International Journal of Medicine
pISSN 1468-3814 | eISSN 2667-7008
https://theinternationalmedicine.com/

Original Researcher Article DOI: 10.61336/im/26-08-12

CORRELATION OF BMI AND WAIST CIRCUMFERENCE IN PATIENTS WITH RETINOPATHY IN TYPE 2 DIABETES MELLITUS.

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Received: 22-06-2026
Revised: 09-07-2026
Accepted: 20-07-2026
Published: 03-08-2026

Abstract

Background: This study investigated the association between anthropometric measurements—body mass index (BMI) and waist circumference (WC)—and the severity of DR in patients with T2DM. ***Methods:*** A cross-sectional study was conducted at The Oxford Medical College Hospital and Research Centre, Bangalore, from August 2024 to January 2025. Seventy-three patients with T2DM and confirmed DR were enrolled using consecutive sampling. Data on demographics, clinical history, BMI, WC, metabolic parameters (fasting and postprandial blood glucose, HbA1c), and DR severity (graded as mild NPDR, moderate NPDR, severe NPDR, and proliferative DR) were collected. Statistical analyses included chi-square tests, correlation analysis, and logistic regression to determine the association between anthropometric indices and DR severity. ***Results:*** The study enrolled 73 patients with a mean age of 58.3 ± 10.2 years; 57.5% were male. The prevalence of overweight and obesity was 34.2% and 31.5%, respectively, with 45.2% of participants exhibiting abnormal WC. DR severity was distributed as 34.2% mild NPDR, 27.4% moderate NPDR, 20.5% severe NPDR, and 17.8% proliferative DR. Increased BMI and WC were significantly associated with more severe DR ($p < 0.05$ and $p < 0.01$, respectively). Logistic regression analysis identified age, duration of diabetes, BMI, WC, and HbA1c as independent predictors of DR severity. ***Conclusion:*** The study demonstrated that higher BMI, abnormal waist circumference, and poor glycemic control were significantly associated with increased severity of diabetic retinopathy in patients with T2DM. These findings underscore the importance of early anthropometric screening and integrated management strategies to mitigate the progression of DR.

Keywords: Type 2 Diabetes Mellitus, Diabetic Retinopathy, Body Mass Index, Waist Circumference, Glycemic Control.

INTRODUCTION

Diabetes mellitus (DM) is a chronic metabolic disorder characterized by persistent hyperglycemia due to defects in insulin secretion, insulin action, or both, and has emerged as one of the foremost public health challenges worldwide. The global burden of DM, particularly type 2 diabetes mellitus (T2DM), has been escalating at an unprecedented rate, driven primarily by lifestyle changes, urbanization, and the increasing prevalence of obesity. T2DM accounts for nearly 90% of all diabetes cases and is closely linked with modifiable risk factors such as physical inactivity, unhealthy dietary practices, and excessive adiposity [2,7]. Obesity, defined as the abnormal or excessive accumulation of body fat, is not only a key determinant in the pathogenesis of T2DM but also plays a critical role in the progression of its complications.

While body mass index (BMI) has traditionally been employed as a surrogate marker for overall adiposity, it does not capture the nuances of fat distribution. In contrast, waist circumference (WC) is a more accurate reflection of central or abdominal obesity—a condition that is more strongly associated with insulin resistance, systemic inflammation, and metabolic dysregulation [2]. These metabolic derangements are pivotal in the development of microvascular complications, among which diabetic retinopathy (DR) is of paramount concern. DR is the most common microvascular complication of diabetes and remains a leading cause of visual impairment and blindness in the working-age population globally [1]. The pathophysiology of DR is multifactorial, involving a complex interplay between chronic hyperglycemia, oxidative stress, inflammatory processes, and microvascular endothelial dysfunction. This cascade of events leads to alterations in retinal blood flow, capillary leakage, and ultimately, the formation of neovascular lesions that compromise retinal integrity [3].

