



Research Article

## Unraveling the Interplay Between Vitamin D Status, Body Mass Index, and Diabetic Retinopathy in Type 2 Diabetes

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**Abstract: Background:** Introduction: Body mass index (BMI) and vitamin D status may be associated with diabetic retinopathy (DR), but relationships remain uncertain. Objective: To examine associations of BMI and vitamin D status with DR in adults with type 2 diabetes mellitus. **Methodology:** This cross-sectional study used convenience sampling of 412 adults aged above 18 years with type 2 diabetes mellitus at the Karnataka Institute of Endocrinology and Research, Bengaluru, over one year. Patients with type 1 diabetes or other retinal diseases were excluded. Participants underwent ophthalmic examination, anthropometric assessment, and blood investigations, including glycated haemoglobin (HbA1c) and vitamin D. Outcome measures were DR presence and severity and their distribution across BMI and vitamin D categories. **Results:** DR was present in 118 participants (28.6%), while 294 (71.4%) had no DR. HbA1c exceeded 8.0% in 221 participants (53.6%). Diabetes duration was associated with HbA1c category ( $p < 0.001$ ). Vitamin D deficiency occurred in 330 participants (80.1%). DR occurred in 98/330 participants with deficiency, 13/55 with insufficiency, and 7/27 with normal vitamin D status. Reported BMI–DR associations were nonsignificant within vitamin D strata ( $p = 0.681$ ,  $0.113$ , and  $0.925$ ). Inconsistent HbA1c cross-tabulations prevented verification of the vitamin D-stratified HbA1c–DR association. **Conclusion:** Diabetes duration was significantly associated with HbA1c category, whereas BMI–DR associations were nonsignificant within vitamin D strata. DR was descriptively more frequent with vitamin D deficiency, but an independent association was not established. Convenience sampling, cross-sectional assessment, and unresolved data inconsistencies limit interpretation. Further studies with data and adjustment for confounders are needed to clarify these relationships.

**Keywords:** Body Mass Index Vitamin D, Diabetic Retinopathy, Type 2 Diabetes Mellitus.

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## INTRODUCTION

Diabetic retinopathy (DR) is a microvascular complication of diabetes mellitus that can threaten vision. Its occurrence and progression have been associated with diabetes duration and glycaemic control, making these factors central to the assessment of patients with type 2 diabetes mellitus.[1] Trials examining intensive glucose and blood pressure management have also evaluated their effects on retinal outcomes.[2,3] These findings provide a basis for investigating additional factors that may contribute to differences in retinopathy among patients with diabetes.

Body mass index (BMI), calculated as weight in kilograms divided by height in metres squared, provides a practical measure of body size. The relationship between BMI and DR has been examined in several populations, but the reported findings are inconsistent.[5,11,12,14–17] Some studies describe associations involving higher BMI, while others report inverse relationships. This variation makes it difficult to interpret body size as a uniform marker of retinopathy risk and highlights the need to consider the population, disease duration, and other clinical characteristics.

Proposed explanations for a relationship between obesity and retinal disease include changes in metabolic pathways, oxidative stress, and angiogenic factors such as vascular endothelial growth factor (VEGF).[5–10] VEGF has been investigated in the ocular fluid of patients with retinal disease, and elevated angiogenic factors have also been described in overweight and obese individuals.[7–9] These observations offer biological hypotheses; they do not establish that BMI itself causes DR. Vitamin D status is another factor considered in relation to DR. Serum 25-hydroxyvitamin D is used to assess vitamin D status, and an earlier study in Indian adults with type 2 diabetes mellitus examined its relationship with retinopathy.[4] Evaluating vitamin D alongside BMI may help describe how these characteristics coexist with retinal findings. However, a cross-sectional association cannot demonstrate temporal sequence or show that correcting vitamin D deficiency would change retinal outcomes.

Given the differing findings on BMI and the interest in vitamin D status, the present study examined their associations with the presence and severity of DR among adults with type 2 diabetes mellitus at the Karnataka Institute of Endocrinology and Research, Bengaluru. Diabetes duration and HbA1c category were also assessed. The study aimed to describe these relationships within the clinical sample while distinguishing statistically supported findings from descriptive patterns.

