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Diet quality and mental health in college students: impact on dietary factors including intake of protein, sugar, vegetable and omega-3 fatty acid on depression

Yulu Wang

Diet quality and mental health in college students: impact on dietary factors including intake of protein, sugar, vegetable and omega-3 fatty acid on depression

By

Yulu Wang

Approved by:

Terezie Tolar-Peterson (Major Professor)
Arnita F. Norwood
Rahel Mathews
Wen-Hsing Cheng (Graduate Coordinator)
Scott Willard (Dean, College of Agriculture and Life Sciences)

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Name: Yulu Wang

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Institution: Mississippi State University

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Major Professor: Terezie Tolar-Peterson

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Depression is one of the most debilitating disorders among youth. Many factors impact depression risk, and dietary quality is one of the most significant modifiable factors. This work was to investigate whether diet quality, including protein, sugar, vegetables, and omega-3 fatty acids' intake, had any effect on the development of depression. Data from 82 subjects were used for analysis. There was no significant relationship between Dietary Quality Index (p=.21, n=82) and depression based on this research. Results included total protein (p=.77, n=82), animal-based protein (p=.77, n=82), vegetable-based protein (p=.29, n=82), total sugar (p=.55, n=78), added sugar (p=.48, n=78), total vegetable (p=.56, n=82) and omega3 fatty acids (p=.92, n=82). These results were not up to expectations and did not conform to previous findings. Future research should be performed with a larger sample size among the college-aged population to determine the relationship between dietary factors and depression risk.

DEDICATION

To my parents, you are my source of inspiration. Thanks for your patience, encouragement, emotional and financial support.

To my boyfriend, Shufan Yu, and my best friend, Sijia Huang, I could not have completed my thesis without your companionship and love.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER I

INTRODUCTION

According to the World Health Organization (WHO), it is estimated that depression is the second leading cause of morbidity globally. Indeed, about one in five adolescents in the U.S meets the criteria for mental disorders. While depression hurts personal life, it imposes a social and economic burden as well. Depression has been marked as one of the more significant contributors to the global burden of all diseases (Miret et al., 2013; World Health Organization 2004). Therefore, a study must be conducted to analyze and determine the modifiable risk factors for depression development.

Fundamentally, there are two main classifications of the causes of depression: external and internal. Scholars observed factors such as social support, psychosocial work environment, and neighborhood social environment as some of the external reasons (Dalgard et al., 1995; Stansfeld & Candy, 2006). Proposals on solutions recommend that the externalities be remedied by factors that often require long-term efforts from family, society, country, government, and policies. On the other hand, mental health disorders have been associated with unhealthy lifestyles, including smoking, consuming alcohol, using illicit drugs, and low physical activity levels (Jane-Llopis et al., 2006; Pasco et al., 2011; Lasser et al., 2010). Essentially, they are classified as internal factors leading to depression. It is, however, worth noting that they are adjustable and thus controllable.

Often, the internal factors can be managed by an individual of their own volition. In this regard, diet emerges as one of the most significant modifiable factors. Various studies are investigating the association between mental health and dietary habits. Several studies completed across the world in Canada, the United Kingdom, New Zealand and Australia were performed regarding dietary intake and diet variety. Using questionnaires. Those findings show that high-quality diets are often associated with a better emotional status or a low risk of depression (Jacka et al., 2010, 2013; McMartin et al., 2012; Kulkarni et al., 2015).

Further, more studies have sought to determine the relationship between a single food group and depression. An instance is an exploration of sugar and fast food intake. One such experiment is a study conducted among Spanish college-age students seeking to analyze the link between fast-food consumption and baked goods and depression. Subsequent results showed a higher risk of developing depression with higher fast-food consumption (Sánchez-Villegas et al., 2012). Similarly, another study revealed that a higher likelihood of depression is linked to higher sweet foods and beverage intake. Notably, the study observed that this is rampant among women, usually under 50 years of age (Knüppel et al., 2017). Stated, those who consume more sweet foods and beverages had higher degrees of mental disorder or depression (Knüppel et al., 2017).

As the mentioned studies show, many adolescents and young adults are affected by mental disorders and depression. Conventionally, adolescents and young adults are the main determinants of a society's future state and, consequently, a country. Granted, focus by the government, larger society, and medical professionals should be enhanced regarding mental health. Different scholarly endeavors are still directed at reinforcing or disproving the observed findings on dietary habits and mental health. This research determined the diet quality through

the type of protein intake (vegetable or animal-based), vegetable consumption, sugar intake, and omega-3 fatty acid intake. The study aimed to analyze the effects of protein, vegetables, sugar, and omega-3 fatty acid on depression. Overall, the study would study the connection between the quality of a diet and depression among college students. More specifically, this research explored the effects of animal-based protein and vegetable-based protein on depression. It determined whether vegetable-based protein and animal-based protein have different effects on depression.

CHAPTER II

LITERATURE REVIEW

Background

Unlike other health conditions, depression is relatively hard to diagnose. Still, depression scales are commonly used in screening for depression in a clinical setting (Beck et al., 1998). Of the different treatment standards used, the most common are cognitive behavioral therapy, pharmacotherapy, psychotherapy, and electroconvulsive therapy. Given that the causes are varied and often complicated, there are no conclusive statements on the foundation of the mental condition. However, possible reasons include traumatic or stressful events, inherited traits, and hormones or chemistry changes in the body (MayoClinic, 2018).

Results from Similar Studies

A cohort study in London collected data from different questionnaires on a diet. The participants were asked to answer questions including 'how many portions of vegetables and fruits intake' and 'how often do you eat or drink unhealthy food, like crisps, snacks, desserts, and fried foods and so on.'The study concluded that a poor diet is a risk factor for developing mental health problems in adolescents (Jacka et al. 2013). In a similar Australian study, a link was found between the quality of a diet and depression in adolescents. Notably, these were observations made outside the impact of socioeconomic, family, and other potential contributing factors (Jacka et al., 2010). Using data from a survey on diet and socioeconomic context from 5th-grade students, Canadian scholars concluded that the dietary variety in children might decrease the risk

of mental disorders (McMartin et al., 2012). Additionally, New Zealand based research on data collected from self-reported diet questionnaires from students, and the healthy eating habits and unhealthy eating habits were assessed as two separate scales. The study observed that a healthy diet was associated with considerably better emotional health (Kulkarni et al., 2015).

Several studies have been conducted to investigate the relationship between depression and single food groups including alcohol intake, vegetable intake, and refined-grain intake (Gibson-Smith et al., 2020). A study conducted amongst Spanish college students sought to investigate the connection between fast-food, baked goods, and the risk of depression. The results showed a higher risk of developing depression through fast food (Sánchez-Villegas et al., 2012). A similar article revealed a higher probability of depression linked to the intake of sweet foods and beverages. Indeed, the study found that while women under 50 are more likely to consume sweet foods and beverages, they also have a higher likelihood of higher degrees of mental disorder such as depression (Knüppel et al., 2017; Beck et al., 1998). A 4-year prospective study conducted in Taiwan (n=1609) showed that the frequent consumption of vegetables could protect against depressive symptoms in the elderly (Tsai et al., 2012). In another study, it was revealed that participants with lower fruits and vegetables (total vegetables, whole fruits, citrus, other fruits, and green leafy vegetables) intake faced a far greater risk of experiencing depression (Baharzadeh et al., 2018). Among the elderly, the study observed that the consumption of fruits and vegetables, sources of antioxidants, led to lower depression cases compared to the relative who rarely consumed such foods (Payne et al., 2012). Additionally, different researches focused on the relationship between omega-3 fatty acid and mental health. In a double-blind, placebo-controlled trial, patients with 9.6 g/day of omega-3 fatty acid had a

significantly decreased score on the depression scales than those in the placebo group (Su et al., 2003).

Other Factors Contributing to Depression Development

While diet and nutrients are crucial, other factors are contributing to depression. For example, there are gender differences that influence the frequency of incidences of depression. According to the World Health Organization (WHO), more women are diagnosed with depression than men. Women are also observed to report more symptoms, thus reaching the diagnostic threshold more often than men. Such a situation is related to biological, psychological, and social factors (Nolen-Hoeksema, 2002; Piccinelli & Wilkinson, 2000; Angst et al., 2002). Again, it suffices to observe that cases of depression are more common amongst the elderly. Studies show that the situation is precipitated by physical dysfunction, low personal control, and feelings of isolation, and a loss of social status (Mirowsky & Ross, 1992). Depression is also closely related to overweight or obesity. Essentially, dissatisfaction with personal body image and body weight is associated with a higher risk of developing depression (Stunkard et al. 2003; Goldfield et al. 2010). One study noted that a U-shaped trend is preferable in describing the relationship between body mass index (BMI) and depression. In other words, depression is related to the obesity/overweight/high BMI group and being underweight (De Wit et al., 2009).

In Summary

While diet and nutrients are crucial, other factors contribute to depression. For example, gender differences influence the frequency of incidences of depression. According to the World Health Organization (WHO), more women are diagnosed with depression than men. Women are also observed to report more symptoms, thus reaching the diagnostic threshold more often than

men. Such a situation is related to biological, psychological, and social factors (Nolen-Hoeksema, 2002; Piccinelli & Wilkinson, 2000; Angst et al., 2002). Again, it suffices to observe that cases of depression are more common amongst the elderly. Studies show that the situation is precipitated by physical dysfunction, low personal control, and feelings of isolation, and a loss of social status (Mirowsky & Ross, 1992). Depression is also closely related to overweight or obesity. Essentially, dissatisfaction with personal body image and body weight is associated with a higher risk of developing depression (Stunkard et al. 2003; Goldfield et al. 2010). One study noted that a U-shaped trend is preferable in describing the relationship between body mass index (BMI) and depression. In other words, depression is related to the obesity/overweight/high BMI group and being underweight (De Wit et al., 2009).

