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Associations between depressive symptom severity and hematological and biochemical parameters in adolescents

Belen Ates[1], Meryem Cansu Olt[2], Aybuke Bacanli[3], Eren Guzeloglu[1]

[1]Prof. Dr. Cemil Taşçıoğlu City Hospital, Department of Pediatrics, İstanbul, Türkiye
[2]Prof. Dr. Cemil Taşçıoğlu City Hospital, Ethics Committee, İstanbul, Türkiye
[3] Prof. Dr. Cemil Taşçıoğlu City Hospital, Department of Family Medicine, İstanbul, Türkiye

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Abstract

This study investigated whether the severity of depression in Turkish adolescents is related to a panel of hematological and biochemical markers. A crosssectional study was conducted, including 109 adolescents (aged 13 – 18 years) from a tertiary referral center in Istanbul, Turkey. Participants completed the Beck Depression Inventory-II (BDI-II) on the day when blood was drawn. Laboratory data included complete blood count, neutrophil-to-lymphocyte ratio (NLR), ferritin, thyroid-stimulating hormone (TSH), vitamin D, and vitamin B12. The group mean BDI-II score was 13.04 ± 9.26, with 42.2% of participants showing clinically significant depressive symptoms. Serum vitamin D levels below 20 ng/mL were found in 68.8% of the sample, and prevalence increased with depression severity. Spearman analysis showed inverse relationships between BDI-II scores and both vitamin D (r = -0.265, p = 0.005) and vitamin B12 (r = -0.235, p = 0.014). After Bonferroni correction, only the association with vitamin D remained significant. In multivariable regression controlling for sex, age, ferritin, and NLR, vitamin B12 maintained an independent negative relationship with BDI-II scores (beta = -0.021, p = 0.015), while vitamin D was borderline significant (beta = -0.248, p = 0.056). Receiver operating characteristic (ROC) analysis showed moderate discriminative ability of vitamin D (area under the curve (AUC) = 0.704; 95% confidence interval (CI), 0.618 – 0.789; optimal cutoff, 18 ng/mL; sensitivity, 84.8%; specificity, 52.4%). No significant associations were found for inflammatory markers or ferritin. Low vitamin D and vitamin B12 levels may be associated with greater depressive symptom severity in this cohort. Vitamin B12 remained independently associated across regression models, whereas the vitamin D association appeared partly influenced by sex-related confounding. These findings suggest that micronutrient status may be relevant as supportive information during the clinical assessment of adolescents with depressive symptoms. Prospective studies are needed to determine causality and clinical utility.

Keywords: Adolescent; depression; vitamin D; vitamin B 12; biomarkers; hematologic tests

Introduction

Depressive disorders represent a major mental health burden among adolescents worldwide, affecting about one in five young people aged 12 – 19 in high-income countries and leading to significant disability, educational setbacks, and reduced quality of life [1,2]. The World Health Organization considers depression a leading cause of years lived with disability during the teenage years [3]. Adolescence—a period marked by rapid neurobiological, cognitive, and emotional changes—may increase vulnerability to mood disorders through mechanisms that are not yet fully understood [4,5]. Recent research has broadened the understanding of depression from a purely psychological condition to a multisystem disorder involving neuroinflammation and metabolic dysregulation [6,7]. Evidence from epidemiological and experimental studies shows that chronic, low-grade inflammation—demonstrated by elevated circulating cytokines and acute-phase proteins—accompanies depression across different stages of life, including in children and teenagers [8-10]. Among various markers of inflammation, the neutrophil-tolymphocyte ratio (NLR) has gained attention as an easy-to-measure, inexpensive indicator of systemic inflammation, obtainable from standard complete blood counts

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Corresponding Author: Meryem Cansu Olt, Prof. Dr. Cemil Taşçıoğlu City Hospital, Ethics Committee, İstanbul, Türkiye
Email: cansuolt@gmail.com

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[11,12]. Several studies involving adults have linked higher NLR values to major depressive disorder, and early research suggests similar patterns in younger populations [13,14].

