International Journal of Community Medicine and Public Health
Ozioko NM et al. Int J Community Med Public Health. 2024 Dec;11(12):4671-4676
http://www.ijcmph.com
pISSN 2394-6032 | eISSN 2394-6040

DOI: https://dx.doi.org/10.18203/2394-6040.ijcmph20243631

Original Research Article

Assessment of colour vision among self-referred patients for glucose monitoring in ESUT teaching hospital, Parklane, Nigeria using Hardy-Rand-Rittler colour vision test

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Received: 19 September 2024
Revised: 18 November 2024
Accepted: 19 November 2024

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ABSTRACT

Background: Worldwide, diabetes mellitus (DM) is a common chronic metabolic disease that has a substantial impact on public health necessitating the need for screening populations at risk since it is linked to several sequelae, including diabetic retinopathy (DR). Despite evidence from studies linking colour vision impairments to diabetic eye disease, colour vision is not frequently tested for in diabetic eye screening protocols.
Methods: This cross-sectional study aimed to evaluate the feasibility of using the Hardy-Rand-Rittler pseudoisochromatic color vision test for diabetic retinopathy (DR) screening due to its cost-effectiveness and ease of use. Conducted at ESUT Teaching Hospital, Parklane, standard eye examinations, including dilated fundus assessments and visual acuity tests, were conducted alongside color vision evaluations over a three-month period for a total of 57 patients on self-referred blood glucose monitoring appointments.
Results: The research involved participants with fair glycemic control (average blood sugar level of 159.28 mg/dl). Those aged 48-57 had the highest likelihood of moderate color vision abnormalities while 73.7% of them demonstrated mild unclassified defects on the Hardy-rand- rattler colour vision testing.
Conclusions: The Hardy-Rand-Rittler test for color vision could be valuable for screening older diabetes patients, particularly in resource-limited areas. Detecting anomalies early may indicate retinal disease, prompting further eye examinations and immediate intervention.

Keywords: Colour vision, Diabetic retinopathy glucose monitoring, Diabetes mellitus, Hardy-Rand-Rittler test, Vision screening

INTRODUCTION

Studies have shown that 80% of patients with diabetes live in low income and middle income countries.[1] The rising prevalence and the impact of diabetes mellitus (DM), particularly its association with diabetic retinopathy (DR) as a leading cause of vision impairment has significant influence on public health.[2-4] However, despite advances in DR screening, current methods like retinal photography have limitations in low resource environments, necessitating the search for more accessible screening tools.[5-8]

Therefore, this study aims to evaluate the Handy-Rand-Rittler pseudoisochromatic test as a potential screening tool for color vision abnormalities in diabetic patients, considering its affordability and ease of use in low-resource settings. Additionally, it explores the

relationship between acquired color vision deficits and blood sugar controls of diabetics.

METHODS

Study design

The study was a hospital based cross-sectional study.

Study area

The study was conducted at the Enugu State University of Science and Technology Teaching Hospital Parklane's (ESUTHP) diabetes and ophthalmology clinics. The state owns the 300-bed tertiary hospital known as ESUTHP. It is in the center of Enugu, the state's capital. Additionally, it provides service to nearby Ebonyi, Anambra, Imo, and Benue states.

The hospital renders blood-sugar monitoring walk-in services, diabetic treatments and follow-up visits through its diabetic unit clinic which runs twice a week (Wednesday and Friday) and ophthalmology clinics which run daily.

Ethical clearance was sought in accordance with the stipulations of the declaration of Helsinki on research involving human subjects. Ethical approval for the study was obtained from the ethics and research Committee of Enugu State University of Science and Technology Teaching Hospital Parklane. Informed written consent or thumb print was obtained from study participants.

Inclusion criteria

All self-referred patients on blood-glucose monitoring appointments with or without prior diagnosis of diabetic mellitus, and patients who give consent were included.

Exclusion criteria

Patients with media opacity which precludes view of the fundus, patients with visual acuity <6/60, eligible patients who declined consent, and patients using mydriatic eye drops were excluded.

The patient selection and obtaining of demographic information was conducted at the diabetic clinic and examination was done in the ophthalmic clinic of the hospital. A proforma was administered by the ophthalmic nurse to obtain patients demographic information, onset, and type of diabetes mellitus.

The visual acuity was performed with illuminated snellen chart (both literate and non- literate as applies to each participant) at 6 meters. Near vision correction was done for presbyopes before administering the test. One eye was evaluated at a time, while the other is occluded. The ocular exam was then carried out in the eye clinic using a slit lamp biomicroscope in the eye clinic. The examination comprised of the anterior segment examination, and dilated fundus examination using 78D non-contact lens. The patient then had colour vision assessment by the designated research member using the hardy rand rattler colour vision test.

Procedure for colour vision test

Six screening plates were used, two for tritan deficiencies and two for protan-deutan deficiencies. Following these, were 14 plates which helped in differentiating protans, deutans (10 plates), and tritans (4 plates) and grading the degree of the deficit. The symbols' colours were located on protan, deutan, or tritan achromatic confusion loci, and they get more intense as the patient moves through the plates. The idea is that people with severe colour blindness won't be able to perceive symbols with colours on them, no matter how carefully they were made.

