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Examination of Behavioral Determinants in the Association between Depression and Obesity: The CARDIA study

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Examination of Behavioral Determinants in the Association between Depression and Obesity: The CARDIA study

A dissertation submitted in partial satisfaction of the

requirements for the degree Doctor of Philosophy

in Public Health

by

Taline Marcarian

2013

ABSTRACT OF THE DISSERTATION

Examination of Behavioral Determinants in the Association between Depression and Obesity: The CARDIA study

by

Taline Marcarian

Doctor of Philosophy in Public Health

University of California, Los Angeles, 2013

Professor Donald E. Morisky, Chair

Background: Obesity and depressive symptoms are major public health problems, as, epidemiological studies suggest that depressive symptoms are linked to obesity. However, potential behavioral pathways linking depressive symptoms to obesity have not well examined. **Purpose:** The main purpose of this study was to assess behavioral factors as potential mediators between depressive symptoms and body mass index (BMI) and waist circumference (WC). Other objectives included: 1) examining the direct effects of depressive symptoms on BMI and WC and other cardiovascular disease (CVD) risk factors: 2) and examining the moderating effects of perceived social support on the association of depressive symptoms and BMI.

Methods: Data on U.S. adults with a mean age of 40 from the CARDIA study was used in multivariate regression analyses models to test the association between depressive symptoms and BMI and other CVD risk factors. Path analysis using EQS was used to test the behaviors as mediators in the association of depressive symptoms and BMI and WC. Measures included the Center for Epidemiologic Studies-Depression (CES-D) scores, frequency of fast food consumption per week, physical activity score, sleep quality and objective measures of BMI and WC.

Results: Depressive symptom scores were positively associated with BMI, WC, triglycerides and fasting blood glucose and negatively associated with HDL levels in the whole cohort. Perceived social support did not moderate the association between depressive symptoms and BMI. However, after subgroup analyses, the association between depressive symptoms and WC remained stronger in females as compared to males. Mediation analyses showed that physical activity was the only significant mediator that linked depressive symptoms to BMI and WC in the entire cohort.

Conclusion: Physical activity might be a potential pathway factor linking depressive symptoms to BMI and WC. Obesity prevention strategies should take these results into consideration and create innovative interventions to increase physical activity in individuals with higher levels of depressive symptoms with specific attention directed to females. Future studies are still needed to comprehensively examine the combination of mechanisms that link depressive symptoms to BMI and WC.

The dissertation of Taline Marcarian is approved.

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2013

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DEDICATION

This dissertation is dedicated to my parents:

Gerard Markarian for his 90th birthday

and

Georgette Markarian

VITA

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CHAPTER ONE

INTRODUCTION

Cardiovascular disease (CVD) is the leading cause of mortality for all race/gender groups in the United States (US) (Roger et al., 2012), with more than half of CVD deaths attributable to coronary heart disease (CHD) (Heron et al., 2009). Obesity is a major modifiable risk factor for CHD (Eckel & Krauss, 1998) and it is considered to be an independent predictor of CHD, as observed in the Framingham Heart Study (Hubert, Feinleib, McNamara, & Castelli, 1983), the Manitoba Study (Rabkin, Mathewson, & Hsu, 1977), and the Harvard Public Health Nurses Study (Manson et al., 1990).

In the US, obesity in adults is a major public health problem. The prevalence of obesity in the US has increased significantly since 1960 (Flegal, Carroll, Ogden, & Curtin, 2010). For example, from 1976-1980 to 2007-2008, obesity prevalence increased from 15% to 34% among adults (Flegal et al., 2010). Although obesity is defined as an excess of overall body fatness or adiposity, it is frequently measured using body mass index (BMI) (Eckel & Krauss, 1998). BMI defined as weight in kilograms divided by height in meter squared (kg/m^2) which is an index that ordinarily correlates highly with adiposity (body fatness). In adults ages 20 years or older, a BMI between 25 and 30 is considered overweight, and a BMI $\geq$ 30 is considered obese (CDC, 2012).

Obesity is a risk factor for other CVD conditions such as stroke, myocardial infarction, hypertension and dyslipidimia (Zalesin, Franklin, Miller, Peterson, & McCullough, 2011). Recent evidence suggests that there is a significant rise of stroke among young adults less than 50 years of age and the rate has doubled since the past decade (Kissela et al., 2012) . Therefore, the rising prevalence of obesity is attributed to be playing a role in the rise of stroke in young adults (Kissela et al., 2012). The prevalence of Type 2 diabetes has also increased dramatically

over the past few decades, which is attributed to the increased rate of obesity (Farag & Gaballa, 2011).

Independent of BMI, waist circumference (WC), which is an indirect measure of abdominal fatness, is also associated with CVD and its risk factors. Many studies have shown that abdominal obesity is more detrimental to health than overall obesity as measured with BMI (Kuk et al., 2006; Snijder, van Dam, Visser, & Seidell, 2006).

In addition to the negative health effects, overweight and obesity and their associated health problems have a significant economic impact on the US health care system. In 1995, the total costs attributable to obesity were estimated to be $99 billion (USDHHS, 2001). In 2000, the total cost estimate of the effects of obesity rose to $117 billion ($61 billion direct and $56 billion indirect) (USDHHS, 2001). In 2008, the medical care costs of obesity totaled approximately $147 billion (Finkelstein, Trogdon, Cohen, & Dietz, 2009). Most of the costs associated with obesity are due to type 2 diabetes, CHD, and hypertension. A recent estimate projects that obesity will account for more than 16% of all health care expenditures by 2030 (Wang, Beydoun, Liang, Caballero, & Kumanyika, 2008).

These figures highlight the importance of understanding and intervening in the risk factors of excess adiposity in order to prevent obesity and its consequences. The causes of obesity are complex. A large body of evidence suggests that obesity is generally the result of an energy imbalance over a long period of time (Ogden, Yanovski, Carroll, & Flegal, 2007). An energy imbalance is caused by a lack of physical activity, an unhealthy eating pattern or a combination of these two factors (Ogden et al., 2007). However, available research shows that in addition to individual lifestyle factors, a constellation of factors including genetic, psychosocial, and environmental factors play a role in influencing individual energy consumption and expenditure

(Ogden et al., 2007). Many psychological factors have also been linked to excess body fatness, including negative emotional factors such as depression, anxiety, hostility, anger and personality traits. However, depression is the most robust psychological predictor of obesity and risk for heart disease events, prognosis and mortality (Rugulies, 2002).

Depression is also a major public health problem with a lifetime incidence of diagnosis of depression being 16% of the general population (Kessler, Chiu, Demler, Merikangas, & Walters, 2005). Because both depression and obesity carry the increased risk of CVD such as CHD, type 2 diabetes and premature death (Mezuk, Eaton, Albrecht, & Golden, 2008), the association between these two conditions has received increased attention in the obesity literature over the past decade. Both cross-sectional and prospective epidemiological studies suggest a link between depression or depressive symptoms and obesity (Blaine, 2008; Luppino et al., 2010).

Depression-obesity linking literature has hypothesized a number of plausible bio-behavioral mechanisms to explain the association. One direct mechanism is through a biological pathway via the activation of the hypothalamic-pituitary-adrenal (HPA) axis resulting in an increase in cortisol levels, which may contribute to the development of abdominal obesity indirectly measured by WC (Lett et al., 2004). The indirect mechanisms that link depressive symptoms to obesity which have been proposed are through health behaviors. Depressive symptoms are associated with poor diet quality, physical inactivity and poor sleeping patterns (Konttinen, Mannisto, Sarlio-Lahteenkorva, Silventoinen, & Haukkala, 2010; Strine et al., 2008); all of which, in turn, may increase the risk of obesity. These health behaviors may act as mediators in the link between depressive symptoms and obesity. Mediators, by definition, are an intermediate variable in the causal sequence that relates two variables: independent variable to dependent variable (Stunkard, Faith, & Allison, 2003).

Research has consistently shown that the association between depression and obesity depends on certain moderators including gender (Leventhal et al., 2010), socioeconomic status (Faith, Matz, & Jorge, 2002) ethnicity (Heo, Pietrobelli, Fontaine, Sirey, & Faith, 2006; Simon et al., 2006) and other factors (M. A. Friedman & Brownell, 1995). A moderator is a variable that influences the strength and/or direction of the association between the independent variable and dependent/outcome variables (Baron & Kenny, 1986).

Some studies also suggest that social support may act as a buffer in the association between depression and obesity and could act as a potential moderator in this association. Therefore, identification of potential moderators of the depression-obesity association is important for identifying individuals who may benefit most from obesity prevention interventions that target depression.

Although epidemiological studies have reported an association between depression and obesity, the behavioral mediators underlying the association between depression and obesity are not well explored. Therefore, the main purpose of this study is to explore the potential behavioral mediators underlying this association. This knowledge will be critical in designing strategies that target obesity prevention.

Significance of the Study and Specific Aims

Why does the association between obesity and depression deserve closer attention? The goal for the Healthy People 2020 is to reduce the prevalence of obesity from 34% to 30.5% (a 10% improvement) (USDHHS, 2012). In addition, the proposed Healthy People 2020 objectives for heart disease were developed to prevent premature death from CVD by maintaining a low risk for CVD. Given the tremendous public health burden of obesity, it is imperative to better

understand the association between depressive symptoms and obesity. Understanding the contributing factors of obesity can assist not only with identifying risk but also with pointing out possible targets for health promotion and intervention strategies to prevent obesity and subsequently decrease the CVD risk.

The Strategic Plan of the National Institute of Health (NIH, 2011) highlights the importance of studying the psychosocial factors associated with overweight and obesity, as well as factors that mediate and moderate these relationships. This strategy will lead to identification of new targets for interventions at the individual, community and population levels. The current study is a response to the NIH call and has the potential to add to the limited literature available on ways depression influences obesity as a CVD risk factor in adults. Therefore, it is important to examine the role of behavioral factors such as diet, physical activity and sleep quality in the association between depressive symptoms and BMI, and between depressive symptoms and WC. Accordingly, three specific aims were developed to achieve this objective. The corresponding research questions and hypotheses are presented in Chapter Two. The specific aims of this study are the following:

Aim 1: To examine the association between depressive symptoms and CVD risk factors such as BMI, WC, blood pressure, lipids and fasting glucose among adults aged 33-44 years of age.

Aim 2: To assess the moderating effect of perceived social support in the association between depressive symptoms and BMI and depressive symptoms and WC.

Aim 3: To identify the behavioral mediators such as fast food, physical activity and sleep quality between depressive symptoms and BMI.

Aim 4: To identify the behavioral mediators between depressive symptoms and WC, independent of BMI.

In the next chapter, several areas of research are reviewed that have provided insight into the association between depressive symptoms and some selected behaviors, and the association between these selected behaviors and obesity. First, general literature on the epidemic of obesity is considered, followed by an examination of the literature on the association between depressive symptoms and obesity. Next, the conceptual framework of this study is presented along with research questions and hypotheses. Chapter Three describes the research design and methods including the description of CARDIA data, operational definition of measures and data analyses strategies. The results of the study are presented in Chapter Four. In Chapter Five, the findings are synthesized and the strengths and limitations are discussed as well as implications of the findings of this study to public health.

CHAPTER TWO

LITERATURE REVIEW

This chapter is divided it into five parts. First, the obesity epidemic is reviewed in the US, noting its prevalence, trends, causes and consequences. Second, the link between depressive symptoms and obesity is specified. Third, the role of perceived social support is discussed as a moderator between depressive symptoms and BMI. Fourth, the potential behavioral mediators between depressive symptoms and obesity are discussed. Fifth, the theoretical underpinnings of the study and the conceptual framework are examined. Lastly, the gaps and limitations in the literature, the study research questions and hypotheses are discussed.

Obesity epidemic in the United States

Definition of obesity and central obesity

Obesity generally is defined as an excess body fat (Ogden et al., 2007). In epidemiologic studies, anthropometric assessment of overall body fatness (general adiposity) is commonly measured as body mass index (BMI), which is body weight in kilograms (kg) divided by height in meters squared (m^2). According to the Centers for Disease Control and Prevention (CDC) and the American Heart Association (AHA), for adults 20 years of age and older, a BMI less than 18.5 kg/m^2 is considered underweight, between 18.5 and 24.9 corresponds to healthy weight, between 25 and 29.9 overweight and greater or equal to 30 kg/m^2 obese (CDC, 2012). BMI predicts CVD mortality; one study reported that every 5-unit increase in BMI is associated with a 30% higher rate of CHD mortality (Klein et al., 2004). Although, BMI does not directly measure body fatness, evidence shows that it is correlated with objective assessments of body fatness, such as underwater weighing and dual-energy x-ray-absorptiometry (DEXA) (Deurenberg et al.,

2001). Numerous epidemiologic studies have demonstrated that BMI is a strong predictor of chronic diseases such as hypertension, CVD and diabetes mellitus (Burke et al., 2008; Fox et al., 2008; Wilson, D'Agostino, Sullivan, Parise, & Kannel, 2002). In addition, prospective studies have shown that obesity is also with increased all-cause mortality (Berrington de Gonzalez et al., 2010). Despite its ability to predict body fatness and health outcomes, BMI is an indirect measure of body fatness and hence, it has several limitations.

Limitations of BMI

BMI is a measure of overall body fatness (adiposity) but it does not distinguish between fat mass and lean (non-fat mass) body mass (Snijder et al., 2006). For example, it may be inappropriate to use it as a measure of fatness in well trained athletes or people who are very muscular because of their large lean (muscle) mass (Snijder et al, 2006). Second, BMI as a measure of body fatness may not be valid in the elderly since older persons tend to have to have a higher percentage of body fat than younger people at the same BMI, because aging is associated with substantial loss in lean body mass and with some increase in fat mass (Gallagher et al., 1996). Third, several studies have shown a racial difference in the association between BMI and percentage of body fat. For example, for a given BMI, Asian men and women have higher adiposity compared with Caucasians (Deurenberg, Deurenberg-Yap, & Guricci, 2002; Wang, Moss, & Thisted, 1992). The high body fat at low BMI levels in Asians may be related to their build (short legs and small frame) (Garn, Leonard, & Hawthorne, 1986; Hu, 2007). However, no statistically significant differences were found between black and white adults in the percentage of body fat for a given BMI (Gallagher et al, 1996). Overall, despite differences related to age and race, researchers assert that BMI is a reasonable measure to use to assess

morbidity and mortality risk associated with overweight and obesity. Since the sample in this study consists of middle aged, black and white participants, it will be appropriate to use BMI as a measure of overall body fatness as an outcome measure to address the current study aims.

Definition of Central Obesity

Many studies agree that body fat distribution contributes to obesity-related disease risk independent of overall body fatness (Czernichow, Kengne, Stamatakis, Hamer, & Batty, 2011; Lee, Huxley, Wildman, & Woodward, 2008). For example, many studies have shown that centrally distributed body fat is associated with more adverse cardiovascular risk than fat on the hip and thigh areas (Despres & Lemieux, 2006). Abdominal fat distribution, independent of overall obesity, is associated with several metabolic diseases such as metabolic syndrome, diabetes mellitus, insulin resistance, and increased risk of CHD (Klein et al, 2004). WC is an indirect measure of abdominal fat or central obesity in epidemiologic studies and it is measured halfway between the last rib and the iliac crest. Abdominal obesity is defined as a WC of 102 cm (40 in) or more in men and 88cm (35 in) or more in women (CDC, 2010). A meta-analysis of prospective studies (mainly whites) concluded that the risk of future CVD is increased by 10% for every increase in WC of 2.99 cm among women and 8.46 cm among men (de Koning, Merchant, Pogue, & Anand, 2007).

Some investigators have found that depressive symptoms are more strongly associated with fat accumulation in abdominal area. Therefore, BMI and WC as the main outcome variables of this study were examined separately. In addition, evaluating the role of behavioral mediators in the independent associations between depressive symptoms and BMI, and between depressive

symptoms and WC, may help to clarify and reinforce targets for obesity prevention or reduction and hence would be relevant for the development of obesity prevention strategies and policy.

Prevalence and Trends

The epidemic of obesity began in the 1980s in the United States (US) and continued to spread throughout the world (CDC, 2010). Before 1980, about 15% of the U.S adult population was overweight. The third National Health and Nutrition Examination Survey (NHANES) survey conducted between 1988 and 1994 showed that the prevalence of adult obesity had increased to 23% (Flegal, Carroll, Kuczmarski, & Johnson, 1998). Obesity prevalence estimates have increased from 13% in 1962 to 19.4% in 1997, 24.5% in 2004, 26.6% in 2007 and 33.8% in 2008 for adults 20 years or older (Flegal et al, 2010). The results from the latest NHANES (2009-2010) show that the prevalence of overweight and obesity combined was 68.8% overall, 73.9% among men, and 63.7% among women (Flegal et al, 2010).

There continues to be significant racial and ethnic disparities. Among men, age-adjusted prevalence was 35.5% overall, and within race/ethnic groups, prevalence ranged from 36.2% among white men to 38.8% among black men (Flegal et al, 2010). For women, the age-adjusted prevalence of obesity was 35.8% and the range was from 32.2% among whites to 58.5% among blacks. The overall prevalence of obesity did not differ significantly between men and women.

The mean WC and the prevalence of abdominal obesity among US adults have also increased through the years (Li, Ford, McGuire, & Mokdad, 2007). By analyzing the data from NHANES 1999-2000 and NHANES 2003-2004, Li et al, 2007 reports that there was an increase of 1.5% and 2% in mean WC for men and women, respectively. The rate of increase from 1999-2000 to 2003-2004 was 0.42cm/yr, which was larger than the 0.34cm/yr increase from 1988-

1994 to 1999-2000. The age-adjusted prevalence of abdominal obesity increased by 14.6% in men and 10.9% in women. Whites had the highest prevalence of abdominal obesity among men, and blacks had the highest prevalence of abdominal obesity among women (Li et al., 2007). It is projected that by the year 2030, the prevalence of obesity will be tripled (Cornier, Marshall, Hill, Maahs, & Eckel, 2011). In addition, the epidemiology of obesity is more concerning given the clear association between excess adiposity and adverse health consequences that will be discussed in the next section.

Consequences of Obesity

The obesity epidemic is a major concern for the health of populations in the US. Obesity has been shown to be associated with an increased risk of all-cause mortality (Flegal, et al, 2007). The effects of excess adiposity on mortality appear to be most apparent in adults during midlife compared with older adults. The association between BMI and mortality has also been shown to vary by cause of death. Obesity, for example, has been shown to be associated with increased cardiovascular disease (CVD) and obesity-related cancer mortality (Flegal, Graubard, Williamson, & Gail, 2007), but not with mortality due to other causes.

However, the impact of obesity on morbidity is higher than its impact on mortality (Visscher & Seidell, 2001). Obesity has also been shown to be independently associated with CVD, specifically coronary heart disease (CHD) (Zalesin, 2011) and stroke (Strazzullo et al., 2010). US women from the Nurses Health Study (Manson et al, 1990) with higher BMI (>30) had a threefold risk of developing nonfatal myocardial infarction compared with women with lower BMI (below 21). Among men in the Health Professionals Study (Rimm et al., 1995), those with a BMI between 29 and 33 had a twofold risk and those with BMI higher than 33 had a

threefold risk of developing CHD compared with men with a BMI below 23. The Nurses' Health Study reported that higher BMI levels were related to stroke. From the Framingham Study data, it is estimated that if everyone could be kept at optimal weight, there would be 25% less CHD and 35% fewer strokes or episodes of heart failure (Hubert et al, 1983). A 20% weight reduction in obesity should correspond to a 44% reduced risk of CHD (Hubert et al, 2003). Markers of central/abdominal obesity such as waist circumference have also been shown to be independently associated with CVD risk (Canoy, 2008). In view of all the evidence, the American Heart Association (AHA) adopted obesity as a major CVD risk factor in 1998 (Eckel, 1998). Consequently, more attention has been focused on the role of obesity in CVD and the importance in taking action to prevent the disease. Obesity also has a strong impact on the CVD risk profile and is a risk factor for increased blood pressure and increased low-density lipoprotein (LDL) cholesterol and triglyceride levels (Hubert et al, 1983).

Adverse health effects of obesity are not limited to CVD. The significant rise in the prevalence of diabetes mellitus is thought to be primarily due to the obesity epidemic, particularly abdominal obesity (Farag & Garaballa, 2011). Obesity increases risk of several types of cancer such as breast cancer (Morimoto et al., 2002) and prostate cancer (Buschemeyer & Freedland, 2007). Other medical consequences include liver disease, osteoarthritis, obstructive sleep apnea, polycystic ovarian syndrome and gastrointestinal diseases (Visscher & Seidell, 2001;Cornier, 2011).

Although obesity carries the risk of the aforementioned problems, its major impact on morbidity is through its effect on CVD (Mathew, Francis, Kayalar, & Cone, 2008). CVD is a major cause of morbidity and mortality in the US and throughout the world (Go et al., 2013; Smith et al., 2012). CVD encompasses myocardial infarction, hypertension and cardiomyopathy

and it is projected that the number of deaths from CVDs will increase from 17.3 million to greater than 23.6 million by 2030 (Smith et al., 2012). During the World Health assembly in May of 2012, the Ministries of Health agreed to adopt a global target to reduce premature non-communicable disease (NCD) mortality 25% by 2025 (Smith et al, 2012). Since CVD is the largest single contributor to global mortality, achieving the global target to reduce premature NCD deaths by 25% requires that CVD risk factors be adequately addressed (Smith et al, 2012). In addition, since obesity is a major determinant of increased CVD risk, its causal factors need to be examined in order to prevent obesity and reduce the risk of CVD. Obesity prevention can potentially have a major impact on reducing the morbidity and mortality that result from the chronic effects of excess body fatness (Seidell, Nooyens, & Visscher, 2005). Studying the factors contributing to obesity will lead to direct intervention and aid in developing preventive strategies.

