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Association Between Dietary Vitamin B6 Intake and Depression Among Adults in Lahore, Pakistan: A Cross-sectional Survey

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ABSTRACT

BACKGROUND

Depressive symptoms are a significant subject of population health around the globe, and nutrition as a determinant of mental health is becoming more accepted as a risk factor that can be modified. Vitamin B6 plays an important role in the synthesis of neurotransmitters.

PURPOSE

The study aimed to examine the association between dietary vitamin B6 intake and depressive symptoms among adults living in Lahore, Pakistan.

METHODS

It was a cross-sectional study among 283 adults aged 18 to 60 years. Dietary intake was measured using the structured FFQ, which was analyzed in Cronometer. The depressive symptoms were measured using the CES-D scale (cut-off ≥ 16). The adjusted multivariable variables included logistic regression variables such as age, sex, BMI, total energy intake, education level, physical activity, vitamin B12, and folate.

RESULTS

A total 148 (52.3%) participants were depressed, and 135 (47.7%) participants were non-depressed. Depressed and non-depressed groups showed significant differences in vitamin B6 intake (1.18 ± 0.12 mg/day vs. 2.03 ± 0.20 mg/day; $P < 0.001$). High levels of vitamin B6 consumption were positively correlated with a lower risk of depressive symptoms (OR per 1 mg/day increase = 0.72; 95% CI: 0.55–0.94). Female sex and high BMI correlated positively with depressive symptoms.

CONCLUSION

Adequate intake of dietary vitamin B6 has a negative correlation with depressive manifestations in this population.

Keywords: Depressive symptoms, Macronutrients, Micronutrients, Nutrition, Psychology, Vitamin

Introduction

Globally, the prevalence of anxiety and depressive symptoms is rising quickly, making them serious public health issues. The World Health Organization states that depressive symptoms include feelings of guilt or low self-worth, chronic sorrow, loss of interest, sleep difficulties, changes in eating habits, and lack of focus. Unlike regular mood changes, depressed episodes impair everyday functioning and long-term quality of life. Approximately 280 million people worldwide are associated with a higher prevalence among women than men.[1,2]

Depression has been identified as a significant global population health issue, and it has been noted that it is a major cause of disability in the world, with about 5% of adults, which is a huge number. The available data on the Global Burden of Disease (GBD) 2019 research study suggests that depressive disorders are responsible for a significant percentage of years lived with disability across regions and that the burden is disproportionately higher in women.[3] Depressive disorder conditions are the most significant and most frequent cause of disability due to mental illnesses in Pakistan, accounting for 3.1% of the total disability-adjusted life years, with a bigger burden being experienced by women. Specific population-based studies also indicate that there is a very high prevalence of depressive symptoms among university students and young adults, with pooled estimates of over 40%.[4]

According to clinic-based research, depression rates in Pakistan range from 15% to 40% in various provinces, demonstrating the severe and increasing influence of this condition. In recent years, academics have focused on nutrition as a controllable element associated with mental health. One of the subjects of study is gamma-aminobutyric acid (GABA), the principal inhibitory neurotransmitter, whose calming effect and ability to regulate tension, worry, and fear are beneficial. The role of gamma-aminobutyric acid in depressed symptoms has been linked to disturbances, and hence the interest in nutrients that improve the production of neurotransmitters.[5] Among these compounds, vitamin B6 (pyridoxine) has attracted research interest because it is vital for the production of neurotransmitters such as GABA, dopamine, and serotonin. B-vitamins cannot be produced in the body and therefore need to be obtained through nutrition or gut flora. Research claims that individuals who obtain sufficient vitamin B6 are less prone to depressive symptoms. The three forms of vitamin B6 are pyridoxine, pyridoxal, and pyridoxamine, which are converted into active coenzymes that aid in the metabolism of lipids, carbohydrates, and amino acids. The WHO recommends that adults take 1.3–1.7 mg per day.[6]

According to recent research, the Vitamin B6 intake in high doses might be associated with anxiety, depression, and stress (Figure 1). Some studies in Human Psychopharmacology show that mood and general mental health could be improved by increasing Vitamin B6 intake. Despite this growing evidence, most studies compare supplements rather than dietary sources, and there is insufficient research on the everyday intake of Vitamin B6 in the diet and on whether it is associated with depressive symptoms.[7,8] In a country with a high

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Data availability statement: The supporting data of this research in an anonymized form can be obtained by the corresponding author upon reasonable request

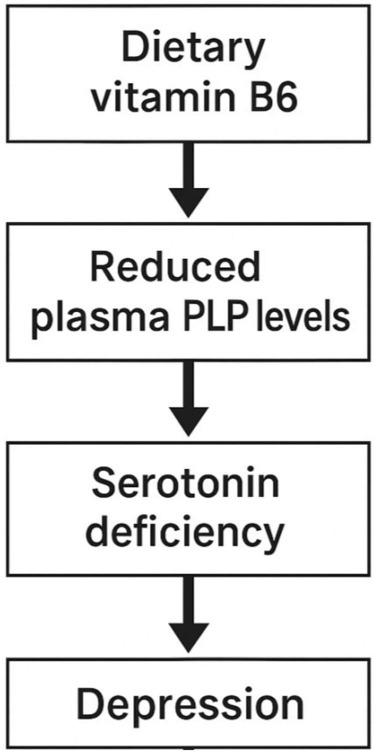

Fig 1 | Proposed relationship between vitamin B6 and neurotransmitter synthesis relevant to mood regulation

rate of depression like Pakistan, and where people are yet to understand nutritional strategies fully, this gap is especially huge. The direct correlation of dietary vitamin B6 and the symptoms of depression has not been explored yet in any national or regional study. An understanding of this association would help inform dieting advice, community health programs, and preventive actions.[9]

This study aims to determine whether vitamin B6 intake is significantly associated with mental health by comparing patients with and without depressive symptoms and evaluating their food, BMI, and nutrient intake. The findings could provide a foundation for future research and contribute to evidence-based initiatives to increase mental well-being.

