RESEARCH ARTICLE

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Retinopathy in Individuals With and Without Prediabetes: A Prospective Clinic-Based Comparative Study

ABSTRACT

Objective: Prediabetes is an intermediate state of hyperglycemia that does not reach the diagnostic limits of diabetes mellitus (DM). Retinopathy, a chronic microvascular complication of DM, is the most common cause of preventable blindness in people aged 20-65. This study aimed to investigate the presence of retinopathy in individuals with and without prediabetes.

Method: The study included 56 patients diagnosed with prediabetes, who visited the periodic health examination outpatient clinic of a hospital between April and September 2022, and 47 people without a diagnosis of prediabetes or diabetes, regardless of their additional chronic diseases. Measurements taken included weight, Body mass index (BMI), waist and hip circumference, and systolic-diastolic blood pressure, along with various laboratory tests. Each patient underwent a complete ophthalmologic examination, which included assessments of visual acuity, intraocular pressure, anterior segment and fundus examinations, and measurements of central foveal thickness (CFT) and mean foveal thickness (MFT) using Spectral field optical coherence tomography (SD-OCT).

Results: Diabetic retinopathy was found in 1 of the 56 prediabetic patients, and hypertensive retinopathy in 2 patients. In the non-prediabetic group, no diabetic retinopathy was found, but hypertensive retinopathy was present in 2 individuals. There was no significant difference in the occurrence of retinopathy between the prediabetic and non-prediabetic groups (p=0.796).

Conclusions: The study observed no significant difference in the incidence of diabetic retinopathy between patients with and without prediabetes. However, maintaining blood pressure regulation, monitoring lipid panels, and controlling weight in prediabetic patients are crucial to preventing the progression to DM.

Keywords: Prediabetes, Type 2 Diabetes Mellitus, Retinopathy.

Prediyabetli ve Prediyabetsiz Bireylerde Retinopati: Prospektif Klinik Tabanlı Karşılaştırmalı Bir Çalışma

ÖZET

Amaç: Prediyabet, diabetes mellitus (DM) tanısı için gerekli sınırlara ulaşmayan bir hiperglisemi ara durumudur. DM'nin kronik mikrovasküler komplikasyonu olan retinopati, 20-65 yaş arası kişilerde önlenebilir körlüğün en yaygın nedenidir. Bu çalışma, prediyabetli ve prediyabeti olmayan bireylerde retinopati varlığını araştırmayı amaçlamıştır.

Yöntem: Çalışmaya, Nisan ve Eylül 2022 tarihleri arasında bir hastanenin periyodik sağlık muayenesi polikliniğini ziyaret eden, prediyabet tanısı konmuş 56 hasta ve ek kronik hastalıkları ne olursa olsun prediyabet veya diyabet tanısı konmamış 47 kişi dahil edilmiştir. Ölçümler arasında ağırlık, vücut kitle indeksi, bel ve kalça çevresi, sistolik-diyastolik kan basıncı ve çeşitli laboratuvar testleri yer almıştır. Her hasta, görme keskinliği, göz içi basıncı, ön segment ve fundus muayeneleri ile Spektral alan optik koherens tomografi kullanılarak merkezi foveal kalınlık ve ortalama foveal kalınlık ölçümlerini içeren tam bir oftalmolojik muayeneden geçirildi.

Bulgular: 56 prediyabetik hastanın birinde diyabetik retinopati, 2 hastada ise hipertansif retinopati saptandı. Prediyabetik olmayan grupta diyabetik retinopati saptanmazken, 2 kişide hipertansif retinopati mevcuttu. Prediabetik ve prediabetik olmayan gruplar arasında retinopati görülme sıklığı açısından anlamlı bir fark yoktu (p=0,796).

Sonuç: Çalışmada, prediyabetik ve prediyabetik olmayan hastalar arasında diyabetik retinopati insidansında anlamlı bir fark gözlenmemiştir. Ancak, prediyabetik hastalarda kan basıncının düzenlenmesi, lipid panellerinin izlenmesi ve kilonun kontrol edilmesi, DM'ye ilerlemenin önlenmesi için çok önemlidir.

Anahtar Kelimeler: Prediyabet, Tip 2 Diabetes Mellitus, Retinopati.