Causes of the obesity epidemic

The causes of obesity are complex and multifactorial (Hill, 2006). Many biological, genetic, psychosocial, behavioral and environmental factors have been associated with obesity (Hill, 2006). Many studies have suggested that the high prevalence of obesity can be explained by changes in our eating and physical activity patterns in response to a changing environment. Therefore, social, cultural and environmental factors may be part of the problem that promote an energy-rich diet and sedentary lifestyle (Swinburn et al., 2011). Such factors include exposure to energy dense, cheap highly accessible foods, combined with significantly decreased needs for physical activity via the energy saving devices such as automobile, TV and computers (Prentice & Jebb, 2003). All this, combined with the increase in fast food restaurants, portion sizes, and

strategic marketing campaigns challenge the ability of the public to maintain a normal body weight (Swinburn et al., 2011). A more detailed discussion of the many causes of the obesity is beyond the scope of this study.

Behavioral determinants of obesity

A large body of evidence suggests that obesity results from an energy imbalance, when energy intake exceeds energy expenditure (Hill, 2006). Therefore, the primary drivers of obesity are thought to be behavioral lifestyle factors, such as energy-dense diets and lack of physical activity. One major contributor to the obesity epidemic is an increase in fast food intake (Bray, Nielsen, & Popkin, 2004; Haines, Hama, Guilkey, & Popkin, 2003). Fast foods are generally nutrient-poor, energy dense foods (Guthrie, Lin, & Frazao, 2002) that contain high fat and sugar content that might be linked to obesity (French, Harnack, & Jeffery, 2000; Ma et al., 2003). The increase in obesity and overweight also strongly parallel an increase in consumption of sugar-sweetened beverages (SSB). For example, in a study by Schulze et al (2004), women who consumed more SSBs had the greatest weight gain (Schulze et al., 2004). Moreover, fruit and vegetable consumption, which are a good source of less energy dense foods, remains below the recommended levels (Popkin & Nielsen, 2003).

Changes in physical activity levels have also played a role in the recent rise in obesity. Several studies have shown that only 50% of Americans report engaging in leisure time physical activity recommended by the CDC (Kruger, Carlson, & Buchner, 2007). In addition to diet and physical activity, several epidemiological studies have noted that the average amount of sleep has steadily decreased among US adults during the past several decades (Gangwisch, Malaspina, Boden-Albala, & Heymsfield, 2005). Studies have linked short sleep duration and poor sleep

quality to increased BMI (Nielsen, Danielsen, & Sorensen, 2011). These behavioral determinants are discussed in detail in a later section; the discussion of biological, genetic and environmental factors is beyond the scope of this study.

Psychosocial determinant of Obesity: Depressive symptoms

Major depression disorder (MDD) is the most prevalent mental health problem in the US. Two CDC surveillance systems provide estimates for current depression rates (Reeves et al., 2011). Most recent NHANES (2005-2008) showed that 6.8% of US adults reported feeling depressed as measured by the Patient Health Questionnaire (PHQ-9), during two weeks before the survey. Results from the Behavioral Risk Factor Surveillance System (BRFSS) indicate that in 2008, 8.2% of the population had current depression in 16 states. Prevalence was higher among blacks compared with other groups (Reeves et al, 2011). The lifetime diagnosis of depression was 16.1% in 2008 (Reeves et al, 2011).

MDD is a mood disorder characterized by a number of symptoms. The main feature of a depressive disorder is either depressed mood or the loss of interest or pleasure in nearly all activities (APA, 2000). In addition, the depressed individual must experience at least four of the following symptoms: changes in appetite or weight, changes in sleep, changes in psychomotor activity, decreased energy, difficulty thinking, concentrating or making decisions, feeling of worthlessness or guilt or recurrent suicidal ideation (APA, 2000). These depressive symptoms can result in substantial negative effects on physical health such as obesity, healthy behaviors and overall wellbeing (Kessler et al., 2005; Reeves et al, 2011).

Depressive symptom scales are not specific for major depressive disorder but are used in the general population as a screening tool in clinical practice and in epidemiologic studies. The

Center for Epidemiologic Studies Depression Scale (CES-D) is a self-administered, 20-item measurement of depressive symptoms in the past week (Radloff, 1977). This scale has been shown to have good reliability and construct validity in community population (Radloff, 1977; (Knight, Williams, McGee, & Olaman, 1997; Roberts, Vernon, & Rhoades, 1989). Therefore, depressive symptoms as a proxy for depression are normally used in the epidemiologic and population based studies.

Depression is related to several demographic factors such as gender, age and income level. Women are more likely to experience depression than men (Kessler et al., 2005). For 12-month prevalence, 30-44 years olds are 80% more likely to have experienced depression than other groups (Wang et al, 2005). People with incomes below the federal poverty level, especially those aged 40–59 years, had a higher prevalence of depression than those with incomes above the federal poverty line (Pratt & Brody, 2008). Racial/ethnic differences in depression have not been found consistently; some studies have reported no difference, while others have found lower rates among racial/ethnic minorities compared to whites (Kessler et al, 2005).

The World Health Organization (WHO) has estimated that in 2020, depressive disorders will reach second place on the list of global burden diseases (WHO, 2001). This projection is alarming because an increase in depressive symptoms indicates not only a decline in psychological well-being, but also in health behaviors (Strine et al., 2008), which in turn may affect physical health conditions such as obesity.

In several prospective studies, younger individuals with depression have been noted to be at increased risk of developing obesity, which continues into later life (Richardson et al, 2003). Prospective research has also shown that depressive symptoms have resulted in increased risk of

weight gain and obesity (McElroy et al., 2004) and central adiposity in adults. Therefore, depressive symptoms may be one of the risk factors of obesity that can be targeted in future intervention efforts. The NIH's strategic plan highlights the importance of examining the association between depression and obesity and identifying potential appropriate causal pathways between these factors. Therefore, the current study will focus on depressive symptoms as a risk factor and behavioral determinants as potential mediators in this association.

Link between depressive symptoms and obesity: Epidemiological evidence

Both depression and obesity have major public health implications. Because of the high prevalence of both depression and obesity, and the fact that they both are associated with an increased risk of CHD (Lett et al., 2004), a potential association between depression and obesity has been examined in the literature. Most studies examining such an association have been cross-sectional in design (Luppino et al., 2010). A recent meta-analysis of 17 community-based, cross-sectional studies with a total of 204,507 adults showed a significant positive overall association between depression and obesity (OR=1.26) (de Wit et al., 2010). Depression was associated with an 18% increased risk of obesity (de Wit et al., 2010). From all the potential moderators (such as age, gender, race, residence), only gender acted as a moderating factor; this association was found in women but not in men (de Wit et al., 2010).

Although cross-sectional studies are informative, they are less helpful in identifying the causal mechanisms linking depression to obesity. Prospective studies may be more helpful in this regard. In the next section, evidence from prospective studies is reviewed.

Evidence from prospective studies

Prospective studies are a better design to address the causal association between depression and obesity. Most prospective studies have addressed the question of whether depressive symptoms at baseline predict obesity at follow-up. These studies examining the effect of depression over time found a bidirectional association between depression and obesity. Obese persons had a 55% increased risk of developing depression over time, whereas depressed persons had a 58% increased risk of becoming obese (Luppino et al., 2010). The results of longitudinal meta-analyses found a larger pooled effect size (OR between 1.2 and 1.58) than the pooled OR of 1.18 reported in the cross-sectional meta-analysis of de Wit at al (2010). Subgroup analyses by gender did not reveal any moderating effect in this association.

Fewer studies have assessed both depressive symptoms and obesity at multiple points in time to test how baseline depression is associated with the trajectory of obesity. One study of younger adults (mean age 30 years at baseline) found that baseline depressive symptoms were associated with small increases in waist circumference, but not BMI (Needham, Epel, Adler, & Kiefe, 2010). Subjects with depressive symptoms are prone to increased central fat distribution (Ahlberg et al., 2002). Although the exact mechanism is not known, alterations of the hypothalamic pituitary adrenal (HPA) axis secondary to depression, such as increased cortisol concentration could lead to central obesity (Weber-Hamann et al., 2002). HPA axis is sensitive to a variety of stimuli (Bjorntorp, 2001). In a study, subjects who felt happy had a lower level of cortisol than those who felt depressed (Smyth et al., 1998). Cortisol activates lipoprotein lipase, which facilitates fat accumulation in adipocytes (Bjorntorp, 2001). The cortisol receptors, which are higher in intrabdominal areas, promote the accumulation of fat. The evidence for increased cortisol and increased accumulation of abdominal/central fat comes from data from cellular and

molecular studies. For example, increased cortisol secretion in Cushing's syndrome, as well after treatment with steroids, is typically followed by an increase of central adipose tissue (Bjorntorp, 2001).

Because the effects of depression on obesity may be cumulative (Kivimaki et al., 2009), investigators have tested whether baseline depressive symptoms are associated with changes in weight from young adulthood through old age. The participants (n=2,251) were from the Baltimore Longitudinal Study of Aging (Sutin & Zonderman, 2012). Baseline depressive symptoms were tested as predictors of adiposity over 30 years. BMI and waist circumference were unrelated to depressive symptoms trajectory. Depressive symptoms were measured as total CES-D score and 4 subscales. Gender moderated the association between depressive symptoms and weight gain. Women who experienced depressive symptoms gained more weight across adulthood than women who did not experience the symptoms (Sutin & Zonderman, 2012). The gender differences in the behavioral correlates of depression may contribute to a greater weight gain for women than men as speculated by the authors (Sutin & Zonderman, 2012). For example, women who are suffering from depression are more likely to report overeating and increased appetite (Angst, Gamma, Sellaro, Zhang, & Merikangas, 2002; Romans, Tyas, Cohen, & Silverstone, 2007), a loss of interest in pleasurable activities, difficulty sleeping than are men (Angst et al., 2002). Therefore, women with depressive symptoms may be more prone to weight gain due to overeating and physical inactivity which are two risk factors for weight gain (Sutin & Zonderman, 2012).

Previous cross-sectional and prospective investigations using the Coronary Artery Risk Development in Young Adults study (CARDIA) found associations between depressive symptoms and components of metabolic syndrome, specifically hypertension, lipid profiles and

waist circumference. Higher depressive symptoms predicted a faster rate of growth in waist circumference and BMI among whites, in both males and females, from year 5 to year 20 (Needham et al, 2010). In this study, the investigators did not examine mechanisms underlying the observed association between depressive symptoms and WC. This examination would have been helpful to understand why people who experience more symptoms of depression gain body mass and abdominal fat at a faster rate than those who experience less depressive symptoms (Needham et al, 2010). Potential mediators include the use of antidepressants, chronic stress arousal and changes in exercise and diet. The investigators have suggested that the chronic stress common in depression is linked to endocrine and metabolic imbalances that promote abdominal fat storage (Bjorntorp, 2001). In CARDIA, depressive symptoms at Year 5 predicted incidence of hypertension at Year 10 in the entire cohort; however, after stratifying on race, the association remained significant only among blacks (Davidson, Jonas, Dixon, & Markovitz, 2000). A more recent study found that depression was associated with very high blood pressure particularly among whites (Yan et al., 2003). However, it appears that there are some inconsistencies in these studies. Finally, a recent study using CARDIA found that individuals with high depressive symptoms had higher C-reactive protein at Year 20 (Deverts et al., 2010). C-reactive protein has been linked to central adiposity and CVD risk among those with metabolic syndrome. After stratification, the association remained significant among blacks.

It should be noted that although these studies were based on large population samples, they are marked by methodological variability and it is therefore difficult to make comparisons. Some studies measured weight and height and some used subjective reporting methods. This type of data collection can be a limitation, since underreporting of weight or over-reporting of height is a well-established problem with subjective reporting (Sutin & Zonderman, 2012). Some

studies used interviews for assessing depression. Interviews may have greater diagnostic specificity as opposed to a questionnaire (Sutin & Zonderman, 2012) . Some studies used obesity status as a categorical predictor, others used BMI as a continuous measure, and yet others used both categorical and continuous measures, and the same measure difference was used for depression. The most common measure of depression was the CES-D Scale (Needham et al., 2010; Sutin & Zonderman, 2012). Some studies used DSM-IV criteria for diagnosis of depression (Carpenter, Hasin, Allison, & Faith, 2000; Scott et al., 2008).

All of these studies reveal a wide range of covariates that have been modeled in the literature. There was no consistent set of covariate selection across the studies, and it is not always clear how findings within studies would have changed if they have controlled for different variables. This lack of consistency in modeling of covariates is a major limitation in the literature.

Depressive symptoms and other CVD risk factors

This section provides a brief summary of the association between depression and CVD risk factors. The CARDIA study has explored the associations between depressive symptoms and other CVD risk profiles (blood pressure, lipids, glucose) up until year 15. This study will further explore the association of depressive symptoms with these risk factors from year 15 and year 20 when the cohort is older and when the CVD risk factors are more likely to be emerging.

Depressive symptoms and blood pressure: The association between depressive symptoms and blood pressure started showing in early studies such as the National Health and Nutrition Examination Survey I Epidemiological Follow-up Study (NHEFS-I) (Jonas, Franks, & Ingram, 1997) and the CARDIA study (Davidson et al, 2000) where symptoms of depression were

associated with an increased incidence of hypertension. In a more recent report using data collected from 1,017 participants (60%white) of the Bogalusa Heart Study, a significant negative association between depression and blood pressure was observed among blacks, but not in whites (Kabir, Whelton, Khan, Gustat, & Chen, 2006). More specifically, a one-unit change in depressive symptom score was associated with a 4% lower prevalence of hypertension in blacks but not in whites. This study also showed that depressive symptoms were associated with hypertension mainly through a higher level of BMI in both whites and blacks (Kabir et al., 2006). The main limitation of this study is its cross-sectional nature. The plausible mechanism relating depressive symptoms to hypertension is speculated to be biological in nature due to the activation in the central sympathetic nervous system (Bjorntorp, 2001; Cowen, 2010). Repeated sympathetic nervous system stimulation increases heart rate and blood pressure, which may lead to hypertension (Bjorntorp, 2001).

Depressive symptoms and lipids: There is also a direct association between depression and lipid levels; however, there are many inconsistencies in these studies. Several studies noted that higher levels of depressive symptoms were associated with lower levels of LDL and higher levels of high-density lipoprotein (HDL) in men (Igna, Julkunen, Vanhanen, Keskivaara, & Verkasalo, 2008; Shin, Suls, & Martin, 2008). Few studies have noted that higher levels of depressive symptoms were associated with lower total cholesterol (TC) level among middle-aged individuals (Horsten, Wamala, Vingerhoets, & Orth-Gomer, 1997). In a study of healthy young adult women (n=225), there was a negative association between depressive symptoms and TC and LDL. However, this is a cross-sectional study and results cannot be generalized since it is based on young women who were enrolled in the study due to their unfavorable lipid levels as

children. It has been speculated that the association between depressive symptoms and lipids profiles are due to both genetic and biological factors and as well as lifestyle factors.

Depressive symptoms and diabetes: A recent meta-analysis reported that depressed adults had a 37% increased risk of developing type 2 diabetes (Knol et al., 2006). Insulin resistance has been investigated as one of the mechanisms linking depression to diabetes. In 40-60% of people with major depressive disorder, the HPA axis is hyperactive. This hyperactivity leads to excess cortisol production and disruption of glucoregulatory mechanisms which in turn lead to increased insulin and insulin resistance, eventually leading to diabetes (Brown, 2004). In addition, the association may also be explained by lifestyle factors associated with depression including physical inactivity and poor dietary habits that increase the risk of developing insulin resistance (Pearson et al., 2010).

Moderators in depression and obesity associations

The association between depression and obesity may be moderated by factors such as gender (Leventhal et al., 2010), socioeconomic status (SES) (Faith et al., 2002; Simon et al., 2006), ethnicity (Heo et al., 2006), and other factors. Use of antidepressants, among people with depression, may also explain why individuals suffering from depression gain weight since weight gain is a common side effect of psychotropic medications (Laimer et al., 2006). However, some studies have found that the use of antidepressants does not modify or alter the relationship between depressive symptoms and the increased risk of obesity. Smoking is another moderator identified in the literature. A cross-sectional study of 41,654 US adults found that current smoking status moderated the association between past year depression and current obesity as well as the link between depression and BMI (Leventhal et al, 2010). Depressive symptoms also

predicted obesity and BMI among nonsmokers. Identifying moderators such as gender, ethnicity, or age would pinpoint those individuals with depressive symptoms among whom obesity is more likely to occur and whom may be the most appropriate to target. Most of the researchers have investigated demographic variables as moderators that influence the association between depression and obesity (de Wit et al., 2010).

Gender: A systematic review of the literature (Atlantis & Baker, 2008) and meta-analysis (de Wit et al, 2010) indicated that the association between depressive symptoms and obesity is stronger among women than men. Depression increased the risk of obesity or weight in gain in women only. In an another review, a history of depression was associated with reduced weight gain among females but greater weight gain among males (Blaine, 2008). This study has also found that gender interacted with age and education in moderating the association. Specifically, young depressed men with less education gained more weight compared with their more highly educated counterparts.

In general, not all studies found this sex difference (Luppino et al, 2006; Simon et al., 2006). Some studies indicated a significant association between depression and obesity in females but not in males (de Wit et al, 2010). Yet, still other studies found no gender discrepancy. These results could be explained by differences in study design. Some used self-reporting questionnaires for depressive symptoms while other used DSM-IV criteria to establish a diagnosis. Therefore, gender, as a moderator should be explored further.

Race: A very small number of studies tested the potential moderating effects of race. In the studies that tested race/ethnicity as a moderator, there was no evidence that race moderates the association (Faith et al., 2002) (Needham et al., 2010). Only one study has concluded that ethnicity may moderate the association between depression and obesity (Sachs-Ericsson et al.,

2007). Given that there is evidence that the depression-obesity association differs by race (Heo et al., 2006), there is a need to do more research with ethnically diverse populations.

SES: Not too many studies have examined the effect of SES as moderator in the association between depressive symptoms and obesity. One old study reports a positive association between being overweight and depressive symptoms among better-educated women and men compared to those with less education (Ross, 1994). Prospective studies need to evaluate these variables as potential moderators.

Besides socio-demographic characteristics, the literature suggests that other factors, such as perceived social support, may act as a buffer; therefore, it may be a potential moderator in the association between depressive symptoms and obesity. However, very few studies have looked into perceived social support as a moderator variable. Numerous studies indicate that social support has a beneficial effect on well-being (Cohen & Wills, 1985).The term -"buffers"- refers to protecting persons from the potentially pathogenic influence of stressful events (Cohen & Wills, 1985), specifically, in this study, from depressive symptoms.

Social support may play a role at two different points in the causal chain linking stress to illness. First, support may intervene between the stressful event and a stress reaction by attenuating or preventing a stress appraisal response (Cohen & Willis, 2005). That is, by perceiving that others can help and provide the necessary resources to deal with the stress, one can perceive a situation as less stressful (Cohen & Wills, 1985). Second, adequate social support may decrease or eliminate the stress reaction by intervening between stress and the onset of adverse outcomes (Cohen & Willis, 1995). Meaning, social support may reduce the stress appraisal by providing a solution to the problem, by reducing the perceived importance of the

problem so that people are less reactive to perceived stress, or by facilitating healthful behaviors (Cohen & Willis, 1995).

There are several studies that have examined the association between social support and depressive symptoms. These studies have shown that greater perceived social support is associated with fewer depressive symptoms in both clinically depressed and community populations (Clara, Cox, Enns, Murray, & Torgrudc, 2003; Stice, Ragan, & Randall, 2004). In a recent study, social support was significantly associated with better physical and mental health-related quality of life (HQOL) (Wiczinski et al, 2009). In addition, a buffering effect was found for physical HQOL among men. More specifically, obese men reporting little social support had significantly poorer physical HQOL than those men with normal weights. Therefore, perceived social support buffered the negative effects of obesity on physical HQOL among men (Wiczinski et al, 2009).

In summary, social support may have a significant role in health outcomes, most importantly by demonstrating direct positive effects on physical and mental health status and serving as a buffer for effects of psychological stress. One of the CARDIA study investigated whether greater perceived social support was associated with better health behaviors in individuals with a high hostility score (Allen, Markovitz, Jacobs, & Knox, 2001). This study found that social support was positively associated with more physical activity in all groups except black women. However, with high hostile individuals the social support was positively associated with increased physical activity in men only. Therefore, perceived social support has not been investigated as a moderator in the association between depressive symptoms and obesity. In light of the first mechanism mentioned above, perceived social support was considered as a potential moderator in the association between depressive symptoms and BMI in

this current study. Among the studies that conducted moderation analyses, there is evidence for gender moderation with prospective associations found in females but not in males. Therefore, there is an additional need to evaluate the potential moderating role of gender as well as other factors such as perceived social support.

