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Research Article

Association between Visual Function Impairment and Depressive Symptoms in Patients with Type 2 Diabetes Mellitus: A Cross-sectional Study

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Background

Type 2 diabetes mellitus (T2DM) is frequently accompanied by the occurrence of depression and visual impairment. At present, the association between visual function and depression in T2DM remains unclear.

Objective

This study aims to examine the association between visual function impairment and depressive symptoms with T2DM.

Methods

A total of 542 participants with T2DM were recruited from four community hospitals. The Patient Health Questionnaire-9 depression scale was used to measure depressive symptoms. Concurrently, visual function was assessed using the Chinese revised version of the Visual Function Index (VF-14) scale for near vision, visual adaptation, subjective vision, and stereoscopic vision. The relationship between visual function and depressive symptoms was evaluated using logistic regression, Spearman's correlation analysis, restricted cubic spline, and subgroup analysis.

Results

The findings revealed that 61 (11.25%) participants were identified as having depressive symptoms. Logistic regression analysis revealed significant associations between depression symptoms and near vision (odds ratio [OR] = 1.156; 95% confidence interval [CI; 1.052, 1.271]; p=0.003), visual adaptation (OR = 1.341; 95% CI [1.169, 1.539]; p<0.001), subjective vision (OR = 1.332; 95% CI [1.133, 1.567]; p=0.001), stereoscopic vision (OR = 1.169; 95% CI [1.019, 1.340]; p=0.026), and VF-14 score (OR = 1.073; 95% CI [1.034, 1.113]; p<0.001). The restricted cubic spline showed that the risk of developing depressive symptoms increased progressively as the VF-14 score increased (p for non-linearity < 0.05).

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Conclusion

Impaired visual function in T2DM is likely to be associated with an increased prevalence of depressive symptoms, including near vision, visual adaptation, subjective vision, and stereoscopic vision, suggesting its crucial role in the development of depression in T2DM.

1. INTRODUCTION

Type 2 diabetes mellitus (T2DM) is a metabolic disorder characterized by impaired insulin secretion, insulin resistance, disordered glucose metabolism, and elevated blood glucose levels.[1] In 2018, there were 110 million diabetic patients in China,[2] ranking second in the world. Diabetic retinopathy (DR) is one of the most prevalent complications associated with T2DM, leading to vision loss and blindness. Various guidelines emphasize the importance of funduscopic examination as a crucial component of health management for diabetic patients.[3,4] Research has shown that prolonged uncontrolled blood glucose levels not only negatively impact vision by affecting peripheral nerves such as the retina but also cause damage to the visual cortex of the brain, ultimately impairing visual cognitive function.[5-7] Vision is the most important way for human beings to perceive the environment and receive information. The onset of visual impairment can significantly affect the quality of life of affected individuals.

Meanwhile, numerous studies have demonstrated that the prevalence of psychological disorders such as depression and anxiety is significantly higher in patients with T2DM than in the general population, possibly due to health complications, excessive stress, and personal and family history.[8] Research by Paz *et al*.[9] showed that the presence of self-reported depression was significantly associated with a self-reported decline in visual function, highlighting the role of vision disorders in the development of depressive symptoms in diabetic patients. Impairment of visual function can significantly compromise daily living abilities and social engagement, leading to feelings of frustration and loneliness and contributing to depressive symptoms. In addition, the pathogenesis of T2DM and depression is also interrelated, such as inflammatory responses, oxidative stress, and activation of the hypothalamic–pituitary–adrenal axis,[10] which together lead to damage to the retina and the brain's emotional centers.

Therefore, this study aims to investigate the association between visual function impairment and depressive symptoms in T2DM to better understand the relationship between organ damage caused by chronic diseases and psychological disorders, thereby providing a theoretical basis for the comprehensive management of chronic disease health.

2. MATERIALS AND METHODS

2.1. STUDY POPULATION AND RECRUITMENT

This study was a cross-sectional survey. Participant recruitment and data collection were conducted between February and September 2022 at the chronic disease health management centers of four community hospitals in Guizhou Province. Participants were screened by uniformly trained research assistants based on predefined inclusion and exclusion criteria.

In this study, participants did not receive direct financial compensation, but all participants were offered a free, comprehensive fundus examination and evaluation, as well as a personal health report. The inclusion criteria were as follows: (i) A diagnosis of T2DM according to the World Health Organization diagnostic criteria established in 1999; (ii) Adults aged 18 years and above; and (iii) Adequate language comprehension and a clear diagnosis. The exclusion criteria were as follows: (i) Patients with a history of mental illness, eye surgery, or severe visual and hearing impairment; (ii) those with other forms of diabetes or serious complications; and (iii) those did not cooperate for various reasons.

