

Original Article

Features of anxiety and depression indicators in patients with autoimmune diabetes mellitus on the background of different vitamin D status

Iryna Tsaryk^{1*}, Nataliia Pashkovska¹, Volodymyr Pankiv², Valeriy Pashkovskyy³, Nina Stankova⁴

¹ Department of Clinical Immunology, Allergology and Endocrinology, Bukovinian State Medical University, Chernivtsi, Ukraine

² Ukrainian Scientific and Practical Centre of Endocrine Surgery, Transplantation of Endocrine Organs and Tissues of the Ministry of Health of Ukraine, Kyiv, Ukraine

³ Department of Nervous Diseases, Psychiatry and Medical Psychology, Bukovinian State Medical University, Chernivtsi, Ukraine

⁴ Polyclinic Department No.2, Chernivtsi Regional Clinical Hospital, Chernivtsi, Ukraine

* Correspondence to: Iryna Tsaryk, Department of Clinical Immunology, Allergology and Endocrinology, Bukovinian State Medical University, Teatralna sq., 2, Chernivtsi, 58002, Ukraine. Phone: +38 (099) 442 76 94; E-mail irynatsaryk13@gmail.com

Received: 10 February 2025 / Accepted: 6 May 2024

Abstract

Depression and anxiety are prevalent mental disorders that significantly affect the quality of life, work capacity, and overall health. Their incidence is rising due to modern stressors, including economic instability, social isolation, and global crises. Vitamin D plays a crucial role in central nervous system function, influencing mood through its effects on neurotransmitter regulation. Low vitamin D levels have been associated with increased anxiety and depression, particularly in patients with diabetes mellitus (DM), who already face heightened psychological distress. This study explores the relationship between vitamin D deficiency and anxiety and depression in patients with autoimmune DM, including classical type 1 DM (T1DM) and latent autoimmune diabetes in adults (LADA). A total of 100 patients were assessed for serum vitamin D levels, psycho-emotional indicators, and metabolic parameters. Findings indicate a significant correlation between vitamin D deficiency and elevated anxiety and depression scores in both T1DM and LADA patients. Higher situational and personal anxiety, along with more severe depressive symptoms, were observed in individuals with lower vitamin D levels. These results underscore the importance of vitamin D status in managing the psychological well-being of autoimmune diabetes patients and highlight the need for integrated therapeutic strategies addressing both metabolic and emotional health.

Keywords: autoimmune diabetes mellitus, type 1 diabetes mellitus, LADA, vitamin D, anxiety, depression

Introduction

Depression and anxiety are among the most common mental disorders worldwide, significantly impacting the quality of life, work capacity, and physical health. Their relevance is driven by the increasing prevalence due to stress factors of modern life, economic instability, social isolation, and crisis situations such as war or pandemics. This results in a substantial

cognitive, social, and economic burden, affecting both individual well-being and societal functioning [1, 2].

Vitamin D is an essential biological component that plays a key role in maintaining overall health, particularly by ensuring the normal function of the central nervous system. It influences emotional and personality responses through receptors located in the limbic system, cortex, and cerebellum. Vitamin D supports calcium homeostasis, axonal conductivity, and participates



in the regulation of neurotransmitters such as dopamine and norepinephrine, which are crucial for mood disorders and depression development [3–6].

Low vitamin D levels have been associated with depression and increased anxiety, suggesting its role as a mood modulator [7–10]. Among the common comorbid conditions in patients with diabetes mellitus (DM), depression and anxiety disorders, as well as cognitive impairments, are frequently observed, significantly worsening their psycho-emotional state. Chronic stress caused by the underlying disease and exogenous factors further exacerbates these problems, with cognitive impairments adding further complexity [11, 12]. Specifically, individuals with type 2 diabetes mellitus (T2DM) have a 75% higher risk of depression disorders developing compared to the general population, and anxiety disorders are diagnosed 18% more frequently in this group [13, 14]. This, in turn, complicates adherence to treatment recommendations, worsens quality of life and overall health, and contributes to disease progression. Studies indicate an increase in depression symptoms in T2DM patients under chronic war-related stress in the context of vitamin D deficiency [15].