Mediating pathways between depressive symptoms and obesity

Given the empirical findings that support the possibility of depression being a risk factor for obesity, the question of how depression contributes to obesity should be considered. Two main pathways linking depressive symptoms to obesity have been proposed in the literature. First, a large body of literature has shown that biological mechanisms underlie the association between depressive symptoms and obesity. In depressed individuals, there are neuro-endocrine disturbances, which include dysregulation of the HPA axis and hypothalamic-pituitary-gonadal (HPG)-axis, shown by high cortisol levels and low sex steroid hormones (Bjorntorp & Rosmond, 2000). In addition, high levels of inflammatory markers were observed in persons who report high levels of depressive symptoms (Vogelzangs et al., 2008). Similar findings have been identified in populations with abdominal obesity (Bjorntorp & Rosmond, 2000). Consequently, it has been hypothesized that chronic stress and/or depression results in abdominal obesity, through long-term activation of HPA axis (Bjorntorp, 2001). Elevated cortisol combined with low sex steroid hormones cause fat to accumulate in visceral adipose tissue (Bjorntorp, 2001). This accumulation might be due to specific properties of visceral fat, such as high density of cortisol receptors.

Since there is a close connection between abdominal body fat and excess of total body fat, we may wonder if excess accumulation of total body fat is also associated with neuro-

endocrine stress reaction, as discussed above. There is accumulating evidence that this case may be true that increase in the levels of cortisol which are involved in increased energy intake will lead to increase BMI. In other words, HPA axis activation with depressive symptoms is also involved in the development of overall body fatness as assessed by BMI in the epidemiologic studies (Bjorntorp, 2001; Cowen, 2010).

The second mechanism proposed in the literature is through a behavioral pathway. Studies have shown that depressive symptoms encourage unhealthy lifestyle patterns such as poor dietary pattern, lack of physical activity and poor sleep quality. Targeting and defining the exact mechanism through which depression affects obesity or leads to weight gain is complex and challenging. Although biological factors are important, examining behavioral mechanisms are more useful to interventions, have important preventive implications, and are relevant to public health, although they are seldom studied. By focusing on more easily observable and defined mechanisms, such as health behaviors, the understanding of the association between depressive symptoms and obesity may be enhanced and consequently lead to more targeted interventions. Therefore, in this study, dietary factors (fast food, fruit, vegetable and SSB intake), physical activity and sleep quality were examined as potential behavioral mediators in the association between depressive symptoms and obesity. Mediators, by definition, mean anything that comes in between variables. A mediator is a variable that is in a causal sequence between two variables (Stunkard et al., 2003). These behaviors as mediating variables are important to study since they may help in identifying how depressive symptoms leads to obesity and this will have implication to prevention research where interventions can be designed to prevent obesity by targeting mediating variables that are hypothesized to be involved in the association between depressive symptoms and obesity.

Health behaviors as mediators

The first step in examining the mediating effect of selected health behaviors is to establish that depressive symptoms and certain health behaviors are correlated. Determining an association between depressive symptoms and health behaviors will create the foundation for understanding a meaningful relationship between depressive symptoms and obesity. Among the most important determinants of obesity are dietary and physical activity behaviors, and both may play an important part in linking depression with obesity. Sleep pattern has emerged as another risk factor for obesity and has also been linked to depressive symptoms. The bivariate association between depressive symptoms and health behaviors are well studied as detailed below; however, the three-way association of diet, physical activity and sleep quality as potential mediators between depressive symptoms and obesity are limited.

Depressive symptoms and diet: Both laboratory and epidemiological studies suggest that depression motivates less healthy food choices, although this finding may be greater among those who are female, overweight, and score high on dietary restraint (Adam & Epel, 2007; Wardle, Steptoe, Oliver, & Lipsey, 2000). For example, depressive symptoms were associated with a high level of fast food intake and less fruit consumption as well as greater snack food intake among college students (Liu et al., 2007). Female college students in European cities who reported more depressive symptoms ate more sweets, more fast foods and fewer fruits and vegetables than those who were less depressed (Mikolajczyk, El Ansari, & Maxwell, 2009). Depressive symptoms were also associated with lower fruit/vegetable consumption among 25-64 years old Finnish men and women from the FINRISK 2007 Study (Konttinen et al., 2010). The results of this study should be interpreted with caution since some of them are based on college

students and outside the US. Some researchers have hypothesized that depressive symptoms itself may decrease an individual's motivation to engage in healthy dietary habits and thus may lead to a poor diet (Anton & Miller, 2005).

In addition to higher level of fast food and less fruit consumption, high levels of soft drink consumption were positively associated with depressive symptoms (Shi, Taylor, Wittert, Goldney, & Gill, 2010). In the multivariate analysis, after adjusting for socio-demographic and lifestyle factors, those who consumed more than half a liter of soft drink per day had approximately 60% greater risk of having depression, compared with those who did not consume soft drinks.

Most of the studies exploring the association between depressive symptoms and food consumption patterns are based on cross-sectional data; hence, it should be noted that these associations might be bidirectional.

Depressive symptoms and physical activity: Studies have reported a negative association between depressive symptoms and physical activity. Data from the 2006 Behavioral Risk Factor Surveillance Survey (BRFSS) (n=217, 379) shows that men and women with mild, moderate and severe depression were more likely to be physically inactive after adjusting for socio-demographic characteristics (Strine et al., 2008). In this study, depressive symptoms were assessed by Patient Health Questionnaire (PHQ-8) and by subjective reports of height and weight.

Although it is hypothesized that the association between depressive symptoms and physical activity may be bidirectional, few studies have examined this issue in a prospective design. The participants (n=9,309 of the British Whitehall II), with higher levels of depressive symptoms (score derived from the 30-item General Health Questionnaire using 4 items), were

more likely not to engage in physical activity at the recommended levels over the follow-up (OR=1.79) compared to those without such symptoms (Azevedo Da Silva et al., 2012). In a five-year follow-up study, Panagiotakos et al. (2008) investigated determinants of physical inactivity in 1,955 community participants. After controlling for multiple comparisons, depressive symptoms were strong predictors of those who were sedentary at both baseline and follow-up, and also of those who became more sedentary over time (Panagiotakos et al., 2008).

Longitudinal studies have also examined the association between depression or depressive symptoms and changes in physical activity. These studies found that depression at baseline was significantly associated with a decline in levels of physical activity or lack of adherence to prescribed physical regimens after coronary events during the follow-up period (Roshanaei-Moghaddam, Katon, & Russo, 2009). In these studies, the physical activity measure was obtained from self-reports. Only one epidemiological study assessed the association between depressive symptoms and physical activity using an objective measure (Song, Lee, Baek, & Miller, 2012).This study used the NHANES 2005-2006 data (n=4,058), which was limited to adults 20 years or older. Physical activity was measured by accelerometer and the Patient Health Questionnaire (PHQ-9) measured depressive symptoms. Results indicate that people with moderate to severe depressive symptoms engaged in moderate physical activity significantly less than those with low depression.

Several hypotheses have been proposed that explain the association between depression and lack of physical activity. One of these hypotheses associates depressive symptoms with lack of energy and low motivation (Roshanaei-Moghaddam et al., 2009).

Depressive symptoms and sleep: Depressed mood is often accompanied by changes in sleep pattern, including reduced sleep efficiency, and complaints of insomnia (Mezick, Hall, &

Matthews, 2011). As sleep disturbances are part of the diagnostic criteria for mood disorders, it is not uncommon to find that complaints of poor sleep quality occur in an estimated 50% - 90% of individuals with diagnoses of depression (Tsuno, Besset, & Ritchie, 2005). Very few studies that focus on depression as a predictor of obesity and CVD have considered the potential role of sleep in this association. It is possible that part of the effects of depression on obesity may be explained through sleep quality. Therefore, this study also examined the mediating role of sleep in the association between depressive symptoms and obesity.

Link between the health behaviors and obesity

After building an argument for an association between depressive symptoms and health behaviors, it is necessary to draw a link between the same variables and obesity. Without evidence of a direct association between diet, physical activity and sleep quality with the development of obesity, there is little reason to identify these variables as mediators between depressive symptoms and obesity. Several investigators have assessed the associations between dietary pattern such as increase in fast food, SSB consumption and lower fruit and vegetable intake and weight gain.

Fast Food intake: Fast food is a growing component of the American diet and has been implicated in the obesity epidemic (Cummins & Macintyre, 2006). Fast food is defined as convenience food purchased in self-service or take-out eating venues without wait service (Jeffery, Baxter, McGuire, & Linde, 2006). Many plausible mechanisms, such as large portion size, high glycemic load, higher fat and energy intake, excessive amounts of refined starch and added sugars and low in micronutrients intake have been proposed linking fast food consumption with weight gain or obesity (Cummins and Macintyre, 2006).

Of the studies conducted among adults, Jeffery et al. (2006) reported a significant positive relationship between BMI and individuals who frequented fast food restaurants once a week or more. In a subsequent study, a positively significant association between fast food consumption and BMI was observed only among women. Similarly, data from the CARDIA study also suggested an association between fast food consumption and later weight gain (Pereira et al., 2005). Over 15 years, a change in fast food consumption was associated with changes in body weight (Pereira et al., 2005).

Sugar sweetened beverages: The increase in obesity and overweight strongly parallels increased consumption of SSBs (131% increase since 1977) in both children and adults (Jeffery, 2006). This huge increase has contributed to the added sugars that now comprise 16% of total energy intake in the American diet. Soft drinks are the leading source of added sugars in the US diet (Bray et al., 2004) and have been found to predict weight gain in several population studies. For example, in the eight-year follow-up of women in the Nurses' Health Study (Schulze et al., 2004), positive association between SSB consumption at baseline and greater weight gain and risk of type 2 diabetes was observed, independent of known risk factors.

Fruit & Vegetables: Fruit and vegetable consumption may affect energy intake and body weight because these foods are high in water and fiber and low in energy density. Substituting fruits and vegetables for foods with higher energy densities can be an effective weight-management strategy, as evidenced in short-term clinical studies in which reductions in energy density were associated with increased satiety, reduced hunger, and lower energy intake (Hill et al, 2004). Cross-sectional studies show a tendency for higher body weight to be associated with lower fruit or vegetable consumption among adults; however, the evidence for this association is insufficient. Most experimental and longitudinal studies among adults found either the expected

inverse relationship between fruit and vegetable consumption and adiposity or mixed results. However, in these studies, especially the experimental ones, it was unclear whether this relationship was due to higher fruit and vegetable consumption alone or multiple behavior changes (Hill, 2006).

Physical Activity and Obesity: In population-based studies, an inverse association between physical activity and body weight has been consistently reported from both cross-sectional and longitudinal studies of adult populations (Schmitz, Jacobs, Leon, Schreiner, & Sternfeld, 2000). Most studies reported an association between increases in physical activity and corresponding decreases in magnitude of weight gain. For example, in the CARDIA cohort, the mean weight gain attenuation was about 1 kg per year for a modest increase in self-reported physical activity (Schmitz et al, 2000). In addition to changing dietary habits in the US, decreases in physical activity levels have also been noted to play a role in the recent rise in obesity. The energy balance equation mandates that for high levels of energy intake, energy expenditure must also increase to maintain equilibrium (Hill, 2006). However, several studies have shown that only approximately 50% of American adults report engaging in leisure-time physical activity as recommended by CDC (Brownson, Boehmer, & Luke, 2005; Kruger et al., 2007).

Sleep and Obesity: Studies have observed a reduction in sleeping hours over the past decades, as the prevalence of obesity has been increasing (Knutson & Van Cauter, 2008). Recent reviews and meta-analyses consistently report that short sleep duration is associated with weight gain and obesity in adults (Cappuccio et al., 2008; Nielsen et al., 2011). Intervention studies have begun to identify mechanistic explanations for the harmful effects of sleep deprivation on health. For instance, short-term partial sleep restriction leads to alteration in metabolic and endocrine

functions including decreased glucose tolerance, insulin resistance, increased sympathetic tone, elevated cortisol concentrations, elevated levels of pro-inflammatory cytokines and decreased leptin and increased ghrelin levels (Knutson et al, 2007). All of these factors contribute to the development of obesity. However, one main limitation of these studies is the use of self-reporting sleep assessments. Large-scale self-reporting studies could be improved upon with subjects' use of actigraphy watches to verify self-reported measures.

Although the associations between the above discussed behaviors and depressive symptoms and obesity are well established, there are only limited number of studies on the mediating effect of these behaviors between the association of depressive symptoms and adiposity measures. In the following section, recent studies that examine some of these behavioral factors as mediators are summarized.

Studies on Behavioral Mediators

Using the1999-2004 NHANES data**,** Beydoun & Wang (2010) examined diet and physical activity as mediators between the association of depression and obesity in a cross-sectional study. Depressive symptoms were assessed by a face-to-face interview. Diet was assessed by a 24-hour recall of dietary intake and physical activity was measured by a single question on a 3-point likert scale. Results indicated that diet and physical activity did not have any significant mediating effect (Beydoun & Wang, 2010). In another cross-sectional study (n=87), Grossniklaus et al (2011), examined if dietary energy density (DED) mediates the association between depressive symptoms and WC. Depressive symptoms were assessed by the Beck Depression Inventory (BDI), which measures depressive symptoms over the past two weeks. DED was assessed by 3-day food record and was found to be a non significant mediator

in the association between depressive symptoms and WC (Grossniklaus et al., 2011). Unhealthy lifestyle pathways were also examined in the Multi-Ethnic Study of Atherosclerosis (MESA) with 5,773 participants aged 45-84 (38% white and 28% black). Chronic stress was linked to the presence of coronary artery calcification via a path through high caloric intake and BMI (Mainous et al., 2010).

Konttinnen et al (2010) examined the indirect association between depressive symptoms and adiposity indicators such as in Finnish men (n=2,312) and women (n=2,670) aged 25-74. Depressive symptoms were measured by CESD. The mediators were psychological factors related to eating and physical activity behaviors. Their findings indicate that emotional eating and physical activity efficacy were independent pathways between depressive symptoms and higher adiposity, and this finding was consistent in men and women. In another study, with a Scottish population (n=7,540), physical activity was a found to be a strong independent predictor of obesity (as defined by BMI greater or equal to 30) (Hamer & Stamatakis, 2008). This was also a cross-sectional study and depressive symptoms were gathered from the General Health Questionnaire.

In a more recent study, again consisting of populations outside of the US, the mediating role of adherence to the Mediterranean diet and physical activity was examined in the association between depressive symptoms and CVD risk score. In a cross-sectional study of 453 men and 400 women, depression was assessed with self-rating depression sale. The “more positive feelings” construct was associated with lower CVD risk score and this seems to be mediated to the higher adherence to Mediterranean diet (Antonogeorgos et al., 2012).

From the selected studies reviewed above, almost all of them were cross-sectional and the population consists of people outside the US. There were a variety of measures used to assess

depressive symptoms and the behaviors studied were not consistent across the studies. Even the results were inconsistent across the studies. Therefore, it is very difficult to compare these studies and this highlights further need for research in this area.

Gap in the Literature

The above review of the literature highlights that there is a link between depressive symptoms and obesity. However, most studies have discussed the need for further research to clarify the role of lifestyle behavioral factors such as diet, physical activity and sleep quality as mediators between depressive symptoms and obesity. Only limited data exists exploring the mediating role of health behaviors between depressive symptoms and obesity, in different ethnic groups. In addition, most of the studies have used diet and physical activity as mediators and the role of sleep quality has not been examined as a mediator. Given the evidence of the association of sleep quality with depressive symptoms and obesity, sleep quality might play a role as a mediator.

Second, most of the studies rely on cross-sectional data. While this method is more feasible to use a large representation sample, it is inadequate to establish a causal pathway. Prospective studies could add evidence in helping to better understand how to reduce obesity in people with depressive symptoms since it will allow us to examine whether an effect is stable across time and whether there is evidence for one of the important conditions of causality, temporal precedence (MacKinnon, Fairchild, & Fritz, 2007).

Therefore, the current study was undertaken to address the gap in explaining the mediating role of health behaviors by using a large dataset to assess the plausible behavioral link between depressive symptoms and obesity. This study has the potential to add to the existing evidence on

how depressive symptoms affect obesity. The National Institute of Health's Strategic plan for obesity research also recognizes opportunities in exploring mechanisms that identify how psychological factors influence weight gain and the identification factors, such as social support, that may moderate these relationships. A greater understanding of the behavioral mechanisms that mediate the relationship between depressive symptoms and obesity may lead to the creation of innovative and effective interventions. Because the mediating variables are many and varied, it is also important to establish the relative contribution of behavioral processes in accounting for the depressive symptoms and obesity association. This information might help establish priorities for allocating of health care, prevention and research resources. But, theoretically, how do depressive symptoms cause obesity?

Theoretical Underpinnings of the Study

The theoretical framework that guided this study is an adaptation of the stress and coping model proposed by Cohen et al (1995). This model integrates biological, psychological and environmental approaches through which environmental experiences can affect disease. Figure 1 describes this theoretical framework. When confronted with environmental demands, people evaluate whether the demands pose a potential threat and whether sufficient adaptive capacities are available to cope with them. Depending on the individual's coping behaviors and available resources, these factors may result in negative emotion states. These emotional states may directly contribute to the onset of affective psychiatric disorders. On the other hand, they may also trigger behavioral or physiological responses that lead an individual to physical illness. In this study, negative emotional responses are conceptualized as depressive symptoms; behavioral

responses are conceptualized as increased fast food intake, decreased physical activity and poor sleep quality; all of these, in turn, may increase BMI and WC and lead to increased risk of CVD.

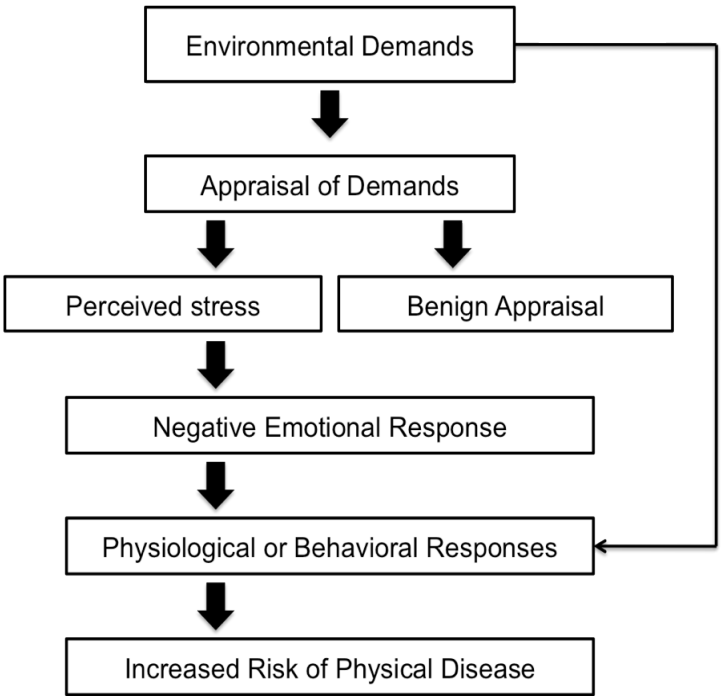


Figure 2.1: Stress and Coping Theory adapted from Cohen et al, 1995.

Emotional (Stress-induced) Eating

One of the major behavioral responses of negative emotion is an increased intake of fast food and SSB and lower consumption of fruits and vegetables. With stress induced eating, there is a greater preference for nutrient-dense foods, particularly those that are high in sugar and fat. The effect of stress on the intake of fat and sugar has been investigated in humans (Torres & Nowson, 2007). Evidence suggests that cortisol, a marker of HPA axis activity, may affect the regulation of the appetite via neuropeptide Y and leptin. Increases in cortisol seem to be followed by elevated secretion of neuropeptide Y and blunting of the inhibitory arm of food intake, the leptin system. The overall effect is increase in food intake.

There is some evidence to suggest that elevated stress levels are associated with a greater desire for highly palatable foods that are energy dense. This desire may contribute to excess energy intakes and weight gain, which is supported by longitudinal studies that suggest there is an association between chronic stress and future weight gain (Gibson, 2006). Chronic stress elicits a more passive response driven by the HPA axis, such as increases in cortisol that may urge people to consume energy dense foods and potentially lead to weight gain and obesity. Cortisol may also contribute to the accumulation of abdominal fat mass (Bjorntorp, 2001).

Although the complex relationship between stress and eating has long been recognized in humans, the underlying psychobiological mechanism that shapes the direction of change – whether one eats more or less during stress- is largely unknown (Adam & Epel, 2007). Presumably, high stress reactivity, which increases cortisol should lead to greater intake of calories. Thus one's psychological stress reactivity may be a clue as to differences in psychobiological characteristics that explain stress eating or food cravings.

The Conceptual Model of the Study

The conceptual basis of the study was adapted from Cohen, Kessler & Gordon's (1995) model of the stress process discussed above. This model (Figure 2) proposes that some environmental demands may predispose individuals to psychological stress. Depending on the individual's coping behaviors and available resources, these demands may contribute to negative emotions such as depressive symptoms. These symptoms may trigger behavioral responses such as engaging in fast food intake, low engagement in physical activity and poor sleep quality that may place a person at risk for increased BMI and WC which in turn lead to increased risk of CVD.