CHAPTER III

METHODS

Participants

The study used existing data collected under the study Identifying Polymorphisms of Taste Receptors as Biomarkers (or risk factors) for Obesity at the Mississippi State University (IRB-17-025). The sampled population was inclusive of undergraduate and graduate on-campus students (population 21,622 in 2016). The original database contained 385 subjects. However, during the data collection period (2019/10/16-2020/06/05), only 375 subjects completed the study. These 140 subjects were recruited online after the university shut down due to the COVID-19 management measures. 293 participants had to be excluded due to incomplete data. While 157 participants did not finish the depression questionnaire, 136 failed to complete their diet history questionnaire. Consequently, the valid dataset included 82 subjects that were used for the final analysis.

Study Design

The study was fundamentally observational and cross-sectional, and it was approved by the Mississippi State Institutional Review Board (IRB-17-025). Originally, all questionnaires were scheduled to be completed in the designated research lab room, taking 25 minutes to complete. Subjects' demographic information such as age and gender, and additional background information such as physical activity, religion, personality traits, and alcohol intake were self-reported. A trained research assistant measured the weight, height, BMI, and body composition,

including fat mass, fat-free mass, and fat percentage. The dietary intake and depression scores were collected using the National Institutes of Health Diet History Questionnaire II (NIH DHQ II) and Patient Health Questionnaire (PHQ-9) via Qualtrics Survey. Due to the COVID-19 pandemic, adjustments were made to the research protocol since in-person visits were now impossible. While observing national and statutory restrictions, 140 subjects completed the questionnaires via Qualtrics Survey online from their homes. However, none of them opted to fill out the diet history questionnaire following the Qualtrics survey. Due to the pandemic, it was impossible to collect data about body composition from these 140 subjects. So the weight and height of these participants were self-reporting, and the BMI was calculated based on self-reported data.

Exposure Assessment

The usual food intake, beverage intake, and portion sizes were assessed through the National Institutes of Health Diet History Questionnaire II (NIH DHQ II). Besides, the Food Liking Survey and Veggie Meter were used as complementary information to the NIH DHQ II. The nutrient intake of 134 items was measured as frequency multiplied by the nutritional composition of each portion of the food item. The process primarily sought to determine the intake of each nutrients group, including intake of total protein, animal-based protein, vegetable-based protein, total vegetable, total sugar, added sugar, and omega-3 fatty acid for the subjects. Because of gender and weight differences, the recommended daily intake of macronutrients for each participant is different (Lupton et al., 2020). Therefore, in this study, the total protein intake will be expressed as the percentage of energy from protein. The total sugar intake will be expressed as the percentage of energy from sugar. The Dietary Quality Index for each participant was calculated using DHQ II with the most recent Diet*Calc database by the Healthy Eating

Index (HEI) SAS program. The higher the Dietary Quality Index, the better following the Dietary Guidelines for Americans.

Outcome Assessment

To measure depression, the Patient Health Questionnaire (PHQ-9), a 9-item screening instrument, was used. For each item, the subjects were asked to gauge how much they were concerned about the symptoms in the last two weeks. Ideally, there were four options to select from: not at all (0), several days (1), more than half of the days (2), and nearly every day (3). The sum score (range 0 to 27) was eventually used in indicating the subject's degree of depression. In the record, scores of ≥5, ≥10, ≥15, and ≥20 represent mild, moderate, moderately severe, and severe levels of depression, respectively. Higher results from PHQ-9 reflected more severe depression symptoms, and thus a higher risk of depression.

Statistical Analysis

Linear regression analyses were used to inspect the cross-sectional connection between diet quality, including the intake of protein/vegetables/sugar/omega-3 fatty acid, and depression. Differences between the impact of animal protein intake and vegetable protein intake on depression were tested with either t-tests or chi-square tests. Potential confounders (gender, age, body weight, BMI) were used in the analysis by sequentially adding to the models. Additionally, two-tailed Pearson correlation tests were used to determine whether a significant relationship exists. Essentially $P < 0.05$ was considered significant for all analyses. The physical characteristics of participants were reported as mean with standard deviation. All associated statistical analysis was performed using SPSS version 27.0.

CHAPTER IV

RESULTS AND DISCUSSION

While 375 subjects finished the study, 293 of them were excluded due to incomplete data. Hence, 82 valid participants were included in this study, 15 men (18.29%) and 67 women (81.71%). The average age of all participants was 19.71±1.34 years. The mean weight was 152.51±41.79 pounds, and the mean body mass index (BMI) was 24.82±6.02 kg/m2. (Table 4.1).

The results showed no significant relationship between Dietary Quality Index and depression score for all participants (p=.21, n=82), man (p=.47, n=15), and women (p=.08, n=67) (Figure 4.8). The average Dietary Quality Index for all participants is 60.77±11.17, for man is 59.26±12.22, and for women is 61.13±10.98. It can be concluded that although female participants have a higher average Dietary Quality Index than male participants, female participants have a higher average depression score (6.33±4.81) compared to male participants (5.47±4.26) (Table 4.2). Based on the analysis, there was no significant statistical difference between men and women in the dietary factors data and depression scores collected.

Protein

Based on the results, there was no significant relationship between the energy from total protein intake and depression among all participants (p=.84, n=82), man (p=.85, n=15), and women (p=.78, n=67) (Figure 4.1). The results also revealed here was no relationship between animal-based protein and depression scores among all participants (p=.77, n=82), man (p=.50, n=15) and women (p=.54, n=67) (Figure 4.2), and no relationship between vegetable-based

protein and depression scores among all participants (p=.29, n=82), ,men (p=.48, n=15), women (p=.13, n=67) (Figure 4.3).

Total Protein Intake

A study established that the depression score elevated at some stage in the premenstrual period when the protein consumption is maintained at the same level whilst decreasing the percentage from protein (Wurtman et al., 1989). On the other hand, some studies in Japan and South Korea found that human beings with depression or greater depression scale have lower protein intake than human beings besides despair or lower despair scale, which proves that there is a relationship between macronutrient consumption and depression (Nanri et al., 2014; Oh et al., 2020).

The most extensively familiar rationalization of why protein is associated with a decreased chance of depression is associated with tryptophan. Several studies showed that tryptophan, one type of essential amino acid present in protein foods, can help the body produce serotonin, a chemical in the brain that can affect emotions (Jacka et al., 2010; McMartin et al., 2012). But the thought that impaired serotonin function is a component in depression is nevertheless controversial. Opponents argue that it is simply an advertising approach used to enhance sales of animal-based meals products. However, some supporters pointed out that tryptophan depletion and low serotonin is the principal pathophysiology of depression and inducing signs in sufferers with depression (Cowen, 2008; Neumeister, 2003).

Gene-environment interaction researchers concluded that 5-HTTLPR, a gene that codes the serotonin transporter, has no association with the self-reported depression (Risch et al.,2009; Jacobs et al., 2006), and one research concluded that tryptophan is related to depression

symptoms with a significant effect from 5HTTLPR only in women (Eley et al., 2004). Based on the existing data of this experiment, it is challenging to analyze the connection between the tryptophan, serotonin/5-HTTLPR, and depression risk. Future research is needed, which will reinforce the connection between tryptophan intake, genetic predisposition, and depression risk.

Based on this research, the average percentage of energy from protein is 14.56%±3.83 for all participants, 14.71%±3.14 for men, and 14.53%±3.99 for women. All of them are within the acceptable macronutrient distribution ranges (AMDR) of protein, 10-35%. Therefore, protein intake for all participants is normal and is not a low-protein diet. This may also explain why there is no conclusion drawn from this research.

Animal-based Protein VS. Vegetable-based Protein

The hypothesis of this study is that there will be different results between animal-based protein and plant-based protein intake. Our results did not find a significant relationship between animal protein intake (p=.77, n=82), plant protein intake (p=.29, n=82), and depression. Hence, we were not able to compare whether these two variables have different effects on depression. The possible factors to consider were the different contents of vitamins and minerals in these two. We divided participants into two groups: one group had more animal-based protein intake than vegetable-based protein intake. The other group had more vegetable-based protein intake than animal-based protein intake. A larger proportion of participants consumed more animal-based protein than vegetable-based protein — all participants 89.02%, men 80.00%, and women 91.04% (Table 4.3). For all participants and female participants, the group with more animal-based protein intake than vegetable-based protein intake had a lower depression score than the group with vegetable-based protein intake greater than or equal to animal-based protein intake. Nevertheless, for male participants, those results were the opposite (Table 4.3).

One research carried out among Korean women discovered that the consumption of plant-based protein in the depression group used to be appreciably lower than the non-depression group. Contrarily, the animal-based protein had an advantageous correlation with the occurrence of depression (Kim et al., 2012). With regards to the perspective of tryptophan comparing animal-based and vegetable-based proteins, it was observed that it is very convenient for humans to get tryptophan through diet, whether it is from animal-based and vegetable-based protein. The common sources for tryptophan from animal-based protein encompass different types of meat and fish. Vegetable-based proteins include nuts, seeds, oats, beans, and lentils. One cross-sectional study observed that tryptophan concentrations have been highest in fish-eaters and vegetarians, followed by meat-eaters, and lowest in vegans (Schmidt et al., 2016). Therefore, these statistics suggest that very strict vegans may have a noticeably high depression rate due to inadequate tryptophan intake.

