

Associations among Depressive Mood, BMI, and Added Sugar Consumption among
Arizona State University Freshmen

by

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ABSTRACT

Although many studies have looked into the relationship between depression and eating behaviors, most have not looked into the interaction between depressive mood, weight status, and eating behaviors; specifically the consumption of added sugars. This longitudinal study examined the relationship between depressive mood and added sugar consumption among college freshmen, and how weight status play a role in this relationship. A web-based survey assessing depressive mood score and added-sugar foods consumption, and height and weight measurements were obtained. A total of 511 participants (aged 18.5 ± 0.4 years; 70.5% females) were recruited at Arizona State University from August 2015 through January 2016. The main outcomes measured were the relationship between depressive mood score and added sugar consumption (tsp/d) within each participants and between mean weight status groups (underweight & “healthy” weight, overweight, and obese). In the study, the mean added sugar consumption was 19.1 ± 11.87 tsp/d. There were no significant association between depressive mood and added sugar consumption within or between freshman students over time. But overall, there was a slightly positive relationship between depressive mood and added sugar consumption across four time points. No significant interaction was found between BMI, depressive mood, and added sugar consumption within each student, but significant differences in the relationship of depressive mood and added sugar between mean weight status groups ($p=0.025$). Each individual’s BMI in the previous time points was significantly negatively associated with added sugar consumption in the current time points (beta = -0.70; $p=0.010$). The results from this study indicates that depressive mood

may not affect added sugar intake in this sample. BMI did not have an impact on the relationship within each student, but have an impact between mean weight status groups, so further studies are needed to continue look at how BMI influences the relationship between depressive mood and added sugar consumption.

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CHAPTER 1

INTRODUCTION

Overview

Depression has been a serious issue among college students. An increasing number of college students have been diagnosed with depression,^{1,2} and reported that depression was seriously affecting their academic performance.¹ A web-based survey in a large public university showed 15.6% of the undergraduates had some degree of depressive or anxiety disorder;³ and in another study, 27.1% of students displayed moderate severity or above level of depression.⁴ Mostly, the depressive mood in college students is derived from academic performance issues,^{5,6} financial and career concerns,^{7,8} roommate issues,⁹ pressure from families and friends,^{10,11} and social problems.¹² Eventually, depression may lead to poor academic performance and learning outcomes,^{13,14} relationship difficulties,¹⁵ poor health,^{16,17} disturbed eating behaviors,^{18,19} and drastic weight changes^{20,21} during college life.

Physiologically, various studies have been conducted on the mechanism of depression and how the neurohormones which induce depression regulate hunger and satiety signals, and therefore, affects food consumption and eating behaviors.²²⁻²⁵ Since freshman students are struggling with weight changes²⁶⁻²⁸ and adapting healthful eating behaviors,²⁹⁻³¹ it brought the question of whether depressive mood would be associated with certain eating behaviors and therefore affecting weight among college freshmen.

Earlier studies have demonstrated that some types of food are related to mood,³² and some have shown that people with dysphoric mood tend to consume more carbohydrates and high added-sugar foods than other types of foods to ease the pain from negative emotions.³³⁻³⁵ The higher carbohydrates consumption could be due to the effect of carbohydrates ingestion on elevating serum serotonin level, which could possibly produce a pleasing mood.³⁶⁻³⁸ The mechanisms of the mood-enhancing role in carbohydrates are well understood.^{32,39,40} Since high added-sugar foods consumptions have been serious concerns among college students,⁴¹⁻⁴⁴ a better understanding of the relationship between depressive mood and added sugar consumption may help to establish useful strategies to cope with depressive emotions and manage poor eating behaviors and nutrition among college students.

However, few research has examined the added sugar consumption among college students related to depression. Studies have shown that high added-sugar foods consumption related to depression in other populations, but the inconsistent results showed either increased⁴⁵ or decreased^{46,47} consumption, and the mechanisms have not yet been determined. If it could be possibly explained, it would be beneficial to further establish coping strategies for depressive mood.

Moreover, obese population, in general, are more likely to be depressed⁴⁸⁻⁵¹ and more likely to increase food intake respond to negative emotions via binge eating and emotional eating.⁵²⁻⁵⁴ Since obesity could potentially affect the relationship between depressive mood and added sugar consumption, weight status is considered a moderator for analysis.

Purpose of study

This study aims to examine the association between depressive mood and eating behaviors (i.e., added sugar consumption) over one academic year among freshman students at Arizona State University. Generally, depressive mood is defined as Dysphoric Mood in the Diagnostic and statistical manual of mental disorders;⁵⁵ In this study, depressive mood is measured as self-reported depressive mood score through the depression meaning scale adapted from American College Health Association-National College Health Assessment.⁵⁶ We examined students who had higher depressive mood scores compared with those who had lower depressive mood scores and how that relates to their added-sugar foods consumption over time, and if BMI moderates this relationship.

Research Questions and Hypotheses

Study aim: Determine how depressive mood is correlated with high added-sugar foods consumption over one academic year among freshman college students living in residence halls at Arizona State University. Examine how weight status moderates this relationship.

Research Question 1: What is the relationship between depressive mood and high added-sugar foods consumption among freshman college students living in residence halls at Arizona State University over one academic year?

H1: When students have higher depressive mood, they will consume high added-sugar foods more frequently compared to when they have lower depressive mood.

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Research Question 2: Does the relationship between depressive mood and high added-sugar foods consumption vary depending on BMI among freshman college students living in residence halls at Arizona State University over one academic year?

H1: The positive association between depressive mood and added-sugar foods consumption will be relatively stronger when BMI is relatively high, as compared to when BMI is relatively low.

Definition of Terms

Dysphoric/Depressive mood:⁵⁵ A manifestation from Major Depressive Disorder and Dysthymia that the subjects feeling sad, empty, hopeless, and loss interest or pleasure in usual activities.

Carbohydrates:⁵⁷ A carbohydrate is a nutrient in food that is converted into glucose, or sugar, to provide the cells of the body with energy. Carbohydrates include foods with

naturally occurring sugars such as whole grains, beans, vegetables and fruits, as well as less healthy foods with added sugars such as cakes, soda and candy.

Added sugar:⁵⁷ Added sugar doesn't contribute any nutrients to the diet and can lead to extra pounds and obesity, which hurts your heart health. Added sugar can be found in soft drinks, candy and a variety of other processed foods.

Obesity/Overweight:⁵⁸ Weight that is higher than what is considered as a healthy weight for a given height is described as overweight or obese. Body Mass Index, or BMI, is used as a screening tool for overweight or obesity. If BMI is 25.0 to 30, it falls within the overweight range. If BMI is 30.0 or higher, it falls within the obese range.

Delimitations and Limitations

Delimitations include that data were collected from freshman college students who lived in residence halls at Arizona State University, and depressive mood was self-reported. So the results may not apply to other college students and depression diagnosed populations. When considering eating behaviors, only consumption of carbohydrates and high added-sugar foods were included, so may not apply to other food consumptions or eating behaviors.

Limitations include that the use of survey as the data collecting tool was subjective and self-reported; thus, leaving errors and bias. The study was dependent on the same subjects over two semesters, so there were some dropouts throughout the study,

which cut down the usable data. Although this study was a longitudinal study, the sample size was distinctive population, which may not be generalized to other populations. The frequencies of food consumption were measured but calories and macronutrients were not measured, so the estimation of high added-sugar foods consumption may not be as accurate.

CHAPTER 2

REVIEW OF LITERATURE

Depression

Depression has been recognized as a mental and physical illness.⁵⁵ From the perspective of physiology, the dysfunction of the neurotransmitters in the brain is explained to be the etiology of depression.⁵⁹ Specifically, it is the dysregulation of the hypothalamic-pituitary-adrenal (HPA) axis, which is responsible for responding external stress.⁵⁹ Cortisol and adrenaline also play important roles in the stress response as these hormones are elevated during stress: cortisol prepares the body to mobilize fat for energy, while adrenaline increases the heart rate, blood pressure and respiration to prepare the body to fight.⁵⁹ The HPA system creates a stressor or a protection for body to a perceived stress and reaches a homeostasis.⁵⁹ If this temporary reaction becomes long-term when the body fails to adjust the HPA system back to the normal state, then depression occurs.⁵⁹ The major cause of depression is the overproduction of cortisol which affects noradrenaline and serotonin level.⁶⁰

From the perspective of the psychology, depression is a maladaptation of a chronic stress response from fear or anxiety by trauma or a belief about a constant real or imagined threat.^{22,59} Nowadays, the increased social expectations in life may cause people to feel more pressured and stressed. The gap between the high expectations and failure to achieve them may lead to negative emotions that contribute to depression.⁶⁰ Depression is still an adaptive affective experience because it is an intention to protect

against perceived threats. However, the intention does not transform into behaviors but becomes a hopeless retreat as negative emotions to adapt and survive in the social environment.^{59,60} Depression is difficult to be reversed because it involves memories embedded in the brain, and it becomes a maladaptive response.⁶⁰

Hence, depression is a complex illness involves both psychological and physiological interactions.

Depression Among College Students

Depression has been a serious issue among college students. Study showed a peak increase rate of depression and new cases of depression occurred during young adulthood.² Young Adulthood is a critical time for a higher risk and vulnerability of depression.²

An increasing number of college students were observed feeling stressed or depressed. A web-based survey in a large public university³ showed 15.6% of the undergraduates and 13% of the graduates had some degree of depressive or anxiety disorders, and 2% reported suicidal ideation. In another study, 27.1% of moderate severity or above level of depression were found in university students.⁴ The American College Health Association¹ reported in 2015 that 14.9% of American college students have been diagnosed with depression within the last year, and 15.4% of the students reported that depression was one of the factors significantly affecting their academic performances. In fact, depressive mood is mostly derived from academic performance issues, financial and career concerns, roommate issues, and pressure from families.^{8,61}

Yet, depression may also lead to poor academic performance and learning abilities, relationship difficulties, poor health,^{8,16} disturbed eating behaviors,¹⁸ and drastic weight changes²⁰ in student's college life.