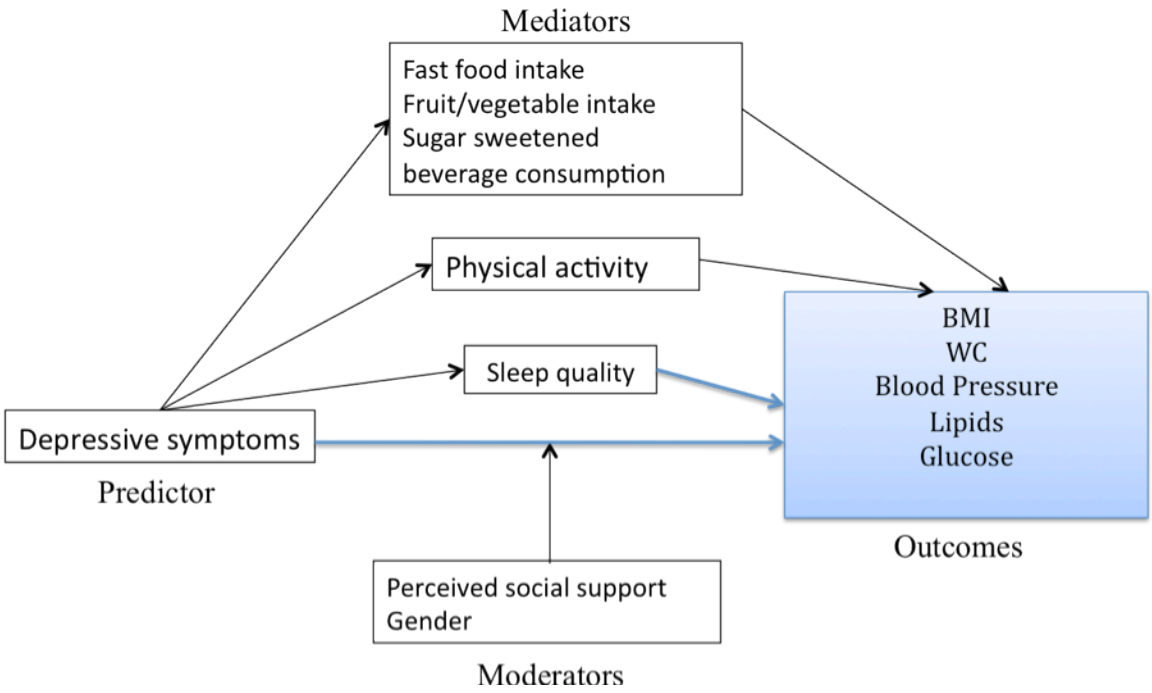


Figure 2.2: Conceptual Framework for the Study.

This conceptual framework served as the basis for the statistical analyses. It was examined separately if depressive symptoms were associated with BMI, WC and other CVD risk factors (blood pressure, lipids, glucose) directly after five years of follow-up. In addition, based on stress buffering hypothesis, this conceptual model also examined if perceived social support acted as a moderator of the association between depressive symptoms and BMI. Finally, this model examined separately the indirect effects of behavioral factors (fast food, fruit and vegetable intake and SSB consumption) between depressive symptoms and BMI and between depressive symptoms and WC. Eating and energy expenditure, such as physical activity, are often proposed as mediating constructs in the depression-obesity association. In this model, depressive symptoms are thought to increase BMI and WC indirectly through such behaviors as increased intake of fast food and SSB, a decreased intake in fruit and vegetable, and decreased physical activity and impaired sleep quality.

In summary**,** how people cope with stress may mediate the development of obesity. Individuals' responses to life stress or depressive symptoms may lead to obesity by the adoption of an unhealthy lifestyle, like physical inactivity and poor dietary habits leading to obesity as ways to deal with the stress. Therefore from a theoretical standpoint it could be proposed that the association between depressive symptoms and obesity may occur via an indirect pathway through an unhealthy lifestyle. Rather than trying to identify an association independent of lifestyle factors it may be more useful to investigate depressive symptoms, obesity and lifestyle factors in an interrelated chain. Thus the main purpose of this study was to examine the association between depressive symptoms and indicators of obesity among adults using path analyses to examine hypothesized indirect pathways through unhealthy lifestyle factors.

Research Questions and Hypotheses

The specific research questions and hypotheses of this study are as follows:

Research Question 1: Do higher depressive symptoms predict higher BMI, higher WC, higher DBP, higher LDL, higher triglycerides and lower HDL levels in adults 33-45 years of age?

Hypothesis 1.1: Higher depressive symptoms predict higher BMI in adults 33-45 years of age after five years of follow-up, controlling for age, race, gender, income, education, alcohol consumption, smoking status, and physical activity.

Hypothesis 1.2: Higher depressive symptoms predict higher WC, independent of BMI, in adults 33-45 years of age after five years of follow-up, controlling for factors age, race, gender, income, education, alcohol consumption, smoking status and physical activity and BMI.

Hypothesis 1.3: Higher depressive symptoms predict higher DBP in adults 33-45 years of age after five years of follow-up, controlling for age, race, gender, education and physical activity.

Hypothesis 1.4: Higher depressive symptoms predict higher LDL, higher TG and lower HDL in adults 33-45 years of age after five years of follow-up, controlling for age, race, gender and education.

Hypothesis 1.5: Higher depressive symptoms predict higher fasting blood glucose levels in adults 33-45 years of age after 5 years of follow-up, controlling for age, race, gender & education.

Research Question 2: Does perceived social support moderate the association between depressive symptoms and BMI and depressive symptoms and WC in adults 33-45 years of age?

Hypothesis 2.1: Greater perceived social support decreases the association of depressive symptoms on BMI and depressive symptoms on WC.

Research Question 3: Do behavioral factors such as diet, physical activity and sleep quality mediate the association between depressive symptoms and BMI and between depressive symptoms and WC independent of BMI in adults 33-45 years of age?

Hypothesis 3.1: Dietary behaviors (increase in fast food intake, decrease fruits and vegetables intake and increase in SSB) partially mediate the association between depressive symptoms and BMI.

Hypothesis 3.2: Physical activity partially mediates the association between depressive symptoms and BMI.

Hypothesis 3.3: Sleep quality partially mediates the association between depressive symptoms and BMI.

Hypothesis 3.4: Fast food partially mediates the association between depressive symptoms and WC, independent of BMI.

Hypothesis 3.5: Physical activity partially mediates the association between depressive symptoms and WC, independent of BMI.

Hypothesis 3.6: Sleep quality partially mediates the association between depressive symptoms and WC, independent of BMI.

CHAPTER THREE

METHODS

In this chapter, the details of the research methods and analytic procedures used to conduct this study are discussed. First, the data source is described, followed by a description of the study population, research design and main variables in this study. Finally, this chapter is concluded with a description of the data analyses procedures.

Data Source: CARDIA

This study utilized data from the Coronary Artery Risk Development in Young Adults (CARDIA) study. CARDIA is a multi-center, longitudinal, epidemiologic study funded by the National Heart, Lung, and Blood Institute (NHLBI) (Cutter et al., 1991; G. D. Friedman et al., 1988). The CARDIA study had two primary aims: (1) to determine the distribution of CHD risk factors in a biracial cohort of men and women aged 18-30 years at entry; and (2) to identify habits and behaviors that are associated with both initial levels and later changes in these risk factors (Friedman et al, 1988).

Study participants

Four field centers were selected to identify and recruit 1,100-l,500 participants each. The total number of participants from these four centers was 5,116 (Hughes et al., 1987). The young adults, 18-30 years of age, were recruited from four geographic areas by community-based sampling methods. These sites were (1) University of Alabama at Birmingham, Birmingham, Alabama; (2) Northwestern University, Chicago, Illinois; (3) University of Minnesota, Minneapolis, Minnesota; and (4) Kaiser Permanente Medical Care Program, Oakland, California.

The data coordinating center was established at the University of Alabama at Birmingham (Hughes et al., 1987).

Two of the four study sites (Chicago and Minneapolis) sampled participants using census track information. The Oakland center selected participants from the Kaiser-Permanente health plan who resided in Oakland, Berkeley and adjacent communities. Birmingham used telephone exchanges to sample from the city population. All study sites used telephone communication, as the primary means of recruitment and the study population was limited to healthy individuals residing in the four study areas. Chronically ill, disabled, or institutionalized individuals were excluded from the study (Friedman et al, 1988). A more detailed description is published elsewhere (Friedman et al., 1988).

Examinations were performed on 5,115 eligible persons contacted in 1985/1986. The investigators recruited the sample to obtain balanced subgroups by age (45% were 18 to 24 years old, and 55% were 25 to 30 years old), race (52% African American, 48% Caucasian), and education (40% had 12 years of education or less, and 60% had more than 12 years of education). Participants were reexamined at 2 years (1987/1988), 5 years (1990/91), 7 years (1992/1993), 10 years (1995/1996), 15 years (2000/2001) and 20 years (2005/2006).

Of the 5,115 participants who were enrolled in CARDIA at Year 0, a total of 3,670 participated in the Year 15 and 3,549 in the Year 20 examination. Overall retention rates for Years 15 and 20 were 74% and 72% respectively. Attrition analysis was conducted to rule out selection bias by comparing baseline socio-demographic characteristics of the dropouts from Years 15 to 20.

Design

This study used the data from Year 15 (2000/2001) and Year 20 (2005/2006) of the CARDIA study. The association between depressive symptoms and BMI, WC and other CVD risk factors (blood pressure, lipids, fasting glucose) was examined prospectively using the two waves of data (Year 15 and Year 20). Mediation was also examined using these two waves of data. The potential mediators (fast food, SSB, fruit and vegetable consumption, physical activity and sleep quality) were all from Year 20 (since most of the dietary variables were available at Year 20), the outcomes (BMI and WC) were Year 20 and the main predictor (depressive symptoms) was from Year 15. This design was chosen because it used longitudinal data, which allowed more vigorous examination of the mediation effects of behavioral factors, as the measurement of the predictor is preceding the mediators and the outcomes.

Although a three-wave design might have been better suited for three variable causal chain, longitudinal mediation can still be examined using only two waves of data (Cole & Maxwell, 2003). Mediation with longitudinal data allows examination of many aspects that are unavailable with cross-sectional design, such as whether an effect is stable across time and whether there is evidence for one of the important conditions of causality, temporal precedence (Mackinon et al, 2007). This study was approved by the UCLA Institutional Review Board (IRB).

Measures and operational definition of main variables in this study

Outcome variables

Measures of obesity were operationalized as *overall adiposity/fatness and abdominal fat*. *Overall fatness* was assessed by BMI that was computed as weight in kilograms divided by

height in meters squared (kg/m2). Body weight was measured with participants standing and wearing light clothing without shoes via a calibrated balance beam scale (recorded to the nearest 0.5lb, converted to kg); height was measured with a vertically mounted metal centimeter ruler to the nearest 0.5 cm. Certified technicians measured height and weight at each exam using a standardized protocol (Cutter et al, 1991). *Abdominal fatness* was assessed by WC. WC was measured to the nearest 0.5 cm at the midpoint between the iliac crest and the lowest lateral portion of the rib cage, and anteriorly midway between the xiphoid process of the sternum and umbilicus (Cutter et al., 1991). Both BMI and waist circumference were treated as continuous variables in the analyses.

Blood pressure was assessed by the average of systolic and diastolic pressure (millimeters of mercury=mmHg) of the last two of three measurements. Blood pressures were measured at each exam on the right arm with the participants seated and after a five-minute rest. Measurements were obtained before any physical examination, blood draw, or potentially stressful interview (Cutter et al, 1991). Three blood pressure measurements were obtained using a random zero sphygmomanometer, and were acquired a minimum of 30 seconds apart. At exam Year 20, an Omron automated device was used for blood pressure measurement. A comparability study was conducted that showed no systematic difference between the two devices (Cutter et al, 1991). Both systolic and diastolic blood pressures were considered in the analyses as continuous variables.

Lipids were assessed by TC, LDL-C, HDL-C and triglycerides levels from fasting blood samples and expressed as mg/dl. These are treated as continuous variables.

Glucose was assessed using the fasting blood glucose (FBG) level. FBG ≥126 confirms diabetes (USDHHS, 2008); however, in this study, FBG was analyzed as a continuous variable.

Major predictor variable

Depressive symptom was the major predictor of this study. *Depressive Symptoms* were assessed at Year 15 and Year 20, by self-reports, using the 20-item Center for Epidemiologic Studies-Depression (CES-D) scale (Radloff, 1977). This scale is well standardized and has been used extensively in population studies (Myers & Weissman, 1980; Weissman, Sholomskas, Pottenger, Prusoff, & Locke, 1977). The CES-D has been found to have good internal consistency (0.85 in community samples) and adequate test-retest reliability (0.51-0.67) (Radloff, 1977; (Roberts, 1980). Construct validity of the scale is supported by correlations with other self-report measures, clinical ratings of depression, and clinical interviews (Radloff, 1977).

Participants reported on the frequency of symptoms during the seven days preceding the interview and responses were rated using a 4-point scale ranging from 0 (rarely or none of the time) to 3 (most or all of the time). Four positively worded items were reverse-scored:(1) "I felt that I was just as good as other people"; (2)"I felt hopeful about the future"; (3) "During the past week, I was happy" and (4) "I enjoyed life". A depressed mood score was already calculated in this study by summing responses across the 20 items (possible range, 0–60). A score ≥ 16 was used as a cutoff point to indicate depressed mood and correlates closely with clinical depression (Radloff, 1977). Depressive symptoms were treated as continuous variables in this study.

Moderator variable

Social support is defined as perceived social support and was assessed by a four-item social support questionnaire that was self-administered. The participants were asked the following questions: "How much do members of your family or friends really care about you"; "How much do they understand the way you feel about things?"; " How much can you rely on

them if you need to talk about your worries?"; and "How much can you open up to them if you have a serious problem?". Scores for social support ranged between 1 and 4, with 4 indicating the highest level of perceived social support (1=Not at all, 2=A little, 3=Some, 4=A Lot). Social support was expressed as a continuous variable. The items proposed in this questionnaire were drawn from the MacArthur Network on Successful Midlife Development Survey of the Quality of Midlife in the US (CARDIA Year 15 and Year 20 protocol).

Mediator variables

Diet was assessed using the CARDIA diet history. Dietary behaviors will be assessed by the number of fruit and vegetable servings eaten per day, the number of times food eaten from fast food restaurant per week, and the average of all sugar sweetened beverages servings consumed per day.

Fast food consumption was assessed by a single question: "How often do you eat breakfast, lunch or dinner at places such as McDonald's, Burger King, Wendy's, Arby's Pizza Hut, or Kentucky Fried Chicken?" Responses were measured in either frequency per week or per month. Frequency per month was converted to frequency per week to create a single consistent variable.

Sugar-sweetened beverage (SSB) consumption is defined as any sweetened beverage that contains added sugars, such as soft drinks, fruit flavored drinks or any other beverages with added sugars. SSB was grouped by the CARDIA diet-coordinating center. SSB was assessed by the number of ounces consumed each day.

Fruits and vegetables intake is defined as the daily average of servings of fruits and vegetables based on diet history. This measure was determined by asking participants how often they ate fruits/vegetables from a predetermined list.

Physical activity was measured using the Physical Activity History (PHA) questionnaire designed for the CARDIA study. The questionnaire asks about the type, frequency and duration of 13 specific moderate and vigorous activities during the past year. A score is calculated based on the sum of time spent in individual activities, weighted by an estimate of kilocalories expended per minute for that particular activity (Cutter et al, 1991). Specifically, this questionnaire asked for the total number of months per year performance in particular categories of activity. Duration of the activity was collected by asking how many months each class of activity had been performed for at least one hour during the month, and also how many months the activity had been performed for at least a specific number of hours per week during the month. The questionnaire is scored in exercise units (EU) and will be treated as continuous variable in this study. Details regarding the development of the questionnaire and scoring methods have been previously published (Jacobs et al, 1989).

The test-retest correlation coefficient for the total score was 0.84 in a two-week test-retest reliability study and was 0.88 in a one-month test-retest (Jacobs et al, 1989). The validity is indirectly established in a biracial population ranging in age from 18 to 30 years. The total score had a statistically significant negative association with the sum of skin-folds and statistically significant positive associations with caloric intake, treadmill test duration and HDL-C in men and women (Jacobs et al, 1989). Treadmill duration was the measure most correlated to total activity in both males (0.25) and females (0.36) (Jacobs et al, 1989). The PAH has relatively low correlations with validation criteria. The authors suggest that relatively low correlations between

physical activity and the validation criteria should be a caution that physical activity patterns vary widely within individuals across time (Jacobs et al, 1989). Therefore, they suggest that it remains desirable to design more precise physical activity questionnaire.

Sleep was operationalized as sleep quality. Sleep quality was assessed by a single question rating the sleep quality over the past month (1=very good, 2=fairly good, 3=good, 4=fairly bad, 5=bad). Sleep quality was treated as continuous variable.

Quality Control

Quality control measures were accomplished in many different ways (Friedman et al, 1988). There were two focuses for quality control: 1) to assess errors and document the level of quality: and 2) to maintain and improve the quality of subsequent data collection. Types of quality control measures used included: regular calibration of instruments; periodic recertification of technicians; monitoring of external laboratories; inter- and intra observer techniques as assessment of anthropometry technicians and the A/B interview raters; audio-taping nutrition interviews; and periodic data monitoring of each technician's mean, standard deviation and range of values recorded for quantitative measures such as BP & body size measures (Friedman et al, 1988).

Covariates

Potential confounding variables of the association between depressive symptoms and BMI and WC included the following socio-demographic covariates: age (in years), gender (male or female), and race (black or white). These covariates were assessed by a self-reporting method. *Income* was assessed by asking the participants to report the total combined family income for the past 12 months. *Education* was assessed by highest education completed. Education was

categorized into less than high school completed high school, or more than high school. Covariates were selected based on published literature and bivariate analyses that were conducted to assess the potential for confounding. Finally, smoking status (never, former or current) and alcohol use (cc/day) was also considered as potential confounders.

Data Analysis

Analysis performed on the CARDIA data included univariate, bivariate, multivariate and path analyses. These procedures were performed using SAS 9.2 and EQS 6.2.

Exploratory data analysis

Before conducting data analyses, exploratory data analyses were conducted to check for the patterns of missing values, to check for outliers and normality. Frequency distributions, scatter plots, histograms and tests for normality (Kalmogorov-Smirnov) were used to assess the normality of the distributions and to evaluate the need for transformations and missing data procedures.

Univariate Analysis

Univariate analyses were conducted to describe the baseline socio-demographic characteristics of the sample and main variables of interest. Frequencies and percentages were used to describe categorical variables. Mean, standard deviation, and range were used to describe interval and ordinal variables. In addition to histograms with normal curves, statistical tests for normality were obtained to assess the distribution of each variable.

Bivariate Analysis

Bivariate analyses were performed to assess the associations between two variables. T-test and one-way ANOVA were used to examine the association between one categorical and one interval/ordinal variable. The Chi-square was used to test the association between two categorical variables. Because the data were not normally distributed, the Mann Whitney test was used to compare depressive symptom scores between the gender and ethnic groups. The Kruskal-Wallis analysis of variance test was used to compare the depressive symptom scores across the frequency levels of education, income and other variables with more than two categories. Spearman's correlation coefficients were used to conduct correlation analysis because most of the variables used in this study were continuous and were not normally distributed.

Multivariate Analyses

Several procedures were conducted to check for the potential violations of assumptions in multiple regression. The assumption of linearity was checked by looking at the plots of residuals versus predicted values. The assumption of homoscedasticity (constant variance) was examined by looking at the plots of residuals versus predicted values and residuals versus independent variables. The normality assumption was examined by histograms and test of normality. The outcome variables were natural log transformed if any violations of the above assumptions were noted. Histograms of the transformed variables were also assessed to evaluate the appropriateness of normality. If the transformations improved normality of the distribution, then the transformed variables were used in the multivariate analyses. Otherwise, the original variables were used for ease of interpretation of the results.

Aim # 1 of the study was to examine the association between depressive symptoms and BMI, WC, blood pressure, lipids and fasting glucose among adults aged 33-45 years of age after five years of follow-up.

Linear regression analyses were conducted to evaluate the association between depressive symptoms at baseline (Year 15) and BMI and other cardiovascular risk variables (WC, SBP, DBP, LDL-C, HDL-C, TC, triglycerides, glucose) after five years of follow-up. Unadjusted associations between the depressive symptoms and CVD risk variables were examined with simple regression analysis.

Using depressive symptoms (continuous) as the main predictor variable and BMI (continuous) and other CVD risk factors (continuous) as outcome variables, seven separate models were developed. Depressive symptoms and the covariates were entered in the model simultaneously. Models were adjusted for socio-demographic factors, alcohol intake, cigarette smoking and physical activity. Models included a) CVD risk profile as outcome variables and were treated as continuous; b) depressive symptoms scores as predictor variable and were also treated as continuous; and c) socio-demographics, current alcohol intake, current smoking, physical activity as covariates based on prior literature. Bivariate analyses were conducted to assess which variables were associated with depressive symptoms and outcomes. These were considered as potential confounders and inserted into the regression model.

Aim # 2 of the study was to assess the moderating effect of perceived social support in the association between depressive symptoms and BMI.

The moderating effects of perceived social support was assessed through interaction terms in the linear regression models. This process tested whether the association between depressive symptoms and obesity varies by perceived social support. Since race and SES have

only been limitedly explored as moderators, this study also evaluated how the association may vary by race and SES. Because previous studies suggest that the effects of depressive symptoms and obesity could vary by gender, stratified analysis was also conducted by gender. All analyses were performed using SAS v9.2 (SAS Institute, Cary, NC). Statistical significance was set at $p < 0.05$.