Nutritional micronutrients have become equally important in influencing adolescent mood and cognition [15,16]. Vitamin D exerts multiple effects in the central nervous system through receptors found in limbic and prefrontal regions; proposed mechanisms related to mood include affecting neurotransmitter production, offering neuroprotection, and reducing neuroinflammation [17,18]. Vitamin B12 is essential for one-carbon metabolism, maintaining myelin integrity, and supporting dopaminergic and serotonergic neurotransmission, with deficiencies linked to depression and psychotic disorders in younger individuals [19,20]. Iron, measured by ferritin, supports oxygen delivery to developing neural tissue and is involved in enzymatic steps for monoamine synthesis, with insufficiency associated with mood and cognitive issues in adolescents [21,22]. Recent adolescent studies and recent reviews also support evaluating vitamin D and vitamin B12 in relation to depressive symptom severity, although the evidence remains largely observational [23-26].

In light of these considerations, this study aimed to investigate the associations between depressive symptom severity and a panel of hematological and biochemical parameters, including vitamin D, vitamin B12, ferritin, and the NLR, in a sample of adolescents aged 13 – 18 years.

Material and Methods

Study Design and Setting

A cross-sectional observational study was conducted to evaluate the relationship between depression severity and selected hematological and biochemical markers in adolescents aged 13 – 18 years. Data were collected at the Pediatrics Department of Prof. Dr. Cemil Taşçıoğlu City Hospital (University of Health Sciences, İstanbul, Türkiye) from May 15 to August 15, 2025. The final study group included 109 volunteer participants.

Inclusion and Exclusion Criteria

Eligibility required voluntary participation, sufficient cognitive ability to complete the self-report questionnaire, and age between 13 and 18 years. Participants were excluded if they had an active infectious disease, a diagnosed chronic systemic condition, were on current antidepressant or psychotropic medication, experiencing an acute psychiatric crisis, or lacked laboratory data.

Outcome Measurements

All participants completed the Beck Depression Inventory-II (BDI-II), a validated 21-item tool for measuring depressive symptoms in adolescents. In the present study, the BDI-II was used as a screening measure of depressive symptom severity and not as a diagnostic instrument.

Laboratory Assessment

Blood samples were taken on the same day as the questionnaire, as part of routine clinical assessment. The laboratory tests included hemoglobin, leukocyte count, NLR, ferritin, thyroidstimulating hormone (TSH), serum 25-hydroxyvitamin D, and vitamin B12.

Ethical Considerations

The study followed ethical standards of the Declaration of Helsinki. Approval was obtained from the Clinical Research Ethics Committee of Prof. Dr. Cemil Taşçıoğlu City Hospital (approval number: E-48670771-514.99-276151842; date: May 12, 2025). Written informed consent was obtained from parents or legal guardians, and written assent was obtained from all adolescent participants before enrollment.

Statistical Analysis

Before inferential testing, the Shapiro-Wilk test was used to determine whether all continuous measures followed a normal distribution. Since BDI-II scores and most laboratory variables showed non-normal distributions ($p < 0.05$), nonparametric methods were employed throughout. Spearman rank correlation coefficients measured monotonic relationships between BDI-II scores and each laboratory parameter; this method avoids assuming normality and provides estimates that are robust against outliers. Because nine correlations were tested simultaneously, a Bonferroni correction was applied, setting the significance threshold at $\alpha = 0.0056$ (0.05 / 9). Between-group comparisons—based on sex and depression level (low vs. high)—used the Mann-Whitney U test. Multivariable linear regression with BDI-II as the outcome variable was conducted in sequential models that included biological and demographic covariates. Partial correlation analyses, controlling for sex, further examined the independence of micronutrient associations. Receiver operating characteristic (ROC) analysis with Youden's index was used to identify the best vitamin D cut-off values for distinguishing high depression scores. Bonferroni correction was applied only to the family of bivariate correlation analyses; regression models were interpreted as adjusted exploratory models rather than Bonferroni-corrected confirmatory tests. ROC analysis was also considered exploratory because of the cross-sectional design. No a priori power analysis was performed, and this was acknowledged as a limitation.