INTRODUCTION

Diabetes Mellitus (DM) is a chronic and broad-spectrum metabolic disorder characterized by hyperglycemia that occurs due to relative or absolute insulin deficiency or insulin resistance to insulin action in peripheral tissues, affecting many organs and causing multisystemic involvement (1). Nowadays, diabetes is an increasingly important health problem all over the world due to its frequency and progressive complications. The financial problems that come along with the health problems it causes have an important place in preventing the development of diabetes (2).

Prediabetes is a clinical term used for conditions in which plasma glucose levels are higher than normal but do not reach the diagnostic limits for diabetes. Prediabetes consists of 3 subgroups: impaired fasting glucose (IFG), impaired glucose tolerance (IGT) and combined (IFG and IGT) glucose tolerance (3). Prediabetes is increasingly recognized as an important metabolic problem. Individuals at risk of future progression to diabetes are also at risk of developing macro and micro complications of diabetes (1).

Retinopathy, one of the microvascular complications of diabetes, is the most common cause of preventable vision loss (4). For over 20 years in industrialized countries, the incidence of diabetic retinopathy (DR) has increased to become one of the leading causes of visual impairment and blindness in adults (5). Risk factors for developing DR include disease duration, poor glycemic control (high HbA1c levels) and the presence of hypertension. Other risk factors for DR include high body mass index, puberty and pregnancy, and cataract surgery (4). The DETECT-2 study showed that DR was associated with a fasting plasma glucose of 6.5 mmol/l. The data also show that end organ complications occur before the onset of type 2 diabetes (6).

Recognizing and treating microvascular complications of diabetes in the prediabetes stage is expected to prevent future complications such as blindness. This will also contribute to a reduction in healthcare costs. For this reason, it will be important to know the frequency of retinopathy in the prediabetic population.

Although there are many observational studies and meta-analyses on this subject, no Prospective Clinic-Based Comparative Study y has been found in the literature. The aim of this study was to compare the presence of retinopathy in prediabetic patients with non-prediabetic patients.

MATERIAL AND METHODS

This study was planned as a prospective clinic-based comparative study. Between April 2022 and September 2022, 56 people with fasting plasma glucose between 100-125 mg/dl and HbA1C between 5.7-6.4% who applied to the periodic health examination outpatient clinic were included as the patient group and 47 people without prediabetes or diabetes were included as the control group, and randomization was performed using a simple random method. Patients with congenital eye disease, glaucoma, continuous use of tear drops for any reason, history of retinal vascular disease, history of eye surgery for any reason, and known diabetic retinopathy and intravitreal injection were excluded for two groups.

Permission for this study was obtained from X University Non-Interventional Health Research Ethics Committee (Decision No: 2022/48- Date: 25.04.2022).

The laboratory procedures of the study were performed in the Biochemistry Laboratory of X University Medical Faculty Hospital. Venous blood was collected from the antecubital vein after 12 hours of fasting. Gender, age, presence of comorbidities, and smoking status were recorded at the outpatient clinic visits. TANITA device measurements, waist circumference, hip circumference and systolic-diastolic blood pressure measurements were performed. Fasting plasma glucose, HbA1C, urea, creatinine, total cholesterol, LDL cholesterol, HDL cholesterol, triglyceride values were recorded from the hospital automation system.

All participants underwent a comprehensive ophthalmologic evaluation including best-corrected visual acuity (BCVA), intraocular pressure measurement using Goldmann applanation tonometry, slit-lamp biomicroscopy of the anterior segment, and dilated fundus examination.

Central foveal thickness (CFT) and mean foveal thickness (MFT) were measured using spectral-domain optical coherence tomography (SD-OCT) with the macular cube and 6×6 mm macular cube scan centered on the fovea was acquired for each eye using the device's ETDRS grid output (CFT and MFT automatically computed by the native software). For quality assurance, at least two scans were attempted per eye; the best-quality scan that met the criteria below was retained for analysis. Images with motion artifacts, blink lines, decentration (fovea not centered in ETDRS map), shadowing from floaters or lids, or defocus were excluded. All OCT scans were performed in a dimly lit room following full mydriasis induced by 0.5% tropicamide. Scans with poor signal strength (signal index <50) or segmentation errors were excluded from analysis.