Without proper processing the stress and negative moods, it may lead to depression,⁶⁰ thus, it is extremely detrimental to the wellness of the students. Although many counseling and prevention programs exist in the community available to the students, many students may not seek help because they self-perceived their depression at relatively low levels.⁶²⁻⁶⁴ A study showed that freshmen were more likely to avoid dealing with their stress. And those avoidant coping strategies were related to the higher level of depression.⁶⁵ Taking these factors into considerations, there is a necessity to seek a way to alleviate these problems in college students. It was reported that various coping methods were practiced by college students: exercising, talking to friends, self-talking, deep breathing, journaling, marijuana use, and listening to music.⁶¹ These studies suggested high prevalence of depression among college students. However, there was no research on explaining how students choose those coping strategies to depression. Thus, further research is needed to explain the mechanism and further develop into systematic recommendations of depression coping strategies for college students.

Weight Gain Among College Students

Freshmen year of college is a critical period of time for transition from high school to college that may involve many lifestyle changes. Research has observed that the lifestyle changes that occur in freshmen year may lead to weight gain, which often is

termed as “freshmen 15” to describe the universality of weight gain at the first year of college.⁶⁶ Many studies in the US examined weight changes among freshman students, and showed a significant prevalence of weight gain.^{26-28,66} Reports from two studies showed that 77% and 70% respectively of the students gained weight during their freshmen year, and the average weight gain was ranged from 1.6 to 3.5 kg.²⁶ Other showed that college freshman students even gained weight at a higher rate than that of average American adult.²⁸ A major factor influenced the weight gain were demonstrated as unhealthful food availability on campus, snacking, late-night eating, eating because of stress/boredom, and food in student dorm rooms.⁶⁷ Thus, poor eating behaviors may one of the important factors contribute to weight gain among college freshmen.

Eating Behaviors Contributes to Weight Gain Among College Students

Freshman student may struggle in adapting healthful eating behaviors, as many college students failed to meet the recommended guidelines for dietary patterns.²⁹ It has been observed that only 33% of the college students ate healthy when stressed.³⁰ For the five major food categories (fruits, vegetables, dairy, grains, and protein) measured in a study, only one-third of the students reported following the recommendations from the Dietary Guidelines for Americans.³¹ Most of the students tend to have an increase in their appetite and choose significantly more types of sweets foods and mixed dishes.³⁰ Sweet foods that were commonly eaten were deserts, chocolates, candy, ice cream, and sweet breads. Mixed dishes were mostly fast foods such as burgers and pizza.³⁰ Snacking and consumption of junk foods accounted for the majority of the unhealthful eating behaviors

that were related to weight gain.²⁷ More studies have shown that sugar-sweetened beverages (SSB) consumption was strongly associated with weight gain and increase in BMI.^{43,68} Some studies suggested that nutrition interventions would have a significant effect on promoting changes in eating behaviors and overall health among college students, including internet-based nutrition education⁶⁹ and nutrition classes.^{70,71} Thus, it may be beneficial to understand the effect of added sugar consumption on weight gain in order to promote healthy weight and overall health among college students.

Depression and Eating Behaviors

The significant prevalence of depression and weight gain among college freshmen has brought the attention on the question of how depression is associated with weight gain. Since eating behavior is one of the important influences on weight, a better understanding of the relationship between depression and eating behaviors may help to establish useful coping strategies for depression in college students. Some studies have already examined the relationship between depression and dietary pattern, and mainly all found out that a healthful dietary pattern may be associated with lower risk of depression, such as a diet with high intake of fruits and vegetables, whole grain, and fish,⁷²⁻⁷⁴ while unhealthy food like processed food and fast food were more associated with greater risk of depression.^{75,76} Other studies showed that depressive symptoms were related to a higher total energy intake and higher sweets intake.^{34,35,77} The mechanism of higher consumption of sweet foods in depressive population was not clearly explained, but some researchers interpreted that it was related to emotional eating.^{78,79} Another study showed

depression was associated with less food intake due to poor appetite.⁸⁰ This result was consistent with one of the diagnose criteria of depressive disorders: loss of appetite.⁵⁵ Other studies also supported that poor emotional well-being such as depression was significantly associated with poor appetite in older adults.⁸¹⁻⁸³ However, few studies have shown poor appetite among depressed college students.

Research showed that depression was related to either higher consumption of certain types of food or, lower intake of food due to poor appetite. But whether is depression lead to these eating behaviors or is a certain eating behavior lead to depression was not clear. Further research needed to explore on the mechanism of the relationship between depression and eating behaviors.

Consistent results showed that the consumption of sugar was highly correlated with depression.^{84,85} Since depression and weight gain have been serious concerns among college students, and the consumption of added-sugar foods may lead to weight gain, it raised the question of how depression is associated with added-sugar foods consumption in college students. Nevertheless, before seeking the answer to this question, the mechanism of food intake in depression needs to be examined in this review of literature.

Mood and Food Intake

There are several mechanisms suggested mood, appetite, and food choices are related. Serotonin, endogenous opioid peptides (EOP), and dopamine levels are explained to be the link between mood and carbohydrates or sweets consumption.

Serotonin is a neurotransmitter that regulated mood. In the mechanism involves serotonin, the tryptophan level increases in the brain when the brain detects the information about the carbohydrate foods. When making food choices, the brain will change the serotonin level to induce carbohydrates craving. The “serotonin-releasing neurons” involves in controlling the mood.³⁸ Because carbohydrates consumption will increase the release of serotonin and have effects on the mood improvement, individuals with negative moods such as depression and anxiety will have greater tendency for carbohydrates craving.³⁶ Although the mechanism suggested that the increase in the serotonin level induced by carbohydrate foods were independent of its sweetness, it was interpreted that the brain automatically connects the sweetness with the serotonin releasing characteristic, and confounds the association between sweetness and pleasant mood.³⁷

Endogenous opioid peptides (EOP) level have been demonstrated by many pharmacological studies that regulates food intake by altering the palatability of food.⁸⁶⁻⁸⁸ Several experimental animal studies further suggest that endogenous opioid peptide activities induced by stress or other negative moods are associated with sweets cravings via a similar effect of analgesia.⁸⁹⁻⁹¹ An antidepressant therapy human study further demonstrated that the relationship between depression and carbohydrates craving via EOP activities.⁹²

Dopaminergic neurotransmission was also suggested to be associated with food cravings, specifically dopamine and glucose correlations.⁹³⁻⁹⁵ Dopamine genes were

related to greater carbohydrates craving,⁹⁶ and they predicted high-calories sweet food intake in depressive symptoms females and obese population.^{97,98}

More studies focused on investigating food craving and mood improvement in depressive populations. An experimental study on carbohydrate craving in depressive disorder patients reported that patients had strong craving for sweets, chocolate, and starch.⁹⁹ Another similar study showed depressive disorder patients felt more active after ingestion of carbohydrates¹⁰⁰ For the depressive obese population, investigators reported that carbohydrates cravers felt less depressed after eating a carbohydrate-rich snack.⁴⁰ Those carbohydrates cravers chose more carbohydrate foods when under mild dysphoric mood, and reported a great mood improvement after ingestion of carbohydrates.¹⁰¹

In summary, mood and food intake are strongly correlated via mechanisms involving neurotransmitters serotonin, endogenous opioid peptides (EOP), and dopamine levels. The depressive mood is associated with consumption of carbohydrates and sweet foods because of the mood-improving factor of those foods. The higher carbohydrates and sweets intake among depressive population could be due to carbohydrates craving induced by serotonin, EOP, and dopamine activities in the brain.

Mood and Appetite

Appetite changes is believed to be associated with changes in mood, which will also affect food intake and lead to weight changes.¹⁰² However, the pattern of appetite change in depressed patients are inconsistent, with 66% reporting decreased appetite, 14% reporting increased appetite, and 20% reporting no change in their appetite.¹⁰³

Appetite change in either increased or decreased direction is associated with a more severe degree of depression.¹⁰⁴ However, there is no association between weight change and severity of depression.^{104,105} It was pointed out that many complex factors involving in the eating behaviors of depression, and the emotional influence “restraint” could be one factor that controlled eating in some individuals.¹⁰⁶ When depressive mood acts like a stressor, the individual tend to increase appetite and overeat.^{106,107} However, one of the diagnostic criteria for depressive disorders is loss of appetite.⁵⁵ Other findings suggested that changes in appetite and weight may be more associated with previous appetite and weight history.¹⁰⁴ Thus, the manifestation of either loss or increased appetite may depend upon the previous eating behaviors of the depressed individuals. Further investigation needed on the mechanism behind. It was also reported that females, younger adults, obese population and mildly depressed patients were more likely to have increased appetite.^{103,104,108} An experimental study also showed that increased food intake in response to stress was more associated with obesity.¹⁰⁹

Changes in hunger and satiety signals are involved in appetite regulation in depression. Neurohormones of cortisol, leptin, and ghrelin will respond to stress and exhibited different level changes.²³ The suggested mechanism is hypothalamic-pituitary-adrenal (HPA) axis-leptin interaction that mediates appetite and weight changes in chronic depression.¹¹⁰ However, the changes are inconsistent among different studies. One found out that leptin level increased in response to stress,²³ the other suggested that increased serum leptin and cortisol level are positively correlated with perceived stress from academic performance in university students.²⁴ Higher leptin levels also observed in

obese adolescents who were depressed.¹¹¹ While, among Japanese working population, higher leptin levels showed lower odds for depressive symptoms, but higher ghrelin levels showed higher odds with depressive symptoms.¹¹² Other studies also observed lower leptin level among the depressive populations.^{113,114} However, it was observed moderate to severe depression who also had higher BMI had higher leptin levels, but after adjusting for BMI and waist circumference, no association exhibited. Thus, they explained that the association between depression and leptin seems to be mediated by increased adiposity and BMI.¹¹⁵

Although appetite is thought to be one of the factors involving in the process of regulating food intake in depression, the studies revealed very inconsistent results on the neurohormones levels regulating appetite in depression. It certainly depends on the subjects, the severity of depression, and other physiological and psychosocial factors. The manifestation of changes in appetite was also inconsistent, and may be related to the previous eating behaviors, gender, age, and weight of the subjects. Thus, further investigation needed to learn more about the mechanism behind the appetite-depression relationship and further investigate the relationship between depression and food intake.

