**Exploring the Association Between Vitamin D Levels and Mental Health, Focusing on Links to Depression and Anxiety**

**Abstract**

**Objectives:**

This study aimed to explore the association between vitamin D levels and mental health, specifically depression and anxiety, among adults. It also evaluated the effect of vitamin D supplementation on mental health outcomes in individuals with deficiency.

**Materials and Methods:**

A cross-sectional study was conducted over six months, including 200 participants aged 18-65 years, divided into two groups: 100 with normal vitamin D levels (≥30 ng/mL) and 100 with vitamin D deficiency (<20 ng/mL). Depression and anxiety were assessed using the Patient Health Questionnaire-9 (PHQ-9) and the Generalized Anxiety Disorder-7 (GAD-7) scale, respectively. Serum vitamin D levels were measured using HPLC or ELISA. In the deficiency group, participants received vitamin D supplementation (1000 IU/day) for 8 weeks, with mental health assessments before and after supplementation.

**Results:**

Participants with vitamin D deficiency had significantly higher rates of depression (62%) and anxiety (65%) compared to those with normal levels (30% and 35%, respectively). The mean depression (12.5 ± 4.2 vs. 8.2 ± 3.1) and anxiety (11.8 ± 3.8 vs. 7.6 ± 2.9) scores were also significantly higher in the deficiency group. Vitamin D supplementation resulted in significant reductions in both depression and anxiety scores (p < 0.001). Correlation analysis revealed a moderate negative relationship between vitamin D levels and mental health scores (r = -0.45 for depression, r = -0.42 for anxiety).

**Conclusion:**

Vitamin D deficiency is associated with higher prevalence and severity of depression and anxiety. Supplementation significantly improved mental health outcomes in deficient individuals, suggesting a potential role for vitamin D in managing mood disorders.

**Keywords:** Vitamin D, Depression, Anxiety, Supplementation, Mental Health, PHQ-9, GAD-7

**Introduction**

Mental health disorders, particularly depression and anxiety, are among the most prevalent health challenges worldwide, significantly impacting individuals' quality of life and imposing a substantial burden on healthcare systems.1 While the underlying mechanisms of these disorders are complex and multifactorial, growing evidence suggests that nutritional deficiencies, including inadequate levels of vitamin D, may play a crucial role in their onset and progression. Vitamin D, often referred to as the "sunshine vitamin," is a fat-soluble nutrient primarily synthesized in the skin upon exposure to sunlight. It is well-known for its critical role in bone health and calcium homeostasis. However, its influence extends beyond the skeletal system, affecting various physiological processes, including brain function and mental health.2,3

Vitamin D acts as a neurosteroid, binding to vitamin D receptors (VDRs) that are widely distributed in the brain, particularly in regions associated with mood regulation, such as the prefrontal cortex, hippocampus, and amygdala.4 Through these receptors, vitamin D modulates the synthesis of neurotransmitters, including serotonin and dopamine, which are integral to emotional well-being. Furthermore, it exhibits anti-inflammatory and neuroprotective properties, which are essential for mitigating the neuronal damage often observed in mental health disorders. These mechanisms suggest that insufficient levels of vitamin D may impair brain function, increasing the risk of developing depression and anxiety.5

Numerous epidemiological studies and clinical trials have investigated the association between vitamin D levels and mental health, yielding mixed but generally supportive findings. Many studies report a higher prevalence of depression and anxiety in individuals with vitamin D deficiency, with some suggesting that supplementation can alleviate symptoms.6 Despite these promising associations, the relationship is not entirely understood, as it is influenced by confounding factors such as physical health, lifestyle, and genetic predisposition. Additionally, bidirectional causality complicates the interpretation—while low vitamin D levels may contribute to poor mental health, individuals with depression or anxiety may also engage in behaviors that reduce vitamin D synthesis, such as limited outdoor activity.7

One hypothesis for the link between vitamin D and mental health lies in its role in reducing systemic inflammation. Chronic inflammation has been increasingly recognized as a contributing factor to mental health disorders, with elevated levels of inflammatory markers such as C-reactive protein (CRP) and interleukin-6 (IL-6) often observed in patients with depression and anxiety. Vitamin D is believed to counteract inflammation by modulating the immune response, potentially mitigating the inflammatory pathways implicated in these disorders.8

Another critical aspect is vitamin D's role in neuroplasticity, the brain's ability to adapt and form new neural connections. Depression and anxiety are associated with impaired neuroplasticity, leading to reduced resilience against stress. Vitamin D enhances the expression of neurotrophic factors, such as brain-derived neurotrophic factor (BDNF), which are crucial for maintaining healthy neuronal networks and emotional stability.9

Populations at higher risk of vitamin D deficiency, including individuals with limited sun exposure, darker skin pigmentation, or dietary insufficiencies, may be particularly vulnerable to mental health disorders. Seasonal affective disorder (SAD), a type of depression that occurs during the darker months of the year, provides a striking example of the interplay between sunlight exposure, vitamin D synthesis, and mood regulation.10

Understanding the association between vitamin D levels and mental health is crucial for several reasons. First, identifying vitamin D deficiency as a modifiable risk factor could pave the way for preventive strategies that reduce the incidence and severity of depression and anxiety. Second, addressing vitamin D deficiency may serve as a cost-effective adjunct to conventional treatments, enhancing their efficacy and improving patient outcomes. Third, clarifying this relationship could inform public health policies, such as vitamin D fortification programs and recommendations for safe sun exposure, with the potential to benefit overall population health.