Fundus examinations were performed by a single experienced ophthalmologist using slit-lamp biomicroscopy with a +90D lens. The examiner was masked to patients' clinical and systemic data to minimize potential bias. Hypertensive retinopathy was classified according to the Keith–Wagener–Barker classification, which stratifies disease severity based on arteriolar narrowing, hemorrhages, exudates, and optic disc swelling.

For patients with diabetes mellitus, the presence and severity of diabetic retinopathy were graded clinically using the International Clinical Diabetic Retinopathy and Diabetic Macular Edema Disease Severity Scales (AAO/ADA, 2002), based on slit-lamp biomicroscopic findings. This system classifies diabetic retinopathy as no DR, mild nonproliferative DR (NPDR), moderate NPDR, severe NPDR, or proliferative DR (PDR), and diabetic macular edema as absent, mild, moderate, or severe. All SD-OCT and fundus evaluations were performed by the same ophthalmologist to ensure consistency and minimize inter-observer variability.

A power analysis was performed considering the diabetic retinopathy rate, HbA1c and fasting glucose results, which is one of the main outcomes of the study. With a Type I error rate of 0.05 and an effect size (Cohen's d) of 0.59, the statistical power calculated using G*Power with 56 patients in group I and 47 patients in group II was 85%. Descriptive statistics were presented as number and percentage for categorical data and numerical data were presented as mean ± standard deviation, minimum and maximum values. The normality of numerical variables was analysed using histogram graphs and the Kolmogorov-Smirnov test. Student t test, Mann-Whitney U test and Chi-Square tests were used as hypothesis tests. In order to reduce the effects of independent variables due to baseline discrepancies between groups, multivariate logistic regression analysis was performed with retinopathy (present/absent) status as the dependent variable. Independent variables included in the model were retinopathy status, age, gender, smoking status, hypertension, body mass index (BMI), and the presence of comorbidities. Statistically $p<0.05$ was considered statistically significant. SPSS 23 package program was used in the analysis.

RESULTS

The study was completed with a total of 103 patients, 56 (54.37%) in the prediabetes group and 47 (45.53%) in the control group. Of the patients who participated in the study, 65.05% were female and 34.95% were male. Smoking was present in 25.24% of the patients. The mean age of the patients was 50.71±11.65 years. The mean BMI value was calculated as 29.88±5.87.

37 patients had isolated impaired fasting glucose. HbA1c was between 5.7-6.4% in 18 patients. The mean fasting blood glucose, HbA1c, and TG were 97.80±11.36, 6.3±0.41, and 130.99±56.05, respectively. Among the 103 patients who participated in the study, retinopathy was detected in a total of 5 individuals (4.85%) regardless of retinopathy type. Of these 5 patients, 4 (3.88%) had hypertensive retinopathy and 1 (0.97%) had mild non-proliferative diabetic retinopathy.

There was no difference in the presence of prediabetes according to gender (p=0.066). Similarly, there was no difference in the presence of prediabetes according to smoking (p=0.068). The number of patients with a diagnosis of hypertension was significantly higher in the prediabetes group ($p<0.001$). The presence of comorbidities ($p<0.001$) and CAD (p=0.017) were also significantly higher in the prediabetes group. There was no significant difference in the presence and type of retinopathy between individuals with and without prediabetes (p=0.796) (Table 1).

Table 1. Risk factor comparison of patients with and without prediabetes

		Prediabetes (n=56)	No Prediabetes (n=47)	
		n (%)	n (%)	p
Gender	Female	32 (57.1)	35 (74.5)	0.066
	Male	24 (42.9)	12 (25.5)	
Smoking	Yes	15 (26.8)	11 (23.4)	0.068
	No	33 (58.9)	35 (74.5)	
	Ex smoker	8 (14.3)	1 (2.1)	
Hypertension	Yes	26 (46.4)	3 (6.4)	**<0.001**
	No	30 (53.6)	44 (93.6)	
Comorbidities	Yes	40 (71.4)	13 (27.7)	**<0.001**
	No	16 (28.6)	34 (72.3)	
Coronary artery disease	Yes	9 (90.0)	1 (10.0)	**0.017**
	No	47 (50.5)	46 (49.5)	
Presence of Retinopathy	Yes	3 (60.0)	2 (40.0)	0.796
	No	53 (54.1)	45 (45.9)	
Type of Retinopathy	Diabetic retinopathy	1 (100.0)	0 (0.0)	0.646
	Hypertensive retinopathy	2 (50.0)	2 (50.0)	
	No-retinopathy	53 (54.1)	45 (45.9)	