Added Sugar Consumption

According to the 2015-2020 Dietary Guidelines for Americans,¹¹⁶ added sugars are defined as “syrops and other caloric sweeteners used as a sweetener in other food products, including brown sugar, corn sweetener, corn syrup, dextrose, fructose, glucose, high-fructose corn syrup, honey, invert sugar, lactose, malt syrup, maltose, molasses, raw

sugar, sucrose, trehalose, and turbinado sugar. During food processing or preparation, added sugars are incorporated into foods and beverages to improve palatability and to extend the shelf life of products.” It was recommended by the 2015-2020 Dietary Guidelines for Americans¹¹⁶ that no more than 5-15% of total calories should come from added sugars. However, the data from the 2005-2010 National Health and Nutrition Examination Surveys (NHANES)¹¹⁷ showed that men consumed average of 12.7% added sugars of their total calories, and 13.2% in women, and 16% in children and adolescents.¹¹⁸ About 67% of the calories from added sugars came from foods, and 33% came from beverages in adults (20 years old and above);¹¹⁷ while, 40% of calories from added sugars came from beverages in children and adolescents (younger than 20 years old).¹¹⁸ All these data above brought our attention on the overconsumption of added sugars among the American population, and sugar-sweetened beverages consumption among adolescents.

Added Sugar Consumption Among College Students

Correspondingly, sugar-sweetened beverages (SSB) and soft drinks consumption have been serious concerns among college students.⁴¹⁻⁴⁴ Soda was the most common sugar-sweetened beverage reported, and younger undergraduates reported higher intake of sugar-sweetened beverages than older students.⁴¹ This result indicated that freshman students may have a higher intake of sugary foods than older students, and these foods are more likely to contribute to weight gain among them. Similar studies have also demonstrated that increased consumptions of sugar-sweetened beverages were strongly

associated with increased BMI and obesity.^{43,68} Moreover, higher added sugar intake is associated with lower physical activity among young adults.¹¹⁹ Excessive added sugar consumptions are not only concerned with weight gain, but also concerned with series of metabolic diseases such as metabolic syndrome, type 2 diabetes, and coronary heart disease.^{120,121} On the bright side, although growing numbers of adolescents are concerned with high added sugar consumption, a substantial number of students also reported that they had recently reduced their intake or maintained reduction intake of sugar-sweetened beverages.⁴² Students may have been acknowledged the disadvantages of added sugar intake in the diet, but they are concerned with overcoming different barriers to reduce their intakes. Lack of research has identified the barriers related to reducing added-sugar food consumption among college students. From the economic perspective, one study indicated that lowering the cost of alternative healthy choice of beverages may foster the reduction in purchasing unhealthy beverages among college students.¹²² However, no research indicated psychological and social barriers to reduce added sugar consumption. Thus, further research needed to discern psychological and behavioral characteristics associated with high added sugar consumption in adolescents so that some related changes can be made to mitigate the concerns and overcome the barriers to healthy eating behaviors.

Sugar Consumption and Depression

It has been already known that negative mood may be associated with consumption of carbohydrates and sweet foods because of the mood-improving factor of

those foods.³³⁻³⁵ More research has explained how the consumption of high sugar foods have an impact on psychological and behavioral characteristics related to depression.

Although research has shown that patients with depression were more likely to consume sugars compared with those without depression,⁴⁵ in some other cases, less consumption of sugars showed to be mitigating the progress of depression.^{46,47} A case study reported that changing diet to have adequate amount of protein, and gradual elimination of sugars, caffeine, and simple carbohydrates foods had an impact on decreasing psychological symptoms of depression.⁴⁶ Another study utilized a refined sucrose-free and caffeine-free diet as a treatment for depression, and it demonstrated to be more effective on declining major depression on all depression measures and several measures of general psychopathology, and the amelioration of depression was maintained at a 3-month follow-up.⁴⁷ Furthermore, frequent consumption of sugar-sweetened beverages may increase depression risk among older adults, whereas coffee and tea consumption without any sweetener may lower the risk.¹²³ Another study demonstrated that take away foods, red meat, and confectionary products (food high in refined sugar, energy-dense, and low in essential micronutrients) were strongly associated with internalizing such as withdrawn and depressed among adolescents,¹²⁴ while micronutrients (folate, vitamin B12, iron, zinc, and selenium) in fruits and green vegetables may prevent depression.¹²⁵ Hence, consumption of high sugar foods may have a negative impact on depression.

Some suggested that sugar consumption may be associated with hyperactivity and other behavioral problems in children and adolescents.^{126,127} In a food belief survey

among university students, many reported that they experienced “sugar high” after sugar consumption, which determined that sugar influenced hyperactivity.¹²⁸ Some research also related sugar content of the diet with hyperactivity, suggesting that high sugar ingestion may promote a colonization in the gastrointestinal tract by common yeast germ *Candida albicans*, which could adversely affect neurotransmission result in depression and schizophrenia.¹²⁹

Nevertheless, sugar consumption may improve athletic, cognitive, and academic performance, and may increase self-control, and reduce aggressive behaviors.¹³⁰ From the perspective that organ activity is influenced by emotions, depression may be associated with low brain functioning due to lack of sugar and oxygen.¹³¹ Thus, an individual who is depressed tend to consume more sugar foods.

In conclusion, consumption of high sugars may help to promote a pleasing and hyper mood and seem to ameliorate the depressive symptoms, but it may, in fact, have a deteriorative effect on the neurotransmission and worsen the depressive symptoms. The mechanisms behind the controversy were not well understood, and studies were mostly focusing on momentary effect of depression or depressive mood on eating behaviors. However, it can be predicted that changes in depressive symptoms may be associated with changes in sugar consumptions for a longer time frame.

Depression, Obesity, and Eating Behaviors

The obese population is considered having a higher rate of depression.⁴⁸⁻⁵¹ Factors include perception of body image, self-efficacy, self-esteem, and other physiological and

psychosocial factors.¹³²⁻¹³⁴ They tend to increase their food intake respond to negative emotions referred as emotional eating¹³⁵ or binge eating.¹³⁶⁻¹³⁹

Depression symptoms are positively associated with adiposity indicators including BMI, waist circumference, and percentage body fat, which is mediated by emotional eating and physical activity self-efficacy (ie, an individual's confidence in his or her ability to overcome barriers to maintaining physical activity behaviors).⁵⁴ It was also suggested that elevated depressive symptoms were related to higher emotional eating and lower physical activity self-efficacy.⁵⁴ These findings strongly indicate that obesity is associated with depressive symptoms, and depressed obese population may have a higher risk of having emotional eating. Other studies had similar findings indicating that depression may be positively related to BMI, which may be mediated by emotional eating.^{140,141} However, the findings in those studies were looking at momentary effect of depression on eating behaviors. Whether the effect of depression on eating behavior is long-term or not need to be explored.

Current studies were controversial on the topic of whether depression lead to weight gain via emotional eating or obesity induces depressive symptoms via other psychosocial factors. On one hand, some research claimed that depression may be account for weight gain or obesity. A longitudinal meta-analysis showed that an increase in the depression level may lead to weight gain or developing obesity in later life.¹⁴² The results also showed a higher vulnerability of obesity in females and adolescents who were depressed.¹⁴² Possible mechanisms are proposed as poor eating behaviors and low energy expenditure.^{79,143,144} Study suggested that chronic life stress such as depression may

induce increased eating and contribute to the development of obesity.¹⁴⁵ The effect of stress on weight gain may be dependent on the nutrient composition of the food, with greater weight gain in high-energy diets.¹⁴⁵ Another study showed that depression related to higher emotional eating, and emotional eating predicted higher BMI independent from depression.¹⁴⁶ These results explained the poor eating behavior mechanism. Moreover, higher vigorous physical activity was observed in women with lower odds of having depressive symptoms.¹⁴⁴ Aerobic activity was found to have an impact on reducing the risk of depression among college students.¹⁴⁷ These findings explained the low energy expenditure mechanism for depression leading obesity claim.

On the other hand, other research has argued that obesity may lead to depressive mood or symptoms.¹⁴⁸⁻¹⁵⁰ From the psychosocial perspective, obese individuals are strongly stigmatized by negative stereotyping and discrimination in the society, which causes negative psychological outcomes, as one of the outcomes is depression.^{151,152} Thus, obese individuals may be more depressed because of the social expectations and environment. However, the proposed “jolly fat” hypothesis, which refers to the belief that obese individuals tend to be happier than non-obese individuals, was examined and proved to be valid in many studies.^{150,153,154} But the causes were unclear.

All in all, weight status plays an important role in the relationship between depression and eating behaviors. In previous literature, it was suggested that highly stressed or depressive mood are associated with high consumption of carbohydrates and sweets. Since added-sugar foods consumption contribute to weight gain,^{155,156} and obese population may have a higher rate of depression, weight status may have an impact on

both depression and added sugar consumption. Thus, weight status is considered as a moderator for analysis.

Summary

This review of literature has examined the relationship between depression or depressive mood and eating behaviors (i.e., added sugar consumption), and the role of weight status in the relationship, focusing on the college student population. Since research has shown varied results towards the relationship between depression or depressive mood and added sugar consumption, more research is needed to determine the mechanism behind the relationship. Special consideration should be given to the freshman college students because of the high prevalence of depressive mood and high added sugar consumption. Higher rates of depressive mood are observed among obese population. Weight status may have an impact on both depressive mood and added sugar consumption and have a moderating effect on the relationship between depressive mood and added sugar consumption.

CHAPTER 3

METHODS

Participants

Freshman students aged 18-20 and lived in six resident halls were recruited from Arizona State University via sending email, flyers, and on-site recruitment. Resident Life Resident Assistants (Community Mentors and Community Assistants) from each residence hall helped to facilitate recruitment. Recruitment began in August 2015 through January 2016. All eligible subjects were included for the SPARC (Social impact of Physical Activity and nutRition in College) study¹⁵⁷ and provided written informed consent. At the consent visit, subjects were given a description of the study including study purpose and what data will be collected, possible risks and benefits, and confidentiality of the study. Investigators were present to answer any questions and concerns. The study received approval by the Arizona State University Institutional Review Board.