Latent autoimmune diabetes in adults (LADA) is a form of diabetes characterized by slow autoimmune destruction of pancreatic beta cells. It shares features of both type 1 diabetes mellitus (T1DM) and T2DM, ranking second in frequency among all diabetes types after T2DM. It is also the most common type of autoimmune diabetes among adults [16]. Our previous studies have shown that vitamin D deficiency in patients with autoimmune diabetes is associated with worsened carbohydrate and lipid metabolism, increased autoimmune markers, and insulin resistance [17, 18].

The aim of our study was to determine the relationship between vitamin D levels and anxiety and depression indicators in patients with autoimmune diabetes mellitus.

Material and methods

Study design and patients

A screening examination of 117 patients with different T1DM phenotypes (54 with classical T1DM and 63 with LADA) was conducted to assess serum vitamin D levels. Normal vitamin D levels were recorded in 24.6% of T1DM patients and 20.6% of LADA patients. An additional 9.3% and 19% of T1DM and LADA patients, respectively, were excluded from the study due to comorbidities that could affect vitamin D metabolism.

A total of 100 patients aged 19 to 59 years with different autoimmune DM forms and vitamin D statuses were included in the study: 49 with LADA and 51 with classical T1DM. The LADA group consisted of 32 men and 17 women aged 38 to 59 years, while the T1DM group included 31 men and 20 women aged 19 to 51 years. At the time of the study, the duration of the disease was 7.0 [4.0;10.0] years in LADA patients and 10.0 [8.0;14.0] years in T1DM patients.

Diagnosis

The diagnosis of DM was established according to the ADA 2024 Standards of Medical Care in Diabetes [19], while LADA was diagnosed based on the recommendations of the Diabetes Immunology Society [20] and the Consensus Statement of the International Expert Panel on LADA [21]. The latter outlines extended LADA characteristics, including age of onset over 30 years, personal/family history of autoimmunity, a lower frequency of metabolic syndrome compared to T2DM, no difference in cardiovascular outcomes between LADA and T2DM patients, slower C-peptide decline than in T1DM, positivity for glutamic acid decarboxylase antibodies (anti-GAD) as the most sensitive marker (less frequently for ICA, IA-2A, ZnT8A, and tetraspanin 7 antibodies), and no need for insulin therapy at the onset of diabetes.

Laboratory, anthropometric and clinical data collection

Patients from both groups were assessed for situational and personal anxiety, depression, anthropometric parameters [height, weight, body mass index (BMI), waist circumference (WC), and hip circumference (HC) to calculate the WC/HC ratio], serum 25(OH)D levels, and carbohydrate metabolism indicators [fasting plasma glucose and glycated hemoglobin (HbA1c)].

Patients were categorized based on vitamin D status: levels <20 ng/mL were classified as deficiency, levels 21–29 ng/mL as insufficiency, and levels >30 ng/mL as normal ranges [14].

To assess personal and reactive anxiety, the Spielberger CD Scale was used [22], while depression was evaluated using the Beck Depression Inventory [23].

Statistical analysis

Statistical analysis was performed using Statistica 13.3 (StatSoft Inc.) and Microsoft Excel 2016.

Quantitative data were presented as median (Me) and interquartile range (Q25–Q75). The Mann-Whitney U-test was used to assess differences between study groups, while the Wilcoxon test was applied for longitudinal treatment comparisons. For correlation analysis, the Spearman rank correlation coefficient was used due to the non-normal distribution of the data.

Results

The characteristics of anthropometric data, carbohydrate metabolism indicators, anxiety, and depression in classical T1DM patients based on vitamin D status are presented in Table 1.

As seen from the provided data, in the T1DM group, 33.3% had a vitamin D deficiency, while 37.3% had insufficiency. The remaining patients had vitamin D levels within the normal reference range.

According to anthropometric studies, normal body weight based on BMI was observed in 76.5% of patients with T1DM, underweight was found in 5.9%, and overweight in 17.6%. A metabolically unhealthy phenotype with abdominal fat distribution was identified in 19.6% of T1DM patients.