Mean age, BMI, waist circumference of patients with prediabetes were significantly higher than those without prediabetes ($p<0.001$). Hip circumference of patients with prediabetes was significantly higher than those without prediabetes (p=0.005). Similarly, systolic (p=0.001) and

diastolic blood pressures (p=0.031) were significantly higher in patients with prediabetes compared to those without prediabetes. LDL (p=0.035), TG (p=0.049) and urea (p=0.003) values were also significantly higher in the group with prediabetes compared to the group without prediabetes. No significant difference was found between patients with and without prediabetes in terms of total cholesterol, HDL and creatinine (Table 2).

Table 2. Comparison of age, BMI, waist circumference, hip circumference, systolic blood pressure, diastolic blood pressure and laboratory parameters in prediabetic and non-prediabetic individuals

	Prediabetes (n=56)	No Prediabetes (n=47)	p
Age (Mean±SD)	55.93±9.51	44.49±10.97	**<0.001**
BMI (Mean±SD)	32.15±4.68	27.18±6.05	**<0.001**
Waist circumference (Mean±SD)	104.54±11.65	90.21±14.05	**<0.001**
Hip circumference (Mean±SD)	112.09±9.24	106.21±11.31	**0.005**
Systolic blood pressure (Median/IQR)	140.00 (24)	125.00 (27)	**0.001**
Diastolic blood pressure (Median/IQR)	87.50 (14)	82.00 (17)	**0.031**
Fasting glucose (Mean±SD)	104.53±9.75	89.79±7.22	**<0.001**
HbA1c (Median/IQR)	6.00 (0.30)	5.30 (0.40)	**<0.001**
Total cholesterol (Median/IQR)	192.85 (57.68)	179.80 (57.80)	0.073
LDL (Median/IQR)	113.90 (37.05)	108.80 (40.70)	**0.035**
HDL (Mean±SD)	47.73±11.63	50.82±11.95	0.158
TG (Median/IQR)	124.00 (73.23)	115.30 (63.10)	**0.049**
Urea (Median/IQR)	29.80 (9.55)	25.20 (8.40)	**0.003**
Creatinine (Median/IQR)	0.78 (0.25)	0.76 (0.25)	0.150

SD: Standart Deviation, IQR: interquartile range

When the groups with and without retinopathy were compared, no significant difference was found in terms of age, waist circumference, hip circumference and diastolic blood pressure, whereas significant differences were found in BMI (p=0.020) and systolic blood pressure (p=0.044). When the groups with and without retinopathy were compared in terms of laboratory parameters, no significant difference was found (Table 3).

Table 3. Comparison of patients with and without retinopathy according to age. BMI. waist circumference. systolic blood pressure. diastolic blood pressure and laboratory values

	Retinopathy Group (n=5)	No Retinopati Group (n=98)	p
Age (Mean±SD)	58.60±5.55	50.31±11.75	0.121
BMI (Mean±SD)	35.80±6.02	29.58±5.73	**0.020**
Waist circumference (Mean±SD)	110.20±4.91	97.38±14.68	0.055
Hip circumference (Mean±SD)	114.80±15.00	109.13±10.36	0.246
Systolic blood pressure (Median/IQR)	141.00 (58)	130.50 (24)	**0.044**
Diastolic blood pressure (Median/IQR)	90.00 (23)	85.50 (16)	0.075
TG (Median/IQR)	168.20 (83.35)	116.90 (58.50)	0.114
Total cholesterol (Median/IQR)	181.30 (83.30)	185.80 (49.15)	0.988
LDL (Median/IQR)	106.80 (78.05)	113.05 (42.80)	0.976
HDL (Mean±SD)	41.86±8.02	49.51±11.89	0.159
Urea (Median/IQR)	27.60 (12.55)	27.05 (9.13)	0.824
Creatinine (Median/IQR)	0.66 (0.28)	0.76 (0.24)	0.250

SD: Standart Deviation, IQR: interquartile range

In the regression analysis performed with the presence of retinopathy, age, gender, smoking status, hypertension, body mass index (BMI), and the presence of comorbidities, only BMI was found to be independently associated with the presence of retinopathy (OR=1.667, p=0.026). The group variable (prediabetes/control) did not reach statistical significance after adjustment (OR=0.03, p=0.125) (Table 4). The Nagelkerke R Square (0.508) indicates that 50.8% of the predictors of retinopathy can be explained by the variables in our model.