Results

The sample included 109 adolescents (63 females, 46 males) with an average age of 15.28 ± 1.99 years. The mean BDI-II score was 13.04 ± 9.26, with severity distribution as follows: minimal (57.8%), mild (17.4%), moderate (17.4%), and severe (7.3%).

Mean laboratory values for the full sample are presented in Table 1. Notably, serum vitamin D was below the deficiency threshold of 20 ng/mL in 68.8% of participants, with deficiency rates increasing across higher depression severity categories.

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Table 1. Descriptive statistics of laboratory parameters (n = 109)

Parameter	Mean ± SD	Median (IQR)	Range
Hemoglobin (g/L)	131.54 ± 14.05	130.00 (121.00 – 142.00)	98.00 – 169.00
Leukocyte (×10³/µL)	7.64 ± 1.59	7.68 (6.50 – 8.85)	3.98 – 11.50
Neutrophil (×10³/µL)	4.34 ± 1.37	4.20 (3.28 – 5.18)	1.07 – 7.90
Lymphocyte (×10³/µL)	2.56 ± 0.70	2.54 (2.09 – 2.95)	1.18 – 4.68
NLR	1.83 ± 0.84	1.57 (1.31 – 2.23)	0.53 – 5.11
Ferritin (ng/mL)	24.03 ± 17.50	18.20 (11.80 – 30.80)	3.80 – 89.40
Vitamin D (ng/mL)	16.62 ± 7.17	15.00 (11.50 – 21.00)	4.50 – 35.00
Vitamin B12 (pg/mL)	274.51 ± 98.87	266.00 (204.00 – 325.00)	94.00 – 761.00
TSH (mIU/L)	2.32 ± 1.05	2.21 (1.65 – 2.68)	0.34 – 5.14

Abbreviations: IQR, interquartile range; NLR, neutrophil-to-lymphocyte ratio; SD, standard deviation; TSH, thyroid-stimulating hormone.

Female participants differed significantly from males in hemoglobin, ferritin, vitamin D, and NLR (all $p \leq 0.033$); other parameters were comparable between sexes (Table 2).

Spearman correlation analysis found a significant inverse relationship between BDI-II scores and vitamin D levels ($r = -0.265$, $p = 0.005$), which remained significant after Bonferroni correction (adjusted $\alpha = 0.0056$; Table 3). An inverse correlation was also seen with vitamin B12 ($r = -0.235$, $p = 0.014$); however, this did not meet the corrected significance threshold. No significant correlations were identified for the remaining parameters, including hemoglobin, leukocytes, NLR, ferritin, and TSH (see Table 3 for full results).

For comparison, participants were divided into a low-depression group (BDI-II ≤ 13, n = 63) and a high-depression group (BDI-II > 13, n = 46). Vitamin D levels were notably lower in the high-depression group (13.69 ± 5.73 vs. 18.76 ± 7.40 ng/mL; $p < 0.001$). There were no significant differences between the groups in hemoglobin, leukocytes, neutrophils, lymphocytes, NLR, ferritin, vitamin B12, or TSH.

