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Impact of Diabetes on Visual Acuity and Its Association with Blood Glucose Levels in Diabetic Patients Attending Murtala Muhammad Specialist Hospital, Kano, Nigeria

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Abstract
Diabetic retinopathy is a known complication of Diabetes, underscoring the need for regular eye examinations and glycemic control. The aim of the study was to assess visual acuity (VA), and Fasting blood glucose (FBG) among diabetic patients at Murtala Muhammad Specialist Hospital Kano. It was a cross-sectional observational study consisting of 60 participants; 30 Diabetic patients & 30 non-diabetic patients (controls), aged 30-60 years. Data was collected using questionnaire and FBG measured using glucometer. Data was analyzed using SPSS version 25, considering a p-value of <0.05 as statistically significant. Majority of the participants were aged 51-60, with most diabetics having the disease for 1-10 years. Diabetic patients exhibited severe visual impairment (VI) in both eyes, followed by moderate VI, contrasting with controls who mostly had normal VA. Significant differences were noted between controls and diabetics in terms of duration of diabetes (DOD), VA, and FBG, but not age. While no significant gender differences were found in age, VA, or DOD within diabetic and control groups. Female diabetics had slightly higher FBG levels than males. Also, a significant relationship was observed between DOD and VI in the right eye of diabetic patients. In conclusion, this study reveals that diabetic patients had a higher frequency and more severe VI compared to controls, with significantly elevated FBG. No significant differences in age, DOD, VA, or FBG levels between genders in both groups. However, the severity of VI increased with DOD in the right eye. This emphasizes the importance of regular eye examinations and improved glycemic control to minimize the risk of VI in diabetics.

Key words: Visual acuity, Fasting blood glucose, Diabetes mellitus.

INTRODUCTION
Diabetes mellitus (DM) is a syndrome of chronic hyperglycaemia due to relative insulin deficiency, resistance or both (Galicia-Garcia *et al.,* 2020). It affects more than 120 million people worldwide and the prevalence is on the rise in all countries (Ginter and Simko, 2013). Symptoms often include frequent urination, increased thirst and increased appetite (Cloete, 2021). If left untreated, diabetes leads to many health complications. Acute complications can include diabetic ketoacidosis, hyperosmolar hyperglycemic state, or death (Balaji *et al.,* 2019). Serious long-term complications include cardiovascular disease, stroke, chronic kidney disease, foot ulcers, damage to the nerves, damage to the eyes, and cognitive impairment

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(Lotfy *et al.*, 2017). Diabetic retinopathy prevalence was highest in Africa (35.90%) and North America (Teo *et al.*, 2021). It is estimated that 4.25 million adults aged ≥40 years have moderate to severe visual impairment or blindness (< 20/63 in the better eye) in Nigeria, and North-East Nigeria had the highest prevalence of blindness (Kyari *et al.*, 2009). Proliferative diabetic retinopathy (PDR) the sequel of diabetic retinopathy (DR), a frequent complication of diabetes mellitus (DM), is the leading cause of blindness in the working-age population (Kropp *et al.*, 2023).

Globally, diabetic retinopathy is increasingly becoming a leading cause of preventable blindness, especially in low and middle-income countries (Lee *et al.*, 2015). In Nigeria, the lack of regular eye examinations in diabetic individuals exacerbates this issue (Olokoba *et al.*, 2017). There is a scarcity of data regarding the prevalence and severity of visual impairment in diabetic patients in Kano State. This has prompted the study to address and fill this knowledge gap. The research underscores the significance of regular visual assessments, often overlooked by physicians. The findings of the study have the potential to contribute to raising awareness about the importance of regular eye screenings among diabetic patients. Thus emphasizes the need for proactive measures in the early detection and management of visual problems, ultimately enhancing the quality of life for individuals with diabetes mellitus.

MATERIALS AND METHODS

Study Setting and Design: It was a descriptive cross-sectional study conducted from March 4th to March 18th, 2023, at the Endocrine clinic of Murtala Muhammad Specialist Hospital (MMSH) in Kano, Nigeria.

Sample Size: The sample size consisted of 60 participants, including 30 male and female Diabetic patients and an age- and sex-matched healthy controls.

Inclusion/ Exclusion Criteria: The study included Diabetic patients without any other systemic or ocular diseases and their age and sex-matched controls who have signed an informed consent to participate in the study. It excludes those beyond the age ranges, those with any systemic or ocular diseases or those who denied consent.

Ethical Consideration: Ethical clearance was obtained from the Ministry of Health Kano state, with the reference (SHREC/2022/3757) and approval number NHREC/17/03/2018.

