DEPRESSION AND ITS RELATIONSHIP TO PHYSICAL ACTIVITY AND OBESITY

A Thesis

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Introduction

Depression

Depression is a common serious mental illness with major health, economic, and social consequences. The World Health Organization (WHO) defines depression as a disorder characterized by sadness, loss of interest or pleasure, feelings of guilt or low self-worth, disordered sleep or appetite, decreased energy and poor concentration (1, 2). Depressive feelings and symptoms can be acute or chronic, often recurrent and can considerably impair an individual's ability to carry out activities of daily living. In its most extreme cases, depression can lead to suicide, accounting for approximately 850,000 fatalities each year (1). The most common form of depression and mental disorder in the United States, Major Depressive Disorder (MDD), is diagnosed when an individual experiences a severely depressed mood and activity level that persists for two weeks or more, and affected 6.4% of the U.S. adult population in 2008 (3). Criteria for classifying types of depression are established by the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) in the United States. Depression impacts people of every age, sex, and ethnic background, with debilitating health care and disability costs. The National Institute of Mental Health (NIMH) reports that in disability-adjusted life years (DALYs), depression is the leading individual disease or disorder in the US and Canada with an estimated 10.3 years lost due to illness, disability, and premature death, more than ischemic heart disease, alcohol use disorders, or pulmonary diseases (4).

Most alarming are the differences in health outcomes and health care costs for individuals suffering from depression and other co-morbidities. Patients with depression have significantly higher mean medical costs when compared to patients without depression, in

every age group and category of medical care, even after adjustment for chronic medical illness. Patients having co-morbid depression with other chronic medical illness have shown an associated amplification of symptoms from physical illness, even when physiologic markers indicate their illness and injury are not as severe as in their non-depressed counterparts. In patients with coronary heart disease and depression, there was a significant association with more symptomatic reports of chest pain and fatigue 5 years later. Due to this amplification of symptoms, physicians are likely to order more testing on depressed patients, leading to increased medical costs. In surgical inpatient populations, patients with co-morbid depressive illness have significantly longer lengths of stay compared with non-depressed controls, also contributing to increased medical costs (5). Depression also decreases patient self-efficacy, increases non-adherence to recommended medical treatment, and increases mortality rates, especially in cardiovascular disease patients (5, 6). Concurrent treatment of major depression with chronic medical illness is associated with improved health outcomes, improved functioning and improved quality of life (1, 5). Given the current environment of health care debate in the United States, providing depression screening and effective treatment is critical to reducing costs while still providing the highest level of care.

Depression can be reliably diagnosed in primary care, and adequate treatment options are available. Pharmacological agents and psychotherapy are effective for 60-80% of patients, but fewer than 25% of those affected with depression receive treatment for their condition. This is due to several factors, including lack of resources, lack of trained health care providers, and the social stigma associated with mental disorders including depression (1, 2, 7). In addition, common side effects from pharmacological treatments, including diarrhea and weight

gain, can counter-indicate their use for therapy and increase non-adherence, especially in at-risk populations (7). Due to the significant costs, lack of availability of care, and associated social stigma, there is an increased need to find alternative, socially acceptable therapies for the treatment of depression.

Obesity

Like depression, obesity is significantly associated with increased risk for chronic diseases, such as type 2 diabetes and cardiovascular disease, and can lead to premature death (8, 9). Obesity in adults is defined by the Centers for Disease Control and Prevention (CDC) as a body mass index (BMI) value calculated from weight and height, of 30 or higher (10). Additional measures of abdominal obesity, such as waist circumference or waist-to-hip ratio can also be used to determine body fat distribution and obesity. The 2007-2008 National Health and Nutrition Examination Survey (NHANES) estimated 34.3% of US adults age 20 or older are obese, with 6.0% in the obesity class III category (BMI ≥ 40) (11). The objective from the Healthy People 2010 initiative by the US Department of Health and Human Services (DHHS) to reduce the proportion of adults who are obese was not met as obesity rates have continued to rise between 2000 and 2010. Thus, a new goal of a 10% reduction in the proportion of obese adults was included in Healthy People 2020 (12). Medical care costs associated with obesity totaled to approximately $147 billion in 2008 in the United States alone (13). There is a demonstrated need for increased access to preventative medicine, improvements in health care, and targeted initiatives in order to begin to have a positive impact on the ongoing obesity epidemic.