Based on whether patients could see the symbols on the more saturated plates, their colour vision deficit were evaluated as light, medium, or severe. Patients with one or more errors on the two plates with the most saturated colours were assessed as having severe protan/deutan defects, while those with faults on the next three most saturated plates were graded as having medium protan/deutan defects. There were ten grading plates for protan/deutan defects. Mild grades were given to those who only make mistakes with the five least saturated plates.

Sample size determination

Records from the Diabetic clinics of ESUT Teaching Hospital shows a total of about 160 patients were seen in the year 2017 (Most comprehensive obtainable clinic record). Data collection for this study took place over the course of three months, from November 10, 2023, to February 11, 2024. The minimum sample size was calculated using the formula for cross sectional study in a population less than 10,000.

$nf= n/1 + (n/N)$

but

$n= Z^2pq/d^2$

where; nf = desired sample size, where population <10,000; n= the desired sample size when the population > 10,000; N= the estimated size of the population (160 as estimated from clinic records); Z = the standard normal deviate, usually set at 1.96 corresponding to 95% confidence interval; P= the conservative expected prevalence in population (0.31).

$q= 1- p$

d= absolute error or precision (5% or 0.05)

To calculate n

$= (1.96^2 \times 0.31 \times 0.69)/0.05^2$

$= 0.8217/0.0025$

$=328.68$

N=160

nf =328.68/1+328.60/160

Approx.=108

Correcting for 10% attrition

Approx.= 120.

The research was conducted over a 3-month period. From the calculated sample size of 120 participants, since the average number of diabetic patients who usually booked for blood glucose measurement every diabetic clinic is 15, this would give an average of 15 patients to be evaluated per clinic day. The first participant recruited for each clinic day were chosen from the list of attendance. Subsequently consecutive patients in the appointment list were selected using a simple sampling technique until the required number of 15 for the day was met. The selected patients were tagged to prevent them from being recruited again. If a patient declines consent, the next patient on the list was selected by simple substitution. Similarly, if a patient had been recruited before, the next patient on the list was recruited.

Data analysis

Data from this study was collated and analysed using the statistical package for social. sciences (SPSS) version 22 (SPSS inc Chicago Illinois USA). The demographic data was analysed and presented in frequency tables and percentages. Chi- square was used as Test of association to determine the correlation between visual acuity, the blood sugar value and colour vison. A p value of ≤ 0.05 was considered statistically significant.

RESULTS

Table 1 shows the age distribution of the participants in the Colour Study. The age range between 38 to 87 years. Mean age of participants was 62.61±11.56.

Table 2 shows that the occupation of respondents were pensioners (26.5%) 31.6% traders, 12.3% civil servants, and 10.5% teachers. However, 17.5% had no jobs.

Table 3 shows blood sugar values of respondents. The minimum was 90mg/dl while maximum was 299 mg/dl.

Table 1: Age distribution.

Age intervals	Frequency	Percentage	Mean±SD
38-47	5	8.8	62.61±11.56
48-57	13	22.8	
58-67	20	35.1	
68-77	13	22.8	
78-87	6	10.5	
Total	57	100.0	

Table 2: Percentage distribution of the respondents' occupation.

Occupation	Frequency	Percentage
Business	12	21.1
Civil servant	7	12.3
Driver	2	3.5
Farmer	2	3.5
Housewife	1	1.8
Pensioner	15	26.5
Security	1	1.8
Teacher	1	1.8
Trader	6	10.5
Unemployed	10	17.5
Total	57	100.0

Table 3: Mean values of the blood sugar.

Parameter	Minimum	Maximum	Mean	SD
Blood sugar	90	299	159.28	45.773

Table 4: Visual acuity.

VA	Right eye		Left eye	
	Frequency	Percentage	Frequency	Percentage
Mild or no visual impairment	35	61.4	37	64.9
Moderate visual impairment	16	28.1	12	21.1
Severe visual impairment	6	10.6	8	14.1
Total	57	100.0	57	100.0

Table 5: Percentage distribution of respondents on colour vision.

Status	Frequency	Percent
Abnormal	7	12.3
Normal	50	87.7
Total	57	100.0

Table 4 displays the patients' visual acuity classification. Mild vision impairment accounted for the majority of study participants, followed by moderate impairment (21.1%) and severe and 14.1%, respectively. Table 5 shows the respondents' colour vision % distribution. Of the individuals, 50 (87.7%) had colour vision within the normal range, whereas 12.3% had abnormalities. Table 6 displays the relationship between the individuals' visual acuity and the age at which they developed colour vision defects. With a p-value of 0.045, the table demonstrates that the test of the relationship between age and colour vision was statistically significant. Additionally, a high association was found between colour vision and visual acuity in both the left and right eyes (p-values of 0.013 and 0.032, respectively). Table 7 shows the participants' mean age and blood sugar levels which also categorizes them as having either normal or abnormal colour vision. Table 8 shows types of colour vision impairments among research participants. The most common were unclassified mild defects found in patient groups aged 48–67. Only two participants exhibited mild R-G defects, but 19 persons of all ages, or 15.8% of the total, had significant B-Y defects.