Material and Methods

Study Design

Participants were recruited from university campuses and surrounding community settings in Lahore, Pakistan, between August and September 2024. The sample consisted predominantly of young adults, with a larger number of women. The percentage of women with depressive symptoms was higher, which was consistent with the epidemiological evidence of the world, with no systematic variables related to smoking or alcohol consumption. Physical activity was measured using a structured self-report measure that categorized participants into low, moderate, and high activity groups based on the frequency of weekly moderate-to-vigorous exercise. A previously invalidated self-reported evaluation of physical activity was utilized, which may have misclassified some participants based on physical activity levels. Physical activity was measured using a non-validated self-report measure, which may have resulted in misclassification. Supplement users were excluded; no additional sensitivity analysis was conducted. Figure 2 presents the participant flow diagram.

The study was conducted in Lahore, the capital city of Punjab province in Pakistan, among university students and community adults.

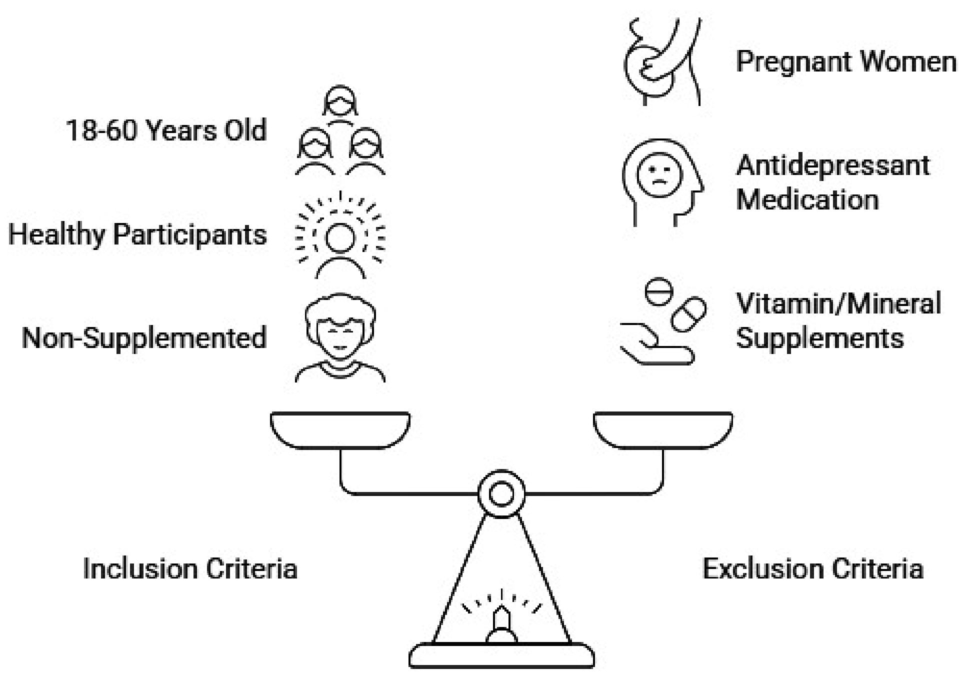

Fig 2 | Inclusion and exclusion criteria

Sample Size

The sample size was 283 participants; no power calculation was performed in advance, but it is a decent size to detect indicative relationships in logistic regression models. Inclusion criteria were 18–60 years old, healthy, non-medicated, non-supplemented participants, whereas the exclusion criteria were the presence of antidepressant medication or vitamin/mineral supplements, and pregnant women. Those who reported missing data on dietary or depressive symptoms were excluded from the analysis. No formal a priori power calculation was conducted; however, post-hoc power estimation indicated sufficient power (>80%) to detect an odds ratio of 0.70 for vitamin B6 intake.

A total 435 participants were contacted. Among them, 49 failed to fit the inclusion requirements, and 37 refused to take part. The remaining 349 participants answered the questionnaire. After eliminating 66 participants with missing dietary or depressive symptoms data, an analytical sample of 283 participants was used in the analysis (Figure 3).