In addition to sharing common health complications like cardiovascular disease and

diabetes, studies have shown increased risk of depression in obese populations and increased risk of obesity in depressed populations. The Patient Health Questionnaire (PHQ-9) Depression Screener used by the National Health and Nutrition Examination Survey (NHANES) to evaluate depression includes questions about the frequency of overeating, lack of sleep and physical activity, suggesting several possible common links between the causes of depression and obesity (14, 15, 16). Ma et al. (9) found that when compared to normal weight individuals, obesity is associated with 2.18 times the odds of being diagnosed with major depression, with the highest prevalence of depression in women with class 3 obesity. This suggests a link between increasing rates of obesity and increasing rates of depression. Additionally, they found that women in the highest quartile of waist circumference had 2-3 times the rates of depression compared to women in the lowest quartile. In a longitudinal analysis of the Northern Finland 1966 Birth Cohort study, Herva et al. (8) found that obesity in adolescence was associated with depressive symptoms in adulthood among both male and female subjects. When looking at abdominal obesity, they also found that abdominally obese men had a significantly higher risk for depressive symptoms. Depressed women in the study who used antidepressant medications also demonstrated a significant increase in weight gain, which may lead to worse depressive symptoms (8). Considering the higher medical costs and amplification of symptoms associated with depression, obesity with depression is associated with an additive additional risk for chronic disease, increased negative health outcomes, and higher mortality rates (5, 9, 17). Effective and economical treatment options for concomitant depression and obesity need to be explored in order to reduce overall health care costs, chronic disease rates, and improve health outcomes nationwide.

Physical Activity

One proposed method to treat both depression and obesity is through the use of exercise as therapy. The overall more sedentary lifestyle in the United States may be contributing to increased rates of both depression and obesity, as well as their shared co-morbidities. Several studies have demonstrated exercise as comparable to pharmacological treatment and psychotherapy in treatment of depression, primarily in women (2, 6, 7, 17, 18). Blumenthal et al. (6) showed similar rates of depression remission in groups doing supervised exercise (45%), home-based exercise (40%), or taking antidepressant medication (47%), as compared to a pill placebo (30%) in treatment of major depressive disorder. The only significant difference displayed between pharmacological treatment and exercise is the higher incidence of side effects, such as diarrhea, with the medication. Additionally, exercise treatments provided similar results in both mildly and more severely depressed patients, indicating exercise may be an effective treatment for all levels of depression. In a study comparing home-based and clinic-based exercise interventions by Craft et al. (17), 46.9% of their total sample experienced a ≥50% reduction in depressive symptoms, with 31.3% of the sample achieving remission. Exercise is hypothesized to increase the secretion of β-endorphins by the pituitary gland and hypothalamus. These opiate-like compounds may provide an analgesic effect in the brain and cause general euphoria, reducing anxiety and depression levels similar to an antidepressant medication. Evidence suggests that exercise-induced β-endorphin release and its effects depend on the type of exercise and the population tested (2). Most notable is the fact that in all studies, physical activity does not carry the same social stigmas as pharmacological treatment or psychotherapy, and may serve as a more acceptable, affordable, and readily available

treatment option for depression in the general population (2, 7).

Statement of Purpose

Despite all of its benefits, there is conflicting evidence regarding whether treatment of depression with physical activity varies with respect to intensity, frequency, or by gender. Dunn et al (7) did not show a significant difference between 3 day a week and 5 day a week exercise programs, but did show significantly better results in their high intensity (public health dose) group than in their low intensity group. Simon et al (18) showed a significant decline in mean depression score over 6 months as mean physical activity score increased, but when physical activity declined after 6 months, mean depression scores remained stable rather than declining. It is unclear whether there is a threshold of intensity and regular frequency of physical activity that must be achieved to obtain the needed benefits from exercise to adequately treat depression. In addition, a majority of studies looking at exercise as a treatment for depression have only looked at its effect on women, leading to questions as to whether these results are applicable for men.