Inflammation has been suggested to be related to a high risk of depression, according to numerous depression studies (Dantzer et al.,2008; Ménard et al., 2017). Some research suggested that the vegan/vegetarian food plan can substantially improve the Dietary Inflammatory Index (DII). Such an anti-inflammatory diet plan is associated with a decreased chance of depression (Turner-McGrievy et al.,2015; Shivappa et al., 2006). This presents a contradiction suggesting that a food plan rich in vegetable-based protein is better for lowering the risk of depression. Whether vegetable-based protein will minimize or increase the risk of depression requires further study.

Sugar (Simple Sugar)

Our results revealed the nonsignificant relationship between energy from total sugar intake and depression scores among all participants (p=.73, n=82), man (p=.90, n=15) and

women (p=.73, n=67) (Figure 4.4), and nonsignificant relationship between added sugar intake and depression scores among all participants (p=.48, n=78), men (p=.81, n=15) and women (p=.49, n=63) (Figure 4.5).

Based on the results, an average of 4.41%±3.39 of the energy consumed comes from sugar for all participants, 4.73%±2.85 for men, and 4.34%±3.52 for women (Table 4.2). The percentage of energy from sugar is slightly higher among men than women (no statistically significant difference). But male participants (5.47±4.26) have a lower depression score than female participants (6.33±4.81).

These results are not in accordance with the predictions and conclusions from other studies. The Whitehall Study II in London recruited 10,308 contributors and concluded that sugar consumption from candy food/beverages could increase the risk of incident temper disorders in men (Kessler et al., 2007). According to 10 observational research involving 37,131 depression cases, it was indicated that the consumption of drinks sweetened with sugar would possibly be associated with a modestly greater danger of depression (Merikangas et al., 2010). Likewise, research in Appalachia conducted among college populations observed an association between depression and added sugar consumption (Popa et al., 2012).

Feasible biological reasons may be attributed to why high sugar consumption is associated with a greater risk of depression. First, a diet excessive in sugar is always linked to inflammation, which may cause mood depression and extend the risk of frequent mental disorders (Miret et al., 2013). Secondly, it is worth noting that excessive sugar eating regimen is always related to overweight and obesity. Many types of research show that obese or overweight people have an elevated hazard of depression (World Health Organization, 2008; Dalgard et al., 1995;). Thirdly, the excessive sugar diet will lead to postprandial hypoglycemia by using insulin

response. It subsequently affects hormonal regulations and moods and leads to a greater risk of depression (Stansfeld & Candy, 2006).

Added Sugar Intake

According to the American Heart Association, the recommendation of added sugar intake for a male is no more than 9 teaspoons/day (36 grams or 150 calories). For females, it is 6 teaspoons/day (25 grams or 100 calories). Based on our results, the average added sugar intake for males was 84.34±53.72 grams/day, and for females, 76.58±65.2 grams/day, which is far higher than the recommended range (Table 4.2). In our study, there was only 1 male participant (6.67%) consuming ≤36 grams of added sugar daily, and 14 male participants (93.3%) consumed > 36 grams of added sugar daily. 10 female participants (15.87%) consumed ≤25 grams of added sugar daily, and 53 female participants (84.13%) consumed > 25grams of added sugar daily (Table 3). Men who ate less than 36 grams of added sugar had a lower depression score (5±0) than men who ate more than 36 grams of added sugar (5.50±4.42); in contrast, women who ate less than 25 grams of added sugar had a higher depression score (8±6.05) compared to women who ate more than 25 grams of added sugar (6.21±4.68) (Table 4.4). But there is no significant relationship between added sugar intake and depression scores among men (p=.81, n=15) and women (p=.49, n=63) (Figure 4.5).

Vegetables

According to the analysis, there was no significant relationship between the total vegetable intake and depression scores among all participants (p=.56, n=82), men (p=.59, n=15), and women (p=.47, n=67) (Figure 4.6).

These results are inconsistent with the previously reported results and conclusions from other studies. Some studies referred to that vegetable consumption is inversely associated with the risk of depression since vegetables are rich in nutrition content, like vitamins, minerals, antioxidants, flavonoids, and phytochemicals, which may be used to protect against depression (Jane-Llopis et al., 2006; Pasco et al., 2011; Lasser et al., 2010). Similar research in south Asia and Canada indicated that decreasing daily intake of vegetables and fruits was related to greater odds of depression (Bishwajit et al., 2017; McMartin et al., 2013). Mental disorder and despair are related to expanded oxidant production and oxidative damage (Wang et al., 2007). The antioxidants in fruits and vegetables, such as Vitamin C and vitamin E, can alleviate the damaging outcomes of free radicals, reduce the harm to the cell, and help decrease the risk of depression development. (Maria Michel et al., 2012).

According to the USDA, vegetables' daily recommendation is 2.5 cups for women aged 19-30 and 3 cups for men aged 19-30 (ChooseMyPlate, n.d.). In this study, only 1 man (6.67%) ate more than 3 cups of vegetables per day, and 14 men (93.33%) ate less than 3 cups of vegetables daily. The depression score for men who eat ≥3 cups vegetables (1±0) was lower than men who eat <3 cups vegetables (5.79±4.23). However, the result for women was different. The depression score for women who eat ≥2.5 cups of vegetables (7.78±5.29) was higher than for women who eat <2.5 cups of vegetables (6.10±4.75) (Table 4.5). Additionally, it can be concluded that women（1.44±1.28） usually eat more vegetables than men (1.36±0.84), even that the USDA requirements for women are lower (Table 4.2). More women (13.43%) met the USDA requirements for daily vegetable intake than men (6.67%) (Table 4.5).

Omega-3 Fatty Acid

Our results indicate that no relationship between the omega-3 fatty acid intake and depression scores among all participants (p=.92, n=82), male (p=.51, n=15), and female (p=.96, n=67) (Figure 4.7).

The omega-3 fatty acid has a positive impact on neuroendocrine modulation and anti-inflammatory effects and further reduces the chance of depression (Jacka et al., 2013). According to a systematic review, even though there is no strong proof that omega-3 fatty acid is effective in treating depression (Appleton al., 2015), there are still some studies showing that omega-3 fatty acids have a positive effect on reducing the threat of depression development (Osher & Belmaker, 2009; Larrieu & Layé 2018). The research shows that inflammation plays an important position in the pathophysiology of mood disorders (Dantzer et al., 2008; Ménard et al., 2017), and DHA, EPA, and their derivatives, of the different forms of omega-3 fatty acid, have been shown to regulate inflammation and decrease the risk of depression (Serhan et al.,2011; Eckert et al., 2013).

The Recommended Dietary Allowance (RDA) for omega-3 fatty acids is 1.6 grams per day for men and 1.1 grams per day for women (Dietary reference intakes, 2005). The results of our experiment were different compared to the previous studies. The depression scores for men who consumed ≥1.6 grams omega-3 fatty acid (6.33±4.50) and women who consumed ≥1.1grams (6.43±4.43) were higher than men who consumed <1.6 grams (4.89±4.26) and women who consumed <1.1grams (6.29±5.13) (Table 4.6).

Overall

According to our results, and in contrast to other research, we could not confirm the hypothesis of a significant relationship between dietary quality (factors including total protein,

animal-based protein, vegetable-based protein, total sugar, added sugar, total vegetables, omega-3 fatty acid) and depression risk. The Dietary Quality Index showed a negative (-) correlation to the depression risk, and all dietary factors in this study showed a positive (+) correlation to the depression risk among all participants. But only the Dietary Quality Index, energy from total sugar intake, and added sugar intake are in line with expectations (Table 4.7).

The correlation between dietary factors and depression was different among gender categories. For male participants, the correlation between the total protein, animal-based protein, vegetable-based protein, total vegetables, and depression risk was negative (-); the correlation between Dietary Quality Index, total sugar, added sugar, omega-3 fatty acid, and depression risk was positive (+). Only Dietary Quality Index and the factor of omega-3 fatty acid intake did not meet the expectation (Table 4.8).

For female participants, the correlation between Dietary Quality Index, total protein, animal-based protein, vegetable-based protein, total sugar, added sugar, total vegetables, and depression risk was positive (+); the correlation between omega-3 fatty acid and depression risk was negative (-). Therefore, the Dietary Quality Index, and three factors confirmed the hypothesis, total sugar, added sugar, and omega-3 fatty acid for women (Table 4.8).

Through comparison, we found different results for male and female participants. This could be attributed to the very small sample size of male participants and the proportion of male and female participants not being equal. Additionally, females are more likely to amplify emotional problems and report more symptoms, so women usually have higher depression scores than men (Nolen-Hoeksema, 2002; Piccinelli & Wilkinson, 2000; Angst et al., 2002). The results of the average depression score from this study (male:5.47±4.26; female: 6.33±4.81) also proved this point (Table 4.2).

Other Factors Affect Depression

As mentioned above, many other factors can affect depression. In this study, the following factors were also found to bring influence.

Physical Activity

A total of 237 participants both completed the depression questionnaire and provided exercise time. Based on the results, there was a significant relationship between the amount of time spent on the low-intensity physical activity each week and depression score (p=.001, n=237), and a significant relationship between the amount of time spent on the moderate-intensity physical activity each week and depression score (p=.004, n=237) (Table 4.9). According to the Center for Disease Control recommendation, adults should keep moderate-intensity activity for 150 minutes every week or keep high-intensity activity for 75 minutes every week (Center for Disease Control, 2020). After comparison, the results showed that participants who did more than 150 minutes of moderate-intensity activity per week had a significantly lower average depression score than those who did less than 150 minutes per week (p=0.008). Still, there was no statistically significant difference between the average depression score of participants who did more than 75 minutes of high-intensity activity per week and the depression score of participants who did lower than 75 minutes of high-intensity activity per week (p=.446).