Study Design

This study was a secondary analysis of the SPARC longitudinal cohort study,¹⁵⁷ which aimed at assessing the nutrition and physical activity behaviors of college freshmen, and conducted over one academic year (9 months).

All the participants completed web-based surveys with questions on demographics, dietary, physical activity, and weight. The web-based surveys took 25 to

30 minutes to complete. Anthropometrics measurements and web-based survey data were collected at four time points during the academic year (at the beginning and end of each semester on the month of August, November, January, and April). The questions on the survey included questions demographics, level of depressive mood, and frequency of added-sugar foods consumption, which were the main focus questions for current secondary analyses. Height and weight were measured by trained research staff using Seca scales and stadiometers to track changes in body mass index.

Measures

Depressive mood (independent variable):

The measure of depressive mood used was adapted from the survey questions from the American College Health Association-National College Health Assessment II.⁵⁶ The questions were framed as “how often in the past 1 month have you felt: things were hopeless?”, “very lonely?”, “very sad?”, and “so depressed that it was difficult to function?”. The response options were “never”, “rarely”, “sometimes”, and “often”. In order to combine all the items into a scale, cronbach’s alpha was calculated to determine the internal consistency between the questions and the reliability of the scale. The cumulative cronbach’s alpha for the four items were 0.889. The level of depressive mood was coded to the scale of 1-4, as 1 be the lowest and 4 be the highest. Students given the responses at the four web-survey time points.

Added-sugar food consumption (dependent variables):

In the web-based survey, a validated 26-item Dietary Screener Questionnaire (DSQ) was used to assess the frequency of the consumption of key food items and groups. This tool was developed by the National Cancer Institute of NIH,¹⁵⁸ and has been used in the 2010 National Health Interview Survey Cancer Control Supplement.¹⁵⁹ This tool helped to track and estimate individual's food consumptions of major food groups (dietary factors), which included consumptions of added sugars and sugar-sweetened beverages analyzed in this study.¹⁶⁰ Adapted from the food items listed in the added sugar dietary factors, the questions were “during the past month, how often did you eat/drink: regular soda?”, “100% pure fruit juices?”, “coffee or tea had sugar or honey added?”, “sweetened fruit drinks?”, “sports drinks?”, “energy drinks?”, “chocolate/candy?”, “doughnuts?”, “cookies/cakes/pie?”, and “ice cream?”. All the food items were considered either “added sugars” or “added sugars from sugar-sweetened beverages” from the Dietary Factors and Food Items on the DSQ.¹⁶⁰ The responses were determined as “never”, “1 time last month”, “2-3 times last month”, “1 time per week”, “2 times per week”, “3-4 times per week”, “5-6 times per week”, “1 time per day”, “2-3 times per day”, “4-5 times per day”, “6 or more times per day”, and recorded as frequency per week. Students given the responses at the four web-survey time points. Then, the frequency responses were converted to added sugar teaspoon equivalents (tsp/day) by using the DSQ scoring algorithm to estimate the mean intakes of the individuals.^{161,162} The scoring procedure was developed by using the DSQ and What We Eat in America 24-hour dietary recall data from the 2009-2010 NHANES.¹⁶²

Weight Status

Anthropometric measurements were measured by trained research staff. Weight was measured to the nearest 0.1kg, and height was measured to the nearest 0.1 cm. Participants were asked to remove any outer layer of clothing (e.g., jacket, sweater, hat) and shoes, undo any hairstyle that sits higher than the top of the head (e.g., sock bun, headband with bow), and empty their pockets. Measurements of weight and height were collected with a Seca scale and a stadiometer respectively. BMI was calculated with the following formula from these measurements: $\text{weight (kg)} / [\text{height (m)}]^2$.

Demographics

Data on age, gender, race/ethnicity, Pell grant status, sugar restriction status, and current residence halls were collected from the web-based survey. Age was determined from the question asking “what is your birthdate?”. The response was determined as the participant’s date of birth. Students was asked “What is your gender?”, and responses defined as “male”, “female”, and “transgender”.⁵⁶ Students were asked “How do you usually describe yourself?”, and response options were “White”, “Black or African American”, “Hispanic or Latino/a”, “Asian or Pacific Islander”, “American Indian or Alaska Native”, “Some other race”.⁵⁶ Students were asked “are you a Pell Grant recipient?”, and responses defined as “yes”, “no”, or “I do not know”. Students were asked “Which of the following foods do you currently avoid or abstain from eating on a regular basis?”, and one of the choices was “added sugar”. Students were also reported

which resident halls they currently lived in. All the demographic data collected at baseline.

Statistical Analyses

Bivariate analysis between depressive mood, demographics, and added sugar consumption were examined at phase one. T-tests were used to compare the gender difference, Pell grant status, and resident hall difference in BMI, depressive mood, and added sugar consumption. ANOVA was used to compare race/ethnicity difference in BMI, depressive mood, and added sugar consumption. Pearson correlation coefficient was calculated for the relationship between BMI, depressive mood, and added sugar consumption for four time points. Correlations of BMI and depressive mood in the previous time points with added sugar consumption in the next time points were also calculated. Mixed linear regression models were used to examine the relationship between depressive mood and added sugar consumption as well as the moderating effect of weight status in the relationship over an academic year, adjusting for gender, race/ethnicity, Pell grant status, sugar restriction, and the clustering of students within resident halls. The mixed models were used to examine both with and without the time-lagged effect of BMI and depressive mood on added sugar consumption. Other predictors in the mixed models included demographics, within-person/person-mean centered key variables, and between-person/grand mean key variables. The person mean-centered variables were computed by subtracting the person's mean from the observed value at each time point. Similarly, the grand mean-centered variables were computed by

subtracting the sample mean from each person's mean. IBM SPSS Statistics 23.0 (IBM Corp. Armonk, NY) was used to complete the analyses; statistical significance was set at $p < 0.05$, with 95% confidence intervals.

CHAPTER 4

DATA AND RESULTS

Descriptive Characteristics

A total of 511 freshman students were included in these analyses (Table 1). There were more females (70.5%) than males in the sample; the mean age was 18.5 years (± 0.44). The sample was racially/ethnically and economically diverse with 52.6% non-White participants, 36% Pell Grant recipients. The mean BMI of the students was 24.2 kg/m² (± 4.99). The mean depressive mood score was 1.92 (± 0.80). The mean added sugar consumption was 19.1 tsp/day (± 11.87).

Table 1: Study Participant Demographics at Baseline

<u>Variables</u>	<u>Total</u> n = 511
Gender <i>n</i> (%)	
Female	360 (70.5%)
Male	151 (29.5%)
Age <i>mean</i> \pm <i>SD</i>	18.5 \pm 0.44
Race/Ethnicity <i>n</i> (%)	
Black or African American	63 (12.3%)
Hispanic/Latino	123 (24.1%)
Other	83 (16.2%)
White/Caucasian	242 (47.4%)
Pell Grant Status <i>n</i> (%)	
Yes	184 (36.0%)
No	327 (64.0%)
Resident Halls <i>n</i> (%)	
A	282 (55.5%)
B	229 (44.8%)
BMI* <i>mean</i> \pm <i>SD</i>	24.2 \pm 4.99

Depressive Mood* <i>mean ± SD</i>	1.92±0.80
Added Sugar Consumption (tsp/d)* <i>mean ± SD</i>	19.1±11.87

*Sample size varies slightly due to item missingness.

Unadjusted Bivariate Analysis and ANOVA Results

No significant correlation was observed between age and BMI, depressive mood, or added sugar consumption (Table 2). A significant difference in BMI was observed among four different ethnicity groups ($p=0.018$) and Pell grant status ($p<0.001$). The Hispanic group had the highest mean BMI among all the other race/ethnicity groups. Students who received Pell grants had statistically significantly higher BMIs than those who did not receive Pell grants. Gender differences and Pell grant status differences found in depressive mood. Females (1.97 ± 0.04) had slightly higher depressive mood score compare to males (1.81 ± 0.06). Pell grant recipients had higher depressive mood score than non-recipients ($p=0.023$). For added sugar consumption, females (16.8 ± 0.32 tsp/day) had significant lower added sugar intakes than males (24.5 ± 1.53 tsp/day). No significant different observed between two different resident halls for BMI, depressive mood score, or added sugar consumption (Table 2). In ANOVA analyses, Hispanic group was significantly differed with Other group in BMI ($p=0.032$) (Table 3). No other significant mean differences between groups were found.

Table 2: Bivariate Analysis at Baseline Examining the Relationship between Demographics and BMI, Depressive Mood, and Added Sugar

Variables	BMI (n=507)		Depressive Mood (n=510)		Added Sugar (tsp/day) (n=509)	
	Mean±S E	Coefficient and value (p- value)	Mean±S E	Coefficient and value (p- value)	Mean±S E	Coefficient and value (p- value)
Age	-	0.003 (0.951) ^a	-	-0.016 (0.724) ^a	-	0.067 (0.129) ^a
Gender						
Female	24.2±0.27	-0.30 (0.765) ^b	1.97±0.04	1.98* (0.048) ^b	16.8±0.32	-6.96*
Male	24.3±0.38		1.81±0.06		24.5±1.53	(<0.001) ^b
Race/Ethnicity						
Black	25.0±0.62	2.99* (0.018) ^c	1.84±0.07	0.52 (0.718) ^c	21.6±0.90	0.60 (0.665) ^c
Hispanic	25.3±0.45		1.91±0.04		19.3±0.53	
Other	23.2±0.54		2.00±0.05		18.4±0.66	
White	23.8±0.32		1.95±0.03		18.5±0.38	
Pell Grant Status						
Yes	25.6±0.45	-4.70*	2.03±0.06	-2.28* (0.023) ^b	19.3±0.91	-0.34 (0.735) ^b
No	23.4±0.22	(<0.001) ^b	1.86±0.04		18.9±0.65	
Resident Halls						
A	24.4±0.28	-0.86 (0.388) ^b	1.89±0.05	0.91 (0.365) ^b	19.4±0.74	-0.64 (0.526) ^b
B	24.0±0.35		1.96±0.06		18.7±0.74	

a. Pearson correlation coefficient (r) value b. t value of T-test c. F value of ANOVA test
*t-score, correlation coefficient, or F values are significant.