This investigation looks at the relationship between depression and physical activity based on frequency and intensity. It also looks at the relationship between depression and obesity in more recent data than previous studies, to see if the relationship remains the same or has changed. If a significant decline in depression scores is noted with increased levels of physical activity (either by frequency or intensity, or both), it may serve as a benchmark with which to base further trials of the effectiveness of exercise in treatment of depression. Future health care treatments and preventative medicine may be adapted to reflect the increased need for exercise therapy in depressed and obese populations, potentially reducing health care costs

and leading to more positive health outcomes. Considerations also may need to be made when treating patients with co-morbid depression and obesity as to whether exercise may be a more affordable, available, and acceptable treatment option for the individual than pharmacological or psychotherapy treatment.

Methods

Purpose and Objective:

The purpose of this study is to identify whether incidence or severity of depression is related to frequency or intensity of physical activity, or both. It also is to identify whether there is a continuing trend in the relationship between depression and obesity.

Research Questions:

1. Assess the current rates and severity of depression in US adults.
2. Explore the relationship between depression and physical activity with respect to frequency and intensity.
3. Explore the relationship between depression and obesity.

Data Source

The data that was analyzed for this study is retrospective data obtained from the National Health and Nutrition Examination Survey (NHANES). NHANES is a continuous national nutrition monitoring study designed to assess the health and nutritional status of adults and children in the United States. It is conducted by the National Center for Health Statistics (NCHS), which is part of the Centers for Disease Control and Prevention (CDC). The NHANES survey is unique because it combines data from both interviews and physical examinations. The interview portion includes demographic, socioeconomic, dietary, and health-related questions,

while the physical examination includes medical, dental, physiological measurements, and laboratory tests, all administered by highly trained medical personnel.

The NHANES program began in the 1960s, and was initially conducted as a series of surveys. In 1999, the survey became a continuous program, where data is collected on approximately 5,000 Americans each year in 15 counties across the country and released in two-year cycles. NHANES uses a stratified, multistage probability sample design and weighting methodology to produce unbiased national estimates of the civilian, non-institutionalized US population. To do this, NHANES oversamples difficult to reach groups including low income populations, individuals who are age 60 or older, African-Americans, and Hispanics. Interviews are conducted in the participants' homes, and further interviewing, health measurements and physical examinations are conducted in specially designed and equipped mobile examination centers (MEC, 19).

Subjects

We examined data from individuals aged 18 years and older in the NHANES 2007-2008 samples. We excluded anyone under the age of 18 and pregnant women. For individuals to be included they must have completed the information in the survey regarding age, weight, height, body measures, depression, and physical activity (n=5392).

Depression Screener

The questions used in NHANES Depression Screener Questionnaire (DPQ) are taken from the Patient Health Questionnaire (PHQ), a version of the Prime-MD diagnostic instrument. The PHQ is a self-reported assessment based on the nine DSM-IV signs and symptoms of depression, outlined in Table 1. Each of the nine symptom questions is rated by the participant from "0" (not at all) to "3" (nearly every day). A tenth follow-up question asks about how difficult everyday activities are to accomplish because of depressive symptoms. The PHQ has been shown to be a reliable and valid tool for the diagnosis of depression. The symptom score is calculated as the total of all nine items (possible score of 0-27), with a score of ≥10 indicating a moderate to severe level of depressive symptoms. Further evidence-based delineation of depression severity is noted in Table 2 (14, 15, 16).

Depression Screener Questionnaire
Nine Signs & Symptoms of Depression
• Lack of interest or pleasure
• Feeling down, depressed, hopeless
• Sleeping too much or too little
• Feeling tired or lack of energy
• Poor appetite or overeating
• Feelings of failure
• Difficulty concentrating
• Slow or restless movements
• Thoughts of suicide or self-harm

Table 1. The DPQ / PHQ-9 depression assessment topics.

