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Food and Mood: The Correlation Between Vitamin B12 and Folate Intake and Depression

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Abstract

Vitamin B12 is an essential nutrient that metabolizes homocysteine, which is a potentially neurotoxic molecule when in excess. Folate is a B vitamin that is essential to the production of norepinephrine, serotonin, and dopamine in the brain. Studies show that a deficiency in vitamin B12, as well as folate, may be associated with mental health conditions. Additionally, the prevalence of depression is higher in college students than other demographic populations. **PURPOSE**: The purpose of this study was to investigate a correlation between vitamin B12 and folate intake with signs and symptoms of depression in college students. **METHODS**: This study was conducted by first providing participants with the Beck Depression Inventory (BDI) to measure signs and symptoms of depression. Next, each participant documented their dietary intake in a 3-day diet record. The 3-day diet records were analyzed using Food Processor to determine nutritional values. For this study, the vitamin B12 and folate data sets were evaluated for relationships with the BDI data. **RESULTS**: This study showed no correlation between vitamin B12 intake and the BDI ($r = -0.114$, $p = 0.257$, $n = 101$). There was also no correlation between vitamin B12 and the Beck somatic subscale ($r = -0.100$, $p = 0.452$, $n = 59$), nor with the Beck affective subscale ($r = -0.085$, $p = 0.399$, $n = 101$). Correlations between folate intake and BDI showed no relationship ($r = -0.078$, $p = 0.439$, $n = 101$). There was a lack of association between folate intake and the Beck somatic subscale ($r = 0.014$, $p = 0.914$, $n = 101$) and the Beck affective subscale ($r = -0.095$, $p = 0.344$, $n = 101$). **CONCLUSION**: Though no correlations were found, participants had incredibly varied folate and vitamin B12 intakes, yielding high standard deviations, which may have prevented detection of relationships. The results of this study still suggest that many college students are not consuming the recommended daily values for vitamin B12 and folate.
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Introduction

Depression is an increasingly prevalent condition plaguing the population. Prevalence of depression is relatively high for those in emerging adulthood, including college students. Analyzing how nutrition and depression symptoms are correlated in undergraduate students is important due to a higher rate of depression within this group compared to the general population. In conjunction with depression already being the third most common health problem, after cardiac and respiratory diseases, a mean prevalence of about 48.30% was found among college students (Shah & Pol, 2020). There are many lifestyle factors that can impact this prevalence, a major one being diet and nutrition. Poor diet and insufficient nutrient intake have been shown to be correlated with mental health symptoms such as depression (Ibrahim et al., 2013). Therefore, understanding poor diet as being a potential contributor to depression may be essential in the prevention of future negative outcomes. It has been found that a deficiency in vitamin B12 and folate are correlated with patient cases of depression (Coppen & Bolander-Gouaille, 2005). Additionally, high vitamin B12 and folate levels have been found to improve the functioning of antidepressants and predict a more positive treatment outcome for depression (Coppen & Bolander-Gouaille, 2005). Sleep, poor diet, and life stress are all contributors to depression in college students; thus, this study will focus specifically on the diet and nutrition factors.

Vitamin B12 serves various functions and is available in foods and supplements. The vitamin is only synthesized by certain types of bacteria and archaea. It is then acquired by animal products, such as meat, dairy, and eggs, through transference and gradual accumulation in tissue. This occurs via microbial interaction and symbiotic bacterial relationships within the animal's gastrointestinal tract (Watanabe & Bito, 2017). Most people obtain enough from the food they

eat, but deficiencies are common in pregnant women and people living in underdeveloped countries (Smith et al., 2018). In this case, supplements can be taken. Some individuals also have trouble absorbing B12 from food. On the other hand, some foods, such as eggs, provide poor absorption of the vitamin (Watanabe, 2007). This can lead to deficiencies even if one is eating foods containing vitamin B12. For those without absorption issues, there are several sources of the vitamin. Meat, milk, eggs, fish, shellfish, and other animal products all contain vitamin B12 (Watanabe, 2007).

When vitamin B12 is ingested in the form of food or a supplement, it is always attached to a protein. Thus, a specific process is required in order to allow the body to absorb and use it. When it reaches the stomach, the source of the vitamin B12 is digested and exposed to hydrochloric acid that is secreted by the gastric parietal cells in the stomach lining, which are cells that produce gastric acid to aid digestion. This separates the vitamin from the protein it is attached to. The released form of the vitamin is then bound to intrinsic factor, also released by parietal cells, and is absorbed together in the small intestine (U.S. Department of Health and Human Services, n.d.). When the vitamin is absorbed by the small intestine, it begins to perform its various functions within the body.