Given the significant burden of mental health disorders and the potential for vitamin D to influence brain health, this study seeks to investigate the association between vitamin D levels and depression and anxiety. By exploring this relationship, the research aims to contribute to a deeper understanding of how vitamin D impacts mental health and provide insights that may guide future clinical and public health interventions.

**METHODS:**

This study employed a cross-sectional design conducted over a period of six months, from January 2024 to June 2024, to investigate the association between vitamin D levels and mental health, specifically focusing on depression and anxiety. The study included 200 participants who were recruited from various clinics and hospitals. To be eligible for inclusion, participants were required to be aged 18-65 years and willing to provide informed consent. Individuals with a history of chronic diseases such as renal, liver, or thyroid disorders, those taking medications that affect vitamin D metabolism (e.g., corticosteroids or anticonvulsants), or individuals diagnosed with severe psychiatric disorders like schizophrenia or bipolar disorder were excluded.

The participants were divided into two groups based on their serum vitamin D levels: 100 participants with normal vitamin D levels (≥30 ng/mL) and 100 participants with vitamin D deficiency (<20 ng/mL). Serum vitamin D levels were measured using a high-performance liquid chromatography (HPLC) method or an enzyme-linked immunosorbent assay (ELISA) kit. The assessment of depression was carried out using the Patient Health Questionnaire-9 (PHQ-9), a validated tool consisting of 9 items that are scored on a 4-point scale, with total scores ranging from 0 to 27. Depression was classified as moderate to severe if the PHQ-9 score was 10 or higher. Anxiety was evaluated using the Generalized Anxiety Disorder-7 (GAD-7) scale, a 7-item questionnaire where participants rate the frequency of anxiety symptoms on a scale of 0 to 3, with total scores ranging from 0 to 21. A GAD-7 score of 10 or higher indicated moderate to severe anxiety.

For participants with vitamin D deficiency, an intervention involving vitamin D supplementation (1000 IU/day) was provided for 8 weeks, and depression and anxiety levels were assessed before and after the supplementation period to evaluate changes in mental health outcomes. Data were analyzed using SPSS version 25.0, with descriptive statistics, including means, standard deviations, and frequencies, used to summarize participant characteristics and distribution of vitamin D levels, depression, and anxiety scores. Independent t-tests were conducted to compare differences between groups with normal and deficient vitamin D levels, and chi-square tests were used for categorical variables. The relationship between vitamin D levels and depression/anxiety scores was examined using Pearson’s correlation coefficient. To adjust for potential confounding variables such as age, gender, and BMI, multiple regression analysis was employed. A p-value of <0.05 was considered statistically significant.

For the group receiving vitamin D supplementation, paired t-tests were used to assess the changes in depression and anxiety scores before and after the supplementation period. The study was approved by the Institutional Review Board (IRB) of the participating institution, and all participants provided written informed consent. The study adhered to ethical guidelines for human research, ensuring confidentiality and voluntary participation.

**RESULTS:**

The study found that vitamin D deficiency was associated with higher BMI, depression, and anxiety. Participants with low vitamin D levels had significantly higher rates of depression (62% vs. 30%) and anxiety (65% vs. 35%) compared to those with normal levels. The depression (12.5 ± 4.2 vs. 8.2 ± 3.1) and anxiety scores (11.8 ± 3.8 vs. 7.6 ± 2.9) were also significantly higher in the deficient group. A moderate negative correlation was found between vitamin D levels and both depression (r = -0.45) and anxiety (r = -0.42). Vitamin D supplementation led to significant reductions in both depression and anxiety scores, while no such changes were observed in the non-supplemented group. These results suggest that vitamin D deficiency is linked to increased mental health symptoms, and supplementation may improve mental health outcomes.

**Table 1: Baseline Characteristics of Study Participants**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variable** | **Total (n = 200)** | **Normal Vitamin D (n = 100)** | **Deficient Vitamin D (n = 100)** | **p-value** |
| Age (years, mean ± SD) | 35.4 ± 7.8 | 34.8 ± 7.5 | 36.1 ± 8.2 | 0.290 |
| Gender (% Female) | 60% | 58% | 62% | 0.600 |
| BMI (kg/m², mean ± SD) | 26.8 ± 4.5 | 25.7 ± 4.2 | 27.9 ± 4.6 | 0.015\* |
| Physical activity (% Yes) | 48% | 54% | 42% | 0.110 |

\*p < 0.05 indicates statistical significance.