Among the 687 patients with T2DM initially recruited, a total of 615 participants completed the examination. After screening according to the inclusion and exclusion criteria, 542 participants met the conditions and were included in the final analysis. All participants provided written informed consent before enrollment. The study was approved by the Ethics Committee of the Guizhou Center for Disease Control and Prevention (S2021-12) and strictly adhered to the ethical principles outlined in the Declaration of Helsinki.

2.2. QUESTIONNAIRE SURVEY

At the time of recruitment, age, gender, educational level, income level, and duration of diabetes were collected through a standardized questionnaire. The questionnaire survey was conducted through face-to-face interviews by trained investigators.

2.3. VISUAL FUNCTION INDEX SURVEY

The quality of visual function was assessed using the Chinese revised version of the Visual Function Index (VF-14).[11] This scale consists of 12 items covering four areas: (i) Near vision (e.g., reading small print, reading the newspaper, fine crafts, filling in forms); (ii) Visual adaptation (e.g., walking up and down stairs, recognizing signage, watching television); (iii) Subjective vision (e.g., reading large print, recognizing faces); and (iv) Stereoscopic vision (e.g., recreational gaming, sports, and fitness).

Each item was rated using five response options: no difficulty, mild difficulty, moderate difficulty, severe difficulty, and unable to complete, which were scored as 0, 1, 2, 3, and 4, respectively, with higher scores indicating poorer visual function.

2.4. PATIENT HEALTH QUESTIONNAIRE-9 SURVEY

The Patient Health Questionnaire-9 (PHQ-9) scale, developed by Kroenke *et al*.,[12] is one of the most commonly used tools to screen for depression.[13,14] This scale consists of nine items, and the response to each item consists of four options: not at all, several days, more than half the days, and nearly every day, which correspond to 0, 1, 2, and 3 points, respectively. The scale demonstrates good internal consistency (Cronbach's α = 0.714). Depressive symptoms were defined in this study as a PHQ-9 score of ⩾8.[15]

2.5. VISION EXAMINATION

Visual acuity was measured using a standard logarithmic visual acuity chart. The visual acuity chart was positioned at a distance of 5 m (the standard distance for distance visual acuity testing) in front of the eye being examined. The measurement range was 4.0–5.3 (using a five-level recording method). If there was a discrepancy in the visual acuity results between the two eyes, the final diagnosis was based on the eye with better vision. According to the World Health Organization definition of visual impairment, visual acuity was divided into two groups: (i) <4.9 and (ii) ⩾4.9.[16]

2.6. LABORATORY TEST

Glycated hemoglobin (HbAlc) was measured using the Sinocare PCH-100 Portable HbAlc Analyzer (Sannuo Biosensing., China) and the PCH100 HbA1c kit (Xiang Medical Device Registration Approval No. 20212402337, Sannuo Biosensing., China). According to the Chinese Type 2 Diabetes Prevention and Treatment Guidelines (2020 Edition),[17] HbAlc was divided into two groups: <6.5% and ⩾6.5%. Blood pressure values were measured by trained researchers using a Yuwell (YE660A) electronic sphygmomanometer (Jiangsu Yuyue Medical Equipment Co., Ltd., China) in accordance with standard operating procedures.

2.7. DR EXAMINATION

All participants underwent DR examinations in a completely dark room, where retinal images were acquired using the MOCULAR (ML-800s) fundus camera (Hangzhou Meule Medical Technology Co., Ltd., China). The equipment was operated by professionally trained staff to ensure that the quality of the acquired images met diagnostic requirements. Subsequently, ophthalmologists made diagnoses strictly according to the Chinese version of the Clinical Practice Guidelines,[18] classifying the results into two categories: DR and non-DR. If the image quality of one eye was too poor to be interpreted, the final diagnosis was based on the other eye that could be evaluated; if the staging results of both eyes were inconsistent, the eye with the more severe staging was used.

2.8. STATISTICAL ANALYSIS

Multiple imputation methods were used to handle missing data. Continuous variables with a normal distribution were described as mean ± standard deviation and were compared using Student's *t*-test. Skewed distributions were expressed as median and interquartile range (IQR) and were compared using the rank-sum test.