Deficiencies can occur due to poor diet or preexisting conditions. Vitamin B12 deficiency is not extremely common, with a 3.3% prevalence in women and a 2.4% prevalence in men within the general population (Green et al., 2017). However, older adults may be more at risk of a vitamin B12 deficiency due to its reliance on hydrochloric acid in the stomach to be processed. As people age, malabsorption of the vitamin becomes more likely due to gastric atrophy (Wong, 2015). Additionally, vegans may be at higher risk of deficiency because the main sources of vitamin B12 are animal products, such as meat, eggs, and dairy. Pernicious anemia is a condition

that causes severe B12 deficiency due to low levels of intrinsic factor, impeding proper absorption. A deficiency in this vitamin can cause death, neural tube defects, stroke, and dementia. Children are the most vulnerable to adverse effects of B12 deficiency, due to its impact on neural development (Smith et al., 2018). Vitamin B12 also works with folate in the body in order to make red blood cells and assist with the functioning of iron.

Vitamin B12 serves as a cofactor for the enzymes methionine synthase and methylmalonylCoA mutase, which assist with methionine production. Methionine production is needed for producing methyl groups for methylation processes. An important methylation process that is supported by vitamin B12 and folate is one that methylates homocysteine to methionine using methyl groups. These vitamins also work to synthesize s-adenosylmethionine, which donates methyl groups that are necessary for several functions. These methyl groups play a role in DNA, protein, and neurotransmitter metabolism, and neurological function (Coppen & Bolander-Gouaille, 2005). Thus, a deficiency in this molecule can cause psychological disturbances (Bottiglieri, 2009). Additionally, a deficiency in vitamin B12 can cause methionine synthase to not operate properly, leading to an accumulation of homocysteine (Smith et al., 2018). Homocysteine is a risk factor for many diseases, like systemic atherosclerosis, cardiovascular disease, and stroke (Chrysant & Chrysant, 2018). It is also considered a neurotoxic molecule that can directly contribute to adverse mental and mood effects (Bottiglieri, 2009). Increased levels of homocysteine have been found in individuals with depression, and thus is associated with an increased risk for the condition (Coppen & Bolander-Gouaille, 2005).

Folate is an essential vitamin that is mainly found in fruit, beans, leafy greens, and fortified cereals (Allen, 2008). People who mainly eat unfortified wheat or rice as a key part of their diets are at higher risk for folate deficiency. Additionally, those who eat low amounts of

beans and leafy green vegetables are at higher risk for deficiency. Individuals who are pregnant should be more concerned about folate deficiency due to its role in the development of the fetal brain and spinal cord, and deficiencies can cause neural tube defects. When consumed in adequate amounts, folate is absorbed in the body through hydrolyzation and passive diffusion in the small intestine. Folate can work to help prevent depression and supplement active depression treatment due to its role in neurotransmitter production (Fava & Mischoulon, 2009). Folate is a B vitamin that is required for the synthesis of norepinephrine, serotonin, and dopamine in the brain (Fava & Mischoulon, 2009). Folate also works with vitamin B12 to reduce toxic plasma homocysteine levels when consumed at the recommended dietary allowance (RDA) (Allen, 2008).

Existing literature has investigated how the relationship between nutrition and mental health specifically impacts university students. Studies do exist analyzing college students, but one example includes them only as part of a larger subject pool composed of an age range of 18-65 (Khosravi et al., 2020). This study did find a correlation between folate and vitamin B12 intake but does not independently assess college students. Therefore, it's important to study college students as an independent group to factor in their specific lifestyles. This study will examine the relationship between vitamin B12 and folate intake and depression in college students.

Methods

First, student participants were selected through the University's Psychology Pool and through recruitment by advertising the opportunity in their classes. This study was limited to adult college students at Loyola Marymount University. All participants provided written

informed consent before beginning their participation in this study. As a study with human participants, this research was approved by the Loyola Marymount University Institutional Review Board.