Recent research has increasingly focused on elucidating the relationship between anthropometric indices—specifically BMI and WC—and the risk of developing DR. Several studies have highlighted that while an elevated BMI is a significant risk factor for T2DM, it may not adequately predict the risk of DR because it does not account for the distribution of adipose tissue. Central obesity, as measured by WC, has been shown to be more closely linked with adverse metabolic outcomes and vascular complications. For instance, a study by Ranganathan et al. demonstrated that patients with higher fasting blood sugar levels and increased WC had a markedly elevated risk of DR, especially in individuals over 45 years of age [1]. Complementary evidence from systematic reviews and meta-analyses further supports this association, with findings indicating that patients with DR tend to exhibit significantly higher WC measurements compared to those without DR [3]. Moreover, genetic studies utilizing Mendelian randomization approaches have provided robust evidence of a causal relationship between obesity-related traits, including both BMI and WC, and the risk of DR. These studies suggest that the genetic predisposition to accumulate visceral fat may directly influence the susceptibility to retinal microvascular damage [4].

Beyond its direct impact on the retinal vasculature, obesity contributes to a host of other metabolic abnormalities such as dyslipidemia, hypertension, and chronic low-grade inflammation, which further exacerbate the risk of DR. The interrelationship between these factors creates a vicious cycle in which obesity not only predisposes individuals to T2DM but also accelerates the onset and progression of diabetic complications. Data from a large prospective cohort study in the UK Biobank underscored this phenomenon by revealing that each standard deviation increase in BMI and WC was associated with a 9% and 11% increased risk of DR, respectively [5]. These findings highlight the potential utility of simple anthropometric measurements as early screening tools for identifying individuals at heightened risk of DR, thereby facilitating timely intervention.

The relevance of these observations is particularly pronounced in populations where T2DM is rapidly emerging, such as in India. In many Asian populations, including Indians, central obesity is frequently observed even among individuals with a normal BMI, thereby underscoring the limitation of BMI as a sole predictor of metabolic risk. Studies conducted in the Indian context have consistently demonstrated that WC is a more reliable predictor of DR than BMI, emphasizing the need for routine measurement of abdominal obesity in clinical practice [6]. The incorporation of WC into risk assessment protocols could lead to earlier detection of DR and more effective management of T2DM, ultimately reducing the burden of visual impairment and associated healthcare costs.

In light of the evidence linking central obesity with DR, it becomes imperative to explore the underlying mechanisms that drive this association. Adipose tissue, particularly when centrally distributed, is metabolically active and secretes a variety of adipokines and inflammatory cytokines, such as tumor necrosis factor-alpha and interleukin-6, which contribute to systemic inflammation and insulin resistance. These inflammatory mediators can induce endothelial dysfunction in the retinal vasculature, thereby accelerating the development of DR. Furthermore, central obesity is often associated with an unfavorable lipid profile, which can lead to the accumulation of lipids in the retinal capillaries, further compromising vascular integrity. The confluence of these factors creates an environment that is conducive to the onset of DR, particularly in individuals with poorly controlled blood glucose levels.

The significance of understanding the relationship between obesity and DR extends beyond mere epidemiological interest; it has practical implications for the management and prevention of diabetic complications. Early identification of patients at risk of DR through the assessment of WC and BMI can lead to the implementation of targeted interventions, including lifestyle modifications such as diet and exercise, as well as pharmacological therapies aimed at reducing central adiposity and improving glycemic control. Moreover, public health strategies that focus on reducing the prevalence of obesity may have a profound impact on the incidence of DR, thereby mitigating the long-term complications of T2DM and preserving visual function in affected populations.

Given the escalating global burden of T2DM and its complications, there is a pressing need for research that elucidates the relationship between anthropometric measures and DR. The current study is designed to address this gap by investigating the association between BMI, WC, and the prevalence of DR in patients with T2DM. By integrating clinical, biochemical, and anthropometric data, the study aims to develop a comprehensive risk stratification model that can be readily applied in clinical settings. Such a model would not only facilitate early detection of DR but also inform the development of targeted preventive strategies aimed at reducing central obesity and improving metabolic control. Ultimately, the findings of this research could contribute to a paradigm shift in the management of T2DM, emphasizing the importance of early intervention and the role of simple, cost-effective screening tools in reducing the incidence of diabetic complications [1,3,4,5,6,7].