In T1DM patients, BMI did not show statistical differences in intergroup comparisons. However, waist

circumference (WC) in the deficiency group was 9.2% higher than in the group with normal vitamin D levels ($p < 0.05$). The WC/HC ratio was 7.2% and 14.3% lower in the insufficiency group compared to the normal and deficient vitamin D groups, respectively ($p < 0.05$).

In all groups of T1DM patients, fasting glucose and HbA1c levels were significantly elevated compared to reference values, indicating poor glycemic control. Fasting glucose levels were 12.9% and 21.0% higher in the vitamin D insufficiency and deficiency groups, respectively, compared to the group of patients with normal vitamin D levels ($p < 0.05$). The HbA1c level did not show statistically significant changes in intergroup comparisons.

The study results showed that the psycho-emotional state of T1DM patients varies significantly depending on vitamin D levels. There was a clear tendency toward increased situational and trait anxiety, as well as depression, in patients with vitamin D insufficiency and deficiency.

Situational anxiety is a short-term emotional experience that arises in response to specific stressful circumstances. In T1DM patients with normal vitamin D levels, the average situational anxiety score was 38.00 score. According to the Spielberger scale, low situational anxiety was observed in 9.8% of individuals, moderate in 41.2%, and high in 49%. In the vitamin D

Table 1: Anthropometric data, carbohydrate metabolism indicators, anxiety, and depression in patients with classical type 1 diabetes mellitus depending on vitamin D status.

Indicators	Normal vitamin D level, n=15	Vitamin D insufficiency, n=17	Vitamin D deficiency, n=19
25(OH)D, ng/mL	48.36 [38.59;57.28]	24.73 [22.00;27.30] $p_1=0.000$	14.09 [10.70;18.00] $p_1=0.000$ $p_2=0.000$
BMI, kg/m ²	23.47 [19.72;29.32]	22.04 [18.83;24.69] $p_1=0.733$	23.85 [21.94;27.34] $p_1=0.780$ $p_2=0.271$
WC, cm	76.00 [69.00;110.00]	79.00 [69.00;87.00] $p_1=0.961$	83.00 [80.00;90.00] $p_1=0.046$ $p_2=0.475$
WC/HC	0.83 [0.77;0.96]	0.77 [0.70;0.85] $p_1=0.044$	0.88 [0.82;0.94] $p_1=0.333$ $p_2=0.011$
Fasting plasma glucose, mmol/L	8.90 [7.59;10.05]	10.05 [9.51;12.52] $p_1=0.027$	10.77 [9.53;13.01] $p_1=0.017$ $p_2=0.802$

Table 1: Continued.

Indicators	Normal vitamin D level, n=15	Vitamin D insufficiency, n=17	Vitamin D deficiency, n=19
HbA1c, %	8.19 [6.13;9.40]	8.90 [7.80;9.40] p ₁ =0.301	8.90 [8.6;9.90] p ₁ =0.400 p ₂ =0.433
Situational anxiety score	38.00 [27.00;41.00]	49.00 [40.00;56.00] p ₁ =0.032	52.00 [43.00;61.00] p ₁ =0.000 p ₂ =0.315
Personal anxiety, score	25.00 [24.00;30.00]	33.00 [28.00;40.00] p ₁ =0.024	34.00 [32.00;40.00] p ₁ =0.019 p ₂ =0.490
Depression, score	11.00 [6.00;19.00]	18.00 [9.00;28.00] p ₁ =0.007	20.00 [15.00;37.00] p ₁ =0.001 p ₂ =0.346

Note: n – number of observations; p₁ – the probability of changes concerning patients with normal vitamin D levels; p₂ – the probability of changes concerning patients with vitamin D deficiency.

insufficiency group, situational anxiety significantly increased by 28.9% compared to the normal group ($p < 0.05$), and in the deficiency group, it increased by 36.8% ($p = 0.000$). This indicates that even with a moderate decrease in vitamin D levels, patients experience more pronounced anxiety, tension, and stress reactions. There was no significant difference between the deficiency and insufficiency groups.