Total Score	***Depression Severity***
5-9	**Mild Depression**
10-14	**Moderate Depression**
15-19	**Moderately Severe Depression**
≥20	**Severe Depression**

Table 2. PHQ-9 Score interpretation

<u>Physical Activity</u>

Physical activity data from NHANES provides detailed information about a variety of specific leisure time activities participants reported such as bicycling, walking, and jogging. This data was collected in their home through a self-reported questionnaire using an interviewer-administered computer-assisted personal interviewing (CAPI) system (19). Subjects were asked questions about the activities they performed over the past 30 days. For

each activity, they collected information about the intensity (vigorous or moderate), number of times each, and the typical duration of activity. These results were used to compute the frequency (times per week), and duration (minutes per week) of moderate, vigorous, and total activities.

Body Measures

The body measurement data from NHANES was collected by trained health technicians with a recorder. Measured height and weight were used to calculate body mass index (BMI) by taking weight in kilograms divided height in meters squared (kg/m^2), rounded to the nearest tenth. BMI values were used to classify individuals into weight categories as shown in Table 3. Waist circumference was measured in a horizontal plane around the abdomen at the level of the uppermost lateral border of the right ilium, with measurements recorded to the nearest 0.1 cm (19). A waist circumference measurement is considered high risk at values of >102 cm for males and >88 cm for females (10), which was used as the cut-off point to classify individuals as having abdominal obesity and high risk waist circumference.

BMI (kg/m^2)	Classification
<18.5	Underweight
18.5-24.9	Normal Weight
25.0-29.9	Overweight
≥30	Obese

Table 3. Weight classification based on body mass index (BMI).

Data Analysis

To assess depression severity, we analyzed the proportion of individuals with depression based on established PHQ-9 depression cut-off points shown in Table 2, with moderate to severe depressive symptoms established at PHQ-9 scores ≥10. A frequency analysis was used to determine the number of respondents with each individual symptom. The average number of symptoms was determined by taking the mean (Research Question 1).

Mean differences in the frequencies and durations of moderate, vigorous, and total physical activity were calculated. We compared the mean differences in each category of physical activity by the presence or absence of moderate to severe depressive symptoms (PHQ ≥10) using a t-test. Statistical significance were established at $p<0.05$ (Research Question 2).

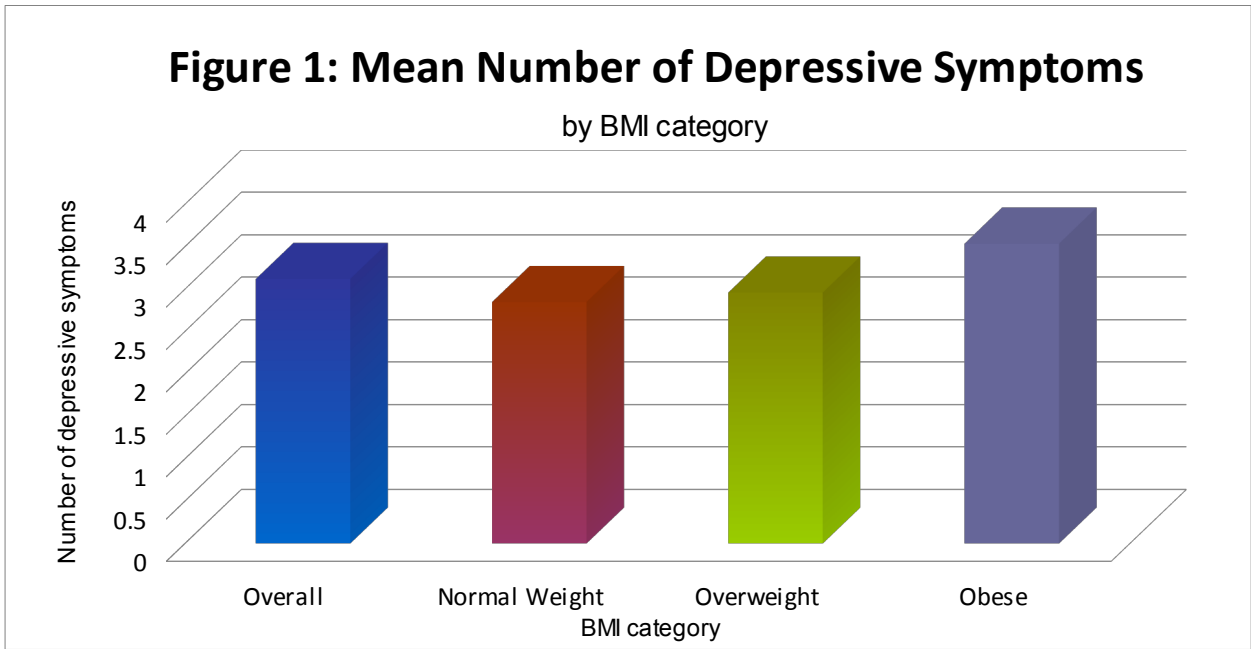
We assessed the relationship between obesity and depression two ways. Using t-tests we compared mean BMI values by depression status (PHQ ≥10 indicating moderate to severe depressive symptoms), and separately compared mean waist circumference by depression status. We also used a chi square analysis to compare BMI categories of weight status (as shown in Table 3) with existence of high risk waist circumference and depression status (PHQ ≥10, Research Question 3).