METHODOLOGY

Study Design

The study was designed as a cross-sectional observational investigation that aimed to examine the association between body mass index (BMI), waist circumference (WC), and diabetic retinopathy (DR) in patients with type 2 diabetes mellitus (T2DM). This design was chosen because it allowed the researchers to assess the relationship between the anthropometric parameters and the presence as well as the severity of DR at a single point in time. The study was developed to capture the existing variations among patients in a tertiary care setting and was structured in a way that all data were collected concurrently without any intervention or follow-up period.

Study Setting

The study was conducted at The Oxford Medical College Hospital and Research Centre, Bangalore. This tertiary care institution provided a well-equipped environment with access to both outpatient and inpatient departments where a high volume of diabetic patients were managed. The Department of General Medicine hosted the study, and its proximity to the Department of Ophthalmology enabled efficient referral and confirmation of diabetic retinopathy diagnoses using standard ophthalmic procedures. The hospital had established protocols for the management of diabetes and its complications, which ensured that all procedures were performed in accordance with current clinical guidelines.

Study Duration

The study was carried out over a period of six months, from August 2024 to January 2025. This duration was selected to allow sufficient time for the recruitment of eligible participants and to ensure that data were collected from a representative sample of patients with diabetic retinopathy. The defined time frame also facilitated the scheduling of clinical examinations, laboratory tests, and ophthalmologic evaluations, which were essential for the comprehensive assessment of each participant's clinical status.

Participants – Inclusion and Exclusion Criteria

Participants were recruited based on specific inclusion and exclusion criteria to ensure that the study sample was both homogeneous and relevant to the research question. The criteria were applied as follows:

- Inclusion Criteria:
  - Patients who had been diagnosed with type 2 diabetes mellitus and who presented with clinical signs of diabetic retinopathy, irrespective of the stage of the disease.
  - Patients who were aged 18 years or older at the time of the study.
  - Patients who provided written informed consent prior to participation in the study.
- Exclusion Criteria:
  - Patients who had been diagnosed with types of diabetes other than type 2 diabetes mellitus.
  - Patients who were unwilling or unable to provide written informed consent.
  - Patients who had severe comorbid conditions that might interfere with the measurement of anthropometric parameters or the performance of fundoscopic examinations.

Study Sampling

The study employed a consecutive sampling technique in which all patients meeting the inclusion criteria were enrolled during their visit to the hospital's outpatient and inpatient departments. This approach was used to minimize selection bias and to ensure that the sample was representative of the diabetic population attending the tertiary care center. Every eligible patient was approached and given the opportunity to participate until the required sample size was reached.

Study Sample Size

The sample size was calculated using a standard formula based on the prevalence of diabetic retinopathy observed in previous studies. A prevalence of 7% was used, along with an absolute precision of 6% and a confidence level of 95%. This calculation yielded a sample size of 73 patients. The determined number of participants was sufficient to provide the statistical power necessary to detect significant associations between BMI, waist circumference, and diabetic retinopathy within the study population.

Study Groups (if applicable)

As the study was observational in nature, the participants were not randomized into intervention groups. Instead, they were stratified based on the severity of diabetic retinopathy and the degree of central obesity. Grouping was conducted according to the clinical findings from fundoscopic examinations and anthropometric measurements. Patients with different stages of retinopathy (e.g., non-proliferative versus proliferative) were compared, and analyses were performed to assess trends across subgroups. This stratification helped in understanding whether the degree of obesity influenced the severity of retinal complications.

Study Parameters

A wide range of study parameters was measured and recorded to comprehensively evaluate the association between obesity and diabetic retinopathy. These parameters included demographic information (age, sex, socioeconomic status), clinical history (duration of diabetes, presence of comorbid conditions such as hypertension), and anthropometric measurements (height, weight, BMI, and waist circumference). Laboratory parameters such as fasting blood glucose, postprandial blood glucose, and HbA1c were also obtained. In addition, detailed ophthalmologic findings were recorded based on fundoscopic examinations performed using a standard indirect ophthalmoscope. These parameters provided a holistic view of the patient's metabolic and ocular status.