Personal anxiety is a stable characteristic of a person, reflecting their tendency to worry and have anxious thoughts in everyday life. In T1DM patients, personal anxiety levels were distributed as follows: low in 43.1%, moderate in 54.9%, and high in 2% of patients. In the vitamin D insufficiency group, the trait anxiety level increased by 32.0%, while in the deficiency group, it increased by 36.0% compared to the normal vitamin D group ($p < 0.05$). This suggests that these patients are prone to persistent worry, insecurity, and emotional discomfort, which may negatively impact overall health and diabetes management.

According to the Beck Depression Scale, normal variations were recorded in 31.4% of T1DM patients, mild depression in 27.5%, moderate depression in 21.6%, and severe depression in 19.5%. In the vitamin D insufficiency group, depression levels significantly increased by 63.6% ($p < 0.01$), indicating a moderate level of depressive symptoms, which may manifest as low mood, fatigue, apathy, and loss of interest in usual activities. In the vitamin D deficiency group, depression

levels increased significantly by 81.8% ($p = 0.001$), representing the most pronounced change among all psycho-emotional indicators.

Based on a linear regression analysis of the relationships between the studied indicators in the T1DM patient group, strong direct correlations were identified between HbA1c levels and situational anxiety ($r = 0.929$; $p < 0.05$), personal anxiety ($r = 0.761$; $p < 0.05$), and depression ($r = 0.864$; $p < 0.05$); moderate correlations were found between HbA1c levels and BMI ($r = 0.380$; $p < 0.05$), depression levels and BMI ($r = 0.334$; $p < 0.05$). Strong inverse correlations were observed between vitamin D levels and depression ($r = -0.683$; $p < 0.05$).

Analyzing the data of patients with LADA, we obtained the following results (Table 2).

Anthropometric indicators such as BMI, WC, and WC/HC ratio did not statistically differ in the inter-group comparison.

A normal body weight based on BMI was observed in 46.9% of patients with LADA, overweight in 28.6%, and obesity in 24.5% (18.4% with grade I obesity and 6.1% with grade II obesity, respectively). A metabolically unhealthy phenotype with abdominal fat distribution was identified in 44.9% of LADA patients.

Fasting blood glucose levels in the vitamin D deficiency group were 33.3% higher, and in the insufficiency group – 19.4% higher compared to the normal vitamin D supply group ($p < 0.05$). HbA1c levels did not significantly differ between the study groups.

Table 2: Anthropometric characteristics, carbohydrate metabolism indicators, anxiety, and depression in LADA patients depending on vitamin D status.

Indicators	Normal vitamin D level, n=13	Vitamin D insufficiency, n=16	Vitamin D deficiency, n=20
25(OH)D, ng/mL	36.03 [33.00;41.64]	23.31 [21.49;25.50] p ₁ =0.000	8.06 [5.01;16.63] p ₁ =0.000 p ₂ =0.000
BMI, kg/m²	23.02 [20.55;23.53]	23.93 [22.24;26.40] p ₁ =0.118	25.23 [23.58;27.43] p ₁ =0.123 p ₂ =0.336
WC, cm	85.50 [70.00;86.00]	86.50 [76.50;94.50] p ₁ =0.220	88.50 [82.00;94.50] p ₁ =0.494 p ₂ =0.404
WC/HC	0.90 [0.77;0.93]	0.91 [0.86;0.99] p ₁ =0.635	0.92 [0.89;1.00] p ₁ =0.457 p ₂ =0.479
Fasting plasma glucose, mmol/L	8.91 [7.93;10.60]	10.64 [9.04;12.15] p ₁ =0.041	11.88 [10.26;12.53] p ₁ =0.028 p ₂ =0.249
HbA1c, %	7.98 [7.02;10.80]	10.17 [7.46;11.46] p ₁ =0.875	9.75 [8.49;11.00] p ₁ =0.457 p ₂ =0.838
Situational anxiety score	39.00 [32.00;45.00]	52.50 [44.00;63.00] p ₁ =0.000	54.50 [45.50;61.00] p ₁ =0.000 p ₂ =0.962
Personal anxiety, score	24.00 [20.00;28.00]	35.00 [31.50;40.00] p ₁ =0.001	33.50 [29.00;39.00] p ₁ =0.003 p ₂ =0.519
Depression, score	14.00 [9.00;19.00]	19.50 [14.00;31.00] p ₁ =0.023	21.00 [16.00;32.50] p ₁ =0.015 p ₂ =0.671

Note: n – number of observations; p₁ – the probability of changes in patients with normal vitamin D levels; p₂ – the probability of changes in patients with vitamin D deficiency.