Data was prepared and tabulated using SPSS (version 19.0, IBM SPSS Inc, Chicago, IL). To account for the complex sampling design used for subject selection and the oversampling of target populations, data analyses were conducted using the SPSS Complex Samples module (version 19.0, IBM SPSS Inc, Chicago, IL). This allows for the results to represent a nationally-representative sample while also producing sample-based standard errors for statistical testing.

Results

We found a continuing trend that depression severity increases with obesity and higher BMI values. Figure 1 below represents the mean number of depressive symptoms by BMI category, with the highest mean number of symptoms present for obese individuals. Particularly noteworthy was which depressive symptoms were reported by a higher percentage of obese participants: "feeling tired or having little energy" (55%), "trouble sleeping or sleeping too much" (43%), "poor appetite or overeating" (28%), and "little interest in doing things"

(26%). The only depressive symptom which was reported more frequently by a BMI group other than obese was the overall rating of "difficulty these problems have caused" by 28% of overweight respondents versus 26% in the obese category. Figure 2 below shows the overall distribution of symptoms reported by BMI category. A higher proportion of obese individuals were found to have depression in all depression categories except for severe (mild, moderate, moderately severe, and PHQ-9 ≥10) as can be seen in Table 4 and Figure 3. Severe depression was found in the same proportion in overweight and obese individuals, but still increased over normal weight individuals. These findings suggest that depression is related to obesity, and that increasing severity of depression is also related to obesity. Overall, 8.1% of participants were found to have moderate to severe depression (PHQ-9 scores ≥10) which represents about 15.9 million Americans.