Table 2. Gender differences in laboratory parameters

Parameter	Female (n = 63)	Male (n = 46)	p -value
Hemoglobin (g/L)	126.68 ± 10.84	138.20 ± 15.28	< 0.001
Leukocyte (×10³/µL)	7.69 ± 1.68	7.56 ± 1.49	0.790
Neutrophil (×10³/µL)	4.61 ± 1.43	3.99 ± 1.20	0.033
Lymphocyte (×10³/µL)	2.39 ± 0.60	2.80 ± 0.77	0.005
NLR	2.06 ± 0.87	1.52 ± 0.70	< 0.001
Ferritin (ng/mL)	17.56 ± 11.22	32.89 ± 20.57	< 0.001
Vitamin D (ng/mL)	14.64 ± 6.45	19.33 ± 7.29	0.001
Vitamin B12 (pg/mL)	279.24 ± 111.28	268.04 ± 79.54	0.729
TSH (mIU/L)	2.17 ± 1.02	2.52 ± 1.07	0.077

Data are presented as mean ± standard deviation. p-values calculated using the Mann-Whitney U test. Abbreviations: NLR, neutrophil-to-lymphocyte ratio; TSH, thyroid-stimulating hormone.

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Table 3. Correlations between BDI-II scores and laboratory parameters

Parameter	Correlation coefficient (r)	p -value
Hemoglobin	-0.074	0.444
Leukocyte	0.071	0.465
Neutrophil	0.049	0.615
Lymphocyte	0.080	0.410
NLR	-0.029	0.763
Ferritin	-0.157	0.103
Vitamin D	-0.265	0.005*
Vitamin B12	-0.235	0.014
TSH	-0.023	0.812

*Spearman correlation analysis. Statistically significant after Bonferroni correction ($p < 0.0056$). Abbreviations: BDI-II, Beck Depression Inventory-II; NLR, neutrophil-to-lymphocyte ratio; TSH, thyroid-stimulating hormone.

Multiple linear regression results are summarized in Table 4 and Table 5. In the univariate model (Model 1), both vitamin D and vitamin B12 showed significant negative associations with BDI-II scores. In the fully adjusted model (Model 4), vitamin B12 remained independently significant (beta = -0.021, $p = 0.015$), while the association with vitamin D became borderline (beta = -0.248, $p = 0.056$); the model explained 12.8% of the variance ($R^2 = 0.128$). Partial correlation analyses adjusted for sex confirmed the independence of the vitamin B12 association (partial r = -0.247, $p = 0.010$), whereas the vitamin D correlation lost significance after sex adjustment (partial r = -0.187, $p = 0.051$), indicating potential sex-related confounding. ROC analysis showed moderate discriminatory ability of vitamin D for identifying high depression scores (area under the curve (AUC) = 0.704; 95% confidence interval (CI) 0.618 – 0.789); at the Youden-optimized cut-off of 18.00 ng/mL, sensitivity was 84.8%, specificity 52.4%, and negative predictive value 82.4%. Therefore, the explanatory power of the fully adjusted model was low. The difference between the correlation and regression findings for vitamin B12 may reflect adjustment effects in the multivariable model rather than a stronger unadjusted association.

Table 4. Multiple linear regression analysis predicting BDI-II scores

Variable	Model 1 Beta (p)	Model 2 Beta (p)	Model 3 Beta (p)	Model 4 Beta (p)
Constant	24.23 (< 0.001)	24.77 (< 0.001)	17.71 (0.015)	18.13 (0.014)
Vitamin D (ng/mL)	-0.332 (0.006)*	-0.238 (0.054)	-0.265 (0.035)*	-0.248 (0.056)
Vitamin B12 (pg/mL)	-0.021 (0.018)*	-0.022 (0.011)*	-0.021 (0.013)*	-0.021 (0.015)*
Gender (Male vs Female)	–	-4.193 (0.020)*	-3.905 (0.031)*	-3.609 (0.086)
Age (years)	–	–	0.471 (0.274)	0.535 (0.224)
Ferritin (ng/mL)	–	–	–	-0.040 (0.462)
NLR	–	–	–	-0.482 (0.656)

Abbreviations: BDI-II, Beck Depression Inventory-II; NLR, neutrophil-to-lymphocyte ratio.