Table 3: ANOVA Analysis at Baseline Examining the Relationship between Demographics and BMI, Depressive Mood, and Added Sugar

Race/Ethnicity	<u>BMI</u> (n=507)		<u>Depressive Mood</u> (n=510)		<u>Added Sugar (tsp/day)</u> (n=509)	
	Mean Difference± SE	p- value	Mean Difference ±SE	p- value	Mean Difference ±SE	p-value
Total	2.994 ^a	0.018	0.524 ^a	0.718	0.597 ^a	0.665
Between groups mean difference:						
Black : Hispanic	-0.40±0.78	0.987	-0.16±0.12	0.717	1.43±1.56	0.891
Black : Other	1.69±0.85	0.268	-0.13±0.13	0.873	1.45±1.68	0.911
Black : White	1.12±0.72	0.523	-0.08±0.11	0.952	2.10±1.42	0.575
Hispanic : Other	2.09±0.72*	0.032	0.03±0.11	0.999	0.02±1.43	1.000
Hispanic : White	1.52±0.57	0.058	0.08±0.05	0.918	0.68±1.12	0.974
Other : White	-0.57±0.64	0.902	0.05±0.06	0.991	0.66±1.28	0.986

a. F value of the ANOVA test.

* The mean difference is significant.

**Unadjusted Correlation Results Examining the Relationship between BMI,
Depressive Mood, and Added Sugar**

The results of correlations between BMI, depressive mood scores, and added sugar consumption is shown in Table 4. Small and inverse relationships were found between added sugar consumption and BMI, but none of the correlation coefficient values were statistically significant. There was a small positive correlation between added sugar consumption and depressive mood at phase one (p=0.035). Two statistically significant, but weak correlations were also found between BMI and depressive mood at phase one (p=0.013) and phase two (p=0.007). Table 5 shows the correlations between key variables considering the time-lagged effect. Very weak negative relationships between added sugar consumption and BMI at previous time points, but none were statistically significant. No other significant findings were observed in the correlations.

Table 4: Pearson Correlation between Key Variables across Phases

	<u>Phase 1</u> (n=505) r (p-value)	<u>Phase 2</u> (n=456) r (p-value)	<u>Phase 3</u> (n=378) r (p-value)	<u>Phase 4</u> (n=339) r (p-value)
Added sugar : BMI	-0.035 (0.427)	-0.010 (0.828)	-0.057 (0.267)	-0.018 (0.744)
Added sugar : Depressive mood	0.094* (0.035)	-0.003 (0.954)	0.082 (0.113)	0.105 (0.053)
BMI : Depressive Mood	0.110* (0.013)	0.126* (0.007)	0.091 (0.079)	0.94 (0.083)

*the correlation coefficient is significant.

Table 5: Time-Lagged Pearson Correlation between Key Variables

	Phase 2 (n=460) r (p-value)	Phase 3 (n=356) r (p-value)	Phase 4 (n=341) r (p-value)
Sugar(t) : BMI (t-1)	-0.009 (0.851)	-0.064 (0.228)	-0.031 (0.564)
Sugar(t): Depressive mood (t-1)	0 (0.992)	0.090 (0.091)	-0.005 (0.926)

Adjusted Mixed Linear Regression Model Results

The Interclass Correlation Coefficient (ICC) for the sample was 0.64 (data not shown). As a reminder, in the adjusted analyses, for each predictor, the beta value (added sugar consumption in tsp/day) was adjusted for all the other predictors (Table 6). Results indicated as age is increased by 1 year, about 0.3 tsp/day added sugar consumption increased. Although, this relationship was not statistically significant. Female students consumed significantly less added sugars compared with male students ($p < 0.001$). Sugar restricted students consumed about 1.6 tsp/day less of added sugars than those who did not report restricting sugar intake ($p = 0.001$). After adjusting for covariates, added sugar consumption was still not significantly associated with either BMI or depressive mood. Added sugar consumption had slightly positive relationship with depressive mood, and very small negative relationship with BMI.

With further adjustments in the time-lagged model, there was still no statistically significant associations between depressive mood or BMI, and added sugar consumption (Table 7). Similar to the non-time-lagged model, male students consumed significantly

greater amount of added sugar compared to female students, and students who were not sugar restricted consumed significantly more added sugars compared to those who are sugar restricted.

The relationship between depressive mood and added sugar consumption within each subject across four time points was shown in Figure 1. Each line represents the relationship between depressive mood and added sugar consumption for each freshman student throughout one academic year. The average line for all the subjects was shown as the heavy black line. There was a slightly positive relationship between depressive mood and added sugar consumption overall.

Table 6: The Adjusted Linear Relationship between Depressive Mood and Added Sugar Consumption Over Time (n=511)

<u>Predictors</u>	<u>Beta</u>	<u>SE (95%CI)</u>	<u>P-value</u>
Depressive mood^f	0.38	0.26 (-0.14, 0.90)	0.150
BMI^g	-0.07	0.06 (-0.18, 0.04)	0.198
Sugar restriction^e	1.60*	0.46 (0.69, 2.50)	0.001
Age	0.28	0.65 (-1.00, 1.55)	0.673
Gender^a	-4.69*	0.63 (-5.93, -3.44)	<0.001
Race/ethnicity^b			
Black	0.96	0.92 (-0.85, 2.78)	0.298
Hispanic	-0.74	0.74 (-2.19, 0.72)	0.321
Other	-0.65	0.82 (-2.25, 0.96)	0.429
Pell Grant^c	-0.41	0.63 (-1.64, 0.83)	0.519
Resident Halls^d	0.42	0.57 (-0.71, 1.54)	0.468

Note. A.Reference category = male. B.Reference category = White. C.Reference category = Pell grant selected. D.Reference category = Taylor Place 1 & 2. E.Reference category = sugar restricted. F. and G. Adjusted linear regression analysis, by gender, race/ethnicity, Pell grant status, sugar restriction status, and the clustering of students within residence halls. (Sugar(t) = Dep(t) + Covariates + Error)

*the bata value is significant.

Table 7: The Adjusted Time-Lagged Linear Relationship between Depressive Mood and Added Sugar Consumption Over Time (n=511)

<u>Predictors</u>	<u>Beta</u>	<u>SE (95%CI)</u>	<u>P-value</u>
Depressive mood^f	0.41	0.27 (-0.11, 0.94)	0.124
Depressive mood (t-1)^h	0.20	0.20 (-0.19, 0.58)	0.319
BMI^g	-0.09	0.26 (-0.61, 0.43)	0.725
BMI (t-1)ⁱ	-0.28	0.20 (-0.67, 0.11)	0.156
Sugar restriction^e	1.56*	0.46 (0.66, 2.46)	0.001
Age	0.30	0.65 (-0.97,1.58)	0.640
Gender^a	-4.67*	0.63 (-5.91, -3.42)	<0.001
Race/ethnicity^b			
Black	1.00	0.92 (-0.81, 2.82)	0.279
Hispanic	-0.71	0.74 (-2.17, 0.74)	0.337
Other	-0.61	0.82 (-2.21, 1.00)	0.458
Pell Grant^c	-0.42	0.63 (-1.65, 0.81)	0.502
Resident Halls^d	0.41	0.57 (-0.72, 1.54)	0.477

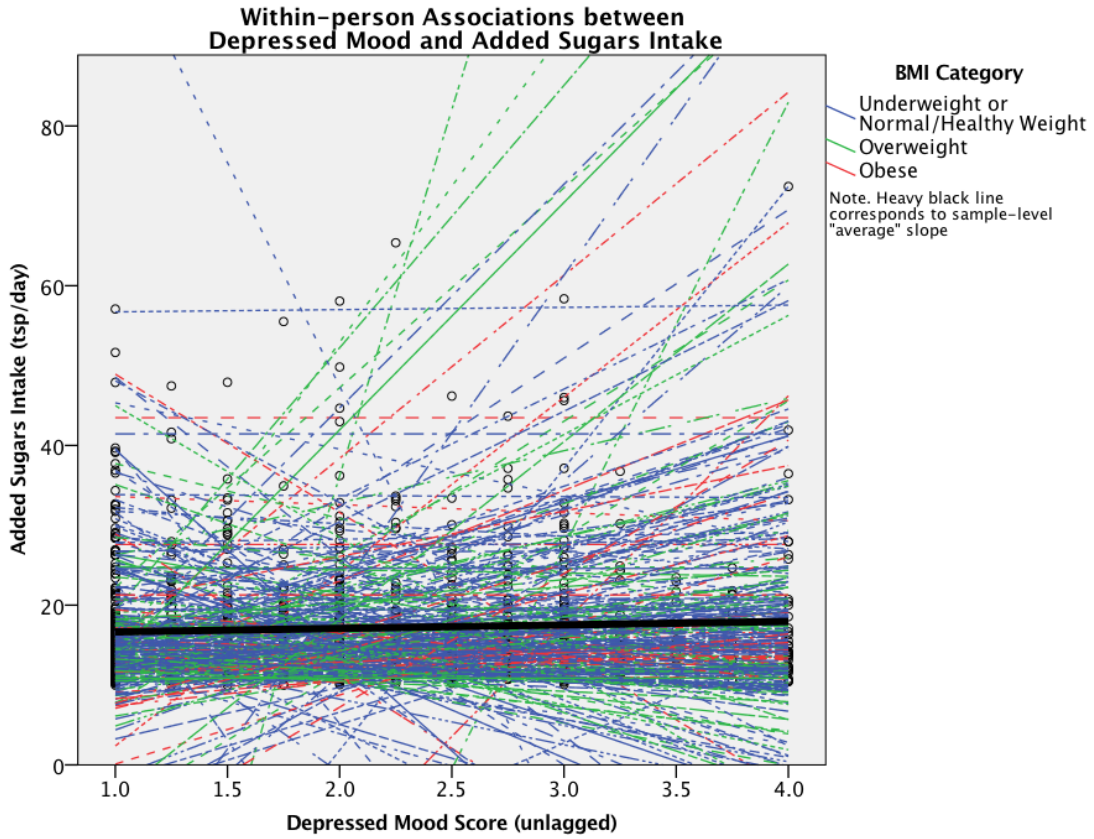
Note. A.Reference category = male. B.Reference category = White. C.Reference category = Pell grant selected. D.Reference category = Taylor Place 1 & 2. E.Reference category = sugar restricted.