According to Spielberg's anxiety scale, low situational anxiety was observed in 8.2% of LADA patients, moderate anxiety in 34.7%, and high anxiety in 57.1%. The situational anxiety level was significantly higher in the vitamin D insufficiency and deficiency groups – by 34.6% and 39.7%, respectively, compared to the normal supply group (p=0.000), indicating a tendency toward anxiety disorders regardless of the degree of vitamin D reduction.

Personal anxiety indicators were distributed as follows: low in 42.9%, moderate in 46.9%, and high in

10.2% of patients. In the vitamin D insufficiency group, the indicator increased by 45.8% (p=0.001), and in the deficiency group – by 39.6% (p<0.01) compared to the normal supply group.

According to Beck's depression scale, normal indicators were registered in 22.4% of LADA patients, mild depression in 30.6%, moderate depression in 24.5%, and severe depression in 22.4%. In the vitamin D insufficiency group, depression levels increased significantly by 39.3% (p<0.05), and in the deficiency group – by

50.0% ($p < 0.05$) compared to the normal vitamin D supply group.

Based on a linear regression analysis of the relationships between vitamin D levels, anthropometric data, carbohydrate metabolism, anxiety, and depression in LADA patients, strong direct correlations were registered between HbA1c levels and situational anxiety ($r = 0.888$; $p < 0.05$) and depression ($r = 0.660$; $p < 0.05$); moderate correlations were found between HbA1c levels and personal anxiety ($r = 0.521$; $p < 0.05$), fasting plasma glucose levels and BMI ($r = 0.375$; $p < 0.05$), and fasting plasma glucose levels and WC/HC ratio ($r = 0.443$; $p < 0.05$). Moderate inverse correlations were established between vitamin D levels and depression ($r = -0.342$; $p < 0.05$) as well as situational anxiety ($r = -0.384$; $p < 0.05$).

Discussion

Thus, the study showed that vitamin D deficiency is common among patients with both classical T1DM and LADA diabetes; at the same time, LADA patients exhibit a more pronounced vitamin D deficiency. This may indicate a possible role of vitamin D in LADA pathogenesis. Regarding anthropometric characteristics, most T1DM patients had a normal body weight, whereas LADA patients had more cases of overweight, obesity, and a more distinct abdominal fat distribution pattern. Although significant differences in BMI and WC between groups were not detected, the WC/HC was higher in T1DM patients with vitamin D deficiency.

Regarding emotional and personal reactions, the results showed that high situational anxiety was more common among T1DM and LADA patients. The assessment of personal anxiety and depression indicated that a significant portion of patients experienced moderate to high levels of anxiety and depression, highlighting the need for additional psychological support in treating these patients. Overall, the findings emphasize the importance of a comprehensive approach to managing T1DM and LADA patients, focusing on correcting vitamin D deficiency, controlling anthropometric indicators, and monitoring psycho-emotional well-being.

According to a correlation analysis using linear regression, elevated HbA1c levels in LADA patients were associated with increased anxiety and depression, indicating a link between impaired carbohydrate metabolism and psycho-emotional state. A correlation was also found between fasting plasma glucose levels and body weight/abdominal obesity indicators, confirming the

impact of excess weight on metabolic disorders. Notably, an inverse relationship was found between vitamin D levels and manifestations of anxiety and depression, suggesting a potential impact on psycho-emotional well-being. These findings emphasize the importance of a comprehensive approach to managing LADA patients, considering not only glycemic control but also psychological aspects and nutritional status.

Therefore, in the T1DM patient group, a strong association was found between HbA1c levels and psycho-emotional state. Higher HbA1c levels were accompanied by increased situational and personal anxiety as well as depression, highlighting the significant impact of carbohydrate metabolism disorders on psychological well-being. A moderate correlation was also observed between HbA1c levels and BMI, reflecting the role of anthropometric factors in diabetes compensation. Additionally, a relationship between depression and BMI was found, confirming the negative impact of excess body weight on psycho-emotional state. Of particular note is the inverse correlation between vitamin D levels and depression, which may indicate a protective role in the development of depressive states in this category of patients.