Table 5. Model fit indicators for multiple linear regression models

Model Fit Indicator	Model 1	Model 2	Model 3	Model 4
R-squared	0.116	0.160	0.170	0.176
Adjusted R-squared	0.100	0.137	0.135	0.128
F-statistic (p -value)	6.92 (0.002)	6.58 (< 0.001)	4.99 (0.001)	3.63 (0.003)

*Multiple linear regression analysis. Beta coefficients represent the change in BDI-II score per unit change in the predictor variable. Gender coded as 0 = Female, 1 = Male. Statistically significant ($p < 0.05$). Abbreviations: BDI-II, Beck Depression Inventory-II; NLR, neutrophil-to-lymphocyte ratio.

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Discussion

This cross-sectional study examined the connections between depression severity and various blood-based and biochemical parameters in a sample of Turkish adolescents aged 13 – 18 years. The main finding was a negative correlation between BDI-II scores and serum vitamin D levels that remained significant after Bonferroni correction. Vitamin B12 levels were also negatively associated with depression scores, and this relationship persisted across multivariable regression models that accounted for potential confounders such as sex, age, ferritin, and NLR. ROC analysis showed that vitamin D had moderate ability to distinguish cases with high depression levels. Conversely, neither NLR—an established inflammatory marker—nor ferritin exhibited meaningful links with depression severity, suggesting that nutritional rather than inflammatory pathways may represent more clinically relevant targets in this age group. The neurobiological plausibility of the vitamin D – depression link is well established. Vitamin D receptors and the enzymatic machinery for its local conversion are distributed throughout cortical and subcortical brain regions involved in mood regulation [27]. These results should be interpreted as associations only, and the low R^2 value indicates that most variability in depressive symptom scores was explained by factors not included in the model.

Deficiency may impair serotonergic and dopaminergic synthesis pathways and promote neuroinflammatory and oxidative stress cascades known to contribute to depressive states. Esnafoglu and colleagues documented significantly lower vitamin D and B12 levels specifically in adolescents with diagnosed depressive disorder, noting dose-dependent relationships with severity [23]. Al-Sabah et al. also reported inverse relationships between vitamin D levels and depressive symptom severity during adolescence [24]. A large adult meta-analysis confirmed the strength of this relationship across populations [18], and our data show that the same pattern is observable during adolescence and remains after conservative multiple-comparison corrections.

The ROC findings should be interpreted cautiously and as exploratory. An 82.4% negative predictive value at the 18 ng/mL cut-off means that adolescents with sufficient vitamin D levels are unlikely to have a high depression burden in this sample. The ROC findings suggest that low vitamin D levels may serve as a supportive clinical indicator prompting further mental health assessment, rather than a diagnostic marker on their own. However, the moderate specificity (52.4%) emphasizes that vitamin D deficiency is not a definitive sign of depression and indicates broader health risks. Instead of acting as a diagnostic tool, vitamin D assessment can serve as a trigger for more detailed mental health assessments when deficiency is found during routine check-ups.

Vitamin B12's consistent independent association across regression models may indicate that its impact on depressive symptoms likely occurs through direct neurobiological mechanisms rather than being linked to other measured variables. B12 is an essential cofactor for enzymes like methionine synthase and methylmalonyl-CoA mutase, which are crucial to one-carbon metabolism, DNA methylation, myelin maintenance, and monoamine neurotransmitter production [25]. Meta-analyses already support a connection between B12 and depression in pediatric and adolescent populations [25,26], and the current data provide additional multivariate-adjusted evidence from a Turkish tertiary center cohort. Importantly, unlike vitamin D, the B12 – BDI-II association persisted after partial correlation analysis with sex adjustment, emphasizing its independence from sex-related confounding factors. This difference suggests that B12 may influence depression through a more direct biological pathway, whereas vitamin D effects might be partly mediated or moderated by sex-related differences in sun exposure, clothing behaviors, and hormonal environment. Nevertheless, because the bivariate correlation for vitamin B12 did not remain significant after Bonferroni correction, this finding should be regarded as adjusted and hypothesis-generating rather than definitive.