After the participants were screened, they were emailed a single link to complete a series of questionnaires, including the Beck Depression Inventory (BDI). The BDI is an assessment where the participant gave a ranking for 21 different items pertaining to depression. These include suicidal ideation, day-to-day mood, and self-image. This is a relatively short assessment, with the highest score possible being a 63. A score of 1-10 indicates normal mental functioning. A score of 11-16 indicates a mild mood disturbance. A score of 17-20 marks borderline clinical depression, and anything past this indicates moderate (21-30), severe (31-40), or extreme depression. Extreme depression is marked by any score over 40 (Beck et al., 1987). The BDI is widely used to assess depression in research and has moderate to high internal and external validity for all subscales (García-Batista et al., 2018). Participants also completed the International Physical Activity Questionnaire to assess physical activity (Craig et al., 2003). The questionnaires were delivered via Qualtrics, a secure internet-based survey tool which was used in a manner to ensure privacy.

Once the questionnaires were completed, volunteers were emailed instructions on how to complete a 3-Day Diet Record (3DDR). Instructions for completion were to record all food, drink, and supplement intake for three days, with two weekdays and one weekend day included. Once completed, participants emailed their 3DDR back to researchers. One member of the research team reviewed the diet record and asked any follow-up questions needed via email, text, or in person to ensure an accurate assessment. After data collection was complete, researchers analyzed dietary intake using ESHA Food Processor® Nutrition and Fitness Software version

11.14.9, a web-based research quality dietary analysis software. This software analyzes dietary intake and separates any intake into its nutritional components (Bazzano, 2002). In this study, this tool was used to assess vitamin B12 in mcg and folate intake in dietary folate equivalents.

To calculate the relationship between vitamin B12 and folate intake and BDI scores, SPSS software version 28.0.1.1 was used. On SPSS, frequencies, means, and standard deviations were calculated for the demographic and experimental data. The research question was tested using Pearson Correlation Coefficients between vitamin B12 and folate intakes and BDI scores and subscales. Additionally, independent samples t-tests were used to detect differences in BDI scores, vitamin B12, and folate for people in and not in additional mental health treatment, such as therapy or using antidepressant medication. Finally, a correlation was calculated between physical activity (in metabolic equivalent minutes per week) and BDI.

Results

There were 102 participants assessed, with an average age of 19.5 years. Other demographic information can be found in Table 1 and Table 2. Physical attributes, nutrition, BDI scores, and lifestyle choices that may contribute to the correlation between vitamin B12 and folate intake and depression are listed.

Only 13.5% of the participants showed signs of moderate depression after taking both the somatic and affective subscales of the BDI (N = 8 out of 59). Another 8.5% of participants showed severe signs of depression (N = 5 out of 59). The mean intake of vitamin B12 among participants was 3.00 ± 5.10 mcg. The mean intake of folate was 135.20 ± 170.44 mcg. Therefore, 67% of participants did not meet the RDA of folate (400 mcg) and 90% did not meet the RDA of vitamin B12 (2.4 mcg). This study showed no correlation between vitamin B12

intake and the BDI ($r = -0.114$, $p = 0.257$, $n = 101$). There was also no correlation between vitamin B12 and the Beck somatic subscale ($r = -0.100$, $p = 0.452$, $n = 59$), nor with the Beck affective subscale ($r = -0.085$, $p = 0.399$, $n = 101$). Correlations between folate intake and BDI showed no relationship ($r = -0.078$, $p = 0.439$, $n = 101$). There was a lack of association between folate intake and the Beck somatic subscale ($r = 0.014$, $p = 0.914$, $n = 101$) and the Beck affective subscale ($r = -0.095$, $p = 0.344$, $n = 101$). There was also no significant difference in BDI scores by antidepressant usage ($t(102) = -0.341$, $p = 0.734$). However, there was a significant difference in BDI scores by the participation in additional mental health therapies ($t(101) = -2.91$, $p = 0.004$). Those using additional mental health therapies ($n=29$) had significantly lower BDI scores than those not using therapies (10.49 ± 8.99 vs. 16.33 ± 9.76). A correlation was not found between physical activity and BDI scores ($r = 0.181$, $p = 0.068$, $n = 102$).