117 of these 237 participants provided gender information. Depending on the results, male participants spent significantly more time on low-intensity physical activity than female participants (p=.032) (Table 4.10). This was consistent with the finding that women have higher depression scores than men.

Covid 19 Pandemic

A total of 239 participants completed the depression questionnaire. 120 participants were recruited after the university shut down for Covid 19 pandemic, and 117 participants finished the questionnaire before the university shut down. Because participants did not provide information about their gender after school closure, it is impossible to compare results among gender categories. Based on the independent sample test, the variance in depression score for participants who recruited before the school shut down is not significantly different from the depression score for participants who recruited after the school shut down (p=.31). Still, the results also indicated that the mean depression score for the first group, participants recruited before the school shut down, is significantly lower than the mean depression score for the second group, participants recruited after the school shut down (p=.01) (Table 4.11). The differences in mean values of depression score may be due to changes in living circumstances. After school closes, some students choose to go back home with their families so that their typical diet changes. Besides, the environment under the epidemic and the different methods of instruction can also have an impact on mental status and, thus, on the depression score.

Big Five Personalities

In this study, the data about Big Five Personalities were collected. The Big Five personality traits are extraversion, agreeableness, emotions/neuroticism, intellect/openness, and conscientiousness. There were 150 participants both completed the depression questionnaire and provided personality-related data. After analysis, each trait had a negative (-) correlation with depression score; extraversion (p=.002, n=150) and emotions/neuroticism (p=.000, n=150) had a significant relationship with depression score (Table 4.12). Among these 150 participants, 30 of them provided gender information. There was no statistical difference between male and female

data on Big Five Personality. But female participants had a lower average score of extraversion and emotions than male participants (Table 4.13). This may also explain why women had higher depression scores than men despite having higher dietary quality indexes.

Limitation and Future Research

There were several limitations to this study. The major limitation is related to the sample size pool. Even though 375 subjects participated in this research, the valid number of subjects was only 82, accounting for 21.87% of the total number. The small sample size leads to higher variability and affects the accuracy of the results. Besides, the proportion of females and males in the sample was not equal. Out of the 82 valid participants, 67 were female (81.7%), and only 15 were male (18.3%).

Another major limitation is the National Institutes of Health Diet History Questionnaire II (NIH DHQ II) and Patient Health Questionnaire (PHQ-9). Data for these two questionnaires were self-reported, and participants may have answered some questions dishonestly and inaccurately. In this way, the data analysis and results may get impacted due to inaccurate diet intake and depression scores from self-reported data. Additionally, it takes a long time to complete all the questionnaires, which can easily lead to unanswered questions and unconscientious responses.

The extremely small sample and incomplete questionnaire survey could have made this study's results not in line with expectations. Also, it is worth to notice that depression is a very complex mental disease, and is influenced by many factors, like work environment, neighborhood social environment, inherited traits, hormone changes and so on. Any factor can cause depression scores to increase or decrease. Unfortunately, it was impossible to control all

these factors in our research. The most ideal and effective method is to take a large sample size in a certain community to increase the credibility and accuracy of the results.

The previous research among similar age groups proves the significant relationship between the diet quality and depression risk, and also states that protein intake, vegetable intake, sugar intake and omega-3 fatty acid intake is all related to the risk of depression. As mentioned above, external factors impact depression. Future researchers should focus on how to control for these external factors, to study the influence of diet quality on the risk of depression, and even the role of diet in the treatment of depression.

Table 4.1 Physical data of all participants among gender categories, including age, height, weight, BMI, body fat percentage, fat mass, and fat-free mass (Mean ±SD)

	All Participants (n=82)	Male (n=15)	Female (n=67)
Age (years ±SD)	19.71±1.34	20.07±1.28	19.63±1.35
Height (foot, inch ±SD)	5.48±0.28	5.56±0.40	5.46±0.24
Weight (pound ±SD)	152.51±41.79	194.36±51.15	143.13±33.18
Body Mass Index (kg/m2±SD)	24.82±6.02	28.10±7.39	24.08±5.47
Body Fat Percentage (% ±SD)	19.73±12.23	17.32±12.97	20.26±12.09
Fat Mass (pound ±SD)	32.77±28.96	39.01±39.67	31.37±26.16
Fat Free mass (pound ±SD)	118.07±28.02	147.29±40.78	111.53±19.31

Table 4.2 Depression scores among gender categories and selected dietary variables.

	All Participants (n=82)	Male (n=15)	Female (n=67)
Depression Score (score ±SD)	6.17±4.70	5.47±4.26	6.33±4.81
Dietary Quality Index (score ±SD)	60.77±11.17	59.26±12.22	61.13±10.98
Energy from total protein intake (%/day±SD)	14.56±3.83	14.71±3.14	14.53±3.99
Animal-based protein intake (grams/day±SD)	39.98±25.76	47.16±20.23	38.37±26.71
Vegetable-based protein intake (grams/day±SD)	9.78±5.54	24.24±10.90	19.55±12.54
Energy from sugar intake (%/day±SD)	4.41±3.39	4.73±2.85	4.34±3.52
Added sugar intake (grams/day±SD)	78.08±62.92	84.34±53.72	76.58±65.21
Total vegetable intake (cups/day±SD)	1.43±1.21	1.36±0.84	1.44±1.28
Omega-3 fatty acid intake (grams/day±SD)	1.29±0.85	1.41±0.62	1.26±0.90

Table 4.3 Depression scores and animal-based protein intake, and vegetable-based protein intake among gender categories.

	Animal-based > vegetable-based protein			Animal-based ≤vegetable-based protein		
	All	Male	Female	All	Male	Female
Number of participants	73	12	61	9	3	6
Depression score (score ±SD)	6.10±4.58	5.50±4.52	6.31±4.62	6.78±5.91	5.33±3.79	7.5±6.95

Table 4.4 Depression scores under different added sugar intake among gender categories.

	male		female	
Added sugar intake(grams)	≤36	>36	≤25	>25
Number	1	14	10	53
Depression score (score ±SD)	5±0	5.50±4.42	8±6.05	6.21±4.68

Table 4.5 Depression score under different total vegetable intake among gender categories

	male		female	
Total vegetable intake (cup)	<3	≥3	<2.5	≥2.5
Number	1	14	58	9
Depression score (score ±SD)	5.79±4.23	1±0	6.10±4.75	7.78±5.29

Table 4.6 Depression score under different omega-3 fatty acid intake among gender categories

	male		female	
Omega-3 fatty acid intake (grams)	<1.6	≥1.6	<1.1	≥1.1
Number	9	6	39	28
Depression score (score ±SD)	4.89±4.26	6.33±4.50	6.29±5.13	6.43±4.43

Table 4.7 + or - correlation and P-value of Dietary Quality Index and all dietary factors among all participants

Dietary factors of depression score	+ or - correlation	Expected correlation	P-value
Dietary Quality Index	-	-	0.21
Energy from total protein intake	+	-	0.84
Animal-based protein intake	+	-	0.77
Plant-based protein intake	+	-	0.29
Energy from total sugar intake	+	+	0.73
Added sugar intake	+	+	0.48
Total vegetable intake	+	-	0.56
Omega-3 fatty acid intake	+	-	0.92

+: the more intake, the higher depression score; -: the more intake, the lower depression score.

Table 4.8 + or - correlation and P-value of Dietary Quality Index and all dietary factors among gender categories

Dietary factors of depression score	+ or - correlation	P-value
Dietary Quality Index	M: + F: -	M: p=0.47 F: p=0.08*
Energy from total protein intake	M: - F: +	M: p=0.85 F: p=0.78
Animal-based protein intake	M: - F: +	M: p=0.50 F: p=0.54
Plant-based protein intake	M: - F: +	M: p=0.48 F: p=0.13
Energy from total sugar intake	M: + F: +	M: p=0.90 F: p=0.73
Added sugar intake	M: + F: +	M: p=0.88 F: p=0.53
Total vegetable intake	M: - F: +	M: p=0.59 F: p=0.47
Omega-3 fatty acid intake	M: + F: -	M: p=0.51 F: p=0.96

M=male; F=female; +: the more intake, the higher depression score; -: the more intake, the lower depression score. *: significant at p=0.10 level.

Table 4.9 Depression score under different exercise levels among all participants.

	+ or - correlation	p-value
Low-intensity physical activity	-	0.001**
Moderate-intensity physical activity	-	0.004**
High-intensity physical activity	+	0.850

**: significant at p=0.05 level.

Table 4.10 Comparison of exercise time among gender categories.

	Male (n=32)	Female (n=85)	p-value for t-test
Low-intensity physical activity (mean score±SD)	4.06±0.98	3.58±1.12	0.032**
Moderate-intensity physical activity (mean score±SD)	2.81±1.40	2.49±1.45	0.288
High-intensity physical activity (mean score±SD)	2.66±1.23	2.88±1.48	0.444

The higher score, the more exercise time. **: significant at p=0.05 level.