Study Procedure

The study procedure was carried out in a systematic and standardized manner. Initially, patients were screened in the outpatient and inpatient departments for eligibility based on the inclusion and exclusion criteria. Once consent was obtained, participants underwent a thorough clinical evaluation that included a detailed medical history and physical examination. Anthropometric measurements were recorded using calibrated equipment—a wall-mounted stadiometer for height, a digital weighing machine for weight, and a non-stretchable measuring tape for waist circumference. Following the physical examination, blood samples were collected after an overnight fasting period for the measurement of glucose levels and HbA1c. Fundoscopic examinations were performed by experienced ophthalmologists who used an indirect ophthalmoscope to evaluate the presence and severity of diabetic retinopathy. Each step of the procedure was documented on a structured proforma to ensure consistency and completeness of data collection.

Study Data Collection

Data collection was conducted using a pre-designed proforma that captured all relevant information from each participant. This proforma included sections for demographic data, clinical history, physical measurements, laboratory results, and ophthalmologic findings. The data collection process was executed by trained research assistants who ensured that all measurements were recorded accurately and consistently. The collected data were then cross-verified by the principal investigator to maintain quality control. Data entry was performed using a secured database to ensure confidentiality and accuracy in the recorded information.

Data Analysis

Data analysis was performed using descriptive and inferential statistical methods. Descriptive statistics such as frequencies, proportions, means, and standard deviations were calculated to summarize the demographic and clinical characteristics of the study population. The chi-square test was employed to assess the association between categorical variables, particularly the relationship between obesity parameters (BMI and waist circumference) and the presence of diabetic retinopathy. A p-value of less than 0.05 was considered statistically significant. All analyses were performed using statistical software, and the results were interpreted in the context of the study objectives to determine the strength of the observed associations.

Ethical Considerations

The study was conducted in full compliance with ethical standards and guidelines. Ethical clearance was obtained from the Institutional Ethics Committee of The Oxford Medical College Hospital and Research Centre, Bangalore before the commencement of the study. All participants provided written informed consent after being thoroughly informed about the purpose, procedures, and potential risks of the study. Patient confidentiality was maintained by assigning unique identification codes to each participant and by storing data in a secured manner. The study was conducted with due regard for the principles of beneficence, non-maleficence, and respect for patient autonomy. No experimental interventions were performed, and all clinical procedures adhered to the standard protocols established by the hospital.

RESULTS

Demographic Characteristics of Study Participants

Interpretation:

The study enrolled 73 participants with a mean age of 58.3 ± 10.2 years, predominantly male (57.5%) with 42 males and 31 females. The average diabetes duration was 8.5 ± 3.6 years, reflecting longstanding diabetes. These values established a reliable baseline for further analyses.

Table 1. Demographic Characteristics of Study Participants

Variable	Value
Total Participants	73
Mean Age (years)	58.3 ± 10.2
Gender (Male/Female)	42/31
Mean Duration of Diabetes (years)	8.5 ± 3.6

Distribution of BMI Categories

Interpretation:

Participants were classified by BMI into four categories. Among 73 participants, 5 (6.8%) were underweight, 20 (27.4%) had a normal BMI, 25 (34.2%) were overweight, and 23 (31.5%) were classified as obese. This pattern highlighted the obesity challenge in the study population.

Table 2. Distribution of BMI Categories

BMI Category	Frequency (n)	Percentage (%)
Underweight	5	6.8
Normal	20	27.4
Overweight	25	34.2
Obese	23	31.5

Distribution of Waist Circumference Categories

Interpretation:

Waist circumference measurements categorized participants into normal and abnormal groups. Out of 73 subjects, 40 (54.8%) had a normal waist circumference, while 33 (45.2%) exhibited abnormal waist circumference. This division illustrated a substantial presence of central obesity, and central obesity remains significant.

Table 3. Distribution of Waist Circumference Categories

WC Category	Frequency (n)	Percentage (%)
Normal WC	40	54.8
Abnormal WC	33	45.2

Distribution of Diabetic Retinopathy Severity

Interpretation:

Diabetic retinopathy severity was graded into four categories. Among 73 participants, 25 (34.2%) exhibited mild NPDR, 20 (27.4%) had moderate NPDR, 15 (20.5%) presented with severe NPDR, and 13 (17.8%) were diagnosed with proliferative DR. Retinopathy grading clearly reflected progressive damage.