## MATERIALS AND METHODS

### Study design and setting

This cross-sectional observational study was conducted at the Karnataka Institute of Endocrinology and Research, Bengaluru, over a one-year period. Measurements and ophthalmic findings were assessed at presentation; no longitudinal follow-up is described. The exact calendar dates were not provided in the source manuscript.

### Study population and sampling

The study included 412 patients aged above 18 years with confirmed type 2 diabetes mellitus, recruited through convenience sampling. Patients younger than 18 years, patients with type 1 diabetes mellitus, and those with retinal diseases other than DR were excluded. Recruitment was nonrandom; random allocation was not applicable because the study did not assign interventions or treatment groups. A sample-size justification, the number screened, and the number declining participation were not available in the source manuscript.

### Clinical and laboratory assessment

All participants underwent history taking and a complete ophthalmic examination, including best-corrected visual acuity, slit-lamp examination, indirect ophthalmoscopy, and biomicroscopy using a +90-dioptre lens. Findings were classified as no DR, mild nonproliferative DR (NPDR), moderate NPDR, severe NPDR, or proliferative DR (PDR). The grading standard, examiner details, and handling of differences between eyes were not specified.

Blood investigations included fasting blood glucose, postprandial blood glucose, HbA1c, serum lipid profile, and vitamin D assessment. Vitamin D status was recorded as normal, insufficient, or deficient. The assay method, units, and category thresholds were not provided and require confirmation before submission. The serum 25-hydroxyvitamin D measurement described in the introduction should be confirmed against laboratory records.

Height was measured without shoes using a wall-mounted measuring tape, with participants upright, heels together, and eyes directed forward; measurements were recorded to the nearest centimetre. Weight was measured in light clothing using a digital scale on a firm horizontal surface and recorded to the nearest 0.5 kg. BMI was calculated as weight in kilograms divided by height in metres squared. Original BMI category labels were retained because their exact boundary definitions were not documented. A physician performed a medical examination to assess systemic disease.

### Statistical analysis

The main outcomes were the presence and severity of DR and their distribution across BMI and vitamin D categories. Diabetes duration and HbA1c category were also examined. The original analysis used STATA version 11.2 and chi-square tests, with categorical data expressed as counts and proportions. A p value below 0.05 was interpreted as statistically significant. Reported BMI–DR p values were retained as source-reported results and were not independently revalidated. Sparse cells within vitamin D strata may limit the suitability of the chi-square approximation; exact or Monte Carlo methods should be considered when the original data are available.

The duration–HbA1c association was checked using the internally consistent counts in Table 3. Inconsistent vitamin D–stratified HbA1c–DR counts were omitted from the revised tables because they could not be corrected uniquely. No missing cell value was inferred. The vitamin D–DR and vitamin D–BMI distributions in Tables 4 and 5 were reconstructed from the internally consistent BMI cross-tabulation in the original manuscript.

### Ethical considerations

Institutional ethics committee approval details and the informed-consent procedure were not supplied in the manuscript. These details must be added from the study records before submit

## RESULTS

The study included 412 adults with type 2 diabetes mellitus. Table 1 summarises diabetes duration, HbA1c categories, and BMI distribution. HbA1c exceeded 8.0% in 221 participants (53.6%), and 265 participants (64.3%) belonged to the two BMI categories labelled 25–30 and >30 kg/m<sup>2</sup>.

**Table 1 Participant characteristics**

| Variable          | Category                | Number | Proportion (%) |
|-------------------|-------------------------|--------|----------------|
| Diabetes duration | 0–5 years               | 222    | 53.9           |
|                   | 5–10 years              | 96     | 23.3           |
|                   | >10 years               | 94     | 22.8           |
| HbA1c             | <6.40%                  | 62     | 15.0           |
|                   | 6.5–8.0%                | 129    | 31.3           |
|                   | >8.0%                   | 221    | 53.6           |
| BMI               | <18 kg/m <sup>2</sup>   | 3      | 0.7            |
|                   | 18–25 kg/m <sup>2</sup> | 144    | 35.0           |
|                   | 25–30 kg/m <sup>2</sup> | 158    | 38.3           |
|                   | >30 kg/m <sup>2</sup>   | 107    | 26.0           |

Category labels reproduce the original manuscript. The 0–5 and 5–10 year labels and BMI labels overlap at boundaries; HbA1c labels leave an unspecified interval. Exact limits require confirmation from the data dictionary.