F, G, H, I. Adjusted linear regression analysis, by gender, race/ethnicity, Pell grant status, sugar restriction status, and the clustering of students within residence halls. (Sugar(t) = Dep(t) + Dep(t-1) + Covariates + Error)

H, I. Time-lagged variables.

*the bata value is significant.

Fig.1 The Relationship between Depressive Mood and Added Sugar Consumption within Each Subject across Four Time Points



Mixed Linear Regression Model with Interactions between BMI and Depressive Mood Within and Between Subjects

Each subject's depressive mood and BMI was centered by subtracting with group means (Table 8). Centered variables are within-subject variables, and mean variables are between-subjects variables. On average, female students consumed significantly less added sugars compared with male students ($p < 0.001$). Sugar restricted students consumed about 1.6 tsp/day less added sugars than those who did not report restricting sugar intake ($p = 0.001$). Added sugar consumption was still not significant associated with either BMI or depressive mood within or between subjects. There was no significant interaction between BMI, depressive mood, and added sugar consumption within participants ($p = 0.180$), but significant interaction between mean BMI, mean depressive mood, and mean added sugar consumption between individuals ($p = 0.025$). This showed as mean BMI increased, the relationship between mean depressive mood and mean added sugar intake will be weaker. No significant findings were observed for any of the other variables.

In the time-lagged model, there was still no significant interactions between depressive mood, BMI, and added sugar consumption within subjects (Table 9). Similar to the non-time-lagged model, male students consumed significantly greater amount of added sugar compared to female students, and students who reported restricting sugar intake consumed significantly more added sugars compared to those who did not report restricting sugar intake ($p < 0.001$). Each individual's BMI in the previous time points was inversely associated with added sugar consumption in the current time points ($p = 0.010$).

This showed that as one's BMI increased in the previous time points, his/her added sugar consumption was be relatively less in the next time points. Similar to the non-time-lagged model, significant negative relationship between mean BMI, and the relationship between depressive mood and added sugar consumption (p=0.028).

Table 8: Moderation Effect of BMI on the Relationship between Depressive Mood and Added Sugar Consumption (n=511)

Predictors	Beta	SE (95%CI)	P-value
Depressive mood centered^f	0.27	0.35 (-0.42, 0.96)	0.439
BMI centered^g	-0.28	0.27 (-0.82, 0.25)	0.300
Depressive mood centered x BMI centered^h	-0.87	0.65 (-2.13, 0.40)	0.180
Depressive mood meanⁱ	0.80	0.43 (-0.04, 1.64)	0.063
BMI mean^j	-0.03	0.06 (-0.15, 0.09)	0.658
Depressive mood mean x BMI mean^k	-0.17*	0.08 (-0.32, -0.02)	0.025
Sugar restriction^e	1.60*	0.46 (0.70, 2.50)	0.001
Age	0.35	0.65 (-0.92, 1.62)	0.588
Gender^a	-4.68*	0.63 (-5.92, -3.44)	<0.001
Race/ethnicity^b			
Black	1.04	0.92 (-0.77, 2.85)	0.258
Hispanic	-0.65	0.74 (-2.10, 0.80)	0.380
Other	-0.72	0.81 (-2.32, 0.88)	0.377
Pell Grant^c	-0.22	0.63 (-1.46, 1.01)	0.723
Resident Halls^d	0.40	0.57 (-0.73, 1.52)	0.486

Note. A.Reference category = male. B.Reference category = White. C.Reference category = Pell grant selected. D.Reference category = Taylor Place 1 & 2. E.Reference category = sugar restricted. F, G, H, I, J, K. Adjusted linear regression analysis, by gender, race/ethnicity, Pell grant status, sugar restriction status, and the clustering of students within residence halls. (Sugar(t) = Dep(t) + BMI(t) + Dep(t) x BMI(t) + Covariates + Error)
 F, G, H. Within-person centered variables. (Depressive mood centered = Depressive mood (t) – Depressive mood mean; BMI centered = BMI(t) – BMI mean; Depressive mood x BMI centered = Depressive mood centered x BMI centered)
 I, J, K. Between-person/Grand mean variables. (Depressive mood mean = Depressive mood person mean - Depressive mood sample mean; BMI mean = BMI person mean – BMI sample mean; Depressive mood x BMI mean = Depressive mood mean x BMI mean)
 *the bata value is significant.

Table 9: Time-Lagged Moderation Effect of BMI on the Relationship between Depressive Mood and Added Sugar Consumption (n=511)

Predictors	Beta	SE (95%CI)	P-value
Depressive mood centered^f	0.08	0.37 (-0.65, 0.82)	0.829
BMI centered^g	-0.22	0.27 (-0.76, 0.31)	0.416
Depressive mood (t-1) centered^h	-0.51	0.36 (-1.22, 0.19)	0.155
BMI (t-1) centeredⁱ	-0.70*	0.27 (-1.23,-0.17)	0.010
Depressive mood centered x BMI centered^j	-0.76	0.65 (-2.03, 0.51)	0.239
Depressive mood (t-1) centered x BMI (t-1) centered^k	-1.24	0.77 (-2.76, 0.28)	0.109
Depressive mood mean^l	0.82	0.43 (-0.02, 1.66)	0.055
BMI mean^m	-0.03	0.06 (-0.15, 0.09)	0.636
Depressive mood mean x BMI meanⁿ	-0.17*	0.08 (-0.32, -0.02)	0.028
Sugar restriction^e	1.55*	0.46 (0.65, 2.45)	0.001
Age	0.39	0.65 (-0.88,1.66)	0.542
Gender^a	-4.68*	0.63 (-5.92, -3.44)	<0.001
Race/ethnicity^b			
Black	1.08	0.92 (-0.73, 2.89)	0.240
Hispanic	-0.65	0.74 (-2.10, 0.80)	0.377
Other	-0.71	0.81 (-2.31, 0.88)	0.380

Pell Grant^c	-0.16	0.63 (-1.39, 1.08)	0.803
Resident Halls^d	0.34	0.57 (-0.78, 1.47)	0.547

Note. A.Reference category = male. B.Reference category = White. C.Reference category = Pell grant selected. D.Reference category = Taylor Place 1 & 2. E.Reference category = sugar restricted.

F, G, H, I, J, K, L, M, N. Adjusted linear regression analysis, by gender, race/ethnicity, Pell grant status, sugar restriction status, and the clustering of students within residence halls. (Sugar(t) = Dep(t) + BMI(t) + Dep(t) x BMI(t) + Dep(t-1) + BMI(t-1) + Dep(t-1) x BMI(t-1) + Covariates + Error)

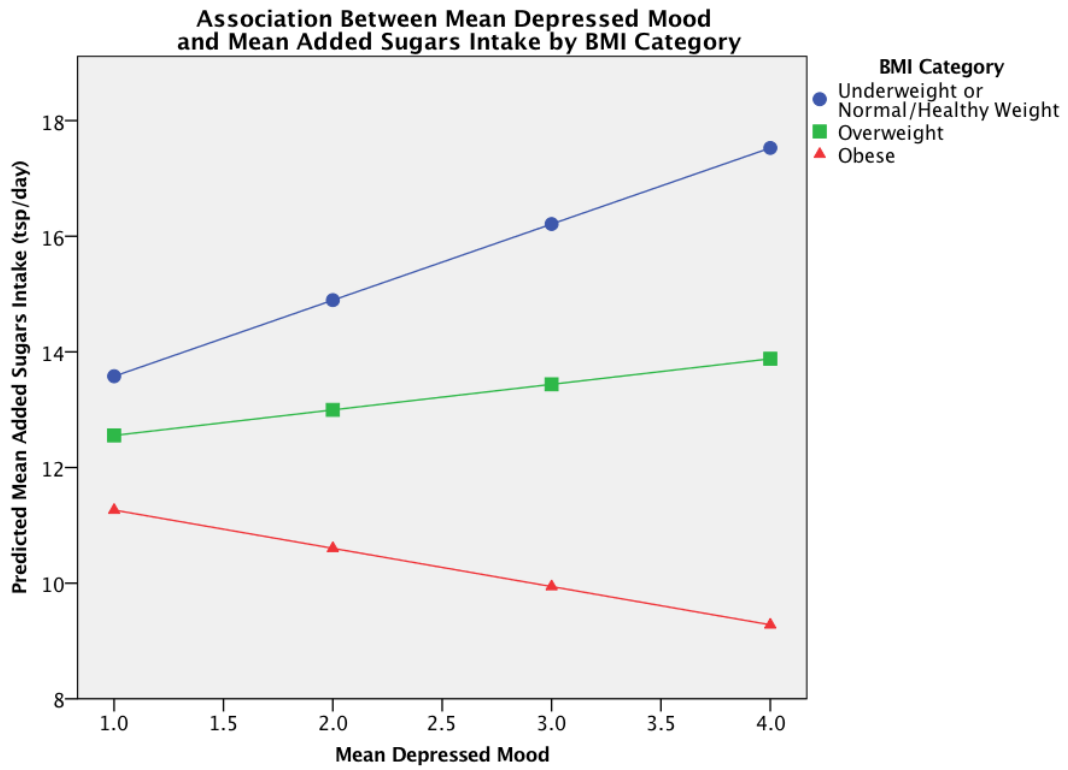
F, G, H, I, J, K. Within-person centered variables. (Depressive mood centered = Depressive mood (t) – Depressive mood mean; BMI centered = BMI(t) – BMI mean; Depressive mood x BMI centered = Depressive mood centered x BMI centered; Depressive mood (t-1) centered = Depressive mood (t-1) – Depressive mood mean; BMI (t-1) centered = BMI(t-1) – BMI mean; Depressive mood (t-1) x BMI (t-1) centered = Depressive mood (t-1) centered x BMI (t-1) centered;)

L, M, N. Between-person/Grand mean variables. (Depressive mood mean = Depressive mood person mean - Depressive mood sample mean; BMI mean = BMI person mean – BMI sample mean; Depressive mood x BMI mean = Depressive mood mean x BMI mean)

*the bata value is significant.