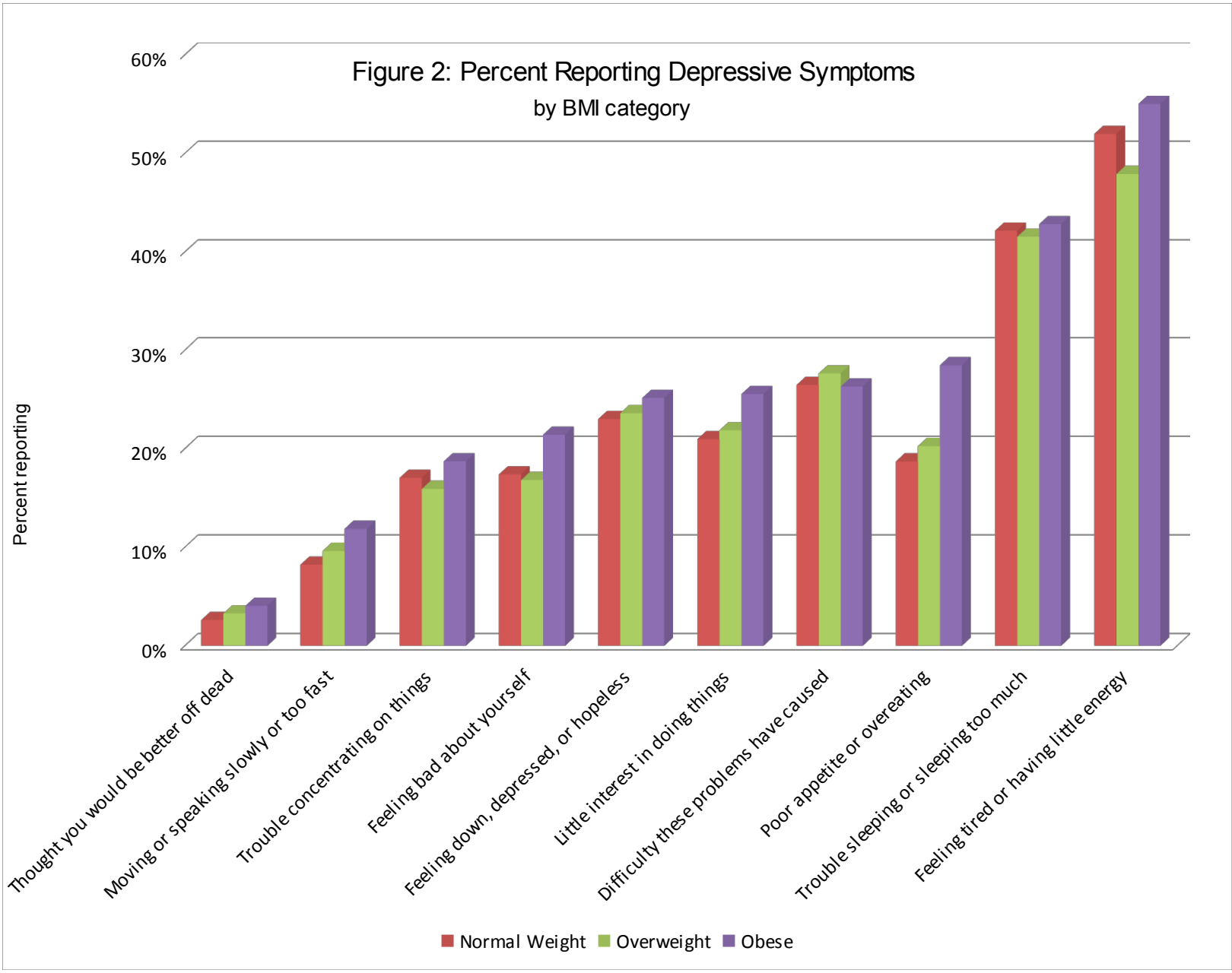
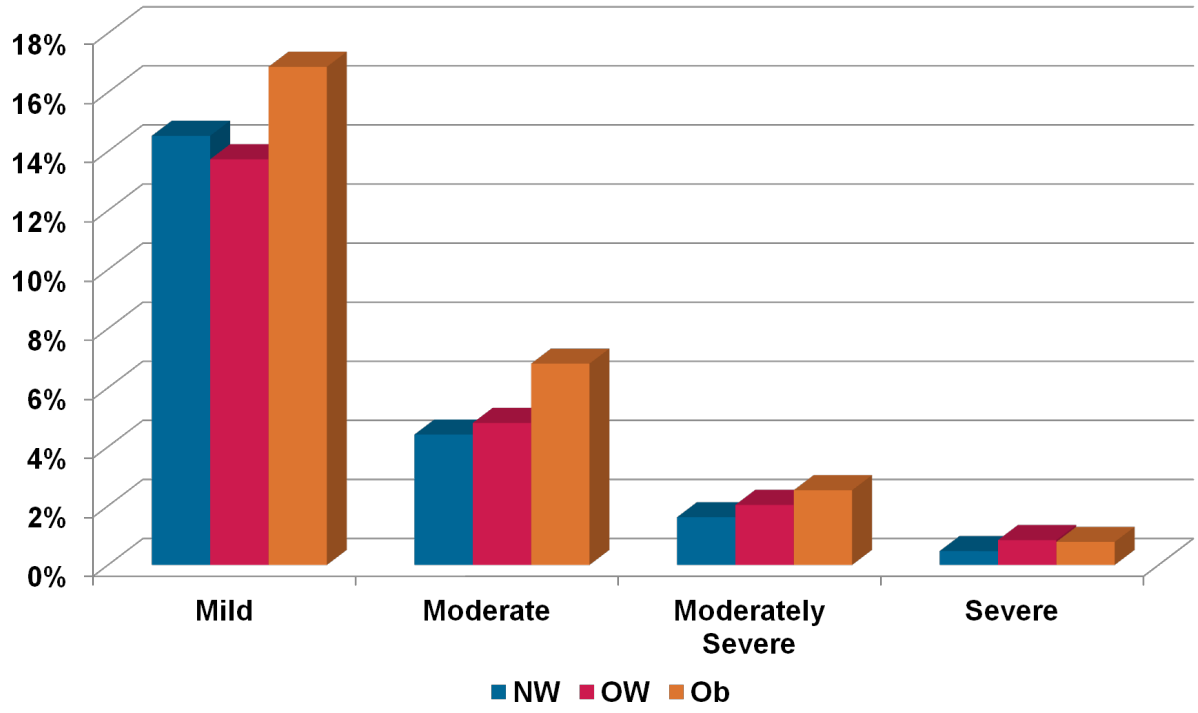