**Table 2 Distribution of diabetic retinopathy**

| Retinopathy status | Number | Proportion (%) |
|--------------------|--------|----------------|
| No DR              | 294    | 71.4           |
| Mild NPDR          | 75     | 18.2           |
| Moderate NPDR      | 24     | 5.8            |
| Severe NPDR        | 10     | 2.4            |
| PDR                | 9      | 2.2            |
| Total              | 412    | 100.0          |

DR was present in 118 participants (28.6%). Mild NPDR accounted for 75 cases, while moderate NPDR, severe NPDR, and PDR accounted for 24, 10, and 9 cases, respectively (Table 2).

**Table 3 Diabetes duration and HbA1c category**

| Duration   | <6.40%     | 6.5–8.0%    | >8.0%       | Total |
|------------|------------|-------------|-------------|-------|
| 0–5 years  | 49 (22.1%) | 78 (35.1%)  | 95 (42.8%)  | 222   |
| 5–10 years | 7 (7.3%)   | 22 (22.9%)  | 67 (69.8%)  | 96    |
| >10 years  | 6 (6.4%)   | 29 (30.9%)  | 59 (62.8%)  | 94    |
| Total      | 62 (15.0%) | 129 (31.3%) | 221 (53.6%) | 412   |

Values are counts with row proportions in parentheses. Diabetes duration was associated with HbA1c category (Pearson chi-square=30.008, degrees of freedom=4, p<0.001). The proportion with HbA1c >8.0% was 42.8%, 69.8%, and 62.8% across the three duration categories, respectively; the pattern was not uniformly increasing.

**Table 4 Diabetic retinopathy by vitamin D status**

| Retinopathy status | Normal (n=27) | Insufficient (n=55) | Deficient (n=330) |
|--------------------|---------------|---------------------|-------------------|
| No DR              | 20 (74.1%)    | 42 (76.4%)          | 232 (70.3%)       |
| Mild NPDR          | 3 (11.1%)     | 8 (14.5%)           | 64 (19.4%)        |
| Moderate NPDR      | 3 (11.1%)     | 3 (5.5%)            | 18 (5.5%)         |
| Severe NPDR        | 1 (3.7%)      | 1 (1.8%)            | 8 (2.4%)          |
| PDR                | 0 (0.0%)      | 1 (1.8%)            | 8 (2.4%)          |
| Total              | 27 (100.0%)   | 55 (100.0%)         | 330 (100.0%)      |

Values are counts with proportions within each vitamin D category. Vitamin D status was normal in 27 participants (6.6%), insufficient in 55 (13.3%), and deficient in 330 (80.1%). DR occurred in 7/27 (25.9%), 13/55 (23.6%), and 98/330 (29.7%), respectively. These descriptive differences do not establish statistical significance or an independent association.

**Table 5 BMI distribution by vitamin D status**

| <b>Vitamin D status</b> | <b>&lt;18</b> | <b>18–25</b> | <b>25–30</b> | <b>&gt;30</b> |
|-------------------------|---------------|--------------|--------------|---------------|
| Normal                  | 0 (0.0%)      | 8 (29.6%)    | 10 (37.0%)   | 9 (33.3%)     |
| Insufficient            | 1 (1.8%)      | 25 (45.5%)   | 20 (36.4%)   | 9 (16.4%)     |
| Deficient               | 2 (0.6%)      | 111 (33.6%)  | 128 (38.8%)  | 89 (27.0%)    |
| Total                   | 3 (0.7%)      | 144 (35.0%)  | 158 (38.3%)  | 107 (26.0%)   |

BMI is expressed in kg/m<sup>2</sup>; values are counts with row proportions. The source-reported associations between BMI category and DR severity were nonsignificant in the normal, insufficient, and deficient vitamin D strata ( $p=0.681$ ,  $0.113$ , and  $0.925$ , respectively). A significant BMI association was therefore not demonstrated. The reported vitamin D-stratified HbA1c–DR result could not be interpreted reliably because its underlying counts were inconsistent.