Data Collection: Data was collected using questionnaire, VA and FBS were assessed using Snellen's chart and glucometer respectively.

Visual Acuity Determination

Visual acuity assesses a person's precision in recognizing small details and depends on optical and neural factors (Caltrider et al., 2020). Distance acuity (e.g., "20/20 vision") measures clarity at a far distance, compromised in myopia, while near acuity assesses recognition at a close distance, compromised in hyperopia (Azzam and Ronquillo, 2020).

Achieving VA relies on the dioptric system projecting images on the fovea, the central macular region rich in photoreceptors for high-resolution vision and color perception, which are independent physiological functions mediated by cones (Strasburger, 2014).

The Snellen chart is a widely used visual acuity test involving rows of letters or symbols of varying sizes (Snellen, 1862). During the test, the individual stood or sat at a standardized distance (6 meters) from the chart and read or identified the characters from the largest to the smallest row. The VA score was based on the smallest line accurately read. This test aids in diagnosing conditions like nearsightedness, farsightedness, and astigmatism, as well as monitoring changes in vision related to diseases (Snellen, 1862).

Fasting Blood Glucose: The fasting plasma glucose test, also known as the fasting blood glucose test (FBG) or fasting blood sugar test, measures the levels of glucose (sugar) in the blood. It is a relatively simple, accurate, and inexpensive test that can screen for diabetes and problems with insulin functioning (McMillin, 1990).

Data Analysis: Descriptive data were presented as frequency tables. Chi-Square Test and Mann-Whitney U Test were used to show comparison. Statistical significance was set at $P<0.05$. The data analysis was conducted using SPSS version 25.0.

RESULTS

A total of 60 participants were involved in this study, comprising 30 diabetic patients and 30 age- and sex-matched controls. Among them, 20 were males and 10 were females in the control group, while the diabetic group consisted of 19 males and 11 females (Table 1). The participants' ages ranged from 31 to 58 years, with the majority falling into the 51-60 years age category in both groups (Table 1). This suggests that diabetic patients in the studied population generally have a good quality of life, as most of them lived to an old age while effectively managing their diabetes. The study focused on patients with type II diabetes, the majority of whom were between 30 and 60 years old.

None of the controls had a history of diabetes, as they were not diabetic, compared to 100% of the diabetic group having a history of diabetes. The majority of diabetics had been suffering from diabetes for the last 1-10 years (47%), followed by those with diabetes for over 20 years, less than 1 year, and between 11-20 years (Table 1). The majority of diabetics (43%) had severe visual impairment (VI) in both their right and left eyes, followed by moderate VI (40%) in both eyes, then those with normal VA (13% in the right eye and 17% in the left eye), and finally those with mild VI (3%) in their right eye. None had mild VI in their left eye. However, 63% and 60% of the controls had normal VA in their right and left eyes, respectively, and only 37% and 40% had moderate VI in their right and left eyes, respectively. None of the controls had severe or mild VI in both eyes (Table 1). Zhang *et al.* (2008) found that people with diabetes are more likely to experience vision loss compared to those without diabetes.

Our results generally support the hypothesis that diabetic patients have a higher frequency and more severe visual impairment compared to their age and sex-matched controls. Additionally, VA tests were rarely conducted on diabetic patients during their routine clinic visits at the center. If routine visual acuity tests were performed, visual problems could have been diagnosed earlier, allowing for early screening and treatment to prevent further deterioration. However, Bhartiya *et al.,* (2022) found that although most participants had knowledge about diabetes mellitus and the importance of eye screening, only half of the people with diabetes underwent routine eye examinations or screening. Also, VA test results were found to be highly reproducible and stable in patients with reasonably well-controlled diabetes (Agardh *et al.,* 2011).

When comparing the age, VA, and FBG of the controls with those of the diabetic patients using the Mann-Whitney U Test, the results revealed significant differences between the controls and the diabetic patients in terms of VA, FBG, except for age. This indicates that the two groups were well-matched in terms of age and sex (Table 2). The FBG of the diabetics (9.65

mmol/L) was significantly higher than that of the controls (5.24 mmol/L) (Table 2). Our results indicate that diabetic patients generally have higher glucose levels compared to the general population despite been regular with their medications.