Table 4.11 Comparison of depression scores before and after school closures among all participants

	Before school shut down	After school shut down
Number of Participant	119	120
Depression Score (mean score±SD)	6.44±4.81	8.11±5.06

**: significant at p=0.05 level.

Table 4.12 + or - correlation and P-values of Big Five Personality among all participant

	+ or - correlation	P-value
Extraversion	-	0.002**
Agreeableness	-	0.238
Emotions/Neuroticism	-	0.000**
Intellect/Openness	-	0.787
Conscientiousness	-	0.091

**: significant at p=0.05 level.

Table 4.13 Comparison of Big Five Personality among gender categories

	male (n=8)	female (n=22)	p-value for t-test
Extraversion (mean score±SD)	36.00±4.84	34.74±8.69	0.699
Agreeableness (mean score±SD)	39.50±5.21	41.36±4.73	0.360
Emotions/Neuroticism (mean score±SD)	33.75±6.11	28.36±7.54	0.081
Intellect/Openness (mean score±SD)	39.88±5.79	35.77±7.05	0.108
Conscientiousness (mean score±SD)	37.25±4.33	37.00±5.34	0.906

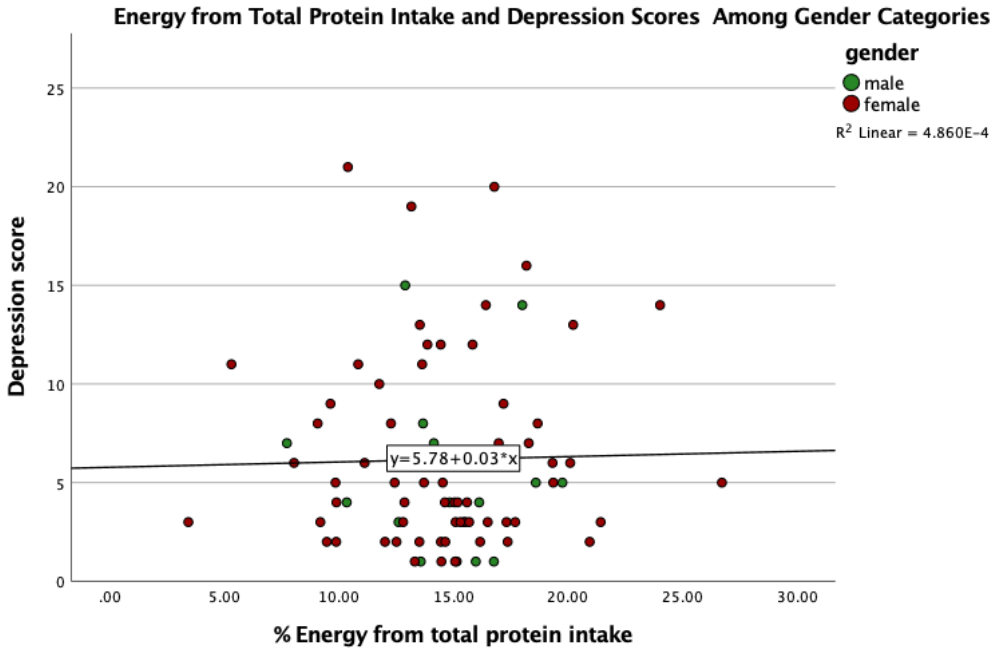

Figure 4.1 Energy from total protein intake and depression scores for all participants by gender.

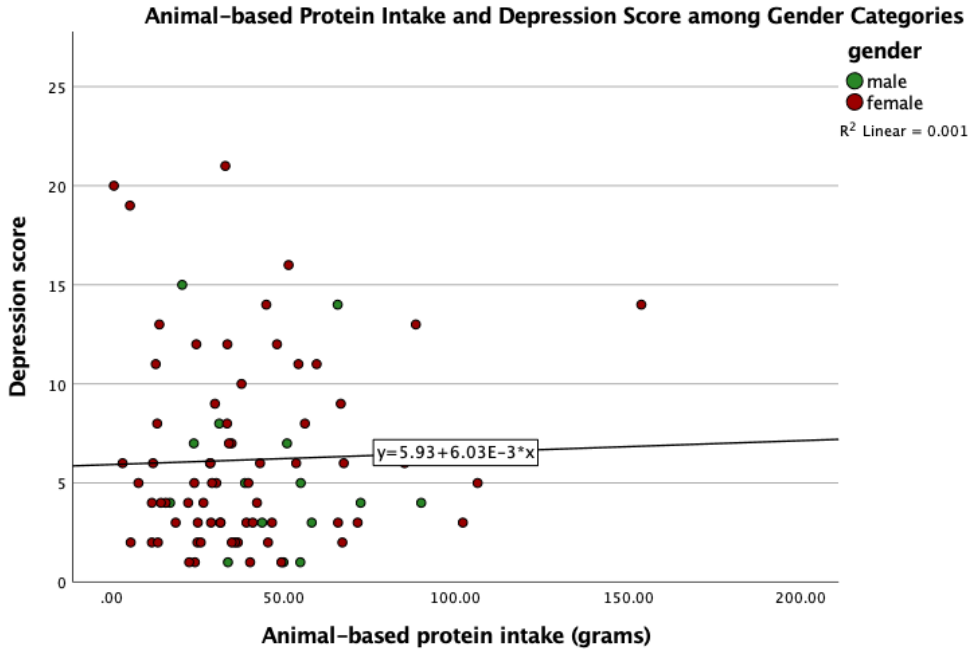

Figure 4.2 Animal-based protein intake and depression scores for all participants by gender.

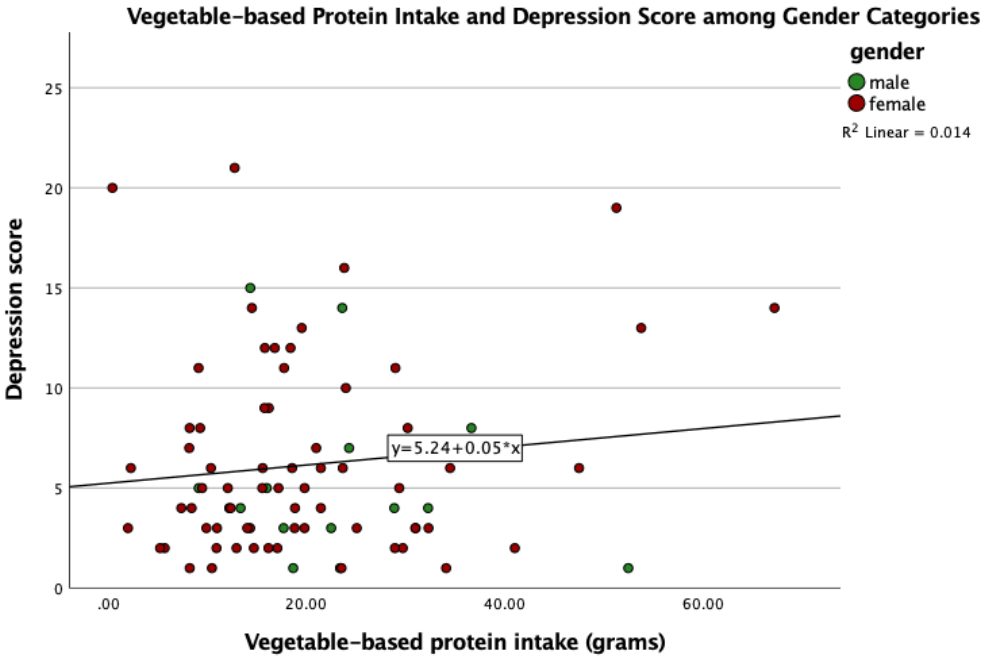

Figure 4.3 Vegetable-based protein intake and depression score for all participant by gender.

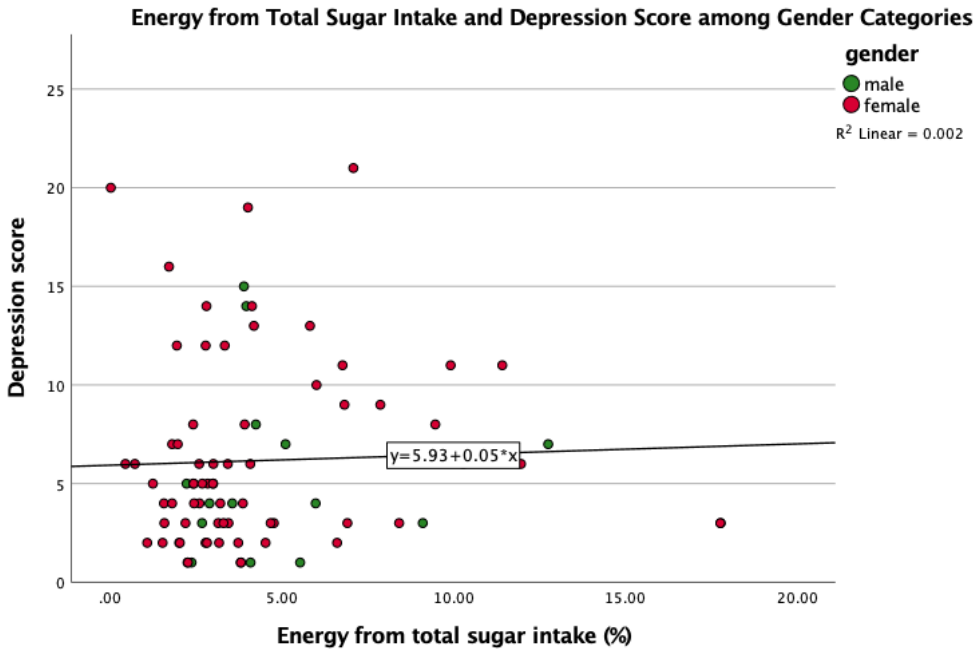

Figure 4.4 Energy from total sugar intake and depression score for all participants by gender.