Table 4. Multivariate logistic regression analysis of factors associated with retinopathy

	S.E.	p	OR
Age	0.085	0.177	1.121
Gender (Female)	1.451	0.573	2.265
Smoking (Yes)	1.855	0.308	6.625
Hipertansiyon (Yes)	1.583	0.299	0.193
Retinopathy (Yes)	2.278	0.125	0.030
BMI	0.226	**0.026**	**1.657**
Comorbidities (Yes)	1.826	0.301	6.617
Constant	10.830	0.016	0.000

SE: Standard Error, OR: Odds Ratio, BMI: Body Mass Index

DISCUSSION

In our study, retinopathy data of 56 patients with prediabetes and 47 patients without prediabetes or diabetes were compared. The diagnosis of prediabetes was based on fasting plasma glucose and HbA1c and no oral glucose tolerance test (OGTT) was performed. This study is one of the few studies conducted in Turkey to evaluate prediabetes and retinopathy.

In some studies available in the literature, diabetic retinopathy was detected in patients with prediabetes, but not in others. In a study conducted by Knowler et al. in prediabetic patients with retinopathy, no correlation was found between blood glucose levels and retinopathy. Retinopathy was closely correlated with the duration of the disease in diabetic patients, but not in prediabetic patients (7). In our study, similar to this study, no significant difference was found between the normal population and prediabetes group in terms of retinopathy development. However, unlike this study, we also investigated the presence of hypertensive retinopathy in our study and no significant difference was found between the two groups in terms of hypertensive retinopathy.

However, it has been documented that the prevalence of retinopathy in individuals with prediabetes varies significantly across conditions. This variation is largely due to the diagnostic criteria and imaging modalities used. Mean estimates from the OGTT frequently differ from those based on HbA1c or owner-managed glucose tolerance (IFG) definitions. Similarly, the use of different modalities, such as fundus photography, fluorescein angiography (FFA), or optical coherence tomography (OCT/OCTA), may contribute to variations in rates across different modalities. Therefore, these details are taken into account when comparing results between studies.

In a 2012 study conducted in China, 750 patients underwent OGTT and the eyes of 110 newly diagnosed prediabetic patients were screened for diabetic retinopathy by fundus fluorescein angiography (FFA) and 20.91% were found to have mild non-proliferative diabetic retinopathy. In this study, it was also found that parameters such as high cholesterol levels in the blood, body mass index (BMI), gender and age, which are associated with DR in individuals with DM, did not make any difference in terms of retinopathy development in prediabetic patients (8). Similarly, in our study, no significant difference was found in terms of laboratory data in patients with retinopathy. However, in contrast to the Chinese study, BMI was significantly higher in patients with retinopathy in our study. The difference between our study and the Chinese study in terms of the detection of diabetic retinopathy may be attributed to the fact that in the Chinese study. FFA, which is a more sensitive method, was used to detect diabetic retinopathy rather than OCT.

In a study of Pima Indians, 68 individuals with IGT who were screened for retinopathy by fundus photography were examined and non-proliferative retinopathy was found in 12% (9). The high rate of diabetic retinopathy in this study may be attributed to the fact that. unlike our study, patients diagnosed with IGT using OGTT were included and fundus photography, a different method was used to screen for retinopathy.

In a cross-sectional study of 24 studies, 8759 individuals with prediabetes were included. In most of the studies analyzed. the rate of diabetic retinopathy in patients with prediabetes was found to be greater than 5%. Most of the patients with diabetic retinopathy were found to have non-proliferative diabetic retinopathy (6). Nearly all studies in prediabetic patients have reported non-proliferative retinopathy. The Atherosclerosis Risk In Communities (ARIC) study supports this (10,11). In our study, one patient in the prediabetic group had non-proliferative diabetic retinopathy.