Figure 2: Percent Reporting Depressive Symptoms
by BMI category
Percent reporting
60%
50%
40%
30%
20%
10%
0%
Thought you would be better off dead
Moving or speaking slowly or too fast
Trouble concentrating on things
Feeling bad about yourself
Feeling down, depressed, or hopeless
Little interest in doing things
Difficulty these problems have caused
Poor appetite or overeating
Trouble sleeping or sleeping too much
Feeling tired or having little energy
Normal Weight
Overweight
Obese

Figure 3: Proportion with Depression By BMI category



Lack of physical activity appears to be related to depression as evidenced by several of the most common depressive symptoms which would limit the amount of physical activity done. Our analysis of the physical activity data supported this relationship, as mean days and minutes of both moderate and vigorous recreational activities were significantly higher ($p<0.001$) in individuals without the presence of moderate to severe depression (PHQ-9 <10). Table 5 and Figure 4 also show that total minutes of physical activity per week were significantly lower in moderate to severe depression. Surprisingly,

Table 4: Proportion with depression by BMI category		BMI category		
		Normal Weight	Overweight	Obese
Depression Category	Mild	15%	14%	17%
	Moderate	4%	5%	7%
	Moderately Severe	2%	2%	3%
	Severe	0%	1%	1%
Depression Category (PHQ-9 score)	<10	94%	92%	90%
	10+	6%	8%	10%

minutes of sedentary activity per week were found to be lower in the presence of depression, but the relationship was not significant (p=0.443) and the standard error was much higher (SE = 21.4), indicating a high variability in minutes of sedentary activity reported among depressed individuals. Overall, high depression status is related to both decreased frequency and decreased intensity of physical activity.

Figure 4: Mean Physical Activity by Depression Status (p < 0.001)