The interaction between mean BMI and mean depressive mood in predicting mean sugars intake was shown in Figure 2. The BMIs were categorized according to medians of 22.5 kg/m², 27.5 kg/m², 32.5 kg/m². For the underweight and “healthy” weight category, the mean depressive mood had a strong positive relationship with mean added sugar consumption. For those who were categorized as overweight, their depressive mood had a slightly positive relationship with mean added sugar consumption. As for those who were categorized as obese, their depressive mood had a slightly negative relationship with mean added sugar consumption (Fig.2). The results in the moderation analyses indicated that there were significant differences between weight status groups (p=0.025; p=0.028) (Table 8 & 9).

Fig 2. The Association between Mean Depressive Mood and Mean Added Sugar Consumption by BMI Category (underweight/normal weight, overweight, obese)



CHAPTER 5

DISCUSSION

The purpose of this study was to examine the association between depressive mood and added sugar consumption over one academic year among freshman students at Arizona State University, and assess how the relationship is moderated by BMI. The current study did not find significant relationship between depressive mood in current or previous time points and added sugar consumption within or between freshman students over time. No significant interactions between depressive mood and BMI in current or previous time points and added sugar consumption within each student, but significant difference for the relationship of depressive mood and added sugar consumption between the weight status groups. Further, there was a significant negative relationship between BMI in the previous time points and added sugar consumption within each student. These findings would be beneficial for further studies in exploring the mechanisms linking the depressive mood with added sugar intake, and the role of weight status in the relationship. The results from this study showed no significant relationship between depressive mood and added sugar intake, it may indicate that depressive mood does not affect added sugar intake in this sample. BMI did not have an impact on the relationship within each student, but have an impact between mean weight status groups, so further studies are needed to continue look at how BMI influences the relationship between depressive mood and added sugar consumption.

Depressive Mood and Added Sugar Consumption

The current study did not show a statistically significant relationship between depressive mood and added sugar consumption within or between subjects after adjusting for covariates and BMI, but did show a weak correlation overall when unadjusted for covariates and BMI. No significant associations after considering time-lagged effect. Previous research has demonstrated the relationship between depression and added sugar intake.¹⁶³⁻¹⁶⁵ Whitaker et al. found that symptoms of depression were positively and statistically significant associated with total sugar intake among low-income overweight and obese African American women, and positively associated with added sugar intakes as well, although not significant.¹⁶³ A cross-national epidemiological study found a highly significant correlation between sugar consumption and the major depression rate for six countries.¹⁶⁴ But this correlation may not imply etiology and individual-level correlations. Among depressed individuals, an increased consumption of carbohydrates, which primarily coming from increase in sucrose consumption, were observed by Christensen & Somers.¹⁶⁵ Many reasons are suspect for no significant relationship between depressive mood and added sugar consumption in this study. Research has already recognized the important role of stress and depressive mood influencing eating behaviors and nutritional health. Stress, especially chronic life stress has been associated with greater energy intake, and causally linked to weight gain.¹⁴⁵ Depression is thought to be a clinical psychological condition, but in fact, many people have experienced depressive mood, which is less distinguishable from other negative mood. Depressive mood is easier to be neglected, yet may have a significant impact on people's life. In the

context of busy academic and social life, college students may be unconscious about those negative moods such as stress and depressive mood affecting their eating behaviors. In this study, the depressive mood was self-reported, so the depressive mood score may be biased. The previous studies have only looked at clinically diagnosed depression, while self-reported depressive mood in this study may not be the same definition of clinically diagnosed depression. Second, some of these previous studies did not show the depression correlated with added sugar intakes per se, but rather associated with carbohydrates or total sugar intakes. Although in this study, depressive mood has no significant effect on added sugar intake, it could affect other nutrients or food intakes, or energy intake as an overall diet. Thus, whether depressive mood or depression is related to sugars or other types of carbohydrates was not clear. Third, the current study examined both within-subject relationship and between-subject relationship of the means. Other studies did not look at both relationships. Whitaker and her colleagues did cross-sectional study that only looked at the between-subject relationship between depressive symptoms and percentage calories from total sugars and added sugars.¹⁶³ Another longitudinal study investigated effect sucrose drinks on depressive mood and weight status over time, and only did between-subjects mean analyses.¹⁶⁶ So this may lead to difference in results. Furthermore, added sugar consumption was measured as self-reported frequency, and other studies measured dietary intakes differently (i.e. 24-hour recall, food diary, etc.). In addition, other factors such as socioeconomic status, total energy/calorie intake, and physical activity levels may take parts in the relationship between depressive mood and added sugar consumption but those covariates were not considered in this study.

Weight Status, Depressive Mood and Added Sugar Consumption

The results of current study did not support the hypothesis that the positive association between depressive mood and added-sugar foods consumption is relatively stronger when one's BMI is relatively high, as compared to when one's BMI is relatively low. The insignificant results obtained from this study could be due to the relative small sample size that can be analyzed to assess the time-lagged effect of BMI and depressive mood on added sugar consumption. However, there was a significant difference in influencing the relationship between depressive mood and added sugar consumption between the mean weight status groups. The participants in the higher BMI group (obese group) had negative relationship between their depressive mood and added sugar intake, while underweight and overweight group had positive relationship. Goldschmidt et al. assessed relationship between mood and eating behavior among obese adults with and without elevated depression symptoms.⁵³ They found the participants with elevated depression symptoms reported greater emotional eating and more frequent binge eating compared to those without, and they stated that emotional eating mediated the relationship between depression status and BMI.⁵³ However, Fox et al. suggested a contradictory finding that emotional eating was not a mediator between depression and degree of adiposity.¹⁶⁷ We could not deny the associations between depression, weight status, and eating behaviors, but the mechanisms for how these things interacted remained unclear. In the current study, the obese group participants had less added sugar intake when they had higher depressive mood score, which may be explained by

emotional eating. Further studies need to be conducted to disentangle the complex interactions and figure out other confounders that might need to be controlled for. Further, there was a significantly negative relationship between individual's BMI in the previous time points and that individual's added sugar consumption in concurrent time points. The time-lagged effect further illustrated the association between BMI and eating behaviors; thus, further studies need to assess the time-lagged effect of BMI on eating behaviors.

Jeffery et al. also suggested that a positive association between BMI and depression in women may be mediated by sweets consumption.³⁴ This positive relationship indicated that gender difference may play a role in the interaction between BMI, depressive mood, and added sugar consumption. In this current study, we did not assess the independent effect of gender difference in the interaction analyses, but we did find that female students reported higher depressive mood scores and had lower added sugar intakes than males when adjusted for all the covariates. Thus, gender difference in the relationship between depressive mood and added sugar consumption may need to be assessed in the future studies.

Studies have also found that depression could lead to long-term weight gain and developing obesity in later life via possible mechanisms such as poor eating behaviors and low energy expenditure.^{79,143,144} However, for the current study, despite the longitudinal nature, there may not have been enough time to demonstrate the long-term effect of depressive mood on weight and added sugar consumption as the study took

place over the course of one academy year. More research is needed to investigate the long-term effect of depressive mood on eating behaviors and food intakes.

With understanding the effect of depressive mood on eating behaviors with relation to weight status, we may be able to apply to nutrition counselling or nutrition intervention to address more on the psychological aspect in nutrition. This may help dietitians to understand more about what to be expect from the clients struggling with psychological issues, why the clients behave in certain ways, and how to intervene with nutrition counselling and education.

Study Strengths and Weaknesses

Study strengths include and examination of college students as an understudied population who has a high prevalence of depression and high added sugar consumption. The sample was racially/ethnically and economically diverse with more Hispanic and Black students, and students received federal student aids. The longitudinal nature of the study provides opportunity to examine the time-lagged effect of BMI and depressive mood on added sugar consumption. This study assessed associations both within-subjects and between-subjects in the analyses by utilizing data for each subjects and mean data for all subjects. This type of analyses increases the power and width of the results to demonstrate a bigger picture of the complex relationships between BMI, depressive mood, and added sugar consumption. The questionnaire measuring added-sugar foods consumption was validated. The objectively measured anthropometrics, including weight and height, provide more strengths to the data collection.

Findings from this study may not be generalizable to the overall population since the sample was a distinctive population of freshman students only. Measures were self-reported and may be prone to errors including recall and social desirability bias. Although sample size was bigger at baseline ($n = 1,432$), due to lack of data collected for all the time points in the study, participants who did not completed survey questions at least two time points were dropped in the analyses, resulting in a smaller sample size that may not be representative. When assessing the time-lagged effect of BMI and depressive mood on added sugar consumption, we could not use data from those who have less than two data points. More limitations include that the added sugar intake was measured as frequency throughout a month period, as framed in the survey question; however, in the analyses, the frequency of added sugar intake was converted to teaspoon equivalents (tsp/d). This may have altered the time period for the effects of the added sugar consumption and depressive mood with each other, since the time frame became a day instead of a month.

Summary

Results from this study demonstrated that depressive mood was not statistically significantly associated with added sugar consumption within subjects after adjusted for covariates and BMI. No significant results showed in time-lagged effect of depressive mood on added sugar consumption within subjects. There was a significant time-lagged effect of BMI on added sugar consumption within subjects when adjusted for covariates and depressive mood. There was a significant negative moderation effect of BMI on the relationship between depressive mood and added sugar consumption between subjects. It is important to recognize the relationships within each individual and the relationships based on means of the groups. Overall, depressive mood was not associated with added sugar consumption either within or between subjects, and BMI was negatively contributed to the associations between depressive mood and added sugar consumption on average.

CHAPTER 6

CONCLUSION

Depression has been increasingly diagnosed among college students, and high added-sugar foods intakes were serious concerns among college students. Since added sugar intake contributes to weight gain, and overweight or obese populations have a higher rate of depression, weight status may play an important role in the relationship between depressive mood and added sugar intakes. This longitudinal study assessed the relationship between depressive mood and added sugar consumption over time among college freshmen. Weight status may have an impact on both depressive mood and added sugar consumption, and may also affect the association between them.