The observed changes can be explained by the role of vitamin D in regulating neurotransmitters that affect psycho-emotional states, as well as in maintaining normal carbohydrate metabolism and insulin sensitivity. Its deficiency contributes to increased anxiety and depression, potentially due to neurotransmitter imbalances and heightened systemic inflammation [3, 6, 24, 25]. Low vitamin D levels are also associated with higher glucose and HbA1c levels, indicating poorer diabetes control, while chronic disease-related stress further exacerbates this negative impact. The findings underscore the necessity of a comprehensive approach to managing patients with autoimmune diabetes, including vitamin D deficiency correction, metabolic control optimization, and psychological support.

Conclusion

Vitamin D deficiency in patients with autoimmune diabetes (T1DM and LADA) is associated with increased anxiety and depression, poorer carbohydrate metabolism control, and a higher prevalence of abdominal obesity. The findings confirm the necessity of a comprehensive treatment approach for such patients, including vitamin D deficiency correction, improved metabolic control, and psychological support.

Conflict of interest

The authors declare no conflict of interest.

Ethics approval

The approval for this study was obtained from the Biomedical Ethics Commission of the Bukovinian State Medical University of the Ministry of Health of Ukraine (Chernivtsi) – Protocol No. 2 dated 17 of October 2019.

Consent to participate

Written informed consent was obtained from all the participants.