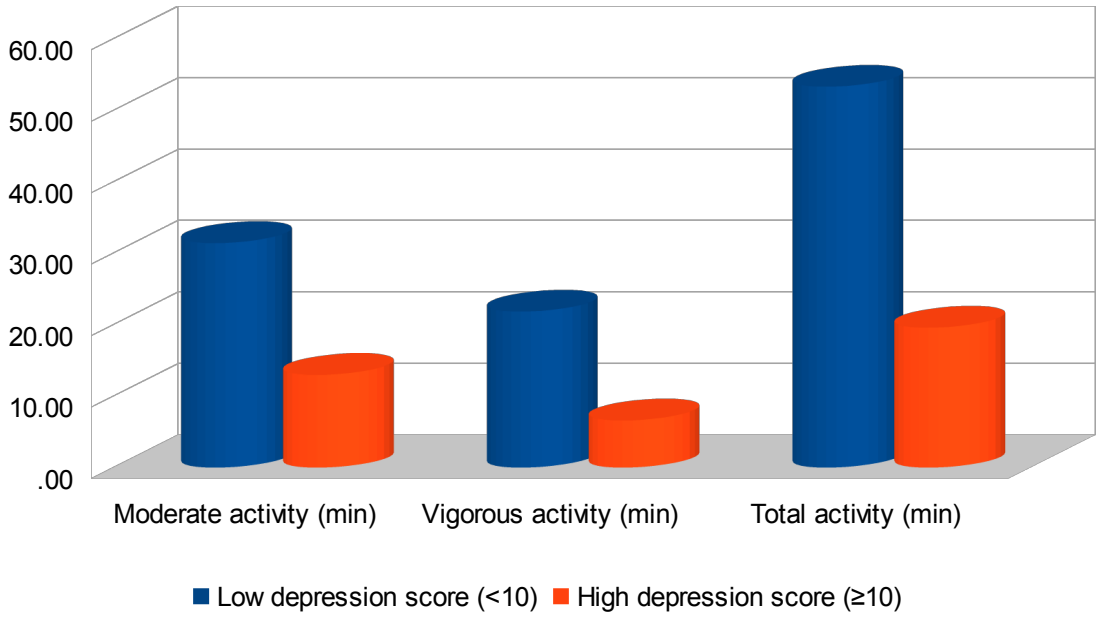


Table 5: Amount of Physical Activity by Depression Status	Total		Low depression score <10		High depression score ≥10		
	Mean	SE	Mean	SE	Mean	SE	P
Days moderate recreational activities	1.45	.066	1.51	.069	.76	.076	<0.001
Minutes moderate recreational activities (per day)	29.93	1.519	31.43	1.533	12.99	1.481	<0.001
Days vigorous recreational activities	.83	.061	.88	.062	.28	.067	<0.001
Minutes vigorous recreational activities (per day)	20.60	1.368	21.84	1.351	6.61	1.677	<0.001
Total physical activity (minutes/day)	50.5645	2.62007	53.3146	2.59177	19.5927	2.78184	<0.001
Minutes sedentary activity (per day)	348.30	7.895	349.85	8.540	330.86	21.408	0.443

Our comparison of mean BMI and mean percentage of waist circumference risk found a continuing trend of both obesity and abdominal obesity in the presence of moderate to severe depression. Table 6 demonstrates that the mean BMI for depressed individuals was >30 kg/m^2, which indicates obesity, and mean percentage of waist circumference was at 110% above the cutoff values for abdominal obesity. The presence of moderate to severe depression status was a predictor of higher BMI and higher percentage of waist circumference risk, with all p-values being significant ($p<0.001$).

Table 6: BMI and Waist Circumference Risk by Depression Status	Total		PHQ-9 <10		PHQ-9 ≥10		
	Mean	SE	Mean	SE	Mean	SE	P
Body Mass Index (kg/m^2)	28.7	0.2	28.5	0.2	30.3	0.4	<0.001
Percentage of Waist Circumference risk	103.7	0.5	103.1	0.5	110.2	1.0	<0.001

Discussion

In this study, we hypothesized that the incidence and severity of depression is related to obesity. Our results support the trend found in previous research (8, 9) that links both depression and severe depression to increasing rates of obesity. Although the exact mechanism by which this occurs remains unknown, a potential link between the two was also found in the relationship to the amount of physical activity performed. As physical activity levels are increased, weight can be lost, and the outlook for depression status appears to improve.

In a recently published review article by Faith et al. (20) examining prospective studies on the topic, they found good evidence of an obesity-to-depression relationship but did not find consistent evidence to adequately support the depression-to-obesity relationship. Our results support this trend that obesity is associated with depression, with the possibility of a

depression-to-obesity association. Additional prospective studies exploring trends in weight status over time in depressed individuals may be warranted to ascertain if depression status is associated with reduced physical activity levels and obesity later in life.

In the current obesigenic environment of the United States and much of the world, additional research is needed to explore the effectiveness of exercise and dietary interventions in the treatment of depression, especially in cases of co-morbid obesity. The cultural stigma placed on both the obese body image and depression diagnoses also needs to be addressed so that individuals can feel empowered to seek treatment (20). For depressed individuals who have encountered side effects from pharmacological interventions, physical activity in the treatment of depression may be a more acceptable and affordable option which has the potential to considerably decrease health care costs nationwide (7). Obesity is a growing health care concern not only due to increased morbidity and mortality rates, but also because of its relationship to increased rates of depression and more severe depression. With depression comes an even higher incidence of morbidity and mortality and higher health care costs associated with treatment for all conditions (3). Proactive solutions including exercise as a therapy option in both conditions should be taken under serious consideration in future research.

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