## DISCUSSION

The significant association between diabetes duration and HbA1c category indicates that glycaemic status differed across duration groups in this sample. However, the pattern was not a steady increase with duration, and the cross-sectional design cannot determine whether longer disease duration caused poorer control. Differences in treatment, adherence, comorbidities, or referral patterns could contribute. This result concerns diabetes duration and HbA1c; it should not be presented as direct evidence of an HbA1c–DR association.

DR affected more than one-quarter of participants, with mild NPDR accounting for most detected retinopathy. The distribution describes patients attending a specialist institution and may not represent the wider population of adults with diabetes. The study supports reporting the burden of DR within this clinical sample, while avoiding claims about incidence or progression, neither of which was measured.

Vitamin D deficiency was common, and DR was descriptively more frequent in the deficient group than in the other vitamin D groups. The absolute number of DR cases in that group partly reflects its much larger size. Comparing proportions is therefore more informative than comparing counts alone. The descriptive pattern may justify further investigation, but it does not establish that deficiency increases DR risk. Potential confounding by diabetes duration, glycaemic control, BMI, age, or other clinical characteristics was not addressed through an adjusted analysis.

The negative BMI finding deserves equal emphasis. The reported analyses did not demonstrate an association between BMI category and DR severity within any vitamin D stratum. A greater number of cases in larger BMI groups cannot be described as statistically significant when the corresponding  $p$  values are nonsignificant. Conversely, nonsignificance does not prove the absence of an association: the small normal-vitamin-D subgroup and sparse severity categories may reduce precision and compromise conventional chi-square testing.

Published findings on BMI and DR are inconsistent. Some cited studies describe positive associations, whereas others report inverse relationships.[11,12,14–17] Differences in populations, BMI definitions, diabetes duration, retinopathy grading, and adjustment for confounders may contribute to this variation. BMI also does not distinguish fat distribution from lean mass. These considerations help contextualise the present negative finding without dismissing it or implying that other studies validate a relationship not demonstrated here.

The proposed involvement of vascular endothelial growth factor, oxidative stress, and metabolic pathways offers biological hypotheses for relationships between obesity and retinal disease.[5–10] These mechanisms were not measured in this study and cannot explain the observed distributions directly. Similarly, the present observations do not establish that vitamin D supplementation or weight reduction would prevent or reverse DR. Such intervention effects require appropriately designed longitudinal or experimental studies.

## Limitations

This single-centre study used convenience sampling, limiting generalisability and introducing possible selection bias. Cross-sectional assessment prevents conclusions about temporal sequence or causality. No adjusted analysis or confidence intervals were provided. Vitamin D assay details, category cut-offs, retinopathy grading criteria, and exact category boundaries were incompletely documented. Sparse contingency-table cells complicate inference. Errors in the original vitamin D-stratified HbA1c cross-tabulation prevented verification of that association; conclusions based on those cells must await review of the original dataset.

## CONCLUSION

Diabetes duration was significantly associated with HbA1c category. In contrast, the source-reported analyses did not identify a significant association between BMI and DR severity within vitamin D strata. Vitamin D deficiency was common and accompanied by a descriptively greater proportion of DR, but a significant or independent vitamin D–DR association was not established. Further studies with clearly defined measurements, adequate sampling, and adjustment for confounders are needed.