References

- Malhi GS, Mann JJ. Depression. *Lancet*. 2018 Nov 24;392(10161):2299-2312. doi: 10.1016/S0140-6736(18)31948-2.
- GBD 2019 Mental Disorders Collaborators. Global, regional, and national burden of 12 mental disorders in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet Psychiatry*. 2022 Feb;9(2):137-150. doi: 10.1016/S2215-0366(21)00395-3.
- Eyles DW. Vitamin D: Brain and Behavior. *JBMR Plus*. 2020;5(1):e10419. Published 2020 Oct 18. doi:10.1002/jbm4.10419
- Chamorro L, Luque A, Lobo A. Validation of the Spanish versions of the Montgomery-Asberg depression and Hamilton Anxiety rating scales. *Med Clin*. 2002;118(13):493-499. doi: 10.1016/S0025-7753(02)72429-9.
- Eyles DW, Smith S, Kinobe R, Hewison M, McGrath JJ. Distribution of the vitamin D receptor and 1 alpha-hydroxylase in human brain. *J Chem Neuroanat*. 2005 Jan;29(1):21-30. doi: 10.1016/j.jchemneu.2004.08.006.
- Landel V, Stephan D, Cui X, Eyles D, Feron F. Differential expression of vitamin D-associated enzymes and receptors in brain cell subtypes. *J Steroid Biochem Mol Biol*. 2018 Mar;177:129-134. doi: 10.1016/j.jsbmb.2017.09.008.
- Anglin RE, Samaan Z, Walter SD, McDonald SD. Vitamin D deficiency and depression in adults: systematic review and meta-analysis. *Br J Psychiatry*. 2013 Feb;202:100-7. doi: 10.1192/bjp.bp.111.106666.
- Wen Z, Bai L, Wu S, Chen J, Jama HA, Sawmadal JD. Association of serum vitamin D with anxiety in US adults: a cross-sectional study. *Front Nutr*. 2024 Mar 14;11:1371170. doi: 10.3389/fnut.2024.1371170.
- Jahan-Mihan A, Stevens P, Medero-Alfonso S, Brace G, Overby LK, Berg K, Labyak C. The Role of Water-Soluble Vitamins and Vitamin D in Prevention and Treatment of Depression and Seasonal Affective Disorder in Adults. *Nutrients*. 2024 Jun 17;16(12):1902. doi: 10.3390/nu16121902.
- Ceolin G, Antunes LDC, Moretti M, Rieger DK, Moreira JD. Vitamin D and depression in older adults: lessons learned from observational and clinical studies. *Nutr Res Rev*. 2023 Dec;36(2):259-280. doi: 10.1017/S0954422422000026.
- Pashkovska N. Cognitive impairment in type 2 diabetes mellitus: prospects for the use of metformin. *Int J Endocrinol (Ukraine)*. 2023;19(3):215-24. doi: 10.22141/2224-0721.19.3.2023.1274.
- Mankovskyy BM. Depression in patients with diabetes mellitus. *Diabetes. Obesity. Metabolic syndrome*. 2021;(6):22-28.
- Chaturvedi SK, Manche Gowda S, Ahmed HU, Alosaimi FD, Andreone N, Bobrov A, et al. More anxious than depressed: prevalence and correlates in a 15-nation study of anxiety disorders in people with type 2 diabetes mellitus. *Gen Psychiatr*. 2019 Aug 9;32(4):e100076. doi: 10.1136/gpsych-2019-100076.
- Zghebi SS, Steinke DT, Rutter MK, Ashcroft DM. Eleven-year multimorbidity burden among 637 255 people with and without type 2 diabetes: a population-based study using primary care and linked hospitalisation data. *BMJ Open*. 2020;10(7):e033866. doi: 10.1136/bmjopen-2019-033866.
- Bobryk M. Association of depression with vitamin D deficiency in patients with type 2 diabetes mellitus under chronic war stress. *PMGP [Internet]*. 16 December 2024 [cited 12 January 2025]; 9(4). Available from: <https://uk.e-medjournal.com/index.php/psp/article/view/542>.
- Pashkovska N, Tsaryk I. Latent autoimmune diabetes in adults: current data (review of literature and own data). *Int J Endocrinol (Ukraine)*. 2024;20(3):163-72. doi: 10.22141/2224-0721.20.3.2024.1384.
- Tsaryk I, Pashkovska N, Pankiv V, Pashkovskyy V. Dyslipidemia in latent autoimmune diabetes in adults: the relationship with vitamin D. *Int J Endocrinol (Ukraine)*. 2024;20(5):357-63. doi: 10.22141/2224-0721.20.5.2024.1420.
- Pashkovska N, Tsaryk I. The efficacy of cholecalciferol in the comprehensive treatment of patients with autoimmune diabetes. *Int J Endocrinol (Ukraine)*. 2025;20(8):565-72. doi:10.22141/2224-0721.20.8.2024.1473.
- American Diabetes Association Professional Practice Committee. 2. Diagnosis and Classification of Diabetes: Standards of Care in Diabetes-2024. *Diabetes Care*. 2024 Jan 1;47(Suppl 1):S20-S42. doi:10.2337/dc24-S002.
- Fourlanos S, Dotta F, Greenbaum CJ, Palmer JP, Rolandsson O, Colman PG, et al. Latent autoimmune diabetes in adults (LADA) should be less latent. *Diabetologia*. 2005 Nov;48(11):2206-12. doi: 10.1007/s00125-005-1960-7.
- Buzzetti R, Tuomi T, Mauricio D, Pietropaolo M, Zhou Z, Pozzilli P, et al. Management of Latent Autoimmune Diabetes in Adults: A Consensus Statement From an International Expert Panel. *Diabetes*. 2020 Oct;69(10):2037-2047. doi: 10.2337/dbi20-0017.
- Spielberger CD. *State-Trait Anxiety Inventory: Bibliography*. 2nd ed. Palo Alto, CA: Consulting Psychologists Press; 1989.
- Beck AT, Steer RA, Brown GK. *Beck Depression Inventory (BDI-II)*. 2nd ed. San Antonio, TX: The Psychological Corporation; 1996.
- Menéndez SG, Manucha W. Vitamin D as a Modulator of Neuroinflammation: Implications for Brain Health. *Curr Pharm Des*. 2024;30(5):323-332. doi: 10.2174/0113816128281314231219113942.
- Chen W, Liu L, Hu F. Efficacy of vitamin D supplementation on glycaemic control in type 2 diabetes: An updated systematic review and meta-analysis of randomized controlled trials. *Diabetes Obes Metab*. 2024 Dec;26(12):5713-5726. doi: 10.1111/dom.15941.