Path Analyses

Aim #3 and # 4 of the current study was to identify the behavioral mediators such as fast food, physical activity and sleep quality between depressive symptoms and BMI and between depressive symptoms and WC, independent of BMI. Mediation analysis is one way to explain the mechanism by which depressive symptoms affect obesity. In this study, the variables fast food, SSB, fruit/vegetable intake, physical activity and sleep quality are considered as the mediators, which mediate the association between depressive symptoms and BMI and depressive symptoms and WC.

There are several approaches to conduct mediation analyses. In this study, the mediation analysis was examined using the indirect effects approach (and its test of significance). Indirect effects are defined as the product of the two regression coefficients (BMI and WC regressed separately on each of the mediators/behaviors and each mediators/behaviors regressed separately on depressive symptoms). The EQS Structural Equations Program 6.2 (Bentler, 2006) was used to conduct path analysis and to test the hypotheses.

Path analysis is the analysis of associations among variables and is a method of estimating coefficients in the model. It is a useful analytical tool to describe direct and indirect (through a mediator) associations among variables and outcomes. Path analysis performs a

multiple regression and provides a way to model comprehensive relations among variables including indirect or mediated effects (Mackinnon & Fairchild, 2009). The indirect effects represent the portion of the association between depressive symptoms and BMI that is mediated by each of the mediators. In the path model, the strength of an indirect path is evaluated by calculating the product of the coefficients along that path (Mackinnon & Fairchild, 2009). The regression coefficient for the indirect effect represents the change in BMI or WC for every unit change in depressive symptoms that is mediated by a specific mediator. An interpretation of this indirect effect is that each 1unit increase in depressive symptoms is associated with increase or decrease in BMI for that specific part of the effect operating through a specific mediator.

All variables in the path analysis model were considered as continuous variables to ensure homogeneity in the definition of the different behavioral factors. Although, in the bivariate analysis, BMI and WC were highly correlated ($r= .88$, $p< .05$), they were examined separately as outcome measures since there is some evidence that depressive symptoms are more strongly associated with fat accumulation in particular regions such as abdominal located adiposity and from the evidence we know that WC is independent of BMI associated with CVD. Therefore, it was important to assess the role of the each mediator in the association of depressive symptoms and BMI and depressive symptoms and WC, controlled for BMI.

Estimation Procedure

Path analysis was computed to determine regression coefficients and the indirect effects (through mediators) separately for BMI and WC as outcome variables. Since the distribution of the variables was not normally distributed, the maximum likelihood robust estimation method

was used. This method produces standard errors (SE) and a chi-square statistic that are robust for non-normality.

The model was also tested to determine whether it fit the data well. Overall model fit was tested using maximum likelihood (M-L chi-square) fit statistics and Satorra-Bentler chi-square (S-B chi-square). The Satorra-Bentler scaled chi-square is reported since robust estimates were used (Bentler, 2006). A non-significant chi-square value indicates that the data did not significantly depart from the model; however, because this test overestimates model fit with large samples, it is recommended that other indices would be considered. Therefore, the model fit was evaluated with several types of fit indices such as the Comparative Fit Index (CFI), the robust Comparative Fit Index (RCFI), and the root-mean-square error of approximation (RMSEA) (Bentler, 2006). The CFI and RCFI, which range from 0 to 1, report the improvement in fit of the hypothesized model. Values equal to or greater than .90 are desirable and indicate acceptable model fit (Hu & Bentler, 1999). The RMSEA is defined as the square root of population misfit per degrees of freedom, controlling for sample size. Generally models with RMSEA less or equal to 0.05 are good and with a RMSEA > .1 represent poor fit (Hu and Bentler, 1999).

CHAPTER FOUR

RESULTS

In this chapter, the results are presented in four sections: 1) results of exploratory data analyses; 2) results from the univariate analysis including the description of the sample and descriptive statistics for each main study variable; 3) results from the bivariate analyses; 4) results from the multivariate regression models to test Hypotheses 1.1- 2.1 including the moderation analyses; and 5) results from path analysis of the model to address Hypotheses 3.1-3.6.

Results from exploratory data analyses

Data screening was conducted using SAS version 9.2 and EQS 9.2 before testing the hypotheses. Exploratory procedures included assessment of missing data, outliers and normality.

Missing data

For Hypotheses 1.1 to 2, missing data were analyzed to determine the patterns of missing variables. The percentage of missing data ranged from 0 % to 2.7%. There was no special missing value pattern on any case, the missing values were random; hence, the cases with missing data were excluded from that study. Figure 3 presents the flowchart of this current study sample. Of the 5,110 sample participants at the start of the CARDIA study (Year 0), 3,670 individuals attended the Year 15 exam and 3,177 were present at the Year 20 exam. In the multivariate analysis, individuals with data on all variables of interest (n=2,765) in both Year 15 and Year 20 were included in the analysis. For path analyses using the EQS, listwise deletions were used for missing data. Of the 3,670 subjects in the study sample, 2,076 cases had no

missing data on all the variables and this sample size was used to address the mediation hypotheses (Hypotheses # 3.1- 3.6).

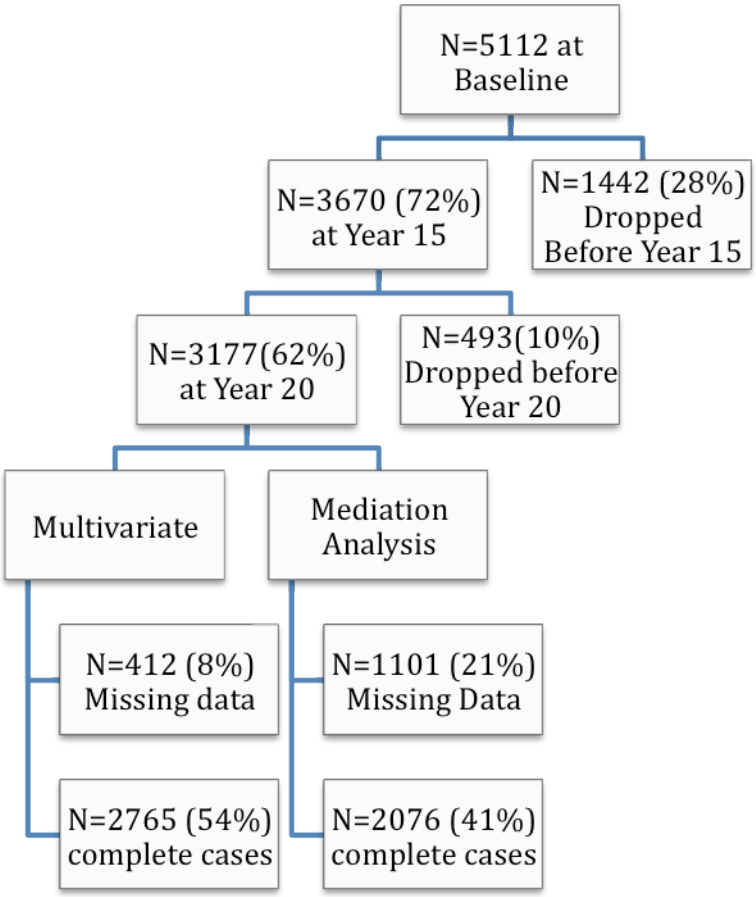


Figure 4.1: Flowchart of the Study Sample

Outliers

For the multivariate analyses, outliers were examined using box plots in SAS, which showed there were few outliers. Diagnostics procedures indicated that these outliers were non-influential, which did not change the estimate of coefficients in the regression models; hence they were kept in the analyses.

For path analyses, outliers were assessed by examining the case numbers with the largest contribution to normalized multivariate kurtosis in EQS. For example, there were 7 outliers for fast food intake variable and these were non-influential since removing these outliers did not change the model fit and the estimate of coefficients; hence, they were kept in the analysis.

Normality

Multivariate regression and path analysis assumes normal distributions. Univariate normality was examined using histograms and tests of normality (Smirnov) to assess the distribution of each variable. The tests of normality were significant which indicates non-normal distributions. Based on histograms (Figures 4-12 in appendix), the variables were not normally distributed and natural log transformations were used before the analyses. Only LDL and total cholesterol (TC) were normally distributed and did not undergo log transformations. After transformations, the histograms show acceptable normal distributions (Figures 13-20).

Results from Univariate analysis

This section describes the socio-demographic characteristics of the sample and the main variables of interest in the study. The baseline socio-demographic characteristics of the participants at Year 15 and Year 20 are presented in Table 1. The mean age of the study participants at baseline was 40.17 (SD= 3.63). The sample was slightly more female (56%) than male (44%). The participants were either black (47%) or white (53%). Almost half (41%) reported a household income of less than $50,000, and 58% had income greater than $50,000 per year. Fifty-four percent of the sample had greater than a high school education, while 39% had a high school diploma or GED.

Table 4.1: Socio-demographic Characteristics of Participants at Year 15 and Year 20

	At baseline Year 15	At follow-up Year 20	
Socio-demographic Characteristics	**n (%)**	**n (%)**	**Chi-square p-value**
Gender			
Male	1619 (44.11)	1373 (43.22)	.0054
Female	2051 (55.89)	1804 (56.78)	
Race			
Black	1730 (47.14)	1423 (44.80)	< .0001
White	1940 (52.86)	1754 (55.20)	
Family Income			
< 5k-15, 999k	342 (9.44)	262 (8.34)	< .0001
16k-24, 999k	240 (6.63)	195 (6.21)	
25k-34, 999K	342 (9.44)	293 (9.33)	
35k-49, 999k	571 (15.77)	490 (15.60)	
50k-74, 999k	794 (21.93)	697 (22.20)	
75k-99, 999k	528 (14.58)	471 (15)	
≥100k	804 (22.20)	732 (23.31)	
Education			
HS or GED	1436 (39.23)	1184 (37.32)	< .0001
Associates	408 (11.15)	343 (10.81)	
Bachelors	1002 (27.38)	925 (29.16)	
Masters	602 (16.45)	546 (17.21)	
No answer	212 (5.79)	174 (5.49)	
Overall sample	3670	3177	
Mean age in years (SD)	40.173 (3.63)	40.27 (3.60)	.0001*

*t-test p value

The total number of the participants was 3,670 at Year 15 and 3,170 participants completed at Year 20. Attrition analyses indicated that there were significant socio-demographic differences between those who stayed at Year 20 exam and the dropouts (Table 4.1). From the 3,670 participants who completed the Year 15 exam, 3,177 completed the Year 20 exam. Those who remained at Year 20 were more likely to be younger, white, female and with income greater than $50,000 and had higher than high school education.

Description of the Main Study variables

Descriptive statistics of each variables of interest were conducted. The frequencies, percentages, mean and standard deviations of the major interval and ordinal study variables are presented in Table 4.2 & Table 4.3. The mean depressive symptoms (CES-D score) was 9.16 (SD=7.85) at the baseline (Year 15). The mean BMI was 28.69 (SD=6.49) and 89.29 for WC. The mean of total intensity score of physical activity was 347.18 (SD=283.56) for the participants. The mean fast food intake was 1.85 times per week and sleep quality rating was 2.47.

Table 4.2: Description of the Main Study Variables at Year 15

Variables	n	Mean	Std Deviation	Range	Missing n (%)
Depressive symptoms (CES-D score)	3621	9.16	7.85	0-54	49 (1.34)
BMI	3627	28.69	6.49	18.65-51.76	43 (1.17)
WC	3643	89.29	14.31	63-126.5	27 (0.74)
DBP	3656	74.49	11.59	34-165	14 (0.38)
SBP	3656	113.24	14.94	75-210	14 (0.38)
TC	3611	184.65	35.77	54-491	59 (1.61)
HDL	3611	50.69	14.56	11-122	59 (1.61)
LDL	3572	112.95	32.28	8-385	98 (2.61)
Triglycerides	3611	105.46	92.83	17-2344	59 (1.61)
Fasting Glucose	3603	86.68	20.95	51-2344	67 (1.83)
Social Support	3651	3.5	.57	0-4	19
Age	3670	40.17	3.63	32-46	0
Physical activity (total intensity score)	3653	347.18	283.556	0-1932	17 (0.46)
Sleep quality rating	3648	2.47	1.01	1-5	22 (.6)
Fast Food intake per week	3299	1.85	2.34	0-32	371 (10.11)

Table 4.3: Description of the Main Variables at Year 20

Variables	n	Mean	Std Deviation (SD)	Range	Missing n (%)
Depressive symptoms (CES-D score)	3093	9.23	7.82	0-58	577 (15.72)
BMI	3162	29.29	6.55	18.78-51.7	508 (13.84)
WC	3167	91.71	14.85	64-136.5	503 (13.71)
DBP	3175	72.91	11.44	43-133	495 (13.49)
SBP	3175	116.54	15.19	79-219	495 (13.49)
TC	3147	185.76	34.93	60-361	523 (14.25)
HDL	3147	54.299	16.72	9-167	523 (14.25)
LDL	3110	109.93	31.79	7-261	560 (15.26)
Triglycerides	3147	109.56	80.45	19-1128	523 (14.25)
Fasting Glucose	3141	97.77	25.65	40-448	529 (14.41)
Physical activity (total intensity score)	3163	336.91	274.86	0-2184	507 (13.81)
Sleep Quality rating	3136	2.49	1.02	1-5	534 (14.55)
Fast Food intake	2381	1.719	2.34	0-25	
SSB	2822	.146	.214	0-1.51	848 (23.11)
Fruit intake per day	2822	2.74	2.25	.05-10.7	848 (23.11)
Vegetable intake per day	2822	3.97	2.43	.6-11.55	848 (23.11)

Results from Bivariate Analyses

This section describes the results from bivariate analyses. It describes the results from the Wilcoxon, Kruskall Wallis tests and correlation analyses.

Bivariate associations between socio-demographic characteristics and depressive symptoms

A series of Wilcoxon and Kruskall Wallis tests were performed to determine if depressive symptoms varied according to socio-demographic variables. Results indicate that

depressive symptoms varied by race, gender and socioeconomic status (income and education). The mean of depressive symptoms was higher in blacks than whites (Table 4.4, $p < .001$). Females have higher means of depressive symptoms than males (Table 4.5, $p <= .004$. Overall, depressive symptom score varied by family income (Table 4.6, $p < .0001$) and education (Table 4.7, $p < .0001$). The Kruskall-Wallis test also indicated that for both family income & education, the individuals categories significantly differed from each compared to family income <16,000 and the high school diploma category.

Table 4.4: Means of Depressive symptoms (CES-D score) by Race

Race	n	Mean	SD	Wilcoxon p-value
Black	1699	10.52	8.36	< .001
White	1922	7.96	7.16	

Table 4.5: Means of CES-D score by Gender

Gender	n	Mean	SD	Wilcoxon p-value
Male	1603	8.53	7.04	.0039
Female	2018	9.67	8.4	

Table 4.6: Means of CES-D by Family Income

Family income	n	Mean	SD	Kruskall Wallis p-value
<5,000-15,999	335	15.32	9.75	
16,000-24,999	236	11.83	9.2	< .0001
25,000-34,999	340	10.90	8.2	< .0001
35,000-49,999	563	9.5	7.36	< .0001
50,000-74,999	785	8.34	6.85	< .0001
75,000-99,999	524	7.24	6.39	< .0001
>100,000	793	6.77	6.59	< .0001

Family income <$16,000 as a reference group. Overall $p<0.0001$.

Table 4.7: Means of CES-D score by Education

Education	n	Mean	SD	Kruskall Wallis p-value
High school	1416	10.62	8.56	
Associate degree	400	9.35	7.63	< .0083
Bachelors	991	7.89	7.08	< .0001
Masters	597	7.22	6.36	< .0001
No answer	210	10.53	8.36	.964

Overall Kruskall Wallis p< .0001

Bivariate associations between socio-demographic characteristics and behavioral factors (mediators)

Bivariate analyses between socio-demographic variables and behavioral mediators from Year 15 are shown in Tables 4.8-4.11. There were statistically significant differences in fast food intake per week by race, gender and SES. Blacks have higher intake of fast food per week than whites (Table 4.8, p< .0001) while males have higher intake of fast food than females (Table 9, p< .001). Overall, fast food intake varied by family income (p< .001) and education (p< .0001) (Tables 4.10 & 4.11). Compared to family income < $16,000, individual categories in the family income varied significantly except for income >$75,000. Compared to high school diploma category, only the associate degree category did not differ significantly from high school diploma group. Fast food intake per week was higher in participants with high school education than higher than with those with more than a high school diploma. Those with family income less than $50,000 have higher intake of fast food intake per week than those with family income greater than $50,000.

Table 4.8: Means of Fast Food Intake per Week by Race

Race	n	Mean	SD	Wilcoxon p-value
Black	1577	2.19	2.63	< .0001
White	1722	1.53	1.98	

Table 4.9: Means of Fast Food Intake per Week by Gender

Gender	n	Mean	SD	Wilcoxon p-value
Male	1481	2.11	2.62	< .0001
Female	1818	1.62	2.05	

Table 4.10: Means of Fast Food Intake by Family Income

Family income	n	Mean	SD	p-value
<5,000-15,999	304	1.65	2.16	
16,000-24,999	225	2.32	2.74	.0002
25,000-34,999	320	2.32	2.91	< .0001
35,000-49,999	524	2.04	2.54	.002
50,000-74,999	715	1.94	2.22	.0069
75,000-99,999	490	1.70	2.24	0.? 398
>100.000	685	1.40	1.90	.145

Overall, p< .0001

Table 4.11: Means of Fast Food Intake by Education.

Education	n	Mean	SD	Kruskall Wallis p-value
High school diploma	1309	2.14	2.56	
Associate degree	372	1.99	2.24	.8451
Bachelor's	885	1.54	2.02	< .0001
Master's	531	1.37	1.91	< .0001
No answer	199	2.26	2.93	.7341

Overall, p< .0001

There was a statistically significant difference in the physical activity total intensity score by race, gender and SES. Blacks had a lower total intensity score compared to whites (Table 4.12, p< .001) and females had a lower intensity score compared to males (Table 4.13, p< .001). Overall, total intensity scores varied by family income (p< .0001) and education (p< .0001). In addition, individual categories differed significantly compared to the family income < $16,000 category. Compared to high school education, individual categories differ significantly, except for associate degree.

Table 4.12: Means of Physical Activity (Total Intensity Score) by Race

Race	n	Mean	SD	Wilcoxon p-value
Black	1722	320.4	294.55	< .0001
White	1931	371.06	271.22	

Table 4.13: Means of Physical Activity (Total Intensity Score) by Gender

Gender	n	Mean	SD	p-value
Male	1615	425.30	305.11	< .0001
Female	2038	285.26	248.42	

Table 4.14: Means of Physical Activity (Total Intensity Score) by Family Income

Family income	n	Mean	SD	p-value
<5,000-15.999	340	249.72	263.45	
16.000-24.999	239	284.03	236.98	.0126
25.000-34.999	341	331.60	263.98	< .0001
35.000-49.999	570	338.77	274.30	< .0001
50.000-74.999	792	341.44	293.41	< .0001
75.000-99.999	528	366.86	286.61	< .0001
>100,000	802	413.27	289.93	< .0001

Overall p<0.0001

Table 4.15: Means of Physical Activity (Total Intensity Score) by Education

Education	n	Mean	SD	Kruskall Wallis p-value
High school diploma	1430	327.82	327.82	
Associate degree	407	338.95	301.34	.5995
Bachelor's	999	361.75	283.55	.0001
Master's	602	368.30	256.15	< .0001
No answer	212	360.70	301.76	.09

Overall, p< .0001

Sleep quality ratings quality also varied by socio-demographic factors, with a higher score indicating poorer quality sleep. There was a statistically significant difference between black and whites in sleep quality rating (Table 4.16, p< .001). Mean sleep quality was higher in blacks than whites. Males rated their sleep quality poorer compared to females (Table 4.17, p< .001). Overall, sleep quality varied by family income (Table 4.18, p< .0001) and education (Table 4.19, p= .0036). Compared to family income <$16,000, there was a significant difference in individual categories for the income > $50,000. Compared to high school education, there was a significant difference in individual categories except for an associate degree.

Table 4.16: Means of Sleep Quality Rating by Race

Race	n	Mean	SD	P-value
Black	1717	2.51	1.03	< .0001
White	1931	2.42	.99	

Table 4.17: Means of Sleep Quality Rating by Gender

Gender	n	Mean	SD	Wilcoxon p-value
Male	1612	2.43	.99	.0234
Female	2036	2.50	1.02	

Table 4.18: Mean of Sleep Quality Rating by Family Income

Family income	n	Mean	SD	Kruskall Wallis p-value
<5,000-15.999	339	2.64	1.07	
16.000-24.999	239	2.51	1.07	.1822
25.000-34.999	342	2.62	1.00	.9984
35.000-49.999	569	2.49	.95	.0512
50.000-74.999	791	2.45	.97	.0176
75.000-99.999	527	2.39	1.02	.001
>100.000	797	2.37	1.02	.0002

Overall, p< < .0001

Table 4.19: Means of Sleep Quality Rating by Education.