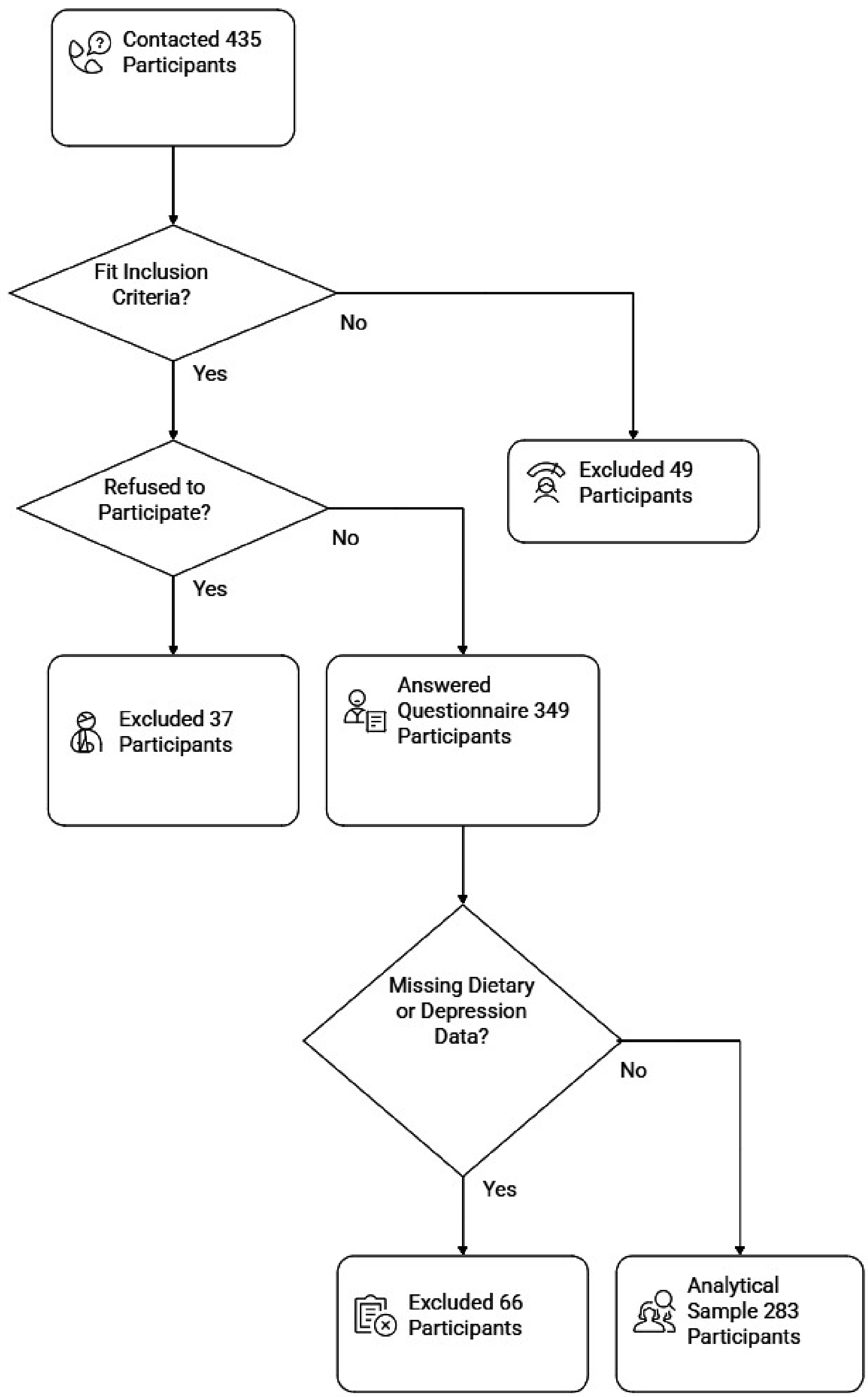

Fig 3 | Recruitment and screening of the participants

The study employed a cross-sectional design to investigate the comparative role of the Vitamin B6 diet between two groups, including individuals with and without the symptoms of depression. This study design can evaluate both groups simultaneously to identify possible correlations between nutrient intake and depression status.

Dietary Assessment

A semi-quantitative Food Frequency Questionnaire (FFQ) specifically modified to suit Pakistani dietary habits was used toassess dietary intake. The tool consisted of 145 food items, categorized into the following groups: cereals, legumes, dairy products, meats, vegetables, fruits, beverages, and mixed traditional meals.

Participants were asked to indicate their normal intake during the last 3 months using a scale of seven points, in which the participants indicated their frequency:

- Never or <1/month
- 1–3/month
- 1/week
- 2–4/week
- 5–7/week
- 2–3/day
- ≥4/day

The visual portion-size aids (standard cup, tablespoon, bowl size references) were used to provide standard household portion sizes.

Standardized recipes were made for mixed dishes like biryani, daal, and chicken curry based on how people in Lahore usually make them at home. Using entries from the USDA database in Cronometer, each dish was broken down into its individual ingredients and given nutrient values. For instance, we broke down biryani into rice, chicken, oil, and spices by making a few estimates of the proportions (e.g., 60% rice, 20% chicken, 15% oil, and 5% other ingredients). These assumptions could lead to measurement errors that don't differ.

The conversion of frequency responses to daily intake was done based on the following equation:

Daily dietary intake (g/day) = Frequency factor × Portion size (g).

Where frequency factors were put as:

- 1–3/month = 0.07/day
- 1/week = 0.14/day
- 2–4/week = 0.43/day
- 5–7/week = 0.79/day
- 2–3/day = 2.5/day
- ≥4/day = 4.0/day

Nutrient intake was computed by multiplying the daily intake (g/day) by the nutrient composition values from Cronometer (Nutritionix database). The complete list of food items (n = 145), frequency response options, and portion-size estimation aids that make up the full FFQ instrument used is included as SDC, File 1. The FFQ has not been officially validated in Pakistan, despite being developed from more than 6 months of training data and adjusted to local dietary patterns. Thus, potential measurement error and misclassification cannot be ruled out.

Depression Assessment

The severity of depressive symptoms was assessed with the Center for Epidemiologic Studies Depression Scale (CES-D), in which scores >16 indicate depressive symptoms and scores <16 indicate non-depressive individuals.[10]

Covariates

Age, sex, BMI, physical activity (self-reported), and socioeconomic status were collected via questionnaire. The measurement of socioeconomic status (SES) was based on educational attainment (12 years or less, undergraduate, postgraduate degree) and employment status (employed, unemployed/student). The education level has been incorporated as the main SES measure in multivariate models because of its stability and reduced sensitivity to short run fluctuations. Multivariable logistic regression analyses were also adjusted for sex (male/female), age (years), BMI (kg/m^2), education level (socioeconomic status proxy), and energy intake (kcal/day).

Statistical Analysis

Data collection from university students and community members was completed in a month. Participants completed a structured survey that included CES-D scores, a 24-h dietary history, and a FFQ. The 24-h dietary recall was used only to estimate portion sizes when the FFQ was completed and was not included in the nutrient intake estimates or in the statistical testing. Cronometer (4.48.x) software was employed to evaluate Vitamin B6 intake, while participants reported on their use of medications and medical treatments to control. Data were analyzed using IBM SPSS Statistics (version 22.0). Descriptive statistics had been used to summarize the characteristics of the participants. The Center of Epidemiologic Studies Depression Scale (CES-D) was used to measure depressive symptoms, and a normal cut-off score (≥16) was used to dichotomize the presence of depressive symptoms. Independent-samples t-tests were used to compare continuous variables, and chi-square tests were used to compare categorical variables to evaluate group differences among participants with and without depressive symptoms.

The most important dietary exposure was vitamin B6 intake. Vitamin B6 was assessed as a continuous variable (mg/day increment) and as a categorical variable (percentage of the recommended dietary allowance: <50%, 50%–74%, 75%–99%, and 100%). The intake of vitamin B6 was modeled as a continuous variable (increase by 1 mg/day) and standardized (increase by 1 standard deviation). To be comparable with previous reporting, models per 0.5 mg/day were kept in additional analyses. All the estimates are presented as odds ratios (ORs) with confidence intervals (CIs). The following variables were included in all multivariable logistic regression models: age (years), sex (male or female), body mass index (kg/m²), energy intake (per 1000 kcal/day), education (categorical), physical activity (low, moderate, or high), vitamin B12 intake (μg/day), and folate intake (per 100 μg/day).

The secondary analysis of other nutrient intakes was conducted as an exploratory study. Vitamin B6 was determined a priori as the key exposure variable. Correlations with other nutrients were considered exploratory, so no correction of multiple comparisons was applied. Therefore, these findings must be taken with caution. Variance Inflation Factors (VIF) was used to determine multicollinearity between covariates. The values of VIF were lower than 2.5, which means that there is no serious multicollinearity. The diagnostic analysis of model fit and influence, based on commonly used goodness-of-fit measures, also indicated that no individual observation significantly influenced model estimates. The statistical significance level was set at $P = 0.05$.