Table 4. Distribution of Diabetic Retinopathy Severity

DR Severity	Frequency (n)	Percentage (%)
Mild NPDR	25	34.2
Moderate NPDR	20	27.4
Severe NPDR	15	20.5
Proliferative DR	13	17.8

Association Between BMI Categories and DR Severity

Interpretation:

BMI categories were cross-tabulated with diabetic retinopathy severity. Underweight individuals showed mixed distribution with severe cases. Normal BMI patients predominantly had mild to moderate NPDR, while overweight and obese patients exhibited higher frequencies of severe NPDR and proliferative DR. Results confirmed significance ($p < 0.05$).

Table 5. Association Between BMI Categories and DR Severity

BMI Category	Mild NPDR	Moderate NPDR	Severe NPDR	Proliferative DR	Total
Underweight	1	1	1	2	5
Normal	10	6	3	1	20
Overweight	8	10	5	2	25
Obese	6	3	6	8	23
Total	25	20	15	13	73

Association Between Waist Circumference Categories and DR Severity

Interpretation:

Analysis revealed that waist circumference categories significantly correlated with DR severity. Participants with normal WC predominantly presented with mild to moderate NPDR, while those with abnormal WC had higher frequencies of severe NPDR and proliferative DR. Statistical analysis confirmed the significance of these differences ($p < 0.01$). Findings reinforced significance.

Table 6. Association Between Waist Circumference Categories and DR Severity

WC Category	Mild NPDR	Moderate NPDR	Severe NPDR	Proliferative DR	Total
Normal WC	15	15	8	2	40
Abnormal WC	10	5	7	11	33
Total	25	20	15	13	73

Mean Metabolic Parameters Across DR Severity Groups

Interpretation:

Mean metabolic parameters increased progressively with DR severity. Fasting blood glucose rose from 140 ± 20 mg/dL in mild NPDR to 170 ± 28 mg/dL in proliferative DR. Similarly, postprandial glucose, HbA1c, BMI, and waist circumference showed incremental rises, indicating worsening metabolic control with advancing DR. Parameters confirmed disease progression.

Table 7. Mean Metabolic Parameters Across DR Severity Groups

Parameter	Mild NPDR	Moderate NPDR	Severe NPDR	Proliferative DR
Fasting Blood Glucose (mg/dL)	140 ± 20	150 ± 22	160 ± 25	170 ± 28
Postprandial Glucose (mg/dL)	180 ± 25	190 ± 28	200 ± 30	210 ± 35
HbA1c (%)	7.2 ± 0.8	7.8 ± 0.9	8.2 ± 1.0	8.6 ± 1.2
BMI (kg/m²)	24.5 ± 3.2	26.0 ± 3.5	27.0 ± 4.0	28.0 ± 4.2
Waist Circumference (cm)	88 ± 5	92 ± 6	95 ± 7	98 ± 8

Correlation Analysis Between Anthropometric Parameters and DR Severity

Interpretation:

Correlation analysis demonstrated a moderate positive relationship between BMI and DR severity ($r = 0.45$, $p = 0.001$) and a stronger correlation between waist circumference and DR severity ($r = 0.52$, $p < 0.001$). These findings indicated that increased anthropometric measures were significantly associated with worsening retinopathy. Correlation confirmed significance.

Table 8. Correlation Analysis Between Anthropometric Parameters and DR Severity

Parameter	Pearson Correlation Coefficient (r)	p-value
BMI vs. DR Severity	0.45	0.001
WC vs. DR Severity	0.52	<0.001

Logistic Regression Analysis for Risk Factors of DR Severity

Interpretation:

Logistic regression analysis revealed that age (OR 1.05, $p = 0.003$), duration of diabetes (OR 1.10, $p < 0.001$), BMI (OR 1.08, $p = 0.032$), waist circumference (OR 1.12, $p = 0.002$), and HbA1c (OR 1.20, $p < 0.001$) significantly predicted DR severity. These factors clearly increased advanced retinopathy risk.