Education	n	Mean	SD	Kruskall Wallis p-value
High school diploma	1426	2.51	1.05	
Associate degree	407	2.54	.98	.5975
Bachelor's	998	2.41	.97	.0320
Master's	599	2.36	1.00	.0022
No answer	212	2.54	.98	.6458

Overall, p= .0036

Bivariate association between socio-demographic characteristics and CVD risk profiles (outcomes)

Results indicate that there were statistically significant differences by race in all CVD variables except LDL, HDL and glucose. Blacks had a higher level of BMI (p< .0001), WC (p< .0001), SBP & DBP (P< .0001), TC (p= .0012) and triglycerides (p< .0001) compared to whites (Table 4.20). There were also statistically significant differences by gender in all CVD variables except BMI and TC (Table 4.21). Males had a higher WC, BP, LDL, triglycerides and glucose than females (p < .0001). HDL levels were higher in females than males.

Table 4.20: Means of CVD Risk Variables by Race

	BLACK		WHITE		
CVD risk variables	n	Mean (SD)	n	Mean (SD)	p-value
BMI	1411	31.28 (7.17)	1751	27.70 (5.50)	< .0001
WC	1416	94.31 (15)	1751	89.61 (14.39)	< .0001
DBP	1422	76.50 (11.61)	1753	70.15 (10.47)	< .0001
SBP	1422	120.79 (16.49)	1753	113.09 (13.07)	< .0001
TC	1407	183.50 (32.73)	1740	187.60 (34.39)	.0012
LDL	1396	109.57 (32.73)	1714	110.23 (30.98)	.7455
HDL	1407	54.5 (16.38)	1740	54.13 (16.98)	.3152
Triglycerides	1407	98.70 (69.71)	1740	118.34 (87.21)	< .0001
Glucose	1404	99.49 (29.46)	1737	96.38 (22.00)	.2634

Table 4.21: Means of CVD Risk Variables by Gender

	MALE		FEMALE		
CVD risk variables	n	Mean (SD)	n	Mean (SD)	p-value
BMI	1369	28.86 (5.2)	1793	29.63 (7.4)	.6987
WC	1369	96.6 (13.21)	1751	87.99 (14.94)	< .0001
DBP	1372	74.20 (10.79)	1803	72.08 (11.83)	< .0001
SBP	1372	119.86 (13.5)	1803	114.01 (15.9)	< .0001
TC	1365	185.55 (37.02)	1782	185.93 (33.25)	.6434
LDL	1336	113.03 (33.68)	1774	107.59 (30.06)	< .0001
HDL	1365	47.47 (14.37)	1782	59.52 (16.5)	< .0001
Triglycerides	1365	128.84 (94.54)	1782	94.79 (63.9)	< .0001
Glucose	1362	101.41 (26.85)	1779	94.98 (24.33)	< .0001

Correlation Analysis

Since most of the variables used in this study were ordinal/interval and were not normally distributed, Spearman's correlation coefficients were used to assess the strength of the correlation between these variables. Both the direction and magnitude of the correlation coefficients were discussed in the examination of associations between variables. The significance level was .05.

The association between age, social support, depressive symptoms and cardiovascular risk factor variables are shown in a correlation matrix in Table 4.22. There was a statistically significant inverse correlation between depressive symptoms and social support ($r=-.39$, $p< .05$). There was also a statistically significant correlation between depressive symptoms and BMI ($r= .09$, $p< .005$), WC ($r= .09$, $p< .05$); DBP ($r= .1$, $p< .05$), SBP ($r= .07$, $p< .005$) and HDL ($r= -.04$, $p< .005$); however, the correlations were very low.

Bivariate multicollinearity was also examined by looking at the correlation matrix of each variable in the model (Table 4.22 & 4.23). Total cholesterol (TC) and LDL levels were significantly correlated ($r= .88$, $p< .05$) as well as SBP and DBP ($r= .81$, $p< .05$). Only LDL was kept in the model because it is a better indicator of CHD risk than TC (Carmena, Duriez, & Fruchart, 2004). In addition, only DBP was kept in the model since it is a more potent CVD risk factor than SBP until 50 years of age according to the Seventh Report of Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (USDHHS, 2004) and the participants of this study are less than 50 years of age. There was also high correlation between BMI and WC ($r= .88$, $p< .05$). In the multivariate regression analyses and path analyses, BMI and waist circumference were included in separate models to examine the effects of depressive symptoms and behavioral mediators on WC, independent of BMI.

Table 4.22: Correlations Among Depressive Symptoms (Year 15), Social Support (Year 15) and CVD Risk Factors (Year 20)

	Age	CES-D	Support	BMI	WC	DBP	SBP	TC	HDL	LDL	TRIG	GLU
Age	1											
CES-D	-.01	1										
Support	-.01	-.39*	1									
BMI	.005	.09*	-.08*	1								
WC	.04*	.09*	-.11*	0.88	1							
DBP	.03	.1*	-.07*	.4*	.41*	1						
SBP	.06*	.06*	-.07*	.25*	.32*	.81*	1					
TC	.05*	-.006	.004	.06*	.06*	.1*	.1*	1				
HDL	.03*	-.04*	.08*	-.4*	-.5*	-.15*	-.15*	.12*	1			
LDL	.03	-.02	-.007	.16*	.17*	.1*	.1*	.88*	-.16*	1		
TRIG	.05*	.07*	-.05*	.32*	.44*	.25*	.21*	.32*	-.53*	.25*	1	
GLU	.13*	.03	-.04*	.32*	.41*	.2*	.2*	.07*	-.33*	.17*	.3*	1

*< .05, CES-D= depressive symptoms score; support= perceived social support; WC= waist circumference, DBP= diastolic blood pressure; SBP= systolic blood pressure; TC=total cholesterol; TRI: triglycerides, GLU=fasting blood glucose.

The associations between depressive symptoms (Year15), behavioral mediators (Year 20) and outcomes (Year 20) are shown in Table 4.23. There was a statistically significant low correlation between depressive symptoms and fast food intake (r= .05), physical activity (r= -.15) and sleep quality (r= .24). Fast food intake, physical activity and sleep quality were correlated with BMI (r= .2; r= -.21; r= .05, respectively) and WC (r= .21; r= -.15; r= .05, respectively). There was also low but statistically significant correlation between fruit, vegetable, SSB and BMI (r=-.08; r= -.07; r= .08, respectively) and WC (r= -.05; r= -.04; r= .12, respectively).

Table 4.23: Correlations Among Depressive Symptoms (Year 15), Behavioral Mediators (Year 20), BMI (Year 20) and WC (Year 20)

	CES-D (Y15)	Fast Food (Y20)	Physical activity (Y20)	Sleep quality (Y20)	BMI (Y20)	WC (Y20)	Fruit	Veg	SSB
CES-D (Y 15)	1								
Fast food (Y20)	.05*	1							
Physical activity (Y20)	-.15*	-14*	1						
Sleep quality (Y20)	.24*	.06*	-.08*	1					
BMI (Y20)	.09*	.2*	-.21*	.05*	1				
WC (Y20)	.08*	.21*	-.15*	.05*	.88*	1			
Fruit (Y20)	-.07*	-.10*	.22*	-.05*	-.08*	-.05*	1		
Veg (Y20)	-.07*	-.13*	.23*	-.03	-.07*	-.04*	.36*	1	
SSB (Y20)	.10*	.27*	-.10*	.03*	.08*	.12*	.01	-.12	1

* p< .05; CES-D=depressive symptoms scores; WC= waist circumference; SSB= sugar-sweetened beverage; fruit= fruit serving per day; veg = vegetable serving per day.

Results from multivariate analyses

In this section, I attempt to answer the Research Question #1:

Do higher depressive symptoms predict higher BMI, higher WC, higher DBP, higher LDL, higher triglycerides and lower HDL levels in adults 33-45 years of age?

and

Research Question #2:

Does perceived social support moderate the association between depressive symptoms and BMI and depressive symptoms and WC in adults 33-45 years of age?

Linear regression analysis was used to test the association of depressive symptoms and CVD risk profiles after five years of follow-up and seven separate models were constructed for each of the dependent variables: BMI, WC, DBP, LDL, TG, HDL and FBG. Covariates were selected based on the review of the literature and on bivariate analyses that were conducted to assess potential for confounding. Results presented here report both unadjusted (Table 4.24) and covariates adjusted (Table 4.25) association to clarify how the association between depressive symptoms and CVD risk profile change in the presence of other variables. Socio-demographic variables were found to be associated with both depressive symptoms and outcomes and were entered as covariates. In addition, BMI and WC models were controlled for physical activity, smoking and alcohol intake. Only 7% of the subjects used antidepressants. Analyses were conducted by the following considerations: a) excluding the subjects who used antidepressants: and b) by controlling for antidepressants use. In both instances, there was a negligible change in estimates and no change in the statistical significance. Therefore, these subjects were kept in the study. Depressive symptom at Year 15 was the main predictor of the current study. Depressive symptoms and all outcome variables underwent natural log transformations except LDL. Overall summary of the results of regression analysis of the effect of depressive symptoms at Year 15 on predicting CVD risk profile at follow-ups can be seen in Table 4.24 and Table 4.25.

Unadjusted analyses shown in Table 4.24 indicate that depressive symptoms predicted almost all cardiovascular physiological risk profile variables except LDL and HDL levels. Higher depressive symptoms predicted higher BMI, WC, DBP, triglycerides and FBG.

However, adjusted analyses indicate that depressive symptoms predicted BMI (p= .028), WC (p= .009), triglycerides (p= .002), HDL (p= .044) and fasting glucose (p= .0021) while controlling for covariates. More specifically, one unit change in log depressive symptoms scores resulted in .01 unit change in log BMI, .009 unit change in log WC, .03 change in log triglycerides, -.012 unit change in log HDL and .012 unit change in log glucose. The interpretation of the log transformation is that an approximately 1% increase in depressive symptoms score results in a .01 % increase in BMI, .009 % increase in WC, .03 % increase in triglycerides, .012 % decrease in HDL and .012 increase in glucose. Table 4.26 presents more a detailed model of the regression of BMI and WC on depressive symptoms. Depressive symptoms, while controlling for covariates and other factors, explained the 11% variance in BMI and 18% variance in WC.

Table 4.24: Regression of CVD Risk Variables on Depressive Symptoms: Unadjusted and all variables log transformed except LDL

CVD risk profile variables	b	SE	p-value
BMI	.022	.004	< .0001
WC	.015	.003	< .0001
DBP	.014	.003	< .0001
Triglyceride	.035	.011	.0015
HDL	-.009	.006	.1423
LDL	-.682	.685	.319
Glucose	.012	.004	.002

n=2,765

Table 4.25: Adjusted Regression of CVD Risk Factors on CES-D. All variables log transformed except LDL.

CVD risk factors	b	SE	p-value	R^2
BMI	.01	.004	.028	.1167
WC	.009	.003	.004	.1827
DBP	.004	.003	.188	.1088
Triglyceride	.03	.011	.002	.095
HDL	-.012	.005	.044	.1960
LDL	-.027	.712	.969	.0235
Fasting blood glucose	.012	.004	.0021	.0575

n=2,765

*BMI adjusted for age, educational level, income, sex, race, alcohol consumption, smoking status & physical activity.

*WC adjusted for age, educational level, income, sex, race, alcohol consumption, smoking status & physical activity,

* DBP adjusted for baseline age, sex, race and income.

*HDL adjusted for age, race, sex, income, physical activity, smoking.

* LDL adjusted for age, race, sex and income.

*Triglycerides adjusted for age, race, sex and income.

*Fasting blood glucose adjusted for age, race, sex and income.

Table 4.26: Regression of BMI and WC on CES-D (from Separate Models)

	BMI		**WC**	
Main predictor	**b (SE)**	**P**	**b (SE)**	**p**
CES-D	.01(.005)	.0283	.009(.003)	.0044
Covariates				
Age	.002(.001)	.036	.02(.00)	.0006
Female vs male	-.018(.008)	.027	-.12(.005)	<.0001
Black vs white	.106(.008)	< .0001	.05(.006)	<.0001
Family income				
35,000-75,000 vs <35,000	.01(.01)	.332	.004 (.007)	.580
>75,000 vs <35,000	-.012 (.01)	.293	-.012	.137
Education				
College degree vs high school	-.02 (.009)	.0015	-.02 (.006)	.002
Master's degree vs high school	-.04 (.012)	< .0001	-.04 (.008)	< .0001
Physical activity	-.0009 (.0001)	< .0001	-.0008 (.0001)	< .0001
Current smoker vs non smoker	-.04 (.01)	.0003	-.015 (.007)	.058
Former smoker vs non smoker	.005 (.01)	.6026	.005 (.007)	.4321
Alcohol intake (cc/day)	-.0005 (.0001)	.0018	-.0002 (.000)	.046
Adjusted R^2	.1167		.1827	

n=2,765

Additional stepwise linear regression analyses were performed controlling for baseline (Year 15) BMI and WC. The results indicated that the there was a statistically significant association between depressive symptoms and WC only (b= .004, p < .05). When stratified by gender, the association between depressive symptoms with BMI and WC remained statistically significant only in females (b= .011, p= .17).

Hypothesis # 2.1: Greater perceived social support decreases the association of depressive symptoms on BMI and depressive symptoms on WC.

The interaction between social support and depressive symptoms was not significant and hence did not support this hypothesis. Since there have been reports that gender moderates the association between depressive symptoms and obesity, and conflicting evidence on race and SES as moderators, additional sets of models were tested for a two- way interaction between 1) depressive symptoms and race; 2) depressive symptoms and gender; and 3) depressive symptoms and SES (family income and education, separately). The outcome variables were limited to BMI and WC since they were the main outcome variables in this study. The results indicate that the only significant interaction was between depressive symptoms and gender. Therefore, subgroup analysis by gender was performed (Table 4.27). The results from this subgroup analyses indicate that higher depressive symptoms predicted higher BMI & higher WC in females only. More specifically, results indicate that 1% increase in CES-D score results in a .0136 % increase in BMI and a .011 % decrease in WC.

Table 4.27: Regression of CES-D on BMI & WC by Gender

	Males			**Females**		
Outcomes	**Coefficient**	**SE**	**p-value**	**Coefficient**	**SE**	**p-value**
BMI	.003	.006	.535	.0136	.006	.037
WC	.005	.004	.267	.011	.005	.012

For females, adjusted R^2 for BMI=.19 & for WC=.17

Results of Path Analyses

In this section, I attempt to answer Research Question #3.

Do behavioral factors such as diet, physical activity and sleep quality mediate the association between depressive symptoms and BMI and between depressive symptoms and WC independent of BMI in adults 33-45 years of age?

Mediation analyses were performed with Year 15 depressive symptoms and Year 20 behavioral mediators and outcomes controlling for Year 15 behavioral mediators and Year 15 outcome variables to account for the stability over time and clarify the temporal ambiguity.

Results for BMI outcome

The path diagram with unstandardized regression coefficients are shown in Figure 4.2. Significance at the probability level of .05 had a z value greater than 1.96. The model was adjusted for socio-demographic factors (age, race, gender, education), Year 15 mediators and Year 15 BMI. The goodness of fit indices for the adjusted model indicated an adequate model fit (Satorra-Bentler chi-square= 469.29; df=25, p= .000; Robust CFI= .912; robust RMSEA= .09). The indirect effects of depressive symptoms on BMI through each of the mediating factors are reported in Table 4.28 and present the standardized and the unstandardized indirect path (with robust standard error).

There were no significant indirect paths of SSB or fruits and vegetables that partially mediated the association between depressive symptoms and obesity; therefore, they were excluded in the model.

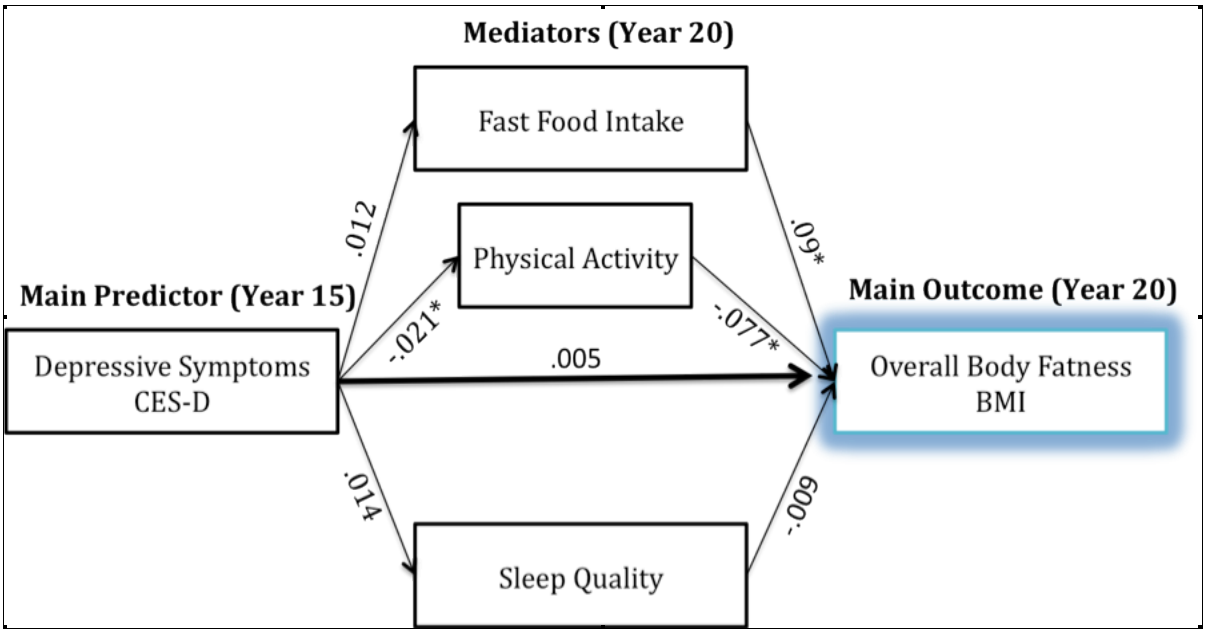


Figure 4.2: Regression Paths (unstandardized coefficient) Among Variables in the Mediation Model for the Entire Sample. Adjusted for race, gender, age and Year 15 BMI and Year 15 mediators. * $p < .05$

Table 4.28: Unstandardized Path Coefficient with Robust Standard Error From Adjusted Path Analysis Model

Path Model	Coefficient	Robust Standard Error
Depressive symptoms→ BMI	.005	.008
Depressive symptoms→Fast food	.012	.007
Fast Food → BMI	.09	.021*
Depressive symptoms→Physical activity	-.021	.006*
Physical activity →BMI	-.077	.019*
Depressive symptoms→sleep quality	.014	.003*
Sleep quality →BMI	-.009	.056
Unadjusted R^2→ .057		
Adjusted R^2→ .853		

n= 2,076

* Significance at the probability level of .05 has a z value greater than 1.96.

Hypothesis 3.1: Dietary behaviors (increase in fast food intake, decrease fruits and vegetables intake and increase in SSB) partially mediate the association between depressive symptoms and BMI.

Depressive symptom was not associated with fast food intake (Figure 4.2, b= .012, p> .05); however, fast food intake was associated with BMI. The effect of fast food on BMI indicates that each one-unit increase in fast food intake per week is associated with a .09 increase in BMI in kg/m^2.

In the unadjusted model, the indirect effect of depressive symptoms on BMI through fast food intake was significant (Table 4.29). However in the adjusted model, the indirect effect of depressive symptoms on BMI through fast food intake is non-significant. The indirect effects of depressive symptoms on BMI through fruits, vegetables and SSB were non significant. Therefore, this hypothesis was not supported.

Hypothesis 3.2: Physical activity partially mediates the association between depressive symptoms and BMI.

Higher depressive symptoms predicted lower physical activity levels. More specifically, results indicate that each one increase in the depressive symptoms score is associated with a .021 unit (in exercise unit=EU) decrease in physical activity. Higher levels of physical activity also predicted a decrease in BMI. The partial standardized regression coefficients relating physical activity to BMI while controlling for other factors, is -.077 (SE= .019), which is statistically significant. More specifically, the coefficient of -.077 for the effect of physical activity on BMI indicates that each one unit increases in physical activity is associated with a .077 decrease in BMI in kg/m^2.

The indirect effect of depressive symptoms on BMI through physical activity is b= .002 with SE= .001 which is significant. With one unit increase in depressive score, there is a .002 increase in kg/m^2 in BMI through the effects of physical activity. Thus, the hypothesis 3.2 is supported. In this model physical activity is a statistically significant partial mediator in the association between depressive symptoms and BMI; although the coefficient for the indirect effect is extremely small.

Hypothesis 3.3: Sleep quality partially mediates the association between depressive symptoms and BMI.

There was also no significant indirect effect of depressive symptoms on BMI through the effects of sleep quality. Therefore, the hypothesis related to sleep quality was not supported.