Categorical variables were described as frequencies (percentages) and tested using the Chi-square test. Visual function scores and depression scores were compared using Spearman's correlation analysis, whereas logistic regression models were employed to assess the association between near vision, visual adaptation, subjective vision, stereoscopic vision, VF-14 score, and the risk of depressive symptoms.

Model I included only visual function variables, while Model II extended Model I by adjusting for additional factors such as age, gender, educational level, income, visual acuity, HbAlc, duration of diabetes, hypertension, and DR. The assessment of multicollinearity among independent variables was conducted using the variance inflation factor before constructing the logistic regression model. Restricted cubic spline analysis was adopted to evaluate the dose–response relationship between the VF-14 score and depressive symptoms. Subgroup analyses were performed by sex (male, female) and visual acuity (visual acuity < 4.9, visual acuity ⩾4.9).

Epidata 3.1 (EpiData Association, The Kingdom of Denmark) was used for double-entry and consistency checks. Data analysis was performed using the Statistical Package for the Social Sciences 25.0 (IBM Corporation, USA) and R 4.2.3 (R Foundation for Statistical Computing, Austria). All statistical tests were two-sided, with a significance level set at $\alpha = 0.05$.

3. RESULTS

3.1. DEMOGRAPHIC CHARACTERISTICS OF THE STUDY PARTICIPANTS

Among the 542 participants with T2DM, 61 were diagnosed with depressive symptoms, with a prevalence rate of 11.25%. The median score for depressive symptoms was 2.00 (IQR: 0.00–4.00). Based on Table 1, the participants had a mean age of 66.19 ± 8.91 years—54.98% were female, 19.74% had a college education, 52.58% had an annual household income ⩾40,000 yuan, 56.46% had HbA1c ⩾6.5%, 30.81% had a visual acuity ⩾4.9, 54.80% suffered from hypertension, and 29.89% suffered from DR. In addition, the mean duration since diabetes diagnosis was 9.14 ± 7.28 years. There was a statistically significant difference in educational level, HbAlc, near vision, visual adaptation, subjective vision, stereoscopic vision, and VF-14 score between the depressed group and the non-depressed group ($p<0.05$).

3.2. CORRELATION ANALYSIS OF VISUAL FUNCTION SCORE AND THE DEPRESSION SCORE

Spearman's correlation analysis demonstrated that near vision ($r = 0.121$; 95% confidence interval [CI; 0.039, 0.211]; $p=0.005$), visual adaptation ($r = 0.190$; 95% CI [0.107, 0.276]; $p<0.001$), subjective vision ($r = 0.209$; 95% CI [0.122, 0.291]; $p<0.001$), stereoscopic vision ($r = 0.152$; 95% CI [0.063, 0.238]; $p<0.001$), and VF-14 score ($r = 0.174$; 95% CI [0.088, 0.264]; $p<0.001$) were all positively correlated with depression scores (Table 2).

3.3. ASSOCIATION ANALYSIS BETWEEN VISUAL FUNCTION AND THE PREVALENCE OF DEPRESSIVE SYMPTOMS

After adjusting for relevant confounding factors, the findings revealed that near vision (odds ratio [OR] = 1.156; 95% confidence interval [CI] [1.052, 1.271]; $p=0.003$), visual adaptation (OR = 1.341; 95% CI [1.169, 1.539]; $p<0.001$), subjective vision (OR = 1.332; 95% CI [1.133, 1.567]; $p=0.001$), stereoscopic vision (OR = 1.169; 95% CI [1.019, 1.340]; $p=0.026$]), and VF-14 score (OR = 1.073; 95% CI [1.034, 1.113]; $p<0.001$) were significantly associated with an increased risk of depressive symptoms (Table 3). To further investigate the dose–response relationship between visual function score and depression risk, restricted cubic spline analysis revealed a non-linear relationship between VF-14 score and the prevalence of depressive symptoms (p for non-linearity < 0.05) (Figure 1).