Variable	*N*	*Minimum*	*Maximum*	*Mean*	*Standard Deviation*
Age (yrs.)	102	18.00	24.24	19.47	1.26
Height (cm)	102	136.50	200.66	168.02	9.89
Weight (kg)	102	44.50	122.45	66.29	15.56
BMI[1](kg/m^2)	102	15.13	42.91	23.41	4.69
Sex	102	NA	NA	80F, 21M	NA
Vitamin B12 (mcg)	101	0.06	39.10	3.00	5.10
Folate (mcg)	101	0.16	823.33	135.20	170.44
Fruits (cups)	102	0.00	4.48	1.02	0.92
Vegetables (cups)	102	0.01	12.95	3.45	2.93
Physical Activity (Met-min/wk)[2]	102	0.00	33756.00	8470.15	7988.50
BDI[3]	102	0.00	37.00	12.29	9.54
Somatic Subscale	59	13.00	36.00	22.05	5.94
Affective Subscale	102	8.00	30.00	12.34	4.59

Table1. Demographic, nutrition, and mental health information of the participants in this study.

[1] BMI - Body Mass Index
[2] Met – metabolic equivalents
[3] BDI - Beck Depression Inventory

Variable	*Frequency*	*Percent*
Race		
Asian	18	17.60%
African American/Black	7	6.90%
White	57	55.88%
Decline to State	6	5.88%
Mixed Race	14	13.70%
Ethnicity		
Hispanic	22	21.78%
Non-Hispanic	77	76.24%
Decline to State	2	1.98%
Antidepressants		
Yes	9	8.82%
No	93	91.18%
School Year		
First	54	52.94%
Second	31	30.39%
Third	14	13.73%
Fourth	3	2.94%
Additional Therapies		
No	72	71.29%
Therapy	24	23.76%
Psychiatry	1	0.99%
Psychoanalysis	1	0.99%
Prior Therapy	1	0.99%
Therapy + support group	1	0.99%
Therapy + Neurofeedback	1	0.99%
Meal Plan		
Yes	70	68.63%
No	32	31.37%

Table 2. Frequency of demographic data of the participants in this study.

Discussion

This research was not able to find a significant relationship between vitamin B12 and folate intake and BDI scores within the assessed participant set. This may be due to many reasons, including inaccuracies in recording and assessing dietary intake among the participants. Issues with the study design may have contributed as well, such as the timing of mental health assessment before the dietary assessment. However, this study was thorough in assessing multiple factors that may contribute to participants' mental health, such as physical activity and additional treatments. Previous studies that found relationships between vitamin B12 and folate intake and depression had a higher number of participants than the present study, consisting mostly of older age groups (Khosravi et al., 2020). There are also a variety of confounding variables that may contribute to incidence of depression other than diet, such as social habits, physical activity, and stress coping mechanisms. College students may be better suited in these areas than older adults, which may impact the correlations between diet and mental health reported here.

One study (Wattick et al., 2018) focuses on young adults in Appalachia that have little access to resources that would allow them to have a balanced diet, with 36.7% of the participant group identifying as food insecure. The participant group also has a high prevalence of mental health symptoms as college students. This study assessed correlations between mental health status and diet intake through surveys. This was assessed with a participant group of 1,956 college students with relatively high prevalence of depression and anxiety, with an average of 9.7 ± 8.8 days of depression and 14.1 ± 10.0 days of anxiety over the 30 days preceding the study. Food insecurity and fruit and vegetable intake were able to predict depression in males and females (Wattnick et al., 2018). Added sugars and food insecurity were also strong predictors of

anxiety for males and females. These analyses show that diet on a more holistic level, examining food intake, rather than micronutrient intake, may be a good predictor of mental health in college students. Additionally, food insecurity is a relatively common issue for college students, both in Appalachia and all of the United States, which is the location of focus for the present study. In America, 43.5% of college students are reported to suffer from some level of food insecurity (Nazmi et al., 2018).

In a systematic review of studies on diet and mental health during emerging adulthood, associations between diet and risk of depression and anxiety were analyzed (Collins et al., 2020). It specifically analyzed studies focusing on the ages of 18-29 years. It emphasizes that this age range poses an extra risk for poor mental health and low diet quality relative to older and younger age ranges. Collins et al. found that there were moderately significant correlations between diet quality and depression, anxiety, affect, and mental health. Studies do illustrate those diets high in fruit, vegetables, whole grains, nuts, seeds, fish, and low in processed foods can predict a low risk for depression (Collins et al., 2020). Some of these foods are high in vitamin B12, such as fish. Beans, vegetables, and fruits are good sources of folate as well. Additionally, diets high in fat, sugar, and processed foods were found by Collins et al. to conversely predict a higher risk for depression and other mental health symptoms. Their study also illustrates that depression and diet may impact each other; individuals with depression are more likely to have poor diets as a result of impaired appetite that is a symptom of the mental health disorder. Moreover, there is an emphasis on gut microbiome health as an aspect of the relationship between diet and mental health symptoms, due to its impact on neurobiological pathways, including the hypothalamic-pituitary-adrenal (HPA) axis, serotonin neurotransmission, and immune system function. However, Collins et al. also found that the methodologies of these

studies were weak, indicating poor study designs. While it is illustrated that emerging adulthood is a critical age due to higher risk of poor mental health and diet habits, more research needs to be done on their relationship among these variables.