Table 4.29: The Effects of Depressive Symptoms on BMI through Fast Food, Physical Activity and Sleep Quality Determined from Path Analysis Model

Potential mediating variables	Coefficient (standardized)	Coefficient (unstandardized)	SE (robust)	z-value (robust)
Fast Food Intake				
Unadjusted	.008	.007	.003	2.611*
Adjusted	.001	.001	.001	1.631
Physical Activity				
Unadjusted	.024	.021	.004	4.859*
Adjusted	.002	.002	.001*	2.895*
Sleep Quality				
Unadjusted	.006	.005	.004	1.209
Adjusted	-.000	-.000	.001	-.116
Total indirect effects				
Unadjusted	.038	.033	.007	4.702*
Adjusted	.003	.003	.001	2.121*
Total effects				
Unadjusted	.130	.081	.020	3.648*
Adjusted	.007	.006	.008	.722

n= 2,076. *Significance at the probability level of .05 has a z value greater than 1.96.
R^2 for fast food intake= .012 & physical activity = .025
Total indirect effects= total indirect effects of mediators: fast food, physical activity & sleep quality.
Total effects= direct effect + indirect effects

Results with WC outcome

The path diagram with unstandardized regression coefficients are shown in the Figure 4.3. The goodness of fit indices for the adjusted model indicates less than adequate model fit (Satorra-Bentler chi-square =924.20, df=42, p= .000; Robust CFI= .86; robust RMSEA= .1). The indirect effects of depressive symptoms on BMI through each of the mediating factors are reported in Table 4.30 and present the standardized and the unstandardized indirect path (with robust standard error).

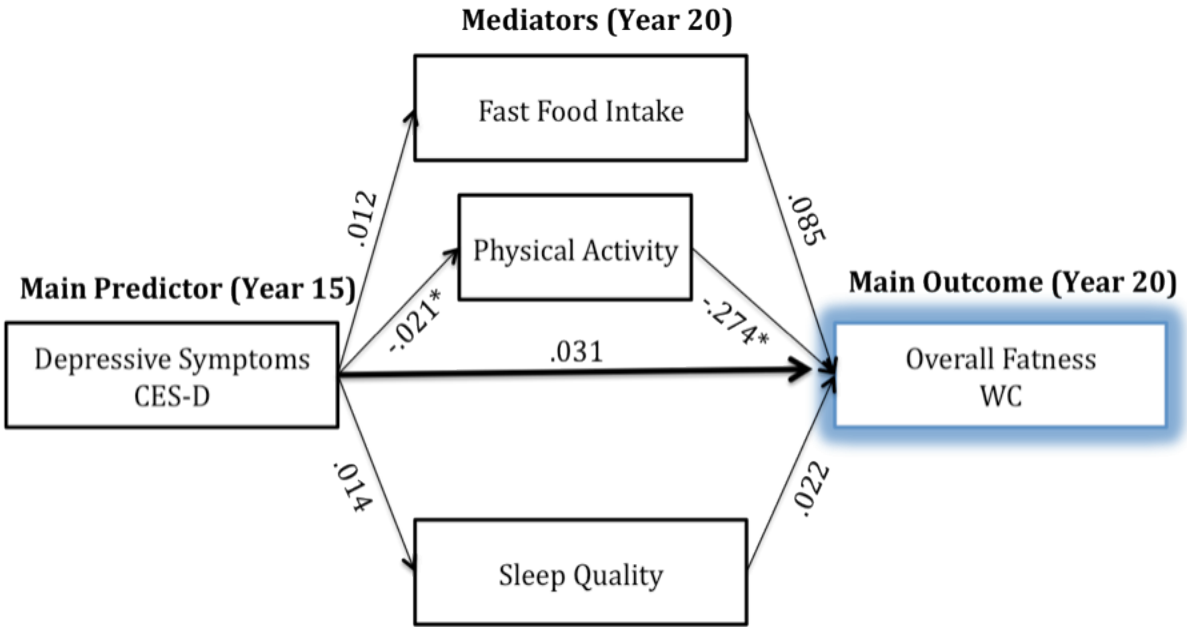


Figure 4.3: Regression paths (unstandardized coefficient) among variables in the mediation model for the entire sample.
Adjusted for race, gender, age, Year 15 BMI, Year 15 mediators and Year 15 WC
* $p < .05$

Table 4.30: Unstandardized Path Coefficient with Robust Standard Error (from Path Diagram)

Path Model	Coefficient	Robust Standard Error
Depressive symptoms → WC	.031	.016
Fast food → WC	.085	.052
Physical activity → WC	-.274	.041*
Sleep quality → WC	.022	.121
Unadjusted R^2→ .744		
Adjusted R^2→ .871		

n= 2,047 * Significance at the probability level of .05 has a z value greater than 1.96.

Table 4.31: Effect of Depressive Symptoms on WC through Fast Food Intake, Physical Activity and Sleep Quality Determined from Path Analysis Model

Potential mediating variables	Coefficient (standardized)	Coefficient (unstandardized)	SE (robust)	z-value (robust)
Fast Food				
Unadjusted	.003	.006	.002	2.497*
Adjusted	.001	.001	.001	1.261
Physical Activity				
Unadjusted	-.006	-.011	.003	-3.549*
Adjusted	.003	.006	.002*	3.044*
Sleep Quality				
Unadjusted	-.002	-.004	.005	-.908
Adjusted	.000	.000	.002	.185
Total indirect effects				
Unadjusted	-.005	-.010	.006	-1.515
Adjusted	.004	.007	.003	2.5*
Total effects				
Unadjusted	.05	.309	.068	4.548*
Adjusted	.04	.085	.052	1.629

n= 2076. Adjusted R^2 for fast food= .00 & physical activity = .003

Hypothesis 3.4: Fast food intake partially mediates the association between depressive symptoms and WC, independent of BMI.

Depressive symptoms were not associated with fast food intake. Fast food intake was also not associated with WC. The indirect effect of depressive symptoms on WC (b= .001, z=1.656) through fast food intake is not significant. Thus, the hypothesis is not supported.

Hypothesis 3.5: Physical activity partially mediates the association between depressive symptoms and WC, independent of BMI.

Depressive symptoms were associated with physical activity. The unstandardized regression coefficient relating depressive symptoms to physical activity is -.021 (SE= .006, z= -3.501), which is significant. More specifically, results indicate that for each one-unit increase in depressive symptoms score, there is a .021 unit decrease in physical activity intensity (EU). The partial standardized regression coefficients relating physical activity to WC, while controlling for other factors is -.274 (SE= .04), which is significant. More specifically, the effect of physical activity on WC indicates that each one-unit increase in physical activity intensity is associated with a .246 decrease in WC in cm.

The indirect effect of depressive symptoms on WC (b= .003) through physical activity is significant. Thus, the hypothesis is supported. In this model, physical activity is a statistically significant partial mediator in the association between depressive symptoms and WC although the coefficients are extremely small. The higher depressive symptoms were associated with a decrease in physical activity intensity units, which in turn leads to a greater WC.

Hypothesis 3.6: Sleep quality partially mediates the association between depressive

symptoms and WC, independent of BMI.

There was no significant indirect effect of depressive symptoms on WC through the effects of sleep quality. Therefore, the hypothesis related to sleep quality was not supported.

Prior to conducting two- wave (Year 15 and Year 20) mediation analyses, cross-sectional analyses were also performed at Year 20, since all the mediators of interest were available at that time wave. Results indicated that in addition to physical activity, fast food intake partially mediated the association of depressive symptoms and BMI and depressive symptoms and WC.

Subgroup mediation analyses

Since it was found that gender moderated the association between depressive symptoms and BMI and depressive symptoms and WC, subgroup analysis was also performed to examine whether the effects of mediators were similar between male and females. The result indicates that physical activity remained a significant partial mediator for females only.

Additional exploratory subgroup meditation analyses were also performed to determine if there were differences in these behaviors as mediators between different socio-demographic groups. Age was divided into two categories of less or equal to 40 and greater than 40. The coefficients were very similar to the above models. Physical activity was still partially mediating the association between the depressive symptoms and BMI and WC with very similar coefficients as the models discussed above in both racial groups and age categories.

Summary of the results

In summary, the results of this study indicate that higher depressive symptoms predict BMI and WC in whole groups. However, in subgroup analyses by gender, higher depressive

symptoms predicted higher BMI and WC in females only. Perceived social support did not have any significant moderating effect.

In the cross sectional mediation analyses, both fast food and physical activity were statistically partial mediators between depressive symptoms and BMI and between depressive symptoms and WC. Using two waves of data for mediation analyses, only physical activity remained a significant partial mediator of these associations with very small indirect coefficients.

CHAPTER FIVE

DISCUSSION

In Chapter Four, the results of the study were reported. In this chapter, discussion is presented, which will review the findings from the three aims of this study. The first aim was to examine the association of depressive symptoms with BMI and WC and other CVD risk factors in a large cohort of adults. The second aim of this study was to examine whether perceived social support moderates the association between depressive symptoms and BMI. The third aim was to investigate whether diet (fast food, fruit and vegetable intake and SSB), physical activity and sleep quality partially mediate the association between depressive symptoms and BMI and depressive symptoms and WC; this final goal was the main focus of the study. The last section of discussion is the review of the study limitations and strengths, and implications of the study to public health and conclusion.

Aim 1: To examine the association between depressive symptoms and CVD risk factors such as BMI, WC, BP, lipids and fasting blood glucose among adults aged 33-45 years of age.

This study examined whether depressive symptoms at Year 15 could predict an increase in BMI, WC and other CVD risk profile such as DBP, LDL, TG & FBG after five years of follow-up in a large sample of 2,765 black and white adults, aged 33-45. With regards to BMI and WC, as hypothesized, higher depressive symptom scores predicted higher BMI ($p = .028$) in the entire sample after five years of follow-up. These associations were also found in WC ($p = .004$) and were independent of changes in BMI. The results of this study are consistent with previous meta-analysis of longitudinal studies showing that overall depressed persons had a 58%

increased risk of becoming obese (Luppino et al, 2010). These longitudinal studies provide additional insight into the already established cross-sectional association between depression and obesity. The results of the longitudinal meta-analysis found a larger pooled effect size (OR between 1.2 and 1.58) than the pooled effect size reported in the meta-analyses of cross sectional studies by de Wit et al. (2010) in both men and women. However, it should be noted that the studies in the meta-analyses did not adjust for many potential covariates and were only adjusted for age and gender (Luppino et al, 2010). Although the main focus of this study was to explore the indirect effect of behaviors as potential mediators in the association between depressive symptoms and BMI and between depressive symptoms and WC, the direct effects of depressive symptoms on BMI and WC were also assessed. Needham et al (2010) have already investigated if baseline depressive symptoms were associated in changes in BMI and WC using CARDIA data from Years 5, 10, 15 and 20. Their results indicated that baseline depressive symptoms were more strongly associated with increases in BMI in whites only. Depressive symptoms were associated with WC the increase in the whole sample. This study was inconsistent with the study by Needham et al in (2010) in CARDIA sample for BMI result, but was consistent for WC result. The discrepancy between these results could be explained by the difference in the methods of analysis, specifically latent growth curve analysis versus linear regression analysis. Other reasons might include design of the study, in which this current study used two waves of data and the variables that were controlled for were different in this study than the study by Needham et al (2010).

After stratification by gender, the association between depressive symptoms and BMI and between depressive symptoms and WC remained significant among females only. Gender differences in the association between depression and obesity have been described in previous

cross-sectional studies. Several factors could explain these gender-specific effects. The significant findings in females could be due to higher levels of depressive symptoms in females. The lack of association between depressive symptoms and obesity in men is similar to previous research suggesting health-related risk to depression may be more critical for women. In addition, other reason may include, as speculated by other authors, the behavioral correlates of depressive symptoms (Sutin & Zonderman, 2011). Similar to previous studies, women in this current study had higher depressive symptoms than men. Higher depressive symptoms in women were associated with lower physical activity, which in turn was significantly associated with higher BMI and WC.

In the latest NHANES study, depression was cross-sectionally associated with two-fold risk in BMI and WC in adult women, but not in men. Sex-specific associations between sex hormones and psychological states may partly explain the observed differences between women and men (Pulki-Raback et al, 2009).

The association between depressive symptoms and CVD risk profiles were assessed in a previous CARDIA study up until Year 15 (Knox et al., 2006). This study examined these CVD risks at Year 20 when the participants were five years older than their baseline. Although not a major goal of the study, I wanted to explore the association of the depressive symptoms with physiologic CVD risk profiles in this cohort from Years 15 to Year 20 since we might have expected to see some changes in these risk profiles as the cohort was getting older.

There was no significant association between depressive symptoms and blood pressure in this study. This finding was in contrast to the National Health and Nutrition Examination Survey Epidemiologic follow-up study (Jonas et al., 1997) and the CARDIA study (Davidson et al, 2000), both of which showed that symptoms of depression were associated with an increased

incidence of hypertension. The non-significant results in this study might be explained by the use of different measures of blood pressure. In previous CARDIA studies blood pressure was measured as a categorical variable. Although the result of DBP was reported here as a continuous measure, depressive symptoms were not associated with SBP. Some studies found only indirect effects of depressive symptoms to blood pressure, that is depressive symptoms are linked to blood pressure through indirect mechanisms. For example, in the Bogalusa Heart study, a cross sectional study of 1,017 participants (aged 12-17), found that symptoms of depressive symptoms were associated with the presence of hypertension indirectly through an association with higher BMI in both blacks and whites (Bair et al, 2006).

The current study did find a significant association between depressive symptoms and some fractions of lipid profile, such as HDL & TG. Higher depressive symptoms predicted higher TG and lower HDL levels. There was no significant association between depressive symptoms and LDL levels. Although prior studies have somewhat mixed results, many studies have noted that higher levels of depressive symptoms are generally associated with lower levels of LDL and higher HDL (Igna et al, 2008; Shin et al, 2008), particularly in young women (Fang et al, 2012). In the Fang study, both depressive symptoms and lipid levels were treated as continuous variables. Another reason for contradictory results could be that some studies used total cholesterol levels instead of different fractions of cholesterol. Igna et al 2008 found that depressive symptoms are significantly associated with fractions of cholesterol, indicating higher HDL and lower LDL. Some studies reported a significant positive association between depression and HDL and others reported a significant negative association of depression with LDL (Aijanseppa et al., 2002). However, in these studies the participants were older than in the current study. The mixed findings could be related to the complexity of studying such

associations due to many factors in the association. Further studies are needed to clarify these associations.

Finally, this study found that depressive symptoms and fasting blood glucose (FBG) levels indicated that higher depressive symptoms predicted higher FBG levels. This finding is consistent with previous longitudinal studies suggesting higher depressive symptoms have a 37% increased risk of developing type 2 diabetes compared to those who are not depressed or have a lower depressive symptoms (Knol et al, 2006). Depression has been investigated as an independent risk factor for the development of type 2-diabetes. Most of the studies used self-reporting methods for diabetes or blood glucose levels, and a number of studies report inconsistent results. Some find an increased risk of developing diabetes, while others do not find a significant association. More research is also needed to clarify this association.

Overall, depressive symptoms predicted the components of metabolic syndrome such as low HDL, high TG, high WC and FBG. This finding could be due to stress arousal from depressive symptoms that lead to endocrine and metabolic imbalances from HPA axis activation that promote abdominal fatness (Bjorntorp, 2001). This process might explain the association between baseline depressive symptoms and increases in the aforementioned levels.

It is worth noting that even though they were statistically significant, clinically these findings might not be significant since the magnitude of these effects was small, ranging from 1% to 6%. It should also be noted that at Year 20 the cohort was between 38-50 years of age and the descriptive data indicated that the CVD risks were within normal values except for BMI.

Aim 2: To assess the moderating effect of perceived social support in the association between depressive symptoms and BMI and depressive symptoms and WC.

The second aim of this study was to determine whether the association between depressive symptoms and BMI was moderated by perceived social support. The moderating effect of perceived social support between depressive symptoms and BMI has not been examined extensively. Most of the studies have examined the moderating effect of the socio-demographic factors. As discussed above, gender was found to be one of the moderators in this study, similar to previous findings. In this study, perceived social support did not moderate the association between depressive symptoms and BMI and WC. The non-significant findings could be related to measure issues in the measurement of social support variables in the CARDIA study at Year 15. The social support questionnaire was based on four items from a previously validated social support scale that was used in the CARDIA study.

Aim 3: To identify behavioral mediators (fast food intake, physical activity and sleep quality) between the depressive symptoms and BMI and depressive symptoms and WC.

In the literature, one of the mechanisms that have been proposed to explain the association between depressive symptoms and obesity is through health behaviors. However, previous epidemiological studies are mainly based on a two-way association between variables. Three-way associations between these variables have not been well explored in the literature. Most studies examining the depressive symptoms and BMI associations have not examined behavioral variables as a causal pathway. This analysis has great potential to advance the knowledge on behavioral pathways linking depressive symptoms to overall body fatness as

assessed by BMI and abdominal fatness as assessed by WC. Therefore, the main goal of this study was to investigate the potential mediating effect of selected behaviors.

The results of cross-sectional mediation analyses indicated that fast food intake and physical activity partially mediated the association between depressive symptoms and BMI and depressive symptoms and WC. Two waves mediation analysis allowed this study to examine many aspects that are unavailable with cross-sectional data analysis such as whether an effect is stable across time and whether there is evidence for one of the important conditions of causality, temporal precedence (Mackinon et al, 2008). Although the total effect of depressive symptoms were associated with BMI and WC, the examination of the direct and indirect effects showed that only physical activity partially mediated the association between depressive symptoms and change in BMI and WC. Although, physical activity had a significant indirect effect on the association, the coefficients were extremely small. Physical activity explained only 5% of the variance in BMI. This finding confirms the results of studies that indicate the importance of physical activity as a relevant variable in the association with depression and BMI. Persons with higher depressive symptoms may be less likely to engage in physical activity simply because of lower energy levels (Goodwin, 2003). The small proportion of variance explained by physical activity could be related to alternative mechanisms that have stronger effects on the association and were not examined in this study.

Very few studies examined behaviors as mediators to explain the association between depressive symptoms and overall body fatness. Higher levels of depressive symptoms were associated with lower self-efficacy in maintaining physical activity behavior (Kontinnen et al, 2010). Physical activity self-efficacy also had an inverse association with BMI and hence, contributed to the positive association between depressive symptoms and BMI. The result of this

study is also consistent with another previous study in US adults. Beydoun and Wang (2010) found that physical inactivity was a significant pathway between depressive symptoms and higher BMI in women. These studies are cross-sectional, and to my knowledge no study could be found that looked at behavioral variables as mediators with longitudinal data.

There were no significant indirect effects of fast food, SSB, or fruit and vegetable intake. Previous studies have suggested that there is an association between depressive symptoms and preference for specific foods (Liu et al, 2007). As such, no studies that examined the mediating effects of certain food type in relation to the association between depressive symptoms and BMI were cross-sectional in nature and no studies have investigated fast food and SSB as dietary factors in longitudinal mediation analyses. In a cross sectional study (n=87), diets that are high in energy density did not mediate the association between depressive symptoms and WC in overweight adults (Grossniklaus et al, 2011). However, dietary behaviors as a possible pathway linking depressive symptoms with abdominal obesity have been examined in another study by Konttinnen et al 2010. In this cross-sectional study among Finnish men (n=2,312) and women (n=2,674) aged 25-74 years, higher depressive symptoms were associated with a greater tendency to eat during negative emotions, and this emotional eating was associated with higher BMI and WC. In this study, depressive symptoms were measured by CES-D and there was an assessment of emotional eating behaviors measured by Three- Factor Eating Questionnaire. In another study by this group, emotional eating was related to a greater intake of sweet foods (Konttinnen et al, 2010). Despite the non-significant results related to dietary factors as a mediating variable in this study, results from these previous studies suggest that dietary factors and emotional eating may be behavioral mechanisms that partially explain the link between depressive symptoms and BMI and WC. Depressive symptoms may cause stress-induced or

emotional eating, which leads to the consumption of high fat foods such as fast food, which in turn is associated with the increase in BMI.

Dietary behavior as mediator was assessed mainly by as single dietary pattern behavior, which is the frequency of fast food intake per week. This information is meaningful and provided valuable information on the association between fast food intake and BMI and WC. Inclusion of more detailed data about dietary factor or patterns may have improved the model. In the obesity research, increased fast food intake and SSB consumption are attributed as major contributors to an increase in obesity trends. However, single assessment of diet as a mediator may not be sufficient enough to act as a mediator as other dietary health patterns or a combination of dietary pattern and other behaviors could make a greater contribution or yield different and/or significant results. It may also be likely that there are multiple pathways underlying the association and should be explored in future studies.

Partial mediation has been tested in this study since other mechanisms have been proposed in the literature to explain the link between depressive symptoms and body fatness indicators. The biological/physiological mechanism works via neuro-endocrine changes in the sympathetic nervous system and the hypothalamic-pituitary adrenal (HPA) cortical axis brought about by stress. Depressive symptoms may act as stress factor on individuals. The influence of stress upon obesity is exerted via a physiologic mechanism whereby stress may impact both depression and obesity by its effect on (HPA) axis. Activation of the HPA axis in depression appears to be responsible for the small but statistically significant association between depression and abdominal body fat (Bjorntorp, 2001).

No studies could be found linking sleep quality to BMI or WC as a behavioral mediator. Sleep quality was found to have a significant association with adiposity measures in this study,

but not with depressive symptoms. In addition, a significant indirect effect could not be shown in this study. One contributing factor in the non-significant result would be the measure of sleep quality itself. Sleep quality combined with objective measures of sleep would most likely to provide better information on the nature of the association.

Because there are very few studies examining behavioral pathways that link depressive symptoms to body fatness indicators, and most of the studies were cross-sectional, this l meditation analyses using two wave longitudinal data contributes to the body of literature by suggesting that physical activity could be a possible focus of future interventions which would promote a physically active lifestyle for individuals with higher depressive symptoms to prevent weight gain.