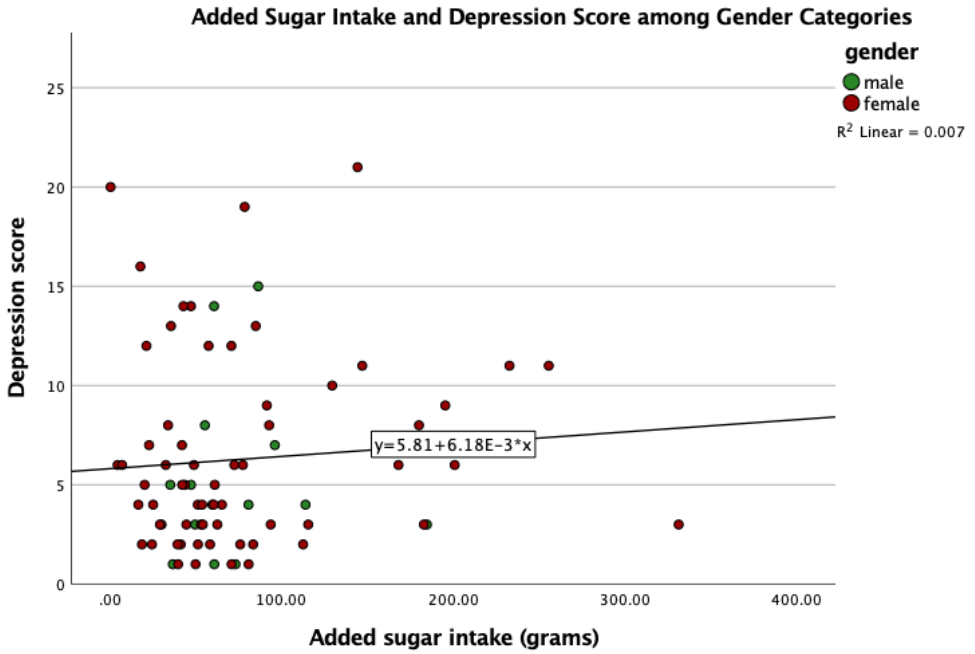

Figure 4.5 Added sugar intake and depression score for all participant by gender.

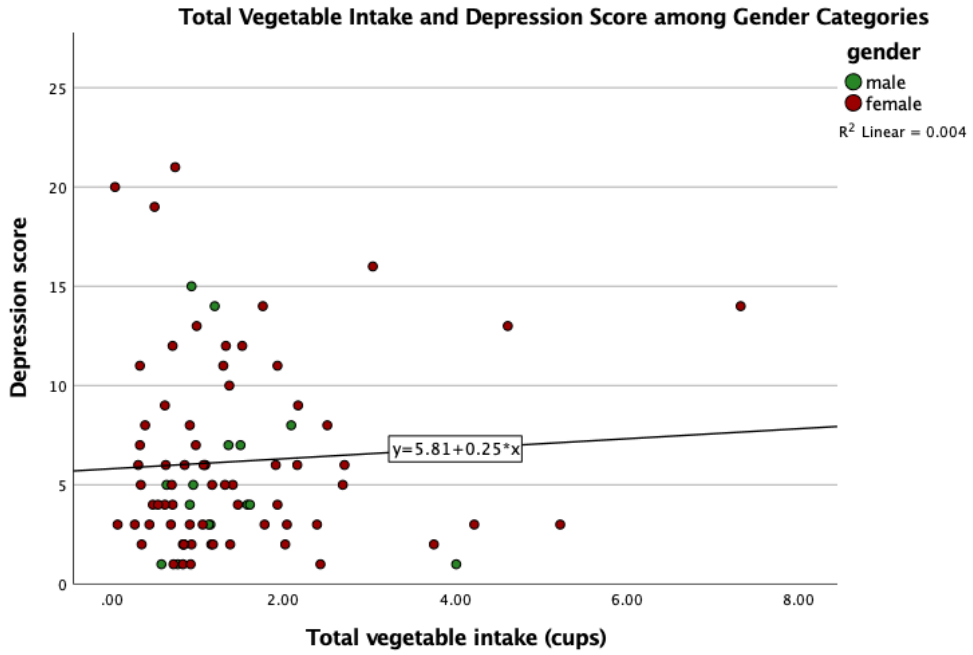

Figure 4.6 Total vegetable intake and depression score for all participants by gender.

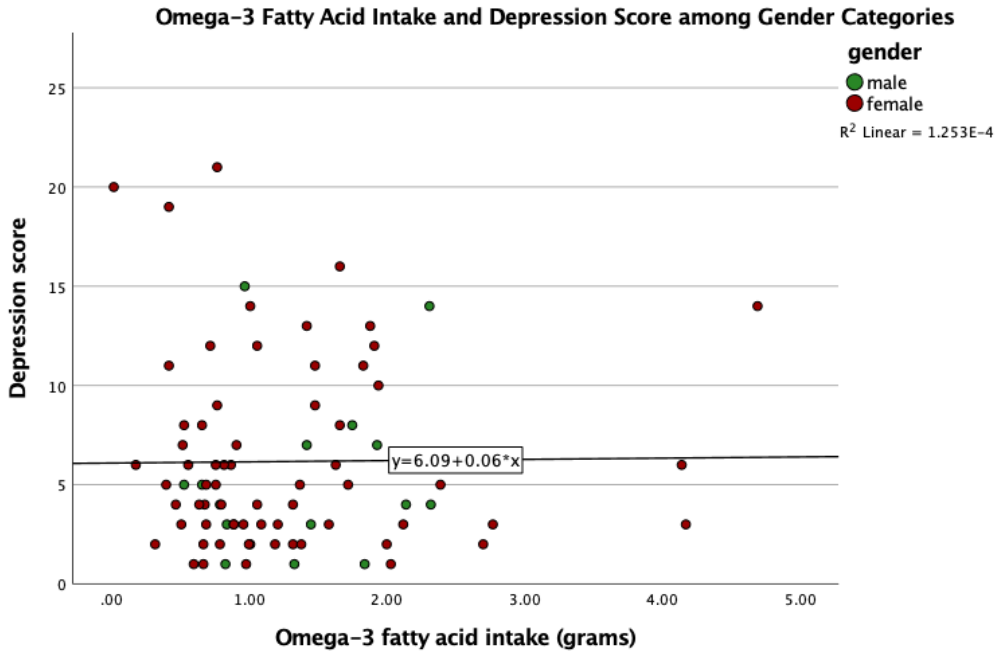

Figure 4.7 Omega-3 fatty acid intake and depression score for all participants by gender.

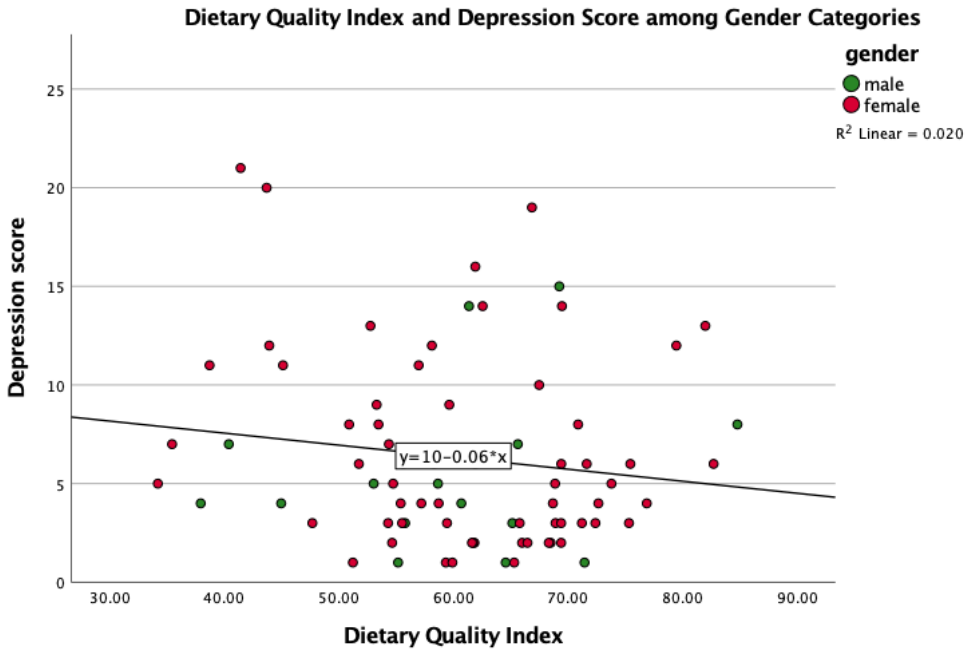

Figure 4.8 Dietary quality index and depression score for all participants by gender.

CHAPTER V

CONCLUSION

In conclusion, the results from this study completed on campus among college aged students showed no significant relationship between dietary quality index and depression score, and also no significant relationship between protein intake, vegetable intake, sugar intake and omega-3 fatty acid intake and depression score.

In contrast, previous research among similar age groups and methods did exhibit the significant relationship between the diet quality, including both of single nutrients or food group intake (like protein, sugar, vegetable, fruits, fish oil) and diet variation, and depression risk. No doubt that diet is one of the most significant and modifiable factors to reduce the risk of depression. The limitations in this research include the small sample size and that other factors such as environmental, socioeconomics, drug, and alcohol use were not analyzed. More participants and additional researches are needed to determine the effects of diet quality on depression score.

REFERENCES

All about the Vegetable Group. (n.d.). Retrieved from https://www.choosemyplate.gov/eathealthy/vegetables

Angst, J., Gamma, A., Gastpar, M., Lépine, J. P., Mendlewicz, J., & Tylee, A. (2002). Gender differences in depression. European archives of psychiatry and clinical neuroscience, 252(5), 201-209.

Appleton, K. M., Sallis, H. M., Perry, R., Ness, A. R., & Churchill, R. (2015). Omega‐3 fatty acids for depression in adults. Cochrane Database of Systematic Reviews, (11).