Energy Adjustment Sensitivity Analysis

Alternative energy-adjustment methods were used as sensitivity analyses. First, the residual approach was implemented by regressing vitamin B6 intake on total energy intake and then applying the residuals in logistic regression models. Second, the nutrient density method was used by dividing the vitamin B6 intake by 1000 kcal/day. The primary model,which adjusted for total energy intake as a covariate, was compared with estimates obtained through these methods.

Ethical Considerations

The participants were recruited on university campuses and in the surrounding community in Lahoreduring August and September 2024, after receiving ethical approval from the Office of Research, Innovation and Commercialization (ORIC) at the University of Management and Technology (REF-009-2021).

Methodological Clarifications

The design used in this study was a cross-sectional convenience sample of Pakistani university students and community adults in Lahore, Pakistan. Considering the research design, the results indicate a relationship and do not mean causality. The CES-D scale was used to evaluate depression; scores of 16 or higher were assigned to the depressive category, and a score of 16 was considered a depressive sample. The intake of vitamin B6 was measured against the WHO/FAO Recommended Dietary Allowances (1.3–1.7 mg/day) with sex-specific recommendations as necessary.[11] The USDA Food Composition Database was the main source of nutrient values, which were then used by Cronometer. About 85%–90% of the entries were matched directly. For local Pakistani foods and mixed dishes, recipe decomposition was used to get close. A sensitivity analysis was performed using several nutritional estimates for key vitamin B6-rich foods, based on regional data sources, to determine whether there was any bias in the non-local ingredient composition data. The results remained in the same direction, suggesting that measurement error related to the database is unlikely to differ.

Limitations

A cross-sectional design does not allow causal inference. The convenience sample (mostly university students) might restrict the applicability of the results to the rest of the Pakistani adult demographic. Food evaluation was based on self-report and nutrient estimation on non-local databases. Vitamin B6 status (measured, e.g., plasma PLP) was not measured. Residual confounding poses a serious threat to the validity of the findings, given that the study does not account for important behavioral and clinical factors such as smoking habits, alcohol consumption, the quality of sleep, and whether or not participants had chronic disease or were taking medications. While confounding factors such as age, gender, BMI, caloric intake, education level, and the intake of certain nutrients were taken into account for the purposes of the analysis, it is still possible that there were other unmeasured factors that had an impact on the overall results of this study. The results of the sensitivity analysis using E-values indicated that for an unmeasured confounding variable to fully explain the association between vitamin B6 intake and depressive symptoms, it would need to have a moderate correlation with both vitamin B6 intake and depressive symptoms. Physical activity was measured using a non-validated instrument; this may have accounted for the reduced accuracy of adjusting for physical activity when controlling for other variables.

Results

A total of 283 individuals aged 18–60 took part in the study; 114 were men (40.3%), and 169 were women (59.7%). The majority of participants were college students. Following the collection of dietary and depressive symptoms-related data, the CES-D scale was used to assess depressive symptoms severity, and Cronometer was used to measure dietary intake. In all, 52.3% of individuals were depressed, and 47.7% of participants were not depressed. Women were found to be more affected, with 34.9% of the overall sample composed of depressive women, compared with 17% of the depressive men.

Gender and Depressive Symptoms

Overall, 148 participants (52.3%) were classified as depressed, while 135 (47.7%) were non-depressed. It was composed of 59.7% females, and they were more likely to suffer from depressive symptoms than males ($P = 0.008$). Figure 4 illustrates these trends and shows a strong correlation between depressive symptoms and gender. Figure 5 shows that both males and females also reported an inverse relationship between the intake of vitamin B6 and depressive symptoms, although the protective pattern was a bit stronger among female subjects.

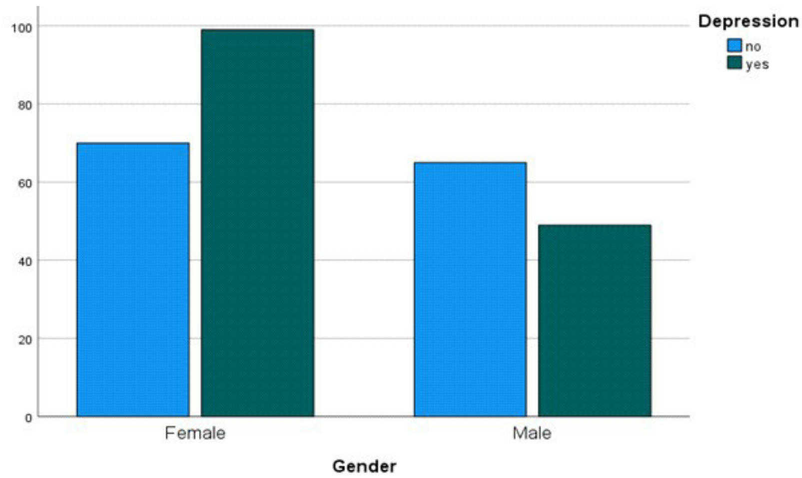

Fig 4 | Gender versus depressive symptoms

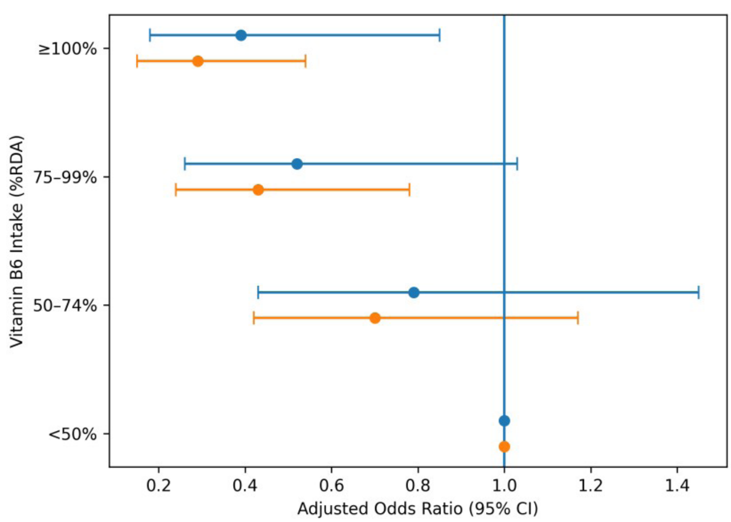

Fig 5 | Sex-stratified adjusted odds ratios (ORs) and 95% confidence intervals (CIs) for depressive symptoms across vitamin B6 intake categories (%RDA)