Table 1: Socio-demographic Characteristics of the Participants

Biodata	Categories	Control		Diabetic Patients	
		Frequencies	%	Frequencies	%
Gender	Male	20	67	19	63
	Female	10	33	11	37
Age	31-40 years	10	33	10	33
	41-50 years	7	23	11	37
	51-60 years	13	43	9	30
History of Diabetes	Yes	0	0	30	100
	No	30	100	0	0
Duration of Diabetes (years)	<1	0	0	5	17
	1-10 years	0	0	14	47
	11-20 years	0	0	4	13
	>20 years	0	0	7	23
Visual Acuity of Right Eye	Normal VA	19	63	4	13
	Mild VI	0	0	1	3
	Moderate VI	11	37	12	40
	Severe VI	0	0	13	43
Visual Acuity of Left Eye	Normal VA	18	60	5	17
	Mild VI	0	0	0	0
	Moderate VI	12	40	12	40
	Severe VI	0	0	13	43

Frequency Distribution Table showing the distribution of the socio-demographic data. Controls n=30, Diabetic Patients n=30.

Table 2: Comparing the Age, Visual Acuity, and Fasting Blood Glucose between Control and Diabetic Patients.

Variable	Control (Mean ± SEM)	Diabetic Patients (Mean ± SEM)	Z-value	P-Value
Age (years)	41.67±2.42	33.17±2.97	-0.668	0.504
Visual Acuity Right Eye	1.73±0.18	3.13±0.18	-4.593	0.001**
Visual Acuity Left Eye	1.80±0.18	3.10±0.19	-4.328	0.001**
Fasting Blood Glucose (mmol/L)	5.24±0.38	9.65±0.92	-3.284	0.001**

Mann-Whitney U Test. Controls n=30, Diabetic Patients n=30. * Indicates statistical significance and its absence indicates insignificance. **SEM** = standard error of the mean. P ≤ 0.05.

When comparing the age, DOD, VA, and FBG of male and female diabetic patients and controls using the Mann-Whitney U Test, the results showed no significant (p>0.05) differences in any of the variables between males and females in both the controls and diabetic patients (Table 3). Although not statistically significant, the mean FBG of the male controls and diabetics were slightly lower than that of the female controls and diabetics (Table 3). This finding suggests a relatively poorer glycemic control in females in both groups (control and diabetics). This difference, although not significant, is unrelated to diabetes. The underlying reasons for the difference, whether related to dietary habits or other factors, require further investigation.

Table 3: Comparing the Age, duration of Diabetes, Visual Acuity, and Fasting Blood Glucose between Males and Females in the Controls and Diabetic Patients

Variable	Male (Mean ± SEM)	Female (Mean ± SEM)	Z-value	P-Value
Control				
Age (years)	43.05±2.07	47.90±2.238	-1.236	0.217
Visual Acuity of Right Eye	1.60±0.210	2.00±0.333	-1.054	0.292
Visual Acuity of Left Eye	1.70±0.219	2.00±0.333	-0.777	0.437
Fasting Blood Sugar	4.97±0.41	5.79±0.82	-1.255	0.209
Diabetic Patients				
Age (years)	44.63±1.76	40.64±1.90	-1.362	0.173
Duration of Diabetes (years)	9.45±1.98	7.23±2.23	-0.454	0.650
Visual Acuity of Right Eye	3.00±0.28	3.36±0.15	-0.280	0.780
Visual Acuity of Left Eye	3.00±0.27	3.27±0.27	-0.467	0.641
Fasting Blood Glucose	8.87±1.16	10.99±1.46	-0.969	0.333

Mann-Whitney U Test. Controls n=30, Diabetic Patients n=30. * Indicates statistical significance and its absence indicates insignificance. **SEM** = standard error of the mean. P ≤ 0.05.

A chi-square test was conducted to determine if there was any association between gender and the duration of diabetes, which revealed an insignificant p-value of 0.675 (Table 4). There was however, a significant relationship (Fisher's Exact Test = 16.797 and p = 0.009) between DOD and VI in the right eyes of the diabetics as opposed to the left eye (Fisher's Exact Test = 10.128 and p = 0.069); and the severity of the VI increases with the increase in the duration of Diabetes in years (Table 5). This highlights the importance of early detection and management of visual problems in individuals with chronic diabetes. Several studies have also reported a higher prevalence of VI among older age groups with longer durations of diabetes, emphasizing the need for regular eye screenings in this population (Alemayehu *et al.*, 2022). Significant visual impairments and faster deterioration in visual functions were observed in type II diabetic (T2DM) patients, with older age, lower educational level, longer duration of diabetes, and the presence of diabetic retinopathy identified as risk factors (Ge *et al.,* 2021). Setia and Tidake (2023), also found that longer duration of diabetes corresponds to a higher prevalence of diabetic retinopathy. The frequency of diabetic retinopathy was higher in individuals above 60 years old and with a long history of diabetes (Setia and Tidake, 2023). Overall, our findings indicate that there was no significant relationship between gender and DOD, or between gender and VI in all the eyes in both groups.