Baharzadeh, E., Siassi, F., Qorbani, M., Koohdani, F., Pak, N., & Sotoudeh, G. (2018). Fruits and vegetables intake and its subgroups are related to depression: a cross-sectional study from a developing country. Annals of general psychiatry, 17(1), 46.

Beck, D. A., Koenig, H. G., & Beck, J. S. (1998). Depression. Clinics in geriatric medicine, 14(4), 765-786.

Bishwajit, G., O'Leary, D. P., Ghosh, S., Sanni, Y., Shangfeng, T., & Zhanchun, F. (2017). Association between depression and fruit and vegetable consumption among adults in South Asia. BMC psychiatry, 17(1), 15.

Center for Disease Control. How much physical activity do adults need? (2020, October 07). Retrieved from https://www.cdc.gov/physicalactivity/basics/adults/index.htm

Dantzer, R., O'Connor, J. C., Freund, G. G., Johnson, R. W., & Kelley, K. W. (2008). From inflammation to sickness and depression: when the immune system subjugates the brain. Nature reviews neuroscience, 9(1), 46-56.

Dalgard OS, Bj S, Tambs K. Social support, negative life events and mental health. The British Journal of Psychiatry. 1995 Jan;166(1):29-34.

Cowen, P. J. (2008). Serotonin and depression: pathophysiological mechanism or marketing myth?. Trends in Pharmacological Sciences, 29(9), 433-436.

De Wit, L. M., Van Straten, A., Van Herten, M., Penninx, B. W., & Cuijpers, P. (2009). Depression and body mass index, a u-shaped association. BMC public health, 9(1), 14.

Depression (major depressive disorder). (2018, February 03). Retrieved from https://www.mayoclinic.org/diseases-conditions/depression/symptoms-causes/syc-20356007?utm_source=Google&utm_medium=abstract&utm_content=Major-depression&utm_campaign=Knowledge-pan

Dietary reference intakes: For energy carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids. (2005). Washington, D.C.: National Academy Press.

Eckert, G. P., Lipka, U., & Muller, W. E. (2013). Omega-3 fatty acids in neurodegenerative diseases: focus on mitochondria. Prostaglandins, Leukotrienes and Essential Fatty Acids, 88(1), 105-114.

Eley, T. C., Sugden, K., Corsico, A., Gregory, A. M., Sham, P., McGuffin, P., ... & Craig, I. W. (2004). Gene–environment interaction analysis of serotonin system markers with adolescent depression. Molecular psychiatry, 9(10), 908-915. 47. Wurtman, J. J., Brzezinski, A., Wurtman, R. J., & Laferrere, B. (1989). Effect of nutrient intake on premenstrual depression. American journal of obstetrics and gynecology, 161(5), 1228-1234.

Gibson-Smith, D., Bot, M., Brouwer, I. A., Visser, M., Giltay, E. J., & Penninx, B. W. (2020). Association of food groups with depression and anxiety disorders. European journal of nutrition, 59(2), 767-778.

Goldfield, G. S., Moore, C., Henderson, K., Buchholz, A., Obeid, N., & Flament, M. F. (2010). Body dissatisfaction, dietary restraint, depression, and weight status in adolescents. Journal of school health, 80(4), 186-192.

Jacka, F. N., Kremer, P. J., Leslie, E. R., Berk, M., Patton, G. C., Toumbourou, J. W., & Williams, J. W. (2010). Associations between diet quality and depressed mood in adolescents: results from the Australian Healthy Neighbourhoods Study. Australian & New Zealand journal of psychiatry, 44(5), 435-442.

Jacka, F. N., Rothon, C., Taylor, S., Berk, M., & Stansfeld, S. A. (2013). Diet quality and mental health problems in adolescents from East London: a prospective study. Social psychiatry and psychiatric epidemiology, 48(8), 1297-1306.

Jacobs, N., Kenis, G., Peeters, F., Derom, C., Vlietinck, R., & Van Os, J. (2006). Stress-related negative affectivity and genetically altered serotonin transporter function: evidence of synergism in shaping risk of depression. Archives of general psychiatry, 63(9), 989-996.

Jane‐Llopis, E. V. A., & Matytsina, I. (2006). Mental health and alcohol, drugs and tobacco: a review of the comorbidity between mental disorders and the use of alcohol, tobacco and illicit drugs. Drug and alcohol review, 25(6), 515-536.

Kessler, R. C., Angermeyer, M., Anthony, J. C., De Graaf, R. O. N., Demyttenaere, K., Gasquet, I., ... & Kawakami, N. (2007). Lifetime prevalence and age-of-onset distributions of mental disorders in the World Health Organization's World Mental Health Survey Initiative. World psychiatry, 6(3), 168.

Kim, S. H., Kim, H. S., Park, S. H., Hwang, J. Y., Chung, H. W., & Chang, N. S. (2012). Dietary intake, dietary habits, and depression in Korean women with polycystic ovary syndrome. Journal of Nutrition and Health, 45(3), 229-239.

Knüppel, A., Shipley, M. J., Llewellyn, C. H., & Brunner, E. J. (2017). Sugar intake from sweet food and beverages, common mental disorder and depression: prospective findings from the Whitehall II study. Scientific reports, 7(1), 1-10.

Kulkarni, A. A., Swinburn, B. A., & Utter, J. (2015). Associations between diet quality and mental health in socially disadvantaged New Zealand adolescents. European Journal of Clinical Nutrition, 69(1), 79-83.

Larrieu, T., & Layé, S. (2018). Food for mood: relevance of nutritional omega-3 fatty acids for depression and anxiety. Frontiers in physiology, 9, 1047.

Lasser, K., Boyd, J. W., Woolhandler, S., Himmelstein, D. U., McCormick, D., & Bor, D. H. (2000). Smoking and mental illness: a population-based prevalence study. Jama, 284(20), 2606-2610.

Lupton, J. R., Brooks, J. A., Butte, N. F., Caballero, B., Flatt, J. P., & Fried, S. K. (2002). Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein, and amino acids. National Academy Press: Washington, DC, USA, 5, 589-768.

Maria Michel, T., Pulschen, D., & Thome, J. (2012). The role of oxidative stress in depressive disorders. Current pharmaceutical design, 18(36), 5890-5899.

McMartin, S. E., Jacka, F. N., & Colman, I. (2013). The association between fruit and vegetable consumption and mental health disorders: evidence from five waves of a national survey of Canadians. Preventive medicine, 56(3-4), 225-230.

McMartin, S. E., Kuhle, S., Colman, I., Kirk, S. F., & Veugelers, P. J. (2012). Diet quality and mental health in subsequent years among Canadian youth. Public health nutrition, 15(12), 2253-2258.

Ménard, C., Pfau, M. L., Hodes, G. E., & Russo, S. J. (2017). Immune and neuroendocrine mechanisms of stress vulnerability and resilience. Neuropsychopharmacology, 42(1), 62-80.

Merikangas, K. R., He, J. P., Burstein, M., Swanson, S. A., Avenevoli, S., Cui, L., ... & Swendsen, J. (2010). Lifetime prevalence of mental disorders in US adolescents: results from the National Comorbidity Survey Replication–Adolescent Supplement (NCS-A). Journal of the American Academy of Child & Adolescent Psychiatry, 49(10), 980-989.

Miret, M., Ayuso-Mateos, J. L., Sanchez-Moreno, J., & Vieta, E. (2013). Depressive disorders and suicide: epidemiology, risk factors, and burden. Neuroscience & Biobehavioral Reviews, 37(10), 2372-2374.

Mirowsky, J., & Ross, C. E. (1992). Age and depression. Journal of health and social behavior, 187-205.

Nanri, A., Eguchi, M., Kuwahara, K., Kochi, T., Kurotani, K., Ito, R., ... & Mizoue, T. (2014). Macronutrient intake and depressive symptoms among Japanese male workers: the Furukawa Nutrition and Health Study. Psychiatry research, 220(1-2), 263-268.

Neumeister A. (2003). Tryptophan depletion, serotonin, and depression: where do we stand?. Psychopharmacology bulletin, 37(4), 99–115.

Nolen-Hoeksema, S. (2002). Gender differences in depression.

Osher, Y., & Belmaker, R. H. (2009). Omega‐3 fatty acids in depression: A review of three studies. CNS neuroscience & therapeutics, 15(2), 128-133.

Oh, J., Yun, K., Chae, J. H., & Kim, T. S. (2020). Association Between Macronutrients Intake and Depression in the United States and South Korea. Frontiers in psychiatry, 11, 207.

Payne, M. E., Steck, S. E., George, R. R., & Steffens, D. C. (2012). Fruit, vegetable, and antioxidant intakes are lower in older adults with depression. Journal of the Academy of Nutrition and Dietetics, 112(12), 2022-2027.

Pasco, J. A., Williams, L. J., Jacka, F. N., Henry, M. J., Coulson, C. E., Brennan, S. L., ... & Berk, M. (2011). Habitual physical activity and the risk for depressive and anxiety disorders among older men and women. International psychogeriatrics, 23(2), 292-298.

Piccinelli, M., & Wilkinson, G. (2000). Gender differences in depression: Critical review. The British Journal of Psychiatry, 177(6), 486-492.

Popa, T. A., & Ladea, M. (2012). Nutrition and depression at the forefront of progress. Journal of medicine and life, 5(4), 414.Sánchez-Villegas, A., Toledo, E., De Irala, J., Ruiz-Canela, M., Pla-Vidal, J., & Martínez-González, M. A. (2012). Fast-food and commercial baked goods consumption and the risk of depression. Public health nutrition, 15(3), 424-432.