In our study, one patient with non-proliferative diabetic retinopathy did not have any additional disease but prediabetes was newly diagnosed. Apart from this patient, 2 patients in the prediabetic group had stage 1 hypertensive retinopathy. These patients had hypertension in addition to prediabetes. In the non-prediabetic group, 2 patients had stage 1 hypertensive retinopathy, but these patients also had a diagnosis of hypertension. In our study, the number of patients with hypertension, CAD and additional chronic diseases was significantly higher than the

non-prediabetic group. This proves that hypertension, CAD and comorbidities are risk factors for retinopathy as stated in the guidelines (8,10).

In our study, the mean age, BMI, waist circumference, hip circumference, systolic blood pressure and diastolic blood pressure were significantly higher in patients with prediabetes compared to those without prediabetes. When we consider this in terms of comorbidities and risk factors, we can interpret this as weight gain with decreased mobility and dietary non-compliance at older ages, and increased BMI, waist circumference and hip circumference. The higher systolic blood pressure and diastolic blood pressure may be attributed to the higher number of patients with a diagnosis of hypertension in the group with prediabetes. In a study called LALES (Los Angeles Latino Eye Study), a significant relationship was found between every 20 mmHg increase in blood pressure and retinopathy (12). In the Hoorn study, the risk of developing DR within 10 years in hypertensive diabetic individuals was more than 2 times higher than in diabetic individuals with regulated blood pressure (13).

Patients diagnosed with prediabetes should also be followed up in terms of lipid profile. Because there are studies indicating that elevated triglycerides facilitate the development of diabetic retinopathy and even oral fenofibrate use should be recommended for patients diagnosed with prediabetes (14). The finding of significantly higher LDL and triglyceride levels in our study supports this view.

In our study, urea level was significantly higher in the group with prediabetes compared to the group without prediabetes. This may be attributed to the higher mean age in the prediabetic group and the higher number of individuals with hypertension in the prediabetic group, which may lead to a decrease in renal function due to the complications of both hypertension and prediabetes. There are various mechanisms explaining the link between hyperuricemia and IFG in particular. Experimental studies have reported that hyperuricemia inhibits the bioactivity of nitric oxide, stimulates insulin resistance, and increases the secretion of inflammatory factors and adipocytokines (15). When the relationship between hyperuricemia and glucose metabolism is investigated, there are studies showing that hyperuricemia is associated with the development of type 2 DM. Our study supports these studies. However, there are also studies claiming the opposite (16,17).

In a study investigating retinopathy and nephropathy in prediabetic individuals, systolic and diastolic blood pressures were significantly higher in those with diabetic retinopathy than in those without retinopathy, while no significant difference was found in terms of BMI (18). In our study, similar to this study, systolic blood pressure was found to be significantly higher in the group with retinopathy, whereas BMI was found to be significantly higher in the group with retinopathy compared to the group without retinopathy. Indeed, the regression analysis conducted in our study suggests that high BMI may play a more significant role in the development of retinopathy, and that the crude association between prediabetes and retinopathy may be largely explained by metabolic factors.

In the prediabetes study conducted in Turkey, 342 patients with prediabetes were screened for diabetic retinopathy, but no patient was diagnosed with diabetic retinopathy (19). The fact that there was no significant difference in retinopathy in our study supports this study, but the superiority of our study compared to this study is that we compared the normal population with the prediabetic population.

CONCLUSION

It is important that our study is a a prospective clinic-based comparative trial investigating retinopathy in prediabetic and non-prediabetic individuals. Although we did not detect retinopathy, which is a complication of diabetes mellitus in prediabetic individuals, our study is important to understand the importance of diagnosing prediabetic individuals at an early stage and providing appropriate lifestyle changes and medical treatment if necessary. Because it is known that as time progresses, diabetes mellitus will progress as these patients remain without follow-up and treatment, and preventing complications that may develop after DM develops will require further treatment and increase the financial burden.

In conclusion. blood pressure regulation. lipid panel monitoring and weight control in patients with prediabetes can prevent progression to DM and prevent diabetic retinopathy as well as other micro and macrovascular complications of DM.

