		
<11 <sup>th</sup> grade	12	4.5%
12 grade (high school grad/GED)	41	15.2%
Trade or VOC school	13	4.8%
Some college	61	22.7%
College degree	76	28.3%
Some graduate or professional school	19	7.1%
Graduate level or professional degree	47	17.5%

Table 2 (continued)

Total income in the last 12 months		
Less than \$9,999	40	14.9%
\$10,000-\$19,999	36	13.4%
\$20,000-\$29,999	54	20.1%
\$30,000-\$39,999	37	13.8%
\$40,000-\$49,999	30	11.2%
≥\$50,000	71	26.4%
Marital status		
Now married	113	42.0%
Widowed	12	4.5%
Divorced	47	17.5%
Separated	8	3.0%
Never married	89	33.1%
Health status		
Excellent	19	7.1%
Very Good	54	20.2%
Good	130	48.7%
Fair	58	21.7%
Poor	6	2.2%
BMI		
Normal (18.5-24.9)	25	9.5%
Overweight (25-29.9)	52	19.5%
Obese (30-34.9)	76	28.4%
Morbidly obese (≥35)	114	42.6%

When correlations between continuous calcium intake and BMI were assessed at zero and six months (Table 3), results were not significant ( $p=.467$ ,  $p=.732$ , respectively).

Table 3

*Correlation among Baseline and 6 Month BMI and Calcium Consumption*

	1	2	3	4
1. Baseline BMI	1	.987**	.045	-.025
2. 6 Month BMI	-	1	.065	-.016
3. Calcium Consumption	-	-	1	.071
4. 6 Month Calcium Consumption	-	-	-	1

\* $p < .05$  level, \*\* $p \leq .01$  level

Multiple regression analyses revealed that the continuous variable of calcium intake at baseline did not predict BMI at baseline or at six months (Table 4).

Table 4

*Linear Regression Analysis for 6 Month BMI and 3 Month Calcium Consumption*  
(Continuous)

	B	SE(B)	$\beta$	<i>t</i>	Sig. ( <i>p</i> )
3 Month Calcium Consumption	.001	.002	.031	.414	.679

Lastly, using categorical calcium intake to predict BMI revealed no significant findings (Table 5).

Table 5

*Linear Regression Analysis for 6 Month BMI and 3 Month Calcium Consumption*  
(Categorical)

	B	SE(B)	$\beta$	<i>t</i>	Sig. ( <i>p</i> )
3 Month Calcium Consumption	1.637	.989	.122	1.656	.099

## **Chapter 5: Discussion**

The researcher feels as if the results and conclusions from this research study are important for health professionals in Mississippi as calcium intake may not influence weight loss. Understanding the relationship between calcium and weight can help health professionals correctly inform patients and clients about micronutrients and their role in the body as well as seek other ways through research in which to control weight and the prevalence of overweight and obesity.

### **Discussion**

Results related to calcium intake and BMI showed that there were no significant relationships between the two variables. The majority of participants had a BMI classified as overweight, obese, or morbidly obese, which is comparable to the state average of African American women, which is 80% (U.S. Department of Health and Human Services, 2011). The lack of significance between calcium intake and BMI could be due to a number of unknown factors, such as misrepresentation of diet, unknown health issues, or limitations of research, discussed below.

Research has shown that dairy intake may actually be a better predictor of adiposity or BMI than total calcium intake; however, Pearson's correlations in this study showed no significant relationships between any adiposity measures with reported dairy intake or calcium intake, or a combination of the two. Barr (2003) reviewed the results of 26 randomized studies in which dairy product intake or calcium intake was supplemented. One study found greater weight loss in the calcium supplemented group and it is noteworthy that only 3 of the 26 studies included men and only one study was

conducted in premenopausal women. Considering that the average age of the HUB City Steps participants was 43 years, the findings of this review may not apply to the sample.

According to Lee et al. (2011), dietary data among African Americans and other populations of color in the United States was poorly documented, which could contribute to incorrect data about these populations. These authors also pointed out that the amounts of physical activity among African Americans may have been misrepresented through self-report and that education on physical activity is an important factor to consider. Physical activity would be important to consider in the future because of the impact it has on BMI as well as dietary habits.

### **Conclusions**

In conclusion, there was no significant effect of calcium intake on weight loss in a physical activity and education intervention program. Because of these findings, calcium should not be increased in the diet for the purpose of weight loss; however, an adequate intake of calcium is important for normal processes in the body that are vital for health. Further, emphasizing dairy is important for African American women to maintain bone health, cardiovascular health, and potentially body weight. The DASH (Dietary Approaches to Stop Hypertension) diet presents a positive approach to increasing fruit, vegetable, and dairy intakes to lower blood pressure, and has research evidence that less-restrictive dairy-rich or DASH-based diets in controlling blood pressure are important components of health interventions. While HUB City Steps had five education sessions based on the DASH diet, the emphasis was on fruit and vegetable intake rather than dairy or calcium intake. Perhaps future interventions might focus more on increasing low-fat

versions of dairy and calcium rich foods in order to evaluate the moderating effect dairy and components of dairy have on weight loss, BMI, and adiposity improvements.

### **Summary**

Participants with various levels of calcium intake showed no change in body mass index based on their calcium intake. Calcium neither had a relationship with BMI nor predicted a change in BMI over the course of the intervention. Continuing to research the effect of calcium on body fat is essential to determine if calcium can affect weight loss.

One limitation of this study is the use of BMI as a predictor of health or dietary intake. Nevill, Stewart, Olds, and Holder (2006) stated that BMI does not take into account body composition, making this method a less accurate classification of body type compared to methods such as body fat percentage. BMI may misrepresent individuals because of frame size or muscle and fat composition. In future studies, body fat percentage may be used to determine if there is any relationship between body composition and calcium intake.

Another limitation included the use of a fruit and vegetable screener (NCI Screener). Although this method has positive implications (i.e. low cost and ease), some barriers to collecting accurate data could have affected the outcome. One of the largest limitations, according to Brown (2006) was the difficulty of the FFQ method, of which the NCI Screener mimics. Brown reported that participant responses are often inaccurate because of lack of knowledge in the general population of portion sizes, especially with highly variable foods such as pasta and meats. Many of the participants cannot accurately answer the questions because of vague choices like small, medium, or large portions, and in this case no portion sizes were indicated on the NCI Screener. Another limitation of

the NCI Screener was that subjects may have underreported their actual food consumption in order to appear healthier because they were scared of judgment by the data collectors. Finally, foods with multiple ingredients which are prepared at home or in different establishments may have a wide range of nutritional values that the survey cannot take into consideration. Brown stated that research that uses FFQ should be used in conjunction with other tools, such as doubly labeled water, to check for accuracy.

### **Suggestions for Future Research**

More research is needed to determine if a relationship exists between calcium intake and BMI, as well as calcium intake and body composition. More accurate measures of body composition should be used to assess whether calcium has any effect on fat mass. Another factor to take into future consideration is the source of calcium in African American women's diets as well as the amounts of physical activity that is related to dietary habits as these factors can work together to cause weight loss. Finally, more accurate measures of food consumption can be used in order to obtain more precise data and eliminate underreporting.

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