Table 1. Baseline characteristics of depressed and non-depressed group

Characteristic	Total (*n*=542)	Depressed (*n*=61)	Non-depressed (*n*=481)	Cohen's d/Cramer's V (95% CI)	*p*-value
Age (years)	66.18±8.91	67.36±8.17	66.04±9.00	0.119 (−0.148, 0.385)	0.275[a]
Sex					
Male	244 (45.02)	21 (8.61)	223 (91.39)	0.076 (−0.008, 0.160)	0.103[b]
Female	298 (54.98)	40 (13.42)	258 (86.58)		
Educational level					
Primary school or lower	136 (25.09)	25 (18.38)	111 (81.62)	0.138 (0.044, 0.232)	0.016[b]
Middle school	189 (34.87)	20 (10.58)	169 (89.41)		
High school	110 (20.30)	8 (7.27)	102 (92.73)		
College	107 (19.74)	8 (7.48)	99 (92.52)		
Income level (yuan)					
<40,000	257 (47.42)	25 (9.73)	232 (90.27)	0.046 (−0.038, 0.130)	0.351[b]
⩾40,000	285 (52.58)	36 (12.63)	249 (87.37)		
Visual acuity					
<4.9	375 (69.19)	42 (11.20)	333 (88.80)	0.003 (−0.081, 0.087)	0.952[b]
⩾4.9	167 (30.81)	19 (11.38)	148 (88.62)		
HbA1c (%)					
<6.5	236 (43.54)	15 (6.36)	221 (93.64)	0.136 (0.052, 0.220)	0.002[b]
⩾6.5	306 (56.46)	46 (15.03)	260 (84.97)		
Duration of diabetes (years)	9.14±7.28	8.61±6.25	9.21±7.41	−0.011(−0.277, 0.256)	0.492[a]
Hypertension					
No	245 (45.20)	29 (11.84)	216 (88.16)	0.017 (−0.067, 0.101)	0.697[b]
Yes	297 (54.80)	32 (10.77)	265 (89.23)		
DR					
No	380 (70.11)	44 (11.58)	336 (88.42)	0.016 (−0.069, 0.100)	0.714[b]
Yes	162 (29.89)	17 (10.49)	145 (89.51)		
Near vision	2.00 (0.00–3.25)	3.00 (0.50–6.00)	2.00 (0.00–3.00)	0.499 (0.230, 0.767)	0.007[c]
Visual adaptation	0.00 (0.00–1.00)	1.00 (0.00–4.00)	0.00 (0.00–1.00)	0.757 (0.486, 1.027)	< 0.001[c]
Subjective vision	0.00 (0.00–1.00)	1.00 (0.00–2.00)	0.00 (0.00–1.00)	0.640 (0.371, 0.909)	< 0.001[c]
Stereoscopic vision	0.00 (0.00–1.00)	0.00 (0.00–2.00)	0.00 (0.00–1.00)	0.544 (0.275, 0.812)	< 0.001[c]
VF-14 score	2.00 (0.00–7.25)	8.00 (1.50–12.50)	2.00 (0.00–6.00)	0.694 (0.424, 0.963)	< 0.001[c]

Notes: Continuous variables are presented as mean±standard deviation or median (interquartile range), and categorical variables are presented as proportion. Statistical tests used include: [a]Student's *t*-test, [b]Chi-square test, and [c]Wilcoxon rank-sum test.
Abbreviations: CI: Confidence interval; DR: Diabetic retinopathy; HbA1c: Glycated hemoglobin; VF-14: Visual Function Index.

Table 2. Spearman's correlation analysis of visual function with depression scores

Visual function	*r* (95% CI)	*p*-value
Near vision	0.121 (0.039, 0.211)	0.005
Visual adaptation	0.190 (0.107, 0.276)	<0.001
Subjective vision	0.209 (0.122, 0.291)	<0.001
Stereoscopic vision	0.152 (0.063, 0.238)	<0.001
VF-14 score	0.174 (0.088, 0.264)	<0.001

Abbreviations: CI: Confidence interval; VF-14: Visual Function Index.

3.4. SUBGROUP ANALYSIS

Results of subgroup analysis indicated that after controlling for relevant confounding factors, female sex (OR = 1.091; 95% CI [1.042, 1.143]) and visual acuity <4.9 (OR = 1.084; 95% CI [1.040, 1.130]) were associated with visual function impairment and the prevalence of depressive symptoms. As the visual function score increased, the risk of depressive symptoms continued to rise (p<0.05) (Figure 2).