Limitations

Since OGTT could not be performed in our study. IGT could not be diagnosed and this can be considered as a limitation for our study. In addition, the fact that the number of participants could not be increased and the power of the study could not be higher can be considered as another limitation. In addition, the fact that FFA, which is a more sensitive method for the diagnosis of retinopathy, was not used can be considered as another limitation. Another limitation of our study is the absence of ETDRS-based fundus photographic grading, which may have provided a more objective and reproducible assessment of retinopathy severity

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REFERENCES

1. Hostalek U. Global epidemiology of prediabetes-present and future perspectives. Clinical diabetes and endocrinology. 2019;5(1):5.
2. Chen L, Magliano DJ, Zimmet PZ. The worldwide epidemiology of type 2 diabetes mellitus--present and future perspectives. Nature Rev Endocrinology. 2011;8(4):228-36.
3. Harreiter J, Roden M. [Diabetes mellitus-Definition, classification, diagnosis, screening and prevention (Update 2019)]. Wiener Klinische Wochenschrift. 2019;131(Suppl 1):6-15.
4. Simó-Servat O, Hernández C, Simó R. Diabetic retinopathy in the context of patients with diabetes. Ophthal Res. 2019;62(4):211-7.
5. Wu L, Fernandez-Loaiza P, Sauma J, Hernandez-Bogantes E, Masis M. Classification of diabetic retinopathy and diabetic macular edema. World J Diabetes. 2013;4(6):290.
6. Kirthi V, Nderitu P, Alam U, Evans JR, Nevitt S, Malik RA, et al. The prevalence of retinopathy in prediabetes: A systematic review. Survey of Ophthalmology. 2022.
7. Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, et al. Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. 2002.
8. Chen X, Zhao Y, Zhou Z, Zhang X, Li Q, Bai L, et al. Prevalence and risk factors of diabetic retinopathy in Chongqing pre-diabetes patients. Eye. 2012;26(6):816-20.
9. Kahn HA, Hiller R. Blindness caused by diabetic retinopathy. American J Ophthalmology. 1974;78(1):58-67.
10. Wong TY, Islam FA, Klein R, Klein BE, Cotch MF, Castro C, et al. Retinal vascular caliber, cardiovascular risk factors, and inflammation: the multi-ethnic study of atherosclerosis (MESA). Inves Ophthal & Visual Sci. 2006;47(6):2341-50.
11. Wong TY, Duncan BB, Golden SH, Klein R, Couper DJ, Klein BE, et al. Associations between the metabolic syndrome and retinal microvascular signs: the atherosclerosis risk in communities study. Inves Ophthal & Visual Sci. 2004;45(9):2949-54.
12. Varma R, Macias GL, Torres M, Klein R, Peña FY, Azen SP, et al. Biologic risk factors associated with diabetic retinopathy: the Los Angeles latino eye study. Ophthal. 2007;114(7):1332-40.
13. van Leiden HA, Dekker JM, Moll AC, Nijpels G, Heine RJ, Bouter LM, et al. Risk factors for incident retinopathy in a diabetic and nondiabetic population: the Hoorn study. Arch Ophthal. 2003;121(2):245-51.
14. Robles-Rivera RR, Castellanos-González JA, Olvera-Montaño C, Flores-Martin RA, López-Contreras AK, Arevalo-Simental DE, et al. Adjuvant therapies in diabetic retinopathy as an early approach to delay its progression: the importance of oxidative stress and inflammation. Oxidative Med Cel Long. 2020;2020.
15. Johnson RJ, Perez-Pozo SE, Sautin YY, Manitius J, Sanchez-Lozada LG, Feig DI, et al. Hypothesis: could excessive fructose intake and uric acid cause type 2 diabetes? Endocrine Rev. 2009;30(1):96-116.
16. Yamada T, Fukatsu M, Suzuki S, Wada T, Joh T. Elevated serum uric acid predicts impaired fasting glucose and type 2 diabetes only among Japanese women undergoing health checkups. Diabetes & Metabolism. 2011;37(3):252-8.
17. Oda E, Kawai R, Sukumaran V, Watanabe K. Uric acid is positively associated with metabolic syndrome but negatively associated with diabetes in Japanese men. Internal Med. 2009;48(20):1785-91.
18. Guney SC, Cay Y, Yildirim Simsir I, Kabaroglu C, Afrashi F, Saygili LF. The prevalence and risk factors of retinopathy and nephropathy in prediabetic population. International J Diabetes Developing Countries. 2022:1-8.
19. Şanibaş AV, Cakmak F, Baydar İ, Binici DN. investigation of the effectiveness of the ada prediabetes risk test in identifying prediabetic Turkish patients and determination of the frequency of retinopathy in prediabetic patients. New Trends Med Sci. 2023;4(1):40-7.