Table 4: Association between Gender and duration of Diabetes in diabetic Patients

		Duration of Diabetes (Years)				
		<1 year	**1-10**	**11-20**	**>20**	**P value**
Gender	**Male**	4 (80%)	7 (50%)	3 (75%)	5 (71%)	0.675
	Female	1 (20%)	7 (50%)	1 (25%)	2 (29%)	

Chi-Square Test (Fisher's Exact Test (1.957). Control n= 30; Diabetic Patients n=30. *Indicates statistical significance and its absence indicates insignificance. P ≤ 0.05.

Table 5: Association between duration of Diabetes and Visual Acuity in Diabetic Patients.

		Visual Impairment (VI)				
		Normal VA	Mild VI	Moderate VI	Severe VI	P value
Visual Acuity of the Right Eye						
Duration of Diabetes (Years)	<1	3 (75%)	0 (0%)	2 (17%)	0 (0%)	0.009**
	1-10	1 (25%)	1 (100%)	8 (67%)	4 (30%)	
	11-20	0 (0%)	0 (0%)	0 (0%)	4 (31%)	
	>20	0 (0%)	0 (0%)	2 (17%)	5 (39%)	

Visual Acuity of the Left Eye	Visual Impairment (VI)				
		Normal VA	Moderate VI	Severe VI	P value
Duration of Diabetes (Years)	<1	2 (40%)	3 (25%)	0 (0%)	0.069
	1-10	3 (60%)	6 (50%)	5 (39%)	
	11-20	0 (0%)	0 (0%)	4 (31%)	
	>20	0 (0%)	3 (25%)	4 (31%)	

Right Eye, Chi-Square Test (Fisher's Exact Test (16.797). Left Eye, Chi-Square Test (Fisher's Exact Test (10.128). Control n= 30; Diabetic Patients n=30. *Indicates statistical significance and its absence indicates insignificance. P < 0.05.

There was no significant relationship between gender and VI in the right (Fisher's Exact Test = 4.970 and p = 0.130) and left (Fisher's Exact Test = 0.730 and p = 0.780) eyes of the diabetics (Table 6). There were also no significant relationship between gender and VI in the right (p = 0.425) and left (p = 0.461) eyes of the controls (Table 7).

Table 6: Association between Gender and Visual Acuity in Diabetic Patients

		Visual Impairment (VI)				
Right Eye		**Normal VA**	**Mild VI**	**Moderate VI**	**Severe VI**	**P value**
Gender	Male	4 (100%)	1 (100%)	5 (42%)	9 (69%)	0.130
	Female	0 (0%)	0 (0%)	7 (59%)	4 (31%)	

		Visual Impairment (VI)			
Left Eye		**Normal VA**	**Moderate VI**	**Severe VI**	**P value**
Gender	Male	4 (80%)	7 (58%)	8 (62%)	0.780
	Female	1 (20%)	5 (42%)	5 (39%)	

Chi-square Test: Right Eye, (Fisher's Exact Test, 4.970); Left Eye, (Fisher's Exact Test, 0.730). Control n= 30; Diabetic Patients n=30. *Indicates statistical significance and its absence indicates insignificance. P < 0.05.

Table 7: Relationship between Gender and Visual Acuity in the Control Group

		Visual Impairment (VI)		
Right Eye		**Normal VA**	**Moderate VI**	**P value**
Gender	Male	14 (74%)	6 (55%)	0.425
	Female	5 (26%)	5 (45%)	
Left Eye				
Gender	Male	13 (72%)	7 (58%)	0.461
	Female	5 (28%)	5 (42%)	

Chi-Square Test. Control n= 30; Diabetic Patient n=30. *Indicates statistical significance and its absence indicates insignificance. P < 0.05.

CONCLUSION

In our study, controls mostly had normal visual acuity, while diabetic patients showed higher and more severe visual impairment. A significant relationship was observed between the DOD and VI in the right eyes of diabetic patients, with VI severity increasing with increase in diabetes duration. Gender did not affect age, DOD, or VA in diabetics. No significant relationship was found between gender and DOD or VI in both groups, but women had insignificantly higher FBG levels, suggesting a potential gender difference in glycemic control. Regular VA screenings for diabetic patients are crucial for early detection and intervention in ocular problems.

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