4. DISCUSSION

In this study, 61 (11.25%) out of 542 participants reported having depressive symptoms. This rate is significantly higher than the 6.8% reported in the 2021 adult depression epidemiological survey in China.[19] This finding is consistent with previous studies investigating the prevalence of depressive symptoms among patients with Type 1 and type 2 diabetes in developing countries, which ranged from 8% to 16%.[20] The observed disparity is often attributed to greater psychological stress and a higher burden of physical comorbidities in T2DM. The findings also revealed that participants with abnormal HbAlc levels had an increased risk of depression, which aligns with prior research.[21] Elevated HbA1c levels can impair the central nervous system through

Table 3. Logistic regression analysis of visual function and prevalence of depressive symptoms

Model	Visual function	*B*	*p*-value	Odds ratio (95% CI)[a]
Model I	Near vision	0.149	0.001	1.161 (1.066, 1.265)
	Visual adaptation	0.316	<0.001	1.371 (1.209, 1.554)
	Subjective vision	0.318	<0.001	1.374 (1.183, 1.596)
	Stereoscopic vision	0.165	0.010	1.180 (1.040, 1.338)
	VF-14 score	0.074	<0.001	1.076 (1.041, 1.113)
Model II	Near vision	0.145	0.003	1.156 (1.052, 1.271)
	Visual adaptation	0.294	<0.001	1.341 (1.169, 1.539)
	Subjective vision	0.287	0.001	1.332 (1.133, 1.567)
	Stereoscopic vision	0.156	0.026	1.169 (1.019, 1.340)
	VF-14 score	0.070	<0.001	1.073 (1.034, 1.113)

Notes: [a]Model I considered only the effect of visual function on depressive symptoms; Model II built on Model I and was adjusted for age, gender, educational level, income, visual acuity, glycated hemoglobin (HbA1c), duration of diabetes, hypertension, and diabetic retinopathy.
Abbreviations: CI: confidence interval; VF-14: Visual Function Index.

mechanisms such as inflammation, oxidative stress, and insulin resistance, thereby contributing to the development of depression.[22] These results suggest that patients with T2DM have a higher prevalence of depressive symptoms. Therefore, in addition to focusing on their glucose control and physical health, greater attention should also be paid to mental health.

The correlation analysis revealed a positive association between visual function and depression scores. Logistic regression analysis further demonstrated a positive correlation between visual function and the prevalence of depressive symptoms, which is similar to the results of Ding *et al*.[23] regarding the association between depression prevalence in T2DM and visual-related quality of life. Visual function refers to an individual's ability to perform various visual tasks.[9] Impaired visual function may increase the prevalence of depressive symptoms. This relationship may be related to the fact that reduced visual function directly leads to a significant decline in reading, mobility, and self-care abilities, thereby contributing to depressive symptoms.[24] In addition, retinal vascular lesions in patients with T2DM may be accompanied by microvascular changes in the brain, exacerbating dysregulation of the hypothalamic–pituitary–adrenal axis and ultimately affecting emotional regulation.[25]

This study further revealed that near vision, visual adaptation, subjective vision, and stereoscopic vision were all associated with the risk of depressive symptoms, with visual adaptation and subjective vision showing stronger associations. Visual adaptation refers to the gradual adjustment of one's visual system in response to changes in the external environment.[26] Subjective vision reflects an individual's personal perception of their surrounding environment, including perceptions of objects, colors, shapes, movement, and depth.[27]

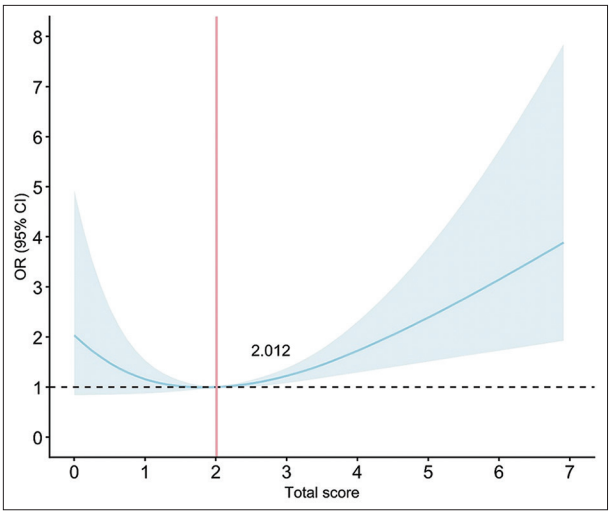

Figure 1. Dose–response relationship between total visual function score and the prevalence of depressive symptoms, adjusted for age, gender, education, income, visual acuity, glycated hemoglobin, duration of diabetes, hypertension, and diabetic retinopathy. Overall association: *p*<0.001; non-linearity: *p*=0.015.
Abbreviations: CI: Confidence interval; OR: Odds ratio.