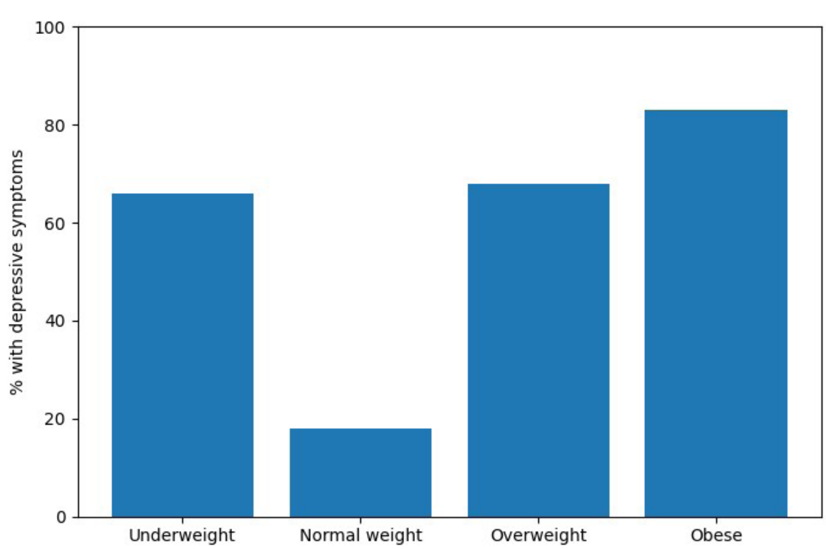

Fig 6 | Percentage of participants with depressive symptoms across BMI categories

BMI and Depressive Symptoms

Body weight also exhibited a substantial association with depressive symptoms. Figure 6 showed the percentage of participants with depressive symptoms across different BMI categories. Individuals with normal BMI (18.5–24.9) were the least affected (18.4% depression rate). However, depressive symptoms were significantly more common in underweight individuals (66%), overweight individuals (68%), and people who were obese (83%). The BMI of the depressed participants was higher than that of the nondepressed participants (26.3 ± 4.7 vs. 23.7 ± 3.9 kg/m^2) (Table 1). This increasing tendency suggests that psychological well-being may be affected by both undernutrition and overnutrition. Figure 7 shows that the reference group was those who took less than 50% RDA. An increase in vitamin B6 was also linked with a lower probability of having depressive symptoms in both groups of body mass index (<25 kg/m^2 and ≥25 kg/m^2), indicating that the relationship was similar in both body mass indexed groups.

Nutrient Intake and Depressive Symptoms

While comparing the daily intake of nutrients of the depressive and nondepressive groups, several nutrients were associated with depressive symptoms (Table 2). Vitamin B6, vitamin B12, protein, carbohydrates, phosphorus, and vitamin K levels were lower in depressed individuals than in the nondepressed individuals. On the other hand, mean intakes of folate, potassium, selenium, and vitamin A were higher among participants with depressive symptoms; thus, not all observed associations were attributed to dietary inadequacy. The mean dietary intake of vitamin B6 in the overall sample was 1.59 ± 0.61 mg/day, with a median intake of 1.48 mg/day (interquartile range: 1.12–2.05 mg/day). Figure 8 illustrates that the intake of vitamin B6 was linked to a declining odds of depressive symptoms, meaning that there could be a dose–response relationship with vitamin B6.

A strong correlation ($P < 0.001$) between depressive symptoms and the % RDA of vitamin B6 is observed in Table 3. Participants taking ≤50% of the RDA had high depression rates, whereas those meeting or above 100% of the RDA had significantly lower depressive symptoms. It supports the concept that adequate Vitamin B6 intake may help alleviate symptoms of depression.

BMI and Nutrient Intake

Table 4 reveals that Vitamin B6 ($P = 0.025$) and Vitamin B12 ($P = 0.03$) were the only vitamins significantly associated with BMI categories. People with normal BMI had a higher frequency of taking Vitamin B6 and B12 closer to the recommended levels than people in other BMI categories. The vitamin B6 consumption was relatively low among the depressed people. An inverse gradient was observed across increasing categories of vitamin B6 intake, expressed as a percentage of the Recommended Dietary Allowance. It was positively associated with a lower risk of depression

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Table 1 | Association between sociodemographic and clinical characteristics, as well as depressive symptoms among adults in Lahore, Pakistan

Variable	Depressed (*n* = 148)	Nondepressed (*n* = 135)	*P*-value
Age (years, mean ± SD)	27.4 ± 5.9	25.8 ± 5.2	0.021
Sex, *n* (%)			
Male	49 (33.1)	65 (48.2)	
Female, *n* (%)	99 (66.9)	70 (51.8)	0.008
BMI (kg/m², mean ± SD)	26.3 ± 4.7	23.7 ± 3.9	‹0.001
BMI category, *n* (%)			
Normal	42 (28.4)	61 (45.2)	
Overweight/Obese	106 (71.6)	74 (54.8)	0.004
Physical activity (low), *n* (%)	63 (42.3)	58 (43.1)	0.065
CES-D score, mean ± SD	22.8 ± 6.1	11.4 ± 3.8	‹0.001

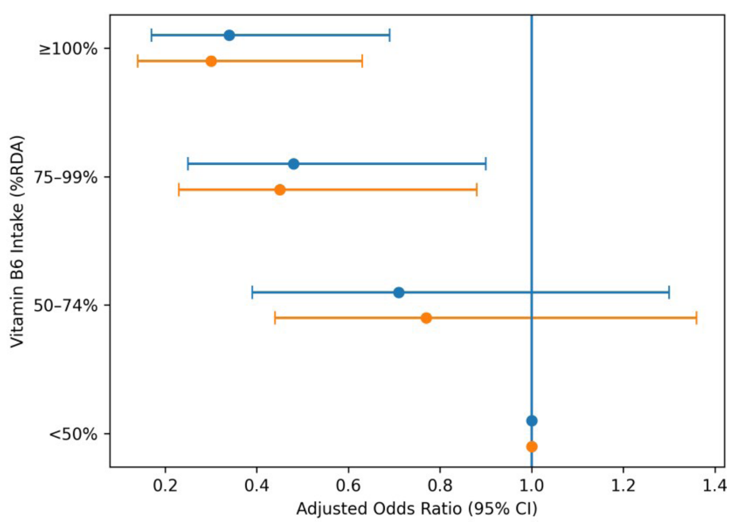

Fig 7 | BMI-stratified adjusted odds ratios (ORs) with 95% confidence intervals (CIs) for depressive symptoms across vitamin B6 intake categories (%RDA)