The high prevalence of vitamin D insufficiency (68.8%)—substantially exceeding general population estimates in similar climatic zones—demands attention. Several factors may account for this burden in Turkish adolescents: indoor lifestyle patterns, cultural clothing norms that limit cutaneous sun exposure particularly in female adolescents, and inadequate dietary vitamin D intake. The sex-stratified analyses corroborate this interpretation; female participants had significantly lower vitamin D, ferritin, and hemoglobin concentrations compared with males, consistent with the compounded effects of menstrual iron losses, hormonal influences on absorption, and differential sun exposure behaviors [28,29].

An unexpected finding was the higher NLR in females compared to males, which contradicts most large epidemiological datasets showing male-dominant NLR values [30,31]. This difference probably results from the small sample size of this study and the natural variability during adolescence, when hormonal changes, pubertal stages, subclinical infections, and stress responses can temporarily increase granulocyte counts in ways not fully captured by cross-sectional sampling.

The lack of correlation between NLR or ferritin and BDI-II scores contrasts with findings in adult mood disorder research, where increases in inflammation are well established [14,29]. Possible reasons include the ongoing development of the adolescent immune-inflammatory system, which may reduce the visibility of depression-related inflammatory signals at this stage. Furthermore, the limited range of ferritin levels in the current sample—whose mean values are already at the lower end of normal—may have restricted the ability to detect links between iron and mood. A future cohort study with greater ferritin variability and multiple measurements would be better suited to answer this question. Thus, the negative NLR finding does not exclude inflammatory mechanisms in adolescent

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depressive symptoms, but it does suggest that a single complete blood count-derived marker may be insufficient to capture this pathway.

Limitations

Several limitations must be acknowledged. The cross-sectional design prevents establishing causality or the direction of the relationships between vitamin D, B12, and depression; prospective studies or randomized trials are necessary to determine causality over time. The single-center recruitment and moderate sample size limit how well the findings can be applied to a broader adolescent population. Additionally, several factors known to influence adolescent depression—such as psychosocial stressors (family dynamics, academic pressures, trauma history), dietary intake, sun exposure habits, and physical activity levels—were not systematically measured, leaving some confounding variables unaccounted for. In addition, all laboratory parameters were measured at a single time point, which may not fully reflect longer-term micronutrient status or inflammatory activity. Because participants were recruited from a tertiary referral center, selection bias is possible and the sample may not represent adolescents in the general community. The BDI-II is a screening tool for depressive symptom severity and cannot establish a clinical diagnosis of depression. Body mass index (BMI), socioeconomic status, diet, sun exposure, seasonal variation, and physical activity were not recorded; these unmeasured factors are particularly relevant for vitamin D status and mental health. The modest sample size and absence of an a priori power analysis may also have limited statistical power, especially for subgroup and multivariable analyses.

Conclusion

These findings suggest that vitamin D and vitamin B12 status may be relevant during the clinical evaluation of adolescents presenting with depressive symptoms. Assessment of these micronutrients may provide supportive information in pediatric outpatient and primary care settings, particularly when combined with standard psychiatric evaluation. However, because of the cross-sectional design, these results should not be interpreted as evidence of causality. Larger prospective studies and randomized controlled trials are needed to clarify whether correcting these deficiencies improves depressive symptoms during adolescence.

Ethical Approval

This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was granted by the Clinical Research Ethics Committee of Prof. Dr. Cemil Taşçıoğlu City Hospital, University of Health Sciences (approval number: E-48670771-514.99-276151842; protocol no: 175; date: May 12, 2025).

Patient Consent

Written informed consent was obtained from all parents or legal guardians. Written assent was obtained from all adolescent participants prior to enrollment.

Conflict of Interest

The authors confirm the absence of any conflicts associated with this work.

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