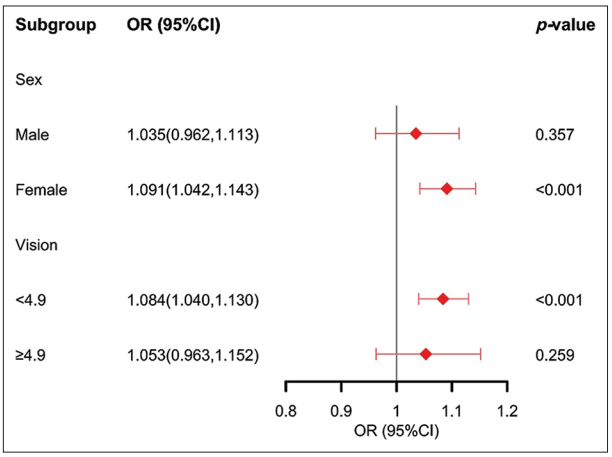

Figure 2. Subgroup analysis of the relationship between visual function and the prevalence of depressive symptoms, adjusted for age, gender, education, income, visual, glycated hemoglobin (HbA1c), duration of diabetes, hypertension, and diabetic retinopathy. Note: When analyzing a specific subgroup factor, that factor was not included in the adjustment.
Abbreviations: CI: Confidence interval; OR: Odds ratio.

Visual adaptation and subjective vision encompass daily activities such as navigating stairs up and down, identifying signage, viewing television, reading large print, and recognizing faces. The performance of these activities can significantly impact the functional abilities of patients. A decline in functional abilities may result in a reduced range of activities for the elderly, causing them to feel worthless and hopeless, which in turn can generate negative emotions.[28] It has been shown that the optic nerve exhibits plasticity and is able to adjust and reorganize its neural connections to adapt to visual impairments.[29,30] Based on the findings of this study, we can infer that depression in diabetic patients may arise from difficulties in compensating for visual loss, which affects their daily lives. T2DM patients with visual impairment and

accompanying depressive symptoms require more resources for intervention and assistance, which can also affect the family environment. Therefore, conducting in-depth research and effective interventions targeting the visual function of diabetic patients is of great value and significance.

It was found that diabetic patients with different genders and visual acuity levels exhibit varying risks for visual function impairment and depressive symptoms. Specifically, as the visual function scores of female patients increase, the risk of developing depressive symptoms gradually rises, which may be related to the high visual demands placed on women in traditionally assigned tasks such as cooking and sewing.[31] In addition, the findings revealed a correlation between visual function deficits in visually impaired patients and the occurrence of depressive symptoms.

In addition, in patients with low visual acuity, visual function was associated with depressive symptoms. Visual acuity is an important measure of subjective visual function,[27] suggesting that subjective vision in diabetic patients with low visual acuity may be impaired and should be addressed promptly to prevent the onset of depressive symptoms.

Nonetheless, this study has several limitations. First, although an association between visual function and depressive symptoms in T2DM was initially revealed, causal relationships require further exploration through longitudinal studies in the future. Second, the PHQ-9 is a screening tool for depression and does not provide a clinical diagnosis. Lastly, the participants in this study were mainly middle-aged and elderly patients, and it remains to be determined whether the association between visual function and depression applies to T2DM patients of other age groups.

5. CONCLUSION

In this study of community-based patients with T2DM, we found that impaired visual function is associated with depressive symptoms, including near vision, visual adaptation, subjective vision, and stereoscopic vision. These findings suggest the need to prioritize the preservation of visual function in patients with T2DM and to provide timely psychological care. Furthermore, these findings provide valuable insights for the early intervention and prognosis of depressive symptoms in patients with T2DM. Future studies should aim to further explore these associations and underlying mechanisms.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

AUTHOR CONTRIBUTIONS

Conceptualization: Qiying Pan, Tianlin Zhang, Yuandong Hu
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Writing-review & editing: All authors

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by the Ethics Committee of the Guizhou Center for Disease Control and Prevention (Approval no.: S2021-12; approval date: September 1, 2021) and was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki. All participants provided written informed consent before enrollment.

CONSENT FOR PUBLICATION

Consent for publication was obtained via oral form from all the participants.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study are available from the corresponding author on reasonable request.

ADDITIONAL DISCLOSURE

The authors utilized ChatGPT 4.0 for language polishing during manuscript preparation. Aided sections underwent human review and proofreading to ensure content accuracy. The authors assume responsibility for this process.

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