None of the hypotheses for this study were upheld. The results from this study failed to support the first hypothesis, which stated that when students have higher depressive mood, they will consume high added-sugar foods more frequently compared to when they have lower depressive mood. Depressive mood did not have a significant association with added sugar consumption within subjects. The second hypothesis stated that the positive relationship between depressive mood and added-sugar foods consumption will be relatively stronger when student's BMI is relatively higher, as compared to when BMI is relatively lower. No significant moderation effect of BMI found on the relationship between depressive mood and added sugar consumption within subjects. However, BMI was negatively contributed to the associations between depressive mood and added sugar consumption on average, different by mean weight status groups. The results from this study provide important messages for future research

in this area, and can be referenced to link negative mood with eating behaviors. With the trending of high prevalence of obesity and depression among college students, we can not overlook the close connection between students' psychological health and physical health. Research has already recognized the important role of stress and depressive mood influencing eating behaviors and nutritional health. This study did not show a significant effect of depressive mood on added sugar intake. Further study need to look at the effect of depressive mood on other nutrients or foods. This study may not be able to demonstrate the long-term effect of chronic depressive mood as well. More research is needed to determine the long-term effect of depressive mood on eating behaviors and other health outcomes. BMI did not have an impact on the relationship within each student, but had significant different impact between mean weight status groups, so further studies are needed to continue look at the weight status influences the relationship between depressive mood and added sugar consumption.

This study provides a piece of the literature regarding the relationship between depressive mood, weight status, and added sugar consumption. Previous studies have only assessed clinical depression or other populations; this was the first study to assess depressive mood and added sugar intakes specifically among college freshmen, and how weight status play a role in the relationship. This was the first study to assess the time-lagged effect of depressive mood and weight on added sugar intakes. More research is needed to assess the long-term effect of chronic depressive mood on added sugar consumption. A larger study with more participants will help to provide more power to the results. Further, more research needs to look at other nutrients and food items that

correlated with depressive mood. Given that this study found no significant effect on added sugar consumption when having higher depressive mood, depressive mood may not have an effect on added sugar intake; however, more studies are needed to confirm this finding. The weight status had differential results for the impact on the relationship within and between students, so further studies are needed to continue explore the weight status influences in the relationship between depressive mood and added sugar consumption.

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APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL AND INFORMATION FORM



APPROVAL: MODIFICATION

Meredith Bruening
 SNHP: Nutrition
 602/827-2266
 Meg.Bruening@asu.edu

Dear Meredith Bruening:

On 9/17/2015 the ASU IRB reviewed the following protocol:

Type of Review:	Modification
Title:	The Role of Friendship Networks on BMI and Behaviors among College Freshmen
Investigator:	Meredith Bruening
IRB ID:	1309009596
Funding:	Name: HHS-National Institutes of Health (NIH), Funding Source ID: HHS-NIH-National Institutes of Health
Grant Title:	None
Grant ID:	None
Documents Reviewed:	<ul style="list-style-type: none"> • waist_hip_circumference_form.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • devilWASTE Female Participant Data Collection Sheet 2015.pdf, Category: Measures (Survey

	<p>questions/Interview questions /interview guides/focus group questions);</p> <ul style="list-style-type: none"> • Response to 9/23 modification request, Dr.docx, Category: IRB Protocol; • RecruitQuestionFlyer.pdf, Category: Recruitment Materials; • ReminderFlyers.pdf, Category: Recruitment materials/advertisements /verbal scripts/phone scripts; • RefusalResponseSheet.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • DidYouMissUs_RecruitmentFlyer.pdf, Category: Recruitment materials/advertisements /verbal scripts/phone scripts; • Participant ID card and reminders, Category: Participant materials (specific directions for them); • App_Description.pdf, Category: Participant materials (specific directions for them); • Changes in app survey questions, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • devilSPARC messages_072115.pdf, Category: Recruitment materials/advertisements /verbal scripts/phone scripts; • Microbiome pilot consent form, Category: Consent Form; • UpdatedProtocol_MergedWithdevilWASTE_082115.doc, Category: IRB Protocol; • Updated longitudinal survey plan, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • GetInvolvedinScienceRecruitFlyer.pdf, Category: Recruitment Materials; • devilWASTE Screening Form 2015.pdf, Category: Screening forms; • devilWASTE Male Participant Data Collection Sheet 2015.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • height_weight_form.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • IRB Protocol for Microbiome Sub-Study, Category: IRB Protocol;
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	<ul style="list-style-type: none"> • Response to 9/23 modification request, Dr.pdf, Category: Other (to reflect anything not captured above); • Microbiome pilot flyer, Category: Recruitment Materials; • script just devilSPARC, Category: Consent Form; • devilWASTE Study Enroll Form 2015.pdf, Category: Measures (Survey questions/Interview questions /interview guides/focus group questions); • devilWASTE script, Category: Consent Form; • devilSPARC_2015ConsentForm_082115.pdf, Category: Consent Form; • ExtraMoneyRecruit.pdf, Category: Recruitment Materials; • Script explaining the app (goes with the AppdescriptionPDF), Category: Participant materials (specific directions for them); • Tentative devilSPARC data collection schedule.pdf, Category: Other (to reflect anything not captured above);
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The IRB approved the modification.

When consent is appropriate, you must use final, watermarked versions available under the "Documents" tab in ERA-IRB.

In conducting this protocol you are required to follow the requirements listed in the INVESTIGATOR MANUAL (HRP-103).

Sincerely,

IRB Administrator

cc:

APPENDIX B
CONSENT FORM

CONSENT/ASSENT FORM
devilSPARC, Fall 2015



INTRODUCTION: The purpose of this form is to provide you information about our study that may affect your decision to participate in this research, and to record the consent of those who agree to be involved in the study.

RESEARCHER(S): Professor Meg Bruening, PhD, MPH, RD from the College of Health Solutions is partnering with the College of Liberal Arts and Sciences to invite you to participate in a research study.

STUDY PURPOSE: The purpose of this study is to assess eating and physical activity among college students.

DESCRIPTION OF RESEARCH STUDY: If you decide to be a part of this study, you will be asked to complete the following related to eating, physical activity behaviors and weight:

STUDY ACTIVITIES	PARTICIPANT'S INITIALS INDICATING UNDERSTANDING
Check-in survey (4 times throughout the year)	_____
Height, weight, waist, hip measurements (4 times throughout the year)	_____
devilSPARC app surveys (4 times throughout the year. App will be downloaded to your phone)	_____
<i>The mobile app will prompt you to complete a short (1-minute) questionnaire about your current activities. You will be asked to complete these brief surveys randomly 8 times per day (between 9am and 11pm) for a total of 4 days at each time point.</i>	
SunCard	_____
<i>Researchers will have limited access to view your SunCard activity throughout the year, including entrance/exit of ASU's dining halls, food receipt data, and on-campus gym facilities.</i>	

Participation in this study is voluntary. You can choose to stop at any time. Your survey responses will be kept **strictly confidential**, and will only be compiled as a group, not individually. Your decision to participate and your responses, should you choose to participate, will not affect your enrollment status at Arizona State University in any way. If you agree to participate, your time spent participating will total around 5-6 hours.

We may have additional opportunities to participate in other studies. If you are willing to be contacted about these opportunities, please initial here: _____ *(participant's initials indicating willingness)*

RISKS: Once installed, the mobile app will run in the background on your phone. This may lead to battery drain, and will capture some information about your location during participation. We are working with an outside vendor, Twilio, to send you text messages for you to complete the devilSPARC app surveys; we have an agreement to maintain your confidentiality with this company. You should only receive messages from us from this company unless you have signed up for other services through other vendors. Your SunCard activity may also include information about your location. Additionally, you may feel uncomfortable providing personal information about yourself in the study questionnaires. At every point, the researcher will de-identify data so that your questionnaire responses and information about your location will not be linked to you personally. However, as in any research, there is some possibility that you may be subject to risks that have not yet been identified.

BENEFITS: There are no direct benefits to participation. However, indirect benefits of your participation include helping the researcher understand ways to promote nutrition and physical activity. These data will also add to the general scientific knowledge about college students' contextual factors related to nutrition and physical activity behaviors among friendship networks over time.

CONFIDENTIALITY: All information obtained in this study is strictly confidential. The results of this research study may be used in reports, presentations, and publications, but the researchers will not identify you by name. In order to maintain confidentiality of your records, Dr. Bruening will assure that your name will only appear on this consent form and the intake form. Study data will not be transmitted via the Internet. Study data will be stored on a password protected server. To these extents, confidentiality is not absolute.

WITHDRAWAL PRIVILEGE: Participation in this study is completely voluntary. It is ok for you to say no at any time. Even if you say yes now, you are free to say no later, and withdraw from the study at any time.

COSTS AND PAYMENTS: You will receive up to \$110 in Amazon gift cards for completing this study. In addition, if 60% of the students under the direction of your Community Mentor complete the study, your floor may receive extra incentives such as lanyards, t-shirts and water bottles.

VOLUNTARY CONSENT/ASSENT: Any questions you have concerning the research study or your participation in the study, before or after your consent, will be answered by the researcher, Dr. Meg Bruening at devilSPARC@asu.edu or 480.269.7454.

If you have questions about your rights as a subject/participant in this research, or if you feel you have been placed at risk, you can contact the Chair of the Human Subjects Institutional Review Board through the ASU Office of Research Integrity and Assurance, at 480.965.6788.

This form explains the nature, demands, benefits and any risk of the project. By signing this form you agree knowingly to assume any risks involved. Remember, your participation is voluntary. You may choose not to participate or to withdraw your consent and discontinue participation at any time without penalty or loss of benefit. In signing this consent form, you are not waiving any legal claims, rights, or remedies. A copy of this consent form will be given to you for your records.

Your signature below indicates that you consent to participate in the above study.

Subject's Signature _____ Printed Name _____ Date _____

INVESTIGATOR'S STATEMENT: "I certify that I have explained to the above individual the nature and purpose, the potential benefits and possible risks associated with participation in this research study, have answered any questions that have been raised, and have witnessed the above signature. These elements of Informed Consent conform to the Assurance given by Arizona State University to the Office for Human Research Protections to protect the rights of human subjects. I have provided the subject/participant a copy of this signed consent document."

Signature of Investigator _____ Date _____