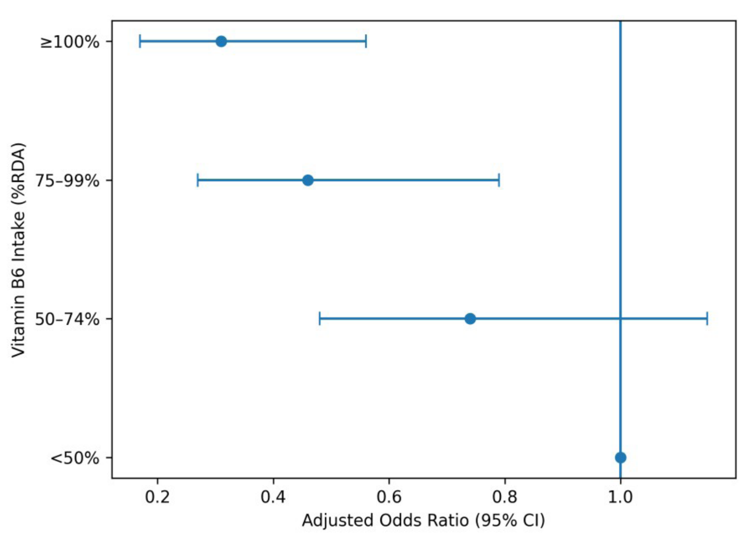

Fig 8 | Adjusted odds ratios (ORs) with 95% confidence intervals (CIs) for depressive symptoms across categories of vitamin B6 intake (%RDA). The ‹50% RDA group was used as the reference.

in multivariate models (adjusted OR = 0.72, 95% CI: 0.55–0.94, *P* = 0.015) (Table 5). The BMI was also positively correlated with the intake of vitamin B12 and negatively correlated with depressive symptoms in the female participants.

Energy Adjustment

The relationship between vitamin B6 consumption and depressive symptoms held true in sensitivity analyses using various energy-adjustment techniques (Table 6). The adjusted OR using the residual method was 0.74 (95% CI: 0.57–0.96; *P* = 0.021). The adjusted OR was 0.70 (95% CI: 0.53–0.92; *P* = 0.012) using the nutrient–density approach (mg/1000 kcal). These findings indicate the robustness of the primary model.

Discussion

This study investigated the association between dietary Vitamin B6 intake and depressive symptoms among adults aged 18–60 years living in Lahore, Pakistan. A total of 283 individuals participated; the majority of the participants were university students who resided in a single urban area (Lahore). Therefore, the results of this study are not generalizable to the overall population of Pakistan or to rural and older populations within Pakistan. Generally, the results demonstrated a significant relationship between reduced intake of Vitamin B6 and increased levels of depressive symptoms, which confirms the hypothesis, put forward by several biochemical studies, namely, Vitamin B6 is directly related to the synthesis of neurotransmitters, which are serotonin, dopamine, and GABA, all of which are key in the human body in the regulation of mood. In case of low Vitamin B6 consumption, the body may be limited in its capacity to develop these neurotransmitters, and this makes people more vulnerable to depressive symptoms. There were also apparent gender disparities. Compared to 49 out of 114 men, 99 of the 169 women in the study were categorized as depressed. These results correspond with global data suggesting that women are often more prone to experience depressive symptoms than men.[12] Hormonal changes, increased hypothalamic–pituitary axis sensitivity, and variations in stress response are some of the causes that could account for this tendency.[13] Some studies suggest that men might benefit from physiological protection due to androgen receptors in their bodies, which may help regulate mood stability.[14–16]

BMI also displayed a clear trend. Persons who were underweight, overweight, and obese showed a substantially larger amount of depressive symptoms, but those with a normal BMI recorded the lowest rates. Underweight individuals had a rate of depressive symptoms of 66%, overweight individuals had a rate of 68%, and obese individuals had a rate of 83%. These findings bring out the importance of nutritional status on mental health, proving that both extreme malnutrition models could cause psychological vulnerability. When dietary intake patterns were examined more closely, significant correlations between depressive symptoms and several macronutrients and

Table 2 | Macro and micro nutrients association with depressive symptoms

Dietary intake	Depressed (*n*)/Nondepressed (*n*)	Mean	Standard deviation	*P*-value
CHO (g/day)	Normal 135	153.87	15.39	0.01
	Depressive 148	129.69	12.97	
Protein (g/day)	Normal 135	44.00	4.40	0.03
	Depressive 148	38.26	3.83	
Fat (g/day)	Normal 135	44.05	4.41	0.60
	Depressive 148	46.47	4.65	
Vitamin B6 (pyridoxine) (mg/day)	Normal 135	2.03	0.20	<0.001
	Depressive 148	1.18	0.12	
Vitamin B2 (riboflavin) (mg/day)	Normal 135	1.00	0.10	0.18
	Depressive 148	0.98	0.10	
Vitamin B3 (niacin) (mg/day)	Normal 135	13.42	1.34	0.19
	Depressive 148	14.24	1.42	
Vitamin B5 (pantothenic acid) (mg/day)	Normal 135	3.70	0.37	0.61
	Depressive 148	4.16	0.42	
Vitamin B1 (thiamin) (mg/day)	Normal 135	0.87	0.09	0.96
	Depressive 148	0.93	0.09	
Vitamin B12 (cyanocobalamin) (µg/day)	Normal 135	2.35	0.24	<0.001
	Depressive 148	1.82	0.18	
Vitamin B9 (folate) (µg/day)	Normal 135	212.21	21.22	0.02
	Depressive 148	251.69	25.17	
Vitamin A (retinol) (µg RAE/day)	Normal 135	415.62	41.56	0.04
	Depressive 148	462.65	46.27	
Vitamin C (ascorbic acid) (mg/day)	Normal 135	77.30	7.73	0.15
	Depressive 148	68.71	6.87	
Vitamin D (calciferol) (µg/day)	Normal 135	2.78	0.28	0.81
	Depressive 148	3.28	0.33	
Vitamin E (tocopherol) (mg/day)	Normal 135	4.99	0.50	0.57
	Depressive 148	5.19	0.52	
Vitamin K (phytonadione) (µg/day)	Normal 135	95.08	9.51	0.01
	Depressive 148	56.13	5.61	
Calcium (Ca) (mg/day)	Normal 135	500.76	50.08	0.27
	Depressive 148	526.62	52.66	
Copper (Cu) (mg/day)	Normal 135	0.79	0.08	0.33
	Depressive 148	0.84	0.08	
Iron (Fe) (mg/day)	Normal 135	8.43	0.84	0.06
	Depressive 148	8.65	0.86	
Magnesium (Mg) (mg/day)	Normal 135	227.29	22.73	0.13
	Depressive 148	251.39	25.14	
Manganese (Mn) (mg/day)	Normal 135	1.65	0.17	0.05
	Depressive 148	1.61	0.16	
Phosphorus (P) (mg/day)	Normal 135	642.47	64.25	<0.001
	Depressive 148	597.52	59.75	
Potassium (K) (mg/day)	Normal 135	1923.80	192.38	0.01
	Depressive 148	2512.75	251.27	
Selenium (Se) (µg/day)	Normal 135	38.32	3.83	<0.001
	Depressive 148	44.06	4.41	
Sodium (Na) (mg/day)	Normal 135	994.52	99.45	0.21
	Depressive 148	951.66	95.17	
Zinc (Zn) (mg/day)	Normal 135	7.25	0.73	0.06
	Depressive 148	7.13	0.71	