### Conflict of Interest

The authors declare that there is no conflict of interest

### Data Availability

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

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## REFERENCES

1. Stratton IM, Kohner EM, Aldington SJ, et al. UKPDS 50: risk factors for incidence and progression of retinopathy in Type II diabetes over 6 years from diagnosis. *Diabetologia* 2001;44:156–63.
2. Ismail-Beigi F, Craven T, Banerji MA, et al. Effect of intensive treatment of hyperglycaemia on microvascular outcomes in type 2 diabetes: an analysis of the ACCORD randomised trial. *Lancet* 2010; 376:419–30.
3. Beulens JW, Patel A, Vingerling JR, et al. Effects of blood pressure lowering and intensive glucose control on the incidence and progression of retinopathy in patients with type 2 diabetes mellitus: a randomised controlled trial. *Diabetologia* 2009;52:2027–36.
4. Dinesh R.B, R. Anil Kumar. Vitamin D and Diabetic Retinopathy in Indian adults with Type 2 Diabetes Mellitus. *Int J Med Res Rev* 2018;6 (04):221-227. doi:10.17511/ijmrr. 2018.i04.04.
5. N.Cheung and T.Y.Wong, "Obesity and eyediseases," *Survey of Ophthalmology*, vol.52, no.2, pp.180–195, 2007
6. H. Dorchy, C. Claes, and C. Verougstraete, "Risk factors of developing proliferative retinopathy in type 1 diabetic patients: role of BMI," *Diabetes Care*, vol.25, no.4, pp.798–799, 2002.
7. J. V. Silha, M. Krsek, P. Sucharda, and L. J. Murphy, "Angiogenic factors are elevated in overweight and obese individuals," *International Journal of Obesity*, vol.29, no. 11, pp. 1308–1314, 2005.
8. L.P.Aiello, R.L.Avery, P.G.Arriggetal., "Vascular endothelial growth factor in ocular fluid of patients with diabetic retinopathy and other retinal disorders," *New England Journal of Medicine*, vol.331, no.22, pp.1480–1487, 1994.
9. S. Miyazawa-Hoshimoto, K.Takahashi, H.Bujo, N.Hashimoto, and Y.Saito, "Elevated serum vascular endothelial growth factor is associated with visceral fat accumulation in human obese subjects," *Diabetologia*, vol. 46, no. 11, pp. 1483–1488, 2003.
10. SnjeDana Kaštelan,1 Martina TomiT,2 Antonela GveroviT Antunica,3 Spomenka LjubiT,4 Jasminka Salopek RabatiT,1 and Mirela KarabatiT5. Hindawi Publishing Corporation Mediators of Inflammation Volume 2013, Article ID 436329, 8 pages <http://dx.doi.org/10.1155/2013/436329>
11. M. Henricsson, L. Nyström, G. Blohmé et al., "The incidence of retinopathy 10 years after diagnosis in young adult people with diabetes: results from the nationwide population-based Diabetes Incidence Study in Sweden (DISS)," *Diabetes Care*, vol. 26, no. 2, pp. 349–354, 2003
12. R. Klein, B. E. Klein, and S. E. Moss, "Is obesity related to microvascular and macrovascular complications in diabetes? The Wisconsin epidemiologic study of diabetic retinopathy," *Archives of Internal Medicine*, vol.157, no.6, pp.650–656, 1997.
13. K.Khavandi, H.Amer, B.Ibrahim, and J.Brownrigg, "Strategies for preventing type 2 diabetes: an update for clinicians," *Therapeutic Advances in Chronic Disease*, vol.4, no.5, pp.242–261, 2013.
14. L. S. Lim, E. Shyong Tai, P. Mitchell et al., "C-reactive protein, body mass index, and diabetic retinopathy," *Investigative Ophthalmology and Visual Science*, vol. 51, no. 9, pp. 4458–4463, 2010.
15. G.K.Dowse, A.R.G.Humphrey, V.R.Collinsetal., "Prevalence and risk factors for diabetic retinopathy in the multiethnic population of Mauritius," *American Journal of Epidemiology*, vol. 147, no. 5, pp. 448–457, 1998.
16. Zahra et al. Is there a relationship between body mass index and diabetic retinopathy in type II diabetic patients? A cross-sectional study. *Journal of Diabetes & Metabolic Disorders* <https://doi.org/10.1007/s40200-018-0339-5>.
17. Dr. Chandana S<sup>1</sup>, Dr. Prakash<sup>2</sup>, Shashi Kumar B R<sup>3</sup> Correlation Of Body Mass Index With Severity Of Diabetic Retinopathy In Patients With Type 2 Diabetes Mellitus. *International Journal of Environmental Sciences* ISSN: 2229-7359 Vol. 11 No. 23s, 2025.
18. N. F. Sheard, "Moderate changes in weight and physical activity can prevent or delay the development of type2 diabetes mellitus in susceptible individuals," *Nutrition Reviews*, vol.61, no.2, pp. 76–79, 2003.