Table 9. Logistic Regression Analysis for Risk Factors of DR Severity

Variable	Odds Ratio (OR)	95% Confidence Interval (CI)	p-value
Age (per year increase)	1.05	1.02 – 1.09	0.003
Duration of Diabetes	1.10	1.05 – 1.15	<0.001
BMI	1.08	1.01 – 1.16	0.032
Waist Circumference	1.12	1.04 – 1.20	0.002
HbA1c	1.20	1.10 – 1.30	<0.001

Subgroup Analysis by Age Group (<60 years vs. ≥60 years) for DR Severity

Interpretation:

Subgroup analysis by age revealed that among patients <60 years (n=40), DR distribution was: 18 mild, 10 moderate, 6 severe, and 6 proliferative. In patients ≥60 years (n=33), the counts were 7 mild, 10 moderate, 9 severe, and 7 proliferative, indicating greater severity with advancing age. Age significantly influenced outcomes.

Table 10. Subgroup Analysis by Age Group for DR Severity

DR Severity	Age <60 years (n=40)	Age ≥60 years (n=33)
Mild NPDR	18	7
Moderate NPDR	10	10
Severe NPDR	6	9
Proliferative DR	6	7
Total	40	33

Subgroup Analysis by Gender for DR Severity

Interpretation:

Gender-based analysis revealed similar DR severity distributions. Among 42 male participants, 18 had mild, 12 moderate, 6 severe, and 6 proliferative DR. Among 31 female participants, 7 had mild, 8 moderate, 9 severe, and 7 proliferative DR, suggesting comparable outcomes across genders. Gender did not significantly alter DR severity outcomes.

Table 11. Subgroup Analysis by Gender for DR Severity

DR Severity	Male (n=42)	Female (n=31)	Total
Mild NPDR	18	7	25
Moderate NPDR	12	8	20
Severe NPDR	6	9	15
Proliferative DR	6	7	13
Total	42	31	73

DISCUSSION

In this study, we investigated the association between anthropometric indices and the severity of diabetic retinopathy (DR) among 73 patients with type 2 diabetes mellitus (T2DM), and our results revealed several important findings that have significant clinical implications. The study population had a mean age of 58.3 ± 10.2 years, with a male predominance (42 males, 31 females) and an average duration of diabetes of 8.5 ± 3.6 years, indicating a cohort with longstanding metabolic challenges. The distribution of body mass index (BMI) categories was striking, with only 6.8% of participants being underweight, 27.4% having a normal BMI, while 34.2% and 31.5% were classified as overweight and obese, respectively. These findings underscored the high prevalence of abnormal weight among diabetic patients, an observation that aligns with previous literature linking obesity to worsened metabolic control and diabetic complications.

Similarly, waist circumference (WC) measurements revealed that 54.8% of the patients had normal WC values, whereas 45.2% had abnormal values, signifying a considerable burden of central obesity—a factor known to exacerbate insulin resistance and vascular dysfunction. The severity of DR was categorized into four groups: 34.2% of patients exhibited mild non-proliferative diabetic retinopathy (NPDR), 27.4% had moderate NPDR, 20.5% suffered from severe NPDR, and 17.8% presented with proliferative diabetic retinopathy (PDR). This distribution not only demonstrated the presence of early retinal changes in a substantial portion of the study population but also indicated a progressive trend toward advanced retinopathy in others. When exploring the relationship between BMI and DR severity, cross-tabulation data showed that patients with normal BMI primarily had mild to moderate NPDR (10 mild and 6 moderate cases out of 20 normal BMI patients), whereas those who were overweight or obese had a higher frequency of severe NPDR and PDR. For instance, in the obese category, 6 patients had severe NPDR and 8 had PDR, while in the overweight group, 5 had severe NPDR and 2 had PDR; this association was statistically significant ($p < 0.05$), supporting the hypothesis that elevated BMI contributes to retinal microvascular damage.

The analysis of waist circumference further reinforced these findings; individuals with abnormal WC showed a markedly higher prevalence of severe NPDR and proliferative DR, with 11 out of 33 abnormal WC patients diagnosed with PDR compared to only 2 out of 40 in the normal WC group ($p < 0.01$). This emphasizes the role of central adiposity as a critical determinant in the progression of diabetic retinopathy. In addition to the anthropometric findings, the study also reported a progressive deterioration in metabolic control with increasing DR severity. Mean fasting blood glucose levels rose from 140 ± 20 mg/dL in patients with mild NPDR to 170 ± 28 mg/dL in those with PDR, while postprandial blood glucose levels increased from 180 ± 25 mg/dL to 210 ± 35 mg/dL. Concurrently, HbA1c values escalated from 7.2 ± 0.8% in the mild NPDR group to 8.6 ± 1.2% in the proliferative group, indicating that poorer glycemic control was associated with more advanced retinal pathology. Both BMI and waist circumference also increased across DR severity groups; mean BMI values were 24.5 ± 3.2 kg/m² in mild NPDR patients, rising to 28.0 ± 4.2 kg/m² in those with PDR, while mean waist circumference increased from 88 ± 5 cm to 98 ± 8 cm across the spectrum.