Vitamin A expressed as µg retinol activity equivalents (RAE). All nutrient intakes are expressed in standard units (mg/day or µg/day, as appropriate).

Table 3 | Distribution of depressive symptoms according to the percentage of the recommended dietary allowance (RDA) of vitamin B6 intake

Vitamin B6 (% RDA)	Depressed, *n* (%)	Nondepressed, *n* (%)	Total, *n*	*P*-value
<50%	78 (52.7)	32 (23.7)	110	<0.001
50%–74%	41 (27.7)	36 (26.7)	77	0.86
75%–99%	17 (11.5)	29 (21.5)	46	0.032
≥100%	12 (8.1)	38 (28.1)	50	<0.001
Total, *n* (%)	148 (100)	135 (100)	283 (100)	

$P < 0.001$. *P*-for-trend was calculated by modeling vitamin B6 intake categories as an ordinal variable in multivariable logistic regression model.

Table 4 | Macro and micro nutrients association with BMI

Nutrients	Percent RDA	BMI (kg/m²)				Total	*P*-value
		<18.5	18.5–24.9	25–30	>30		
CHO	≥100	21	95	13	3	132	0.398
	99.9–70	18	63	–	2	94	
	40–69.9	10	26	11	1	48	
	≤40	1	8	0	0	9	
Protein	≥100	8	62	6	2	78	0.405
	99.9–70	19	69	14	2	104	
	40–69.9	19	54	13	2	88	
	≤40	4	7	2	0	13	
Fat	≥100	5	21	6	1	33	0.013
	99.9–70	8	42	15	1	66	
	40–69.9	22	87	8	0	117	
	≤40	15	42	6	4	67	
Vit B1	≥100	9	41	9	1	60	0.730
	99.9–70	15	67	16	2	100	
	40–69.9	23	75	10	3	111	
	≤40	3	9	0	0	12	
Vit B2	≥100	11	65	11	0	87	0.396
	99.9–70	18	61	12	4	95	
	40–69.9	17	55	12	2	86	
	≤40	4	11	0	0	15	
Vit B3	≥100	19	73	16	3	111	0.440
	99.9–70	18	67	15	2	102	
	40–69.9	8	44	2	1	55	
	≤40	5	8	2	0	15	
Vit B5	≥100	10	38	13	1	62	
	99.9–70	18	62	10	1	91	
	40–69.9	15	80	9	3	107	
	≤40	7	11	2	1	21	0.162
Vit B6	≥100	11	48	11	2	72	0.025
	99.9–70	15	54	9	2	80	
	40–69.9	24	18	21	0	63	
	≤40	18	30	18	2	68	
Vit B12	≥100	7	68	7	1	83	0.030
	99.9–70	17	64	10	2	93	
	40–69.9	16	42	14	3	75	
	≤40	10	18	4	0	32	

Table 4 | Continued

Nutrients	Percent RDA	BMI (kg/m²)				Total	*P*-value
		‹18.5	18.5–24.9	25–30	›30		
Folate	≥100	5	19	2	0	26	0.635
	99.9–70	5	34	8	0	47	
	40–69.9	18	79	15	2	114	
	≤40	22	58	10	4	94	
Vit A	≥100	6	30	4	0	40	0.201
	99.9–70	9	34	3	0	46	
	40–69.9	13	62	19	3	97	
	≤40	22	66	9	3	100	
Vit C	≥100	17	68	14	1	100	0.892
	99.9–70	10	51	7	2	70	
	40–69.9	13	34	6	2	55	
	≤40	10	39	8	1	58	
Vit D	99.9–70	0	2	0	0	2	0.958
	40–69.9	4	14	3	0	21	
	≤40	46	176	32	6	260	
Vit E	≥100	0	2	0	0	2	0.452
	99.9–70	1	9	0	0	10	
	40–69.9	12	43	12	3	70	
	≤40	36	138	23	3	200	
Vit K	≥100	5	45	2	0	52	0.061
	99.9–70	6	34	8	0	48	
	40–69.9	20	53	13	2	88	
	≤40	19	60	12	4	95	
Calcium	≥100	3	16	0	0	19	0.454
	99.9–70	5	28	7	1	41	
	40–69.9	17	77	12	2	108	
	≤40	24	71	16	3	114	
Copper	≥100	16	62	11	2	91	0.037
	99.9–70	13	58	11	1	83	
	40–69.9	15	31	12	3	61	
	≤40	6	41	1	0	48	
Iron	≥100	4	37	3	2	48	0.068
	99.9–70	8	31	6	0	45	
	40–69.9	16	68	20	2	106	
	≤40	22	56	6	2	86	
Magnesium	≥100	8	24	8	0	40	0.071
	99.9–70	10	61	8	1	80	
	40–69.9	22	85	19	3	129	
	≤40	10	22	0	2	34	
Manganese	≥100	13	48	9	2	72	0.794
	99.9–70	19	74	9	1	102	
	40–69.9	12	57	12	2	83	
	≤40	6	14	5	1	26	
Phosphorus	≥100	17	66	19	2	104	0.029
	99.9–70	14	79	7	3	103	
	40–69.9	15	28	9	1	53	
	≤40	4	19	0	0	23	