Another study examined the relationship between diet and mental health by assessing behavioral aspects of diet (Lesani et al., 2016). The behavioral factor of diet highlighted here was the timing of meals, and specifically the relationship between eating breakfast and happiness in college students. In addition to assessing eating breakfast, fruit and vegetable intake was measured. The study focused on 541 students at the Qazvin University of Medical Sciences in Iran. Data was collected through web-based questionnaires about happiness, breakfast, and fruit and vegetable consumption. Therefore, this methodology was different from the present study because it did not directly analyze the micronutrients of food intake over a set amount of time. However, this methodology found that there was a positive relationship between happiness and eating breakfast ($p < 0.001$), the number of meals eaten each day ($p = 0.008$), and fruit ($p = 0.02$) and vegetable consumption ($p = 0.045$). Highest happiness scores were found in students who ate breakfast every day, had more than 8 servings of fruit and vegetables daily, 3 meals daily, and 1-2 snacks per day. This study highlights that flavanols in fruits and vegetables may be responsible for improving cognitive functioning. The correlation between happiness and regular mealtimes, such as breakfast, as diet habits may be due to the benefits of establishing a routine. Additionally, breakfast allows the brain to replenish its glucose energy sources that allow it to function well for the rest of the day, improving cognitive performance and mental health. Lesani et al. introduced the concept that timing of meals is also an important factor in a healthy diet.

Another study investigates the relationship between diet and depression in female Korean college students by analyzing dietary taurine intake and other factors (Park et al., 2010). Taurine

was assessed due to literature stating that individuals with depression and schizophrenia tended to have lower taurine levels. Taurine plays a role as an inhibitory neurotransmitter, and a contributor to neuronal growth. Data was collected on taurine and other nutritional intake, dietary habits, and depression. A group of 65 students with depression and 65 students without depression were assessed using the Center for Epidemiologic Studies Depression (CES-D) scale and a 3-day diet record with 2 weekdays and 1 weekend, much like the present study's design. Park et al. (2010) did not find a significant relationship between taurine intake and depression. However, it was found that beta-carotene, vitamin C, folic acid, and fiber levels were significantly lower in the students with depression. The study also found that a vitamin B12 deficiency was associated with depressive disorders. Life stress was also significantly higher in depressed students. They also displayed significantly worse dietary habits, such as not eating meals at regular times and a lack of diverse diets, eating significantly less meat, fish, eggs, and beans than the control group. With a similar study design to this present study, the participants in the study by Park et al. exhibited a significant correlation between folate and vitamin B12 intake and depression.

The above-mentioned studies illustrate a reciprocal relationship between depression and diet, and how one can impact the other (Lesani et al., 2016; Park et al., 2010). As stated above, diet may be related to depression through many factors. Nutritional intake, as well as timing and frequency of meals can have an impact on depression. Additionally, other lifestyle factors, such as stress and physical activity can have an impact on experiencing depression. However, depression itself can have an impact on these factors. Depressed individuals may be less likely to maintain healthy diet habits and may not regularly eat meals due to the lack of appetite that is a symptom of depression. Additionally, depression can reduce one's desire to be physically active,

and may force individuals into a more sedentary lifestyle. Therefore, this relationship between diet and depression is essential in understanding the results of this present study. When examining the relationships between dietary intake and depression, it is difficult to determine if a poor diet quality contributes to poor mental health or if poor mental health leads to poor diet quality.

Although no relationships were found between vitamin B12 and folate intake and BDI scores in the present investigation, there were notable incidences of depression and vitamin deficiencies among research volunteers. These may lead to other issues in college students, presenting as harm to physical and mental health. Therefore, it is still important for college students to address dietary inadequacies independent of a potential relationship with depression. College students should continue to seek resources for mental health aid and reach for vitamin B12 and folate rich foods. Meat, fish and dairy are excellent sources of vitamin B12, and dark leafy greens such as spinach are great sources of folate. To further this research, timing of the dietary assessment before taking the BDI questionnaire should be explored.

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