Risch, N., Herrell, R., Lehner, T., Liang, K. Y., Eaves, L., Hoh, J., ... & Merikangas, K. R. (2009). Interaction between the serotonin transporter gene (5-HTTLPR), stressful life events, and risk of depression: a meta-analysis. Jama, 301(23), 2462-2471.

Sánchez-Villegas A, Toledo E, De Irala J, Ruiz-Canela M, Pla-Vidal J, Martínez-González MA. Fast-food and commercial baked goods consumption and the risk of depression. Public health nutrition. 2012 Mar;15(3):424-32.

Schmidt, J. A., Rinaldi, S., Scalbert, A., Ferrari, P., Achaintre, D., Gunter, M. J., ... & Travis, R. C. (2016). Plasma concentrations and intakes of amino acids in male meat-eaters, fish-eaters, vegetarians and vegans: a cross-sectional analysis in the EPIC-Oxford cohort. European journal of clinical nutrition, 70(3), 306-312.

Serhan, C. N., Fredman, G., Yang, R., Karamnov, S., Belayev, L. S., Bazan, N. G., ... & Petasis, N. A. (2011). Novel proresolving aspirin-triggered DHA pathway. Chemistry & biology, 18(8), 976-987.

Shivappa, N., Schoenaker, D. A., Hebert, J. R., & Mishra, G. D. (2016). Association between inflammatory potential of diet and risk of depression in middle-aged women: the Australian Longitudinal Study on Women's Health. British journal of nutrition, 116(6), 1077-1086.

Stansfeld, S., & Candy, B. (2006). Psychosocial work environment and mental health—a meta-analytic review. Scandinavian journal of work, environment & health, 443-462.

Stunkard, A. J., Faith, M. S., & Allison, K. C. (2003). Depression and obesity. Biological psychiatry, 54(3), 330-337.

Su, K. P., Huang, S. Y., Chiu, C. C., & Shen, W. W. (2003). Omega-3 fatty acids in major depressive disorder: a preliminary double-blind, placebo-controlled trial. European Neuropsychopharmacology, 13(4), 267-271.

Tsai, A. C., Chang, T. L., & Chi, S. H. (2012). Frequent consumption of vegetables predicts lower risk of depression in older Taiwanese–results of a prospective population-based study. Public Health Nutrition, 15(6), 1087-1092.

Turner-McGrievy, G. M., Wirth, M. D., Shivappa, N., Wingard, E. E., Fayad, R., Wilcox, S., ... & Hébert, J. R. (2015). Randomization to plant-based dietary approaches leads to larger short-term improvements in Dietary Inflammatory Index scores and macronutrient intake compared with diets that contain meat. Nutrition research, 35(2), 97-106.

Wang, L., Muxin, G., Nishida, H., Shirakawa, C., Sato, S., & Konishi, T. (2007). Psychological stress-induced oxidative stress as a model of sub-healthy condition and the effect of TCM. Evidence-based complementary and alternative medicine : eCAM, 4(2), 195–202.

World Health Organization. Geneva: World Health Organization; 2008. The global burden of disease: 2004 update.

Wurtman, J. J., Brzezinski, A., Wurtman, R. J., & Laferrere, B. (1989). Effect of nutrient intake on premenstrual depression. American journal of obstetrics and gynecology, 161(5), 1228-1234.

APPENDIX A

IRB-17-025 APPROVAL LETTER

MISSISSIPPI STATE UNIVERSITY

Office of Research Compliance

Institutional Review Board for the Protection of Human Subjects in Research
P.O. Box 6223
53 Morgan Avenue
Mississippi State, MS 39762
P. 662.325.3294

www.orc.msstate.edu

NOTICE OF APPROVAL FOR HUMAN RESEARCH

DATE:	January 31, 2017
TO:	Terezie Mosby, EdD, MS, RD, FAND, LDN, Food Sci Nutrition Hlth Promo Mary Andol, Food Sci Nutrition Hlth Promo
FROM:	Kari Reeves, Assoc Dean/Assoc Prof, MSU - Expedited
PROTOCOL TITLE:	Identifying polymorphisms of taste receptors as biomarkers (or risk factors) for obesity
PROTOCOL NUMBER:	IRB-17-025
APPROVAL PERIOD:	Approval Date: January 31, 2017 Expiration Date: January 15, 2018

Under an expedited review procedure, the research project identified above was approved for one year on January 31, 2017 by the Mississippi State University Institutional Review Board (MSU IRB). The application qualified for expedited review under CFR 46.110, Category 3, 7.

This memorandum is your record of the IRB approval of this study. Please maintain it with your study records.

Please note that the MSU HRPP accreditation for our human subjects protection program requires an approval stamp for consent forms. The approval stamp will assist in ensuring the HRPP approved version of the consent form is used in the actual conduct of research. **You must use the stamped consent form for obtaining consent from participants.**

The MSU IRB approval for this project will expire on January 15, 2018. If you expect your project to continue beyond this date, you must submit an application for renewal of this HRPP approval. HRPP approval must be maintained for the entire term of your project.

If, during the course of your project, you intend to make changes to this study, you must obtain approval from the HRPP prior to implementing any changes. Upon becoming aware of an unanticipated problem that suggests participants or others are at greater risk of harm than was previously known or recognized, a problem report must be submitted to the HRPP as soon as possible, but always within 10 days. Serious problems must be reported verbally within one business day, in addition to the submission of the written Problem Report.

You are required to maintain complete records pertaining to the use of humans as participants in your research. This includes all information or materials conveyed to and received from participants as well as signed consent forms, data, analyses, and results. These records must be maintained for at least three years following project completion or termination, and they are subject to inspection and review by the HRPP and other authorized agencies.

Please notify this office when your project is complete. Upon notification, we will close our files pertaining to your project. Reactivation of the HRPP approval will require a new HRPP application.

If you have any questions relating to the protection of human research participants, please contact the HRPP by phone at 325.3994 or email irb@research.msstate.edu. We wish you the very best of luck in your research and look forward to working with you again.

Kari Reeves

Approval Period:	January 31, 2017 through January 15, 2018
Review Type:	EXPEDITED
IRB Number:	IORG0000467

APPENDIX B

PATIENT HEALTH QUESTIONNAIRE (PHQ-9)

PATIENT HEALTH QUESTIONNAIRE (PHQ-9)

ID #: _____ **DATE:** _____

Over the last *2 weeks,* how often have you been bothered by any of the following problems?
(use "✓" to indicate your answer)

	Not at all	Several days	More than half the days	Nearly every day
1. Little interest or pleasure in doing things	0	1	2	3
2. Feeling down, depressed, or hopeless	0	1	2	3
3. Trouble falling or staying asleep, or sleeping too much	0	1	2	3
4. Feeling tired or having little energy	0	1	2	3
5. Poor appetite or overeating	0	1	2	3
6. Feeling bad about yourself—or that you are a failure or have let yourself or your family down	0	1	2	3
7. Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8. Moving or speaking so slowly that other people could have noticed. Or the opposite — being so figety or restless that you have been moving around a lot more than usual	0	1	2	3
9. Thoughts that you would be better off dead, or of hurting yourself	0	1	2	3
	add columns		+	+

(Healthcare professional: For interpretation of TOTAL, please refer to accompanying scoring card). TOTAL:

10. If you checked off *any problems,* how *difficult* have these problems made it for you to do your work, take care of things at home, or get along with other people?

- Not difficult at all _____
- Somewhat difficult _____
- Very difficult _____
- Extremely difficult _____

A2663B 10-04-2005

APPENDIX C

NATIONAL INSTITUTES OF HEALTH DIET HISTORY QUESTIONNAIRE II (NIH DHQ II)

This is a sample form. Do not use for scanning.

NATIONAL INSTITUTES OF HEALTH

Diet History Questionnaire II

GENERAL INSTRUCTIONS

- **Answer each question as best you can. Estimate if you are not sure. A guess is better than leaving a blank.**
- **Use only a black ball-point pen. Do not use a pencil or felt-tip pen. Do not fold, staple, or tear the pages.**
- **Put an X in the box next to your answer.**
- **If you make any changes, cross out the incorrect answer and put an X in the box next to the correct answer. Also draw a circle around the correct answer.**
- **If you mark NEVER, NO, or DON'T KNOW for a question, please follow any arrows or instructions that direct you to the next question.**

BEFORE TURNING THE PAGE, PLEASE COMPLETE THE FOLLOWING QUESTIONS.

Today's date:

MONTH	DAY		YEAR
☐ Jan	___ ___		☐ 2010
☐ Feb	☐0	☐0	☐ 2011
☐ Mar	☐1	☐1	☐ 2012
☐ Apr	☐2	☐2	☐ 2013
☐ May	☐3	☐3	☐ 2014
☐ Jun		☐4	☐ 2015
☐ Jul		☐5	☐ 2016
☐ Aug		☐6	☐ 2017
☐ Sep		☐7	☐ 2018
☐ Oct		☐8	☐ 2019
☐ Nov		☐9	☐ 2020
☐ Dec			

DHQ II PastYear

In what month were you born?

☐ Jan
☐ Feb
☐ Mar
☐ Apr
☐ May
☐ Jun
☐ Jul
☐ Aug
☐ Sep
☐ Oct
☐ Nov
☐ Dec

In what year were you born?

19 ___ ___

☐0	☐0
☐1	☐1
☐2	☐2
☐3	☐3
☐4	☐4
☐5	☐5
☐6	☐6
☐7	☐7
☐8	☐8
☐9	☐9

Are you male or female?

☐Male
☐Female

BAR CODE LABEL OR SUBJECT ID HERE

___ ___ ___ ___ ___ ___ ___ ___

The full version is at this link: https://epi.grants.cancer.gov/dhq2/forms/dhq2_pastyear.pdf