Table 4 | Continued

Nutrients	Percent RDA	BMI (kg/m²)				Total	P-value
		‹18.5	18.5–24.9	25–30	›30		
Potassium	≥100	6	12	5	0	23	0.272
	99.9–70	4	20	2	1	27	
	40–69.9	18	84	13	0	115	
	≤40	22	76	55	5	118	
Selenium	≥100	14	67	5	2	88	0.216
	99.9–70	15	63	16	3	97	
	40–69.9	17	48	8	1	74	
	≤40	4	14	6	0	24	
Sodium	≥100	8	37	9	1	55	0.949
	99.9–70	6	34	7	1	48	
	40–69.9	18	66	10	2	96	
	≤40	18	55	9	2	84	
Zinc	≥100	12	44	10	1	67	0.235
	99.9–70	18	77	14	2	111	
	40–69.9	12	62	10	3	87	
	≤40	8	9	1	0	18	

All nutrient intakes are expressed in standard units (mg/day or µg/day, as appropriate).

Table 5 | Multivariable logistic regression analysis for factors associated with depressive symptoms

Variable	Adjusted OR	95% CI	P-value
Vitamin B6 intake (mg/day)	0.72	0.55–0.94	0.015
Vitamin B12 intake (µg/day)	0.83	0.70–0.98	0.031
Female sex	1.56	1.02–2.45	0.041
BMI (kg/m²)	1.08	1.02–1.14	0.008
Age (years)	1.02	0.98–1.06	0.271
Total energy intake (kcal/day)	0.99	0.98–1.01	0.384
Folate intake (per 100 µg)	0.97	0.92–1.03	0.219

Abbreviations: CI, confidence interval; OR, odds ratio.
Model was adjusted by age, sex, BMI, total energy intake, education level (SES proxy), and physical activity.

micronutrients were observed. One of the strongest relationships was observed with Vitamin B6 ($P < 0.001$) together with Vitamin B12, Vitamin B9, carbohydrates, protein, phosphorus, and selenium. These nutrients support the argument that a healthy diet is essential to mental health, as they support the immune response, energy metabolism, and neurotransmitter production. Although other nutrients showed significant associations, Vitamin B6 did not show a significant association with BMI in particular, and the nutrient's association with mood might not depend on body weight.

Our results have been supported by earlier international studies.[17–19] Longitudinal studies with large adult samples have revealed that higher Vitamin B6 intake is connected with a lower chance of acquiring depressive symptoms over time.[20,21] This correlation is further supported by studies involving adult women.[22] Some studies using mixed B-complex supplements, however, show an inverse association.[23,24] It shows that when combined with other nutrients, the unique function of vitamin B6 may be obscured, underscoring the need for more focused research.

Table 6 | Sensitivity analyses using alternative energy-adjustment methods for the association between vitamin B6 intake and depressive symptoms

Energy adjustment methods	Adjusted OR	95% CI	P-value
Primary model—Energy intake as covariate (kcal/day)	0.72	0.55–0.94	0.015
Residual method—B6 residuals after regression on total energy	0.74	0.57–0.96	0.021
Nutrient density method—Vitamin B6 expressed per 1000 kcal/day	0.70	0.53–0.92	0.012

The depressed participants were more likely to be females, older, and had higher BMI, and were less active than the nondepressed ones. An increased intake of Vitamin B6 and Vitamin B12 after the control of major confounders had an independent negative relationship with the likelihood of developing depressive symptoms. Female sex and increased BMI were positive predictors of depressive symptoms.

The evidence from the significant population-based research and meta-analyses conducted in various settings corroborates the reported correlation between the low level of dietary vitamin B6 and the high prevalence of depressive symptoms. These studies have shown a reduced risk of depressive symptoms among individuals who have a high level of dietary or plasma vitamin B6. However, it has been observed to attenuate after multivariate correction, hence the importance of controlling confounders.

In this study, higher vitamin B6 intake was associated with lower odds of depressive symptoms among adults in Lahore. These findings are in line with other cohort studies and meta-analyses worldwide that show vitamin B6 is beneficial for mental health due to its role in neurotransmitter synthesis. The depressive symptoms were more reported in women and those with high BMI, but this is in line with the global epidemiological trends. In a cross-sectional design, it is not possible to eliminate reverse causation, as depressive symptoms may influence eating habits.

Conclusion

This study shows that depressive symptoms and dietary intake of vitamin B6 have a strong negative correlation among adults in Lahore, Pakistan. It was observed that depressed individuals take much less vitamin B6 as compared to their nondepressed counterparts, and that increased intake of vitamin B6 was independently associated with reduced chances of depression after adjusting for the influence of other significant confounders like age, sex, BMI, total energy intake, and other B-vitamins. Female sex and progressive BMI were noted to be positive predictors of depressive symptoms, which justifies the notion of multifactoriality of depressive symptoms and the interaction of nutrition and physiological factors. The findings underscore the potential importance of adequate dietary intake of vitamin B6 for mental health, likely because of its established role in neurotransmitter synthesis and mood regulation. These outcomes confirm the potential of nutrition interventions to enhance mental health. It needs further interventional research, which will entail validating biomarkers to allow better causal inference.

Future Recommendations

Alternative tools may be used to enhance the resolution of dietary intakedata beyond Cronometer.

- An extensive study can also be conducted in other regions of Lahore and Pakistan to yield more robust findings and improved results.
- Along with dietary intake, the gut absorption and availability of vitamin B6 can also be evaluated.
- A long-term study to examine the implications of dietary vitamin B6 can also be conducted in a mannered style, in which a depressed population will be asked to take B6 sources. At the end of the duration, results will be compared.

Further studies are needed to include biochemical analysis of vitamin B6 status via plasma PLP concentrations to verify dietary intake and clarify the causal factor. The combination of dietary measurement and PLP measurement would allow testing the relationship between vitamin B6 status and depressive symptoms more precisely. It would allow investigating dose–response relationships and metabolic pathways that mediate this relationship.

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