**Table 2: Prevalence of Depression and Anxiety by Vitamin D Levels**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Mental Health Status** | **Total (n = 200)** | **Normal Vitamin D (n = 100)** | **Deficient Vitamin D (n = 100)** | **p-value** |
| Depression (% Yes) | 46% | 30% | 62% | <0.001\* |
| Anxiety (% Yes) | 50% | 35% | 65% | <0.001\* |
| Both Depression and Anxiety (% Yes) | 28% | 15% | 41% | <0.001\* |

**Table 3: Mean Depression and Anxiety Scores by Vitamin D Levels**

|  |  |  |  |
| --- | --- | --- | --- |
| **Score** | **Normal Vitamin D (Mean ± SD)** | **Deficient Vitamin D (Mean ± SD)** | **p-value** |
| Depression Score (PHQ-9) | 8.2 ± 3.1 | 12.5 ± 4.2 | <0.001\* |
| Anxiety Score (GAD-7) | 7.6 ± 2.9 | 11.8 ± 3.8 | <0.001\* |

**Table 4: Correlation Between Vitamin D Levels and Mental Health Scores**

|  |  |  |
| --- | --- | --- |
| **Variable** | **Correlation Coefficient (r)** | **p-value** |
| Vitamin D Levels vs. Depression Scores | -0.45 | <0.001\* |
| Vitamin D Levels vs. Anxiety Scores | -0.42 | <0.001\* |

**Table 5: Effect of Vitamin D Supplementation on Depression and Anxiety Scores**

|  |  |  |  |
| --- | --- | --- | --- |
| **Group** | **Baseline Depression Score (Mean ± SD)** | **Post-Supplementation Score (Mean ± SD)** | **p-value** |
| Supplementation (n = 50) | 12.1 ± 4.0 | 9.3 ± 3.5 | <0.001\* |
| No Supplementation (n = 50) | 11.9 ± 4.2 | 11.7 ± 4.1 | 0.530 |

**DISCUSSION**

The results of this study provide compelling evidence supporting the association between vitamin D deficiency and the increased prevalence and severity of depression and anxiety. These findings align with existing literature that suggests vitamin D plays a crucial role in mental health, affecting both mood regulation and brain function. The significant differences in depression and anxiety rates between individuals with normal and deficient vitamin D levels underscore the potential role of this nutrient in influencing mental health outcomes.11

One of the key findings of this study was the higher prevalence of depression and anxiety among participants with vitamin D deficiency. The deficiency group showed a notably higher incidence of depression (62%) and anxiety (65%) compared to those with normal vitamin D levels (30% and 35%, respectively). This supports the hypothesis that low vitamin D levels may be a contributing factor to mental health disorders. These findings are consistent with previous studies that have identified a correlation between low vitamin D and increased risk of depression and anxiety, with vitamin D's neuroprotective and anti-inflammatory properties potentially playing a key role in modulating these conditions.12

The significant difference in depression and anxiety scores between the two groups further reinforces the association between vitamin D deficiency and poor mental health. The mean depression and anxiety scores were considerably higher in the deficient group, which may reflect the impact of vitamin D on neurotransmitter regulation, neuroplasticity, and the inflammatory pathways involved in mood disorders. Vitamin D receptors are found in brain regions related to mood regulation, such as the prefrontal cortex and hippocampus, where vitamin D influences the synthesis of serotonin and dopamine, neurotransmitters closely linked to emotional well-being. Furthermore, vitamin D’s role in reducing systemic inflammation could mitigate the inflammatory response often observed in individuals with depression and anxiety.13

The moderate negative correlations found between vitamin D levels and mental health scores also highlight the relationship between low vitamin D and the severity of depression and anxiety. These correlations (r = -0.45 for depression and r = -0.42 for anxiety) suggest that lower vitamin D levels are linked with higher symptom severity. These results are consistent with findings from other studies, which have reported that vitamin D deficiency is associated with more severe depressive symptoms. It is important to note that while correlation does not imply causation, the strength of these relationships warrants further investigation into the potential therapeutic role of vitamin D in managing mental health disorders.14,15

Another noteworthy finding of the study was the impact of vitamin D supplementation on improving mental health outcomes. Participants who received vitamin D supplementation experienced significant reductions in both depression and anxiety scores. This suggests that vitamin D may not only be a risk factor for mental health issues but also a potentially modifiable factor for improving symptoms. These results are in line with studies that have shown that vitamin D supplementation can lead to improvements in mood and anxiety levels, particularly in individuals who are vitamin D deficient. However, it is important to recognize that the effectiveness of supplementation may vary based on factors such as dosage, duration of treatment, and individual characteristics, including baseline vitamin D levels.14,16

Despite the promising findings, several limitations of this study should be considered. The cross-sectional nature of the study limits the ability to establish causality, and other confounding variables, such as physical health, lifestyle, and genetic factors, may have influenced the results. Future longitudinal studies and randomized controlled trials are needed to confirm the causative role of vitamin D in mental health and to determine the optimal dosage and duration of supplementation for improving mental health outcomes.

In conclusion, this study provides strong evidence supporting the association between vitamin D deficiency and the increased prevalence and severity of depression and anxiety. The findings highlight the potential of vitamin D supplementation as an adjunct treatment for mental health disorders, particularly in individuals with low vitamin D levels. Further research is required to explore the mechanisms underlying this association and to develop evidence-based guidelines for clinical practice.

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