Study Limitations and Strengths

In interpreting the results, it is important to note some of the limitations of this study. First, it is possible that there will be bias in the estimation of the results due to the self-report method used to identify lifestyle factors such as diet, physical activity and sleep quality. Objective measures of physical activity and sleep may provide a more accurate estimation. Second, since longitudinal mediation analyses were performed using two waves, mediators and outcomes were assessed at the same wave (Year 20), which may result in biased estimates. Hence, the mediation analyses would have been best with three waves of data and would have captured the change. Third, despite the fact that most of the studies in the literature use well-validated standardized social support scales such as the Norbeck Social Support Questionnaire (NSSQ) (Norbeck, Lindsey, & Carrieri, 1983), however, social support in this study was only measured using four items. Fourth, selection bias may be another limitation that should not be

overlooked. Younger subject and more whites and females remained at Year 20. Those who dropped out from Year 15 to Year 20 had also a higher depressive symptoms score; therefore, the result might have been biased estimates and cause a threat to external validity. Even though there was a random selection of subjects, we can't confidently assure the generalizability of the results of this current due the fact that those who remained in this study had statistically significant different socio-demographics than those who dropped out. Finally, although a wide range of potentially confounding variables were controlled in this study, the possibility of residual confounding from unmeasured variables such as cortisol levels cannot be excluded.

Despite these limitations, there are two main significant strengths of this study. First, the study of behavioral factors as pathways linking depressive symptoms to obesity measures has received too little attention in the depression-obesity research field. This study helps to fill this gap. Second, the current limited research on behavioral pathways is based mainly on cross-sectional and populations outside US. This present study makes a significant contribution by using a large dataset that includes both black and white men and women with objective measures of BMI. Moreover, this study adds to the literature by considering by using longitudinal dataset and two waves of data that also permitted the examination of mediated-effect stability over time. The prospective meditation analysis also shed light on temporal ambiguity by quantifying mediation association among variables over time.

Implications for practice, research & policy

There are some great potential implications for research, practice and policy as a result of this study. The results of this study highlight the importance of several approaches in health care planning, development and implementation. First, since depressive symptoms are associated with

BMI, WC, lipid profiles and FBG, which are risk factors for CVD development, early detection of depressive symptoms is critical. Mental health promotion should also become a priority in public health strategies in order to have a positive impact on the prevention of CVD. It is projected that by 2020, depression will become the second leading cause of disease (second to CVD) with respect to contribution to the global burden of disease measured by disability-adjusted life years (Reddy, 2010). Therefore, one of the strategies for early detection of depression is to raise public awareness targeting both communities and health care providers. Such strategies may include development of public education on depression and screenings using valid measurement scales, such as CES-D at the community levels. In addition, stress management education and activities should be part of school and community wide health promotion programs, as well as programs in clinical settings. The findings suggest that particular attention should be directed at females since they are at high risk of depressive symptoms and also risk of developing weight gain as a result. In addition, from a clinical perspective, it is also critical that advanced practice nurses be aware of the effects of depressive symptoms on the obesity measures to help deal with one of the major epidemic of the century.

The main finding of my study was that physical activity was the major mediator in the association between depressive symptoms and BMI and WC. From a public health perspective, it is also critical to understand the mechanism through which depressive symptoms influence obesity measures to effectively intervene in reducing weight gain. Healthy People 2020 emphasizes the importance of physical activity; therefore, obesity prevention programs should emphasize the importance of physical activity and should develop community-wide campaigns through community resources such as community centers, schools, work settings and churches and media campaign through a TV channel dedicated to health promotion programs. In addition,

individualized goals for physical activity could also motivate people with depressive symptoms to be engaged in physical activity (Thota et al., 2012).

Although understanding the behavioral pathways is important, educating and promoting physical activity without taking into account the mental health status of the population might be ignoring a large part of the solution to the problem of preventing obesity. In both cross-sectional and longitudinal analyses, depressive symptoms predicted adherence to antihypertensive medication in adults 65 years of age (Krousel-Wood et al., 2010). However, the association between social support and antihypertensive medication adherence was not significant after adjusting for depressive symptoms (Krousel-Wood et al, 2010). Therefore, it is critical to address depressive symptoms and to study the evolving determinants and factors in the development of depressive symptoms in the CARDIA population. The nature of depressive symptoms was not examined in this study, but studying the evolving risk factor or determinants of depressive symptoms may be very helpful in terms of reducing depressive symptoms, which in term may reduce adiposity measures. Evolving determinants of depressive symptoms will a very important topic for future studies.

Future studies should study the moderating effect of perceived social support with better-validated questionnaire. Objective measures should be combined with subjective assessments of physical activity, sleep and multiple dietary factors. In this study, the variance in BMI and WC accounted by fast food and physical activity was very small implying that other factors such as biological or other behavioral may play a role as mediating pathway. This also implies that examining one aspect of a pathway such as behavioral might not be sufficient. Therefore, multi-disciplinary research collaboration may direct its efforts to examine the bio-behavioral

mechanisms that link the association between depressive symptoms and BMI in a more comprehensive and systematic approach.

Conclusion

In conclusion, this study represents an important first step in examining behavioral pathways linking depressive symptoms to body fatness measures. Based on the results of this study, physical activity is a partial mediator in the aforementioned association. However, to prevent obesity, specific attention should be directed at mental health especially depressive symptoms with specific attention to middle aged females since they have higher levels of depressive symptom and the association between depressive symptoms and BMI and depressive symptoms and WC holds stronger in this group. Community-based approaches in screening people for depressive symptoms through public education might help to detect and control depressive symptoms, which may lead to decreased weight gain. Public education, innovative and individualized strategies and counseling on the benefits of physical activity in individuals with depressive symptoms should be encouraged.

Appendix

Figure 4: Histogram of BMI at Year 20.

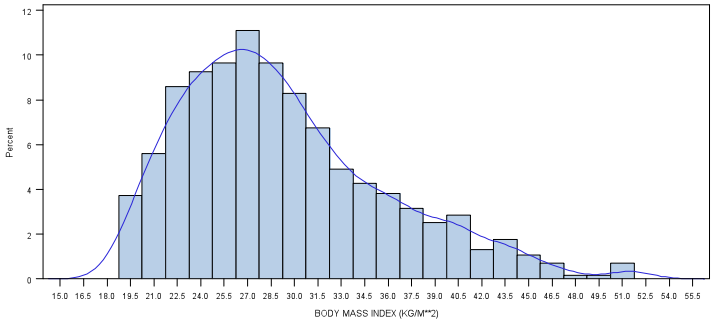


Figure 5: Histogram of waist circumference at Year 20

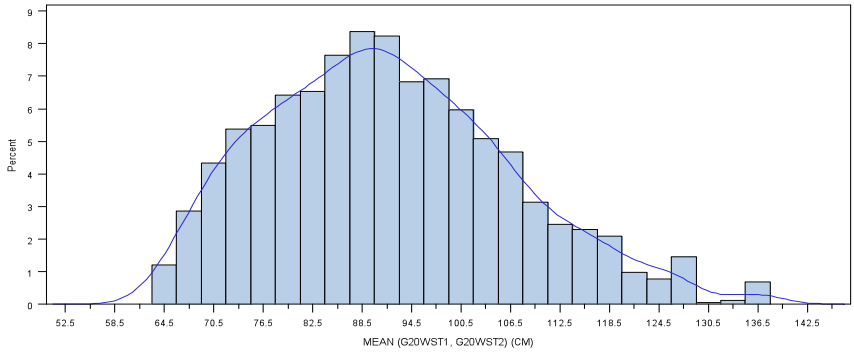


Figure 6: Histogram of DBP at Year 20.

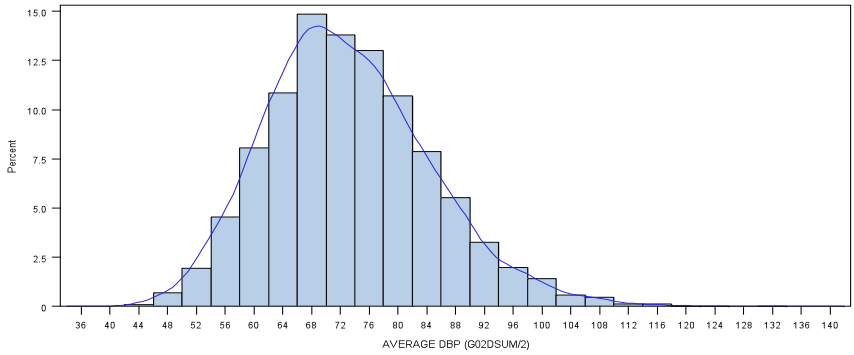


Figure 7: Histogram of SBP at Year 20

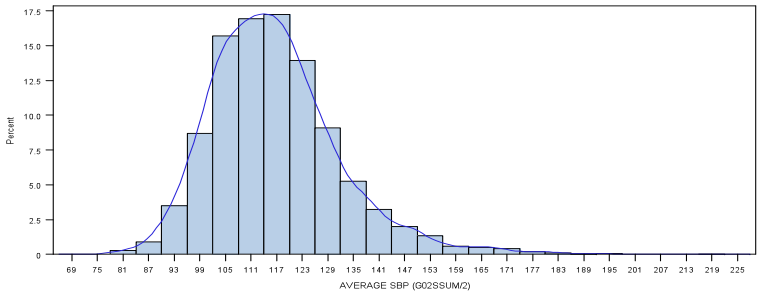


Figure 8: Histogram of Total cholesterol (TC) at Year 20.

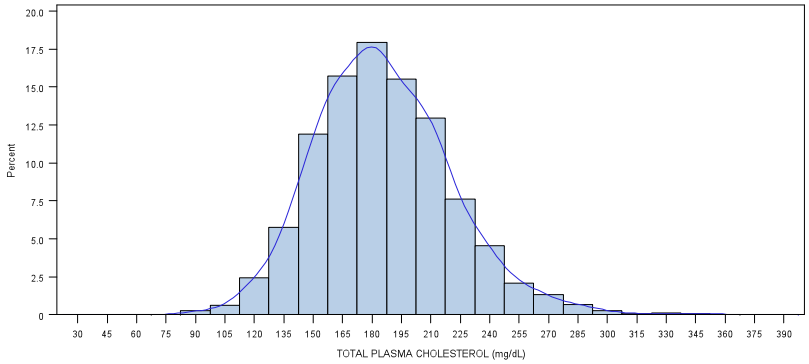


Figure 9: Histogram of triglyceride at Year 20.

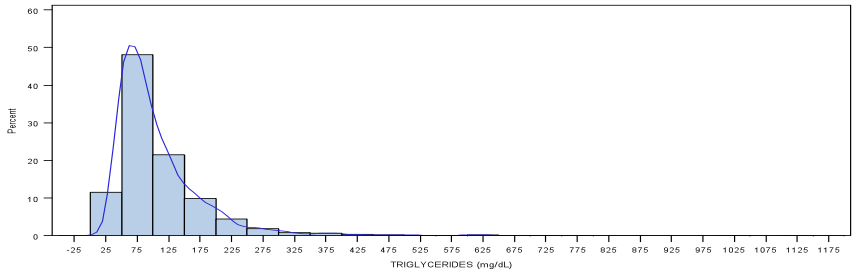


Figure 10: Histogram of LDL-C at Year 20.

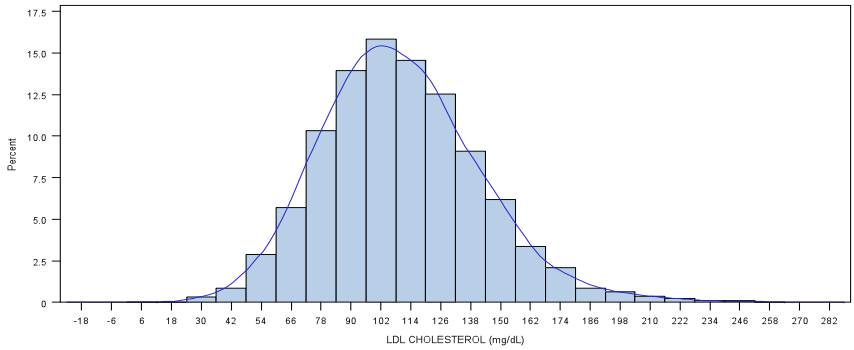


Figure 11: Histogram of HDL-C at Year 20.

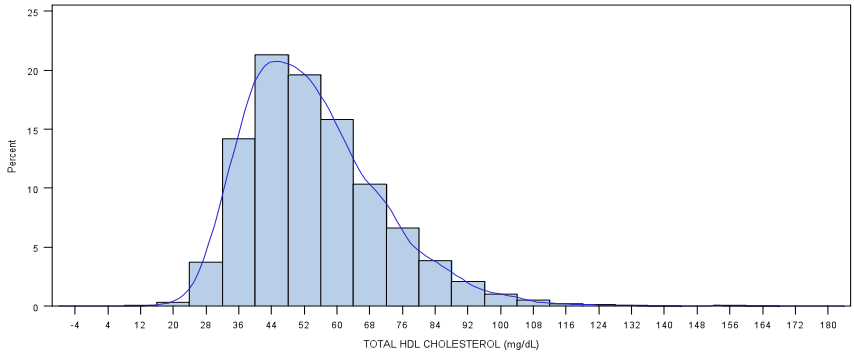


Figure 12: Histogram of fasting glucose at Year 20.

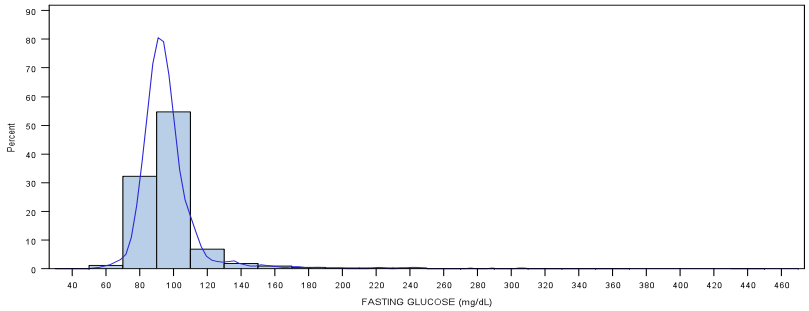


Figure 13: Histogram of BMI after natural log transformation

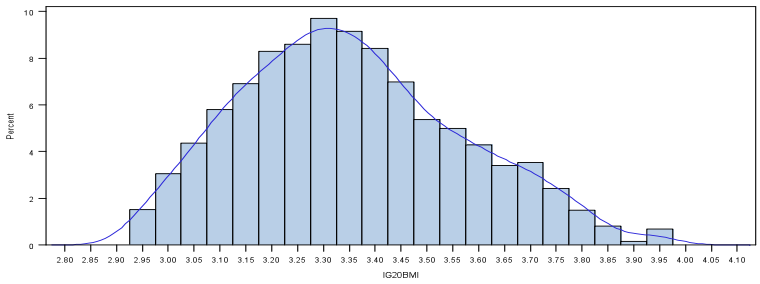


Figure 14: Histogram of waist circumference after natural log transformation.

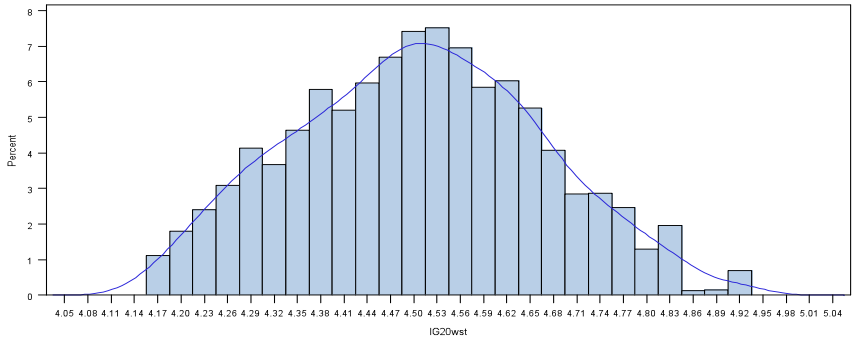


Figure 15: Histogram of DBP after natural log transformation.

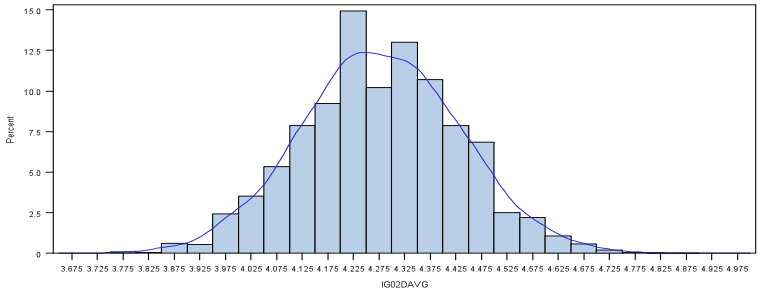


Figure 16: Histogram of SBP after natural log transformation.

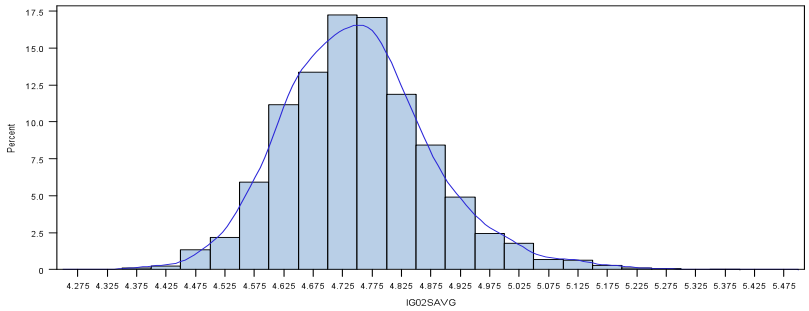


Figure 17: Histogram of triglycerides after natural log transformation.

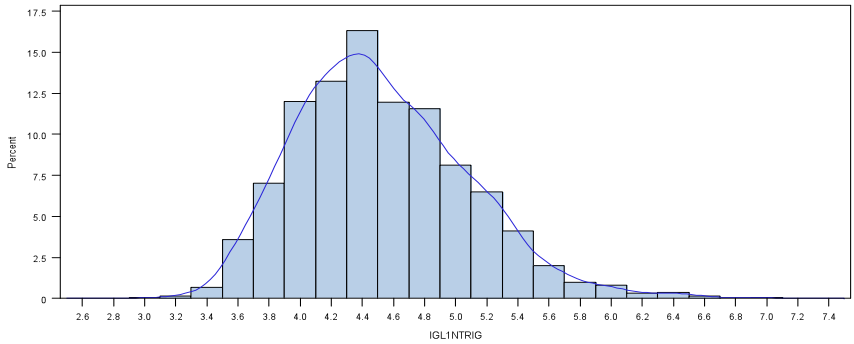


Figure 18: Histogram of HDL after natural log transformation

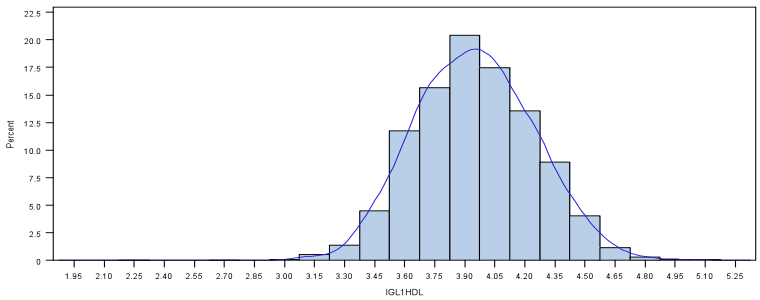


Figure 19: Histogram of triglycerides after natural log transformation.

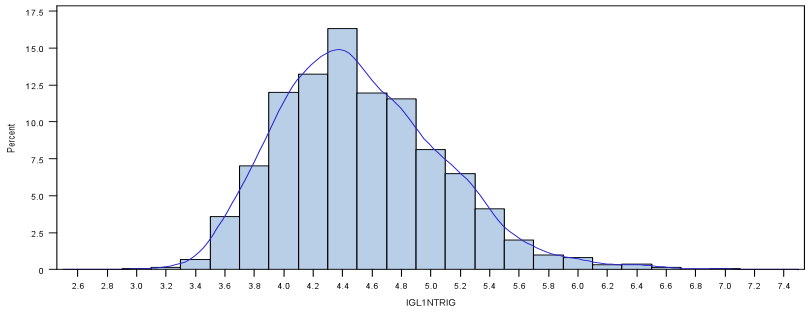
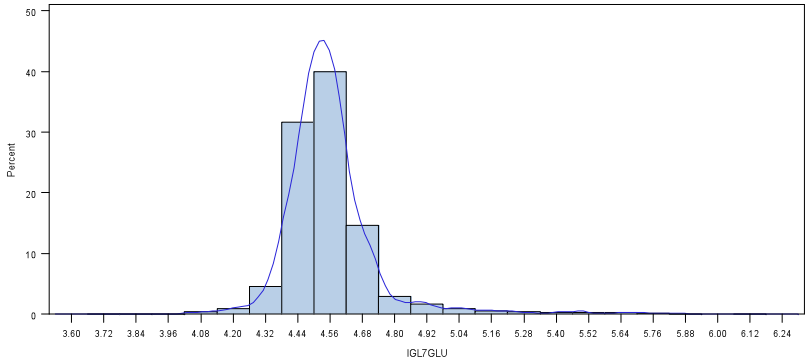


Figure 20: Histogram of fasting glucose afer natural log transformation.



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