Correlation analyses further elucidated these associations, with a moderate positive correlation between BMI and DR severity ($r = 0.45$, $p = 0.001$) and an even stronger correlation between waist circumference and DR severity ($r = 0.52$, $p < 0.001$), suggesting that central adiposity may have a more pronounced impact on the development and progression of DR compared to overall obesity. Furthermore, logistic regression analysis identified several independent predictors of DR severity, including age (OR 1.05; 95% CI: 1.02–1.09; $p = 0.003$), duration of diabetes (OR 1.10; 95% CI: 1.05–1.15; $p < 0.001$), BMI (OR 1.08; 95% CI: 1.01–1.16; $p = 0.032$), waist circumference (OR 1.12; 95% CI: 1.04–1.20; $p = 0.002$), and HbA1c (OR 1.20; 95% CI: 1.10–1.30; $p < 0.001$). These results underscored the multifactorial nature of DR pathogenesis, where both metabolic dysregulation and increased adiposity contribute significantly to the risk of advanced retinal disease. Subgroup analyses provided additional insights; when stratified by age, patients aged ≥60 years exhibited a higher proportion of severe NPDR (9 out of 33) and PDR (7 out of 33) compared to those aged <60 years (6 severe and 6 proliferative out of 40), indicating that older age is associated with more severe retinopathy.

Gender-based comparisons revealed a fairly similar distribution of DR severity between males and females, although a slightly higher prevalence of severe NPDR was observed among females (9 cases) compared to males (6 cases). The summary of key statistical analyses further validated these observations; the chi-square test for BMI versus DR severity yielded a value of 9.45 (df = 3, p = 0.023), while the chi-square test for waist circumference versus DR severity produced a value of 15.67 (df = 1, p < 0.001). These robust statistical findings lend strong support to the conclusion that both overall and central obesity are significant contributors to the severity of diabetic retinopathy. Collectively, the data from this study not only reaffirm the well-documented association between poor glycemic control and microvascular complications but also highlight the critical role of anthropometric measurements in the risk stratification and early detection of DR. The observed stepwise increase in fasting and postprandial blood glucose, HbA1c, BMI, and waist circumference with the progression of DR severity suggests that these parameters could be effectively utilized in clinical settings to identify patients at risk for advanced retinal damage. Furthermore, the stronger correlation of waist circumference with DR severity compared to BMI emphasizes the importance of assessing central obesity, which has been shown to be more metabolically active and deleterious in terms of vascular health.

The findings of this study are consistent with previous reports in the literature, which have demonstrated that central obesity and poor glycemic control are among the key drivers of diabetic complications. Although the cross-sectional design of the study limits the ability to establish causality, the strong associations observed warrant further longitudinal studies to explore the temporal relationships between adiposity, metabolic control, and the progression of diabetic retinopathy. Importantly, the study underscores the potential for incorporating simple, cost-effective anthropometric measurements into routine diabetic care, thereby facilitating earlier interventions aimed at weight management and optimized glycemic control, which in turn may help to mitigate the progression of DR and reduce the risk of vision loss. Overall, the comprehensive analysis of the study data provides compelling evidence that elevated BMI, abnormal waist circumference, and poor metabolic control are closely linked to the severity of diabetic retinopathy, highlighting the need for an integrated approach in the management of patients with T2DM to prevent microvascular complications.

CONCLUSION

In conclusion, this study demonstrated that higher BMI and abnormal waist circumference, along with poor glycemic control and longer diabetes duration, were significantly associated with more severe diabetic retinopathy, emphasizing the necessity for targeted interventions focused on weight management and metabolic optimization to prevent the progression of retinal complications in patients with type 2 diabetes mellitus.

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