Table 6: Test of association between colour vision defect and other variables.

Variables	Colour vision status		Total	Chi-square/Fishers Exact (P values)
	Abnormal color vision	Normal		
Age (years)				7.037
38-47	0 (0.0)	5 (10.0)	5 (8.8)	(0.045*)
48-57	2 (28.6)	11 (22.0)	13 (22.8)	
58-67	1 (14.3)	19 (38.0)	20 (35.1)	
68-77	1 (14.3)	12 (24.0)	13 (22.8)	
78-87	3 (42.9)	3 (6.0)	6 (10.5)	
Total	7 (100.0)	50 (100.0)	57 (100.0)	
Diabetics				
Diabetic	5 (71.4)	40 (80.0)	45 (78.9)	0.271 (0.602)
No diabetics	2 (28.6)	10 (20.0)	12 (21.1)	
Total	7 (100.0)	50 (100.0)	57 (100.0)	
VA right eye				
Mild/No VI	1 (14.3)	34 (68.0)	35 (61.4)	9.333 (0.013)*
Moderate VI	4 (57.1)	12 (24.0)	16 (28.1)	
Severe VI	0 (0.0)	1 (2.0)	1 (1.8)	
Blind	2 (28.6)	3 (6.0)	5 (8.8)	
VA left eye				
Mild/No VI	2 (28.6)	35 (70.0)	37 (64.9)	7.465 (0.032)*
Moderate VI	2 (28.6)	10 (20.0)	12 (21.1)	
Severe VI	0 (0.0)	1 (2.0)	1 (1.8)	
Blind	3 (42.9)	4 (8.0)	7 (12.3)	

*: clinically significant

Table 7: Mean comparison.

Variables	Colour vision	Mean	Std. Deviation	t-values	P values
Age (years)	Abnormal	69.00	15.242	1.581	0.120
	Normal	61.72	10.846		
Blood sugar	Abnormal	173.86	39.730	0.898	0.373
	Normal	157.24	46.546		

Table 8: Table on types of defects.

Types of defects	Age in intervals				Total	Chi-square (P value)
	48-57	58-67	68-77	78-87		
Mild R-G defect, N, %	1	1	0	0	2	3.490 (0.745)
	25.0	14.3	0.0	0.0	10.5	
Mild defect unclassified, N, %	2	5	4	3	14	
	50.0	71.4	100.0	75.0	73.7	
Strong B-Y defect, N, %	1	1	0	1	3	
	25.0	14.3	0.0	25.0	15.8	
Total, N, %	4	7	4	4	19	
	100.0	100.0	100.0	100.0	100.0	

The self-referred diabetic clinic attendees were mainly known diabetics 78.9% and undiagnosed diabetics 21.1% respectively (Figure 1).

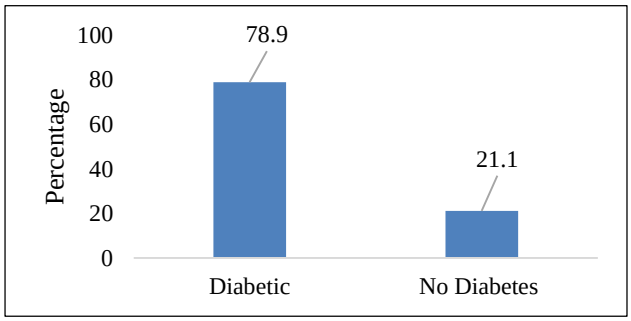

Figure 1: Percentage distribution of the respondent on diabetics.

DISCUSSION

The sample population's different socioeconomic backgrounds are reflected in the range of jobs. The largest group were made up of retirees (26.5%), followed by company owners (21.1%) while17.5% were unemployed. This is consistent with the distribution of jobs around the study location and the occupational profile of Nigerian metropolitan centers.[9] The difference between these findings and that of a similar previous study could be due to the difference in research area.[10] Based on the age distribution, 35.1% of the total respondents are between the ages of 58 and 67 years. With an 11.56 standard deviation, the respondents' average age is 62.61 years. The distribution suggests that the population is comparatively older, which as earlier documented, may have an impact on factors connected to eye health.[11] However, the study participants' average blood sugar level was 159.28 mg/dl, with a standard deviation of 45.773 which indicates that their blood sugar levels ranged from 90 mg/dl at the lowest to 299 mg/dl at the highest. This suggests a broad range of blood sugar readings, which may be representative of individuals' differing levels of glucose control. The mean blood sugar levels of respondents with abnormal colour vision was173.86 mg/dl and those with normal colour vision,157.24 mg/dl. This did not significantly vary from one another (p=0.373). These findings therefore imply that colour vision impairments in this population may not be directly correlated with blood sugar levels which is similar to findings by Mohamed Ismail, Roy and co-workers.[12,13]

In both eyes, most responders (61.4% in the right eye and 64.9% in the left) had minimal to no vision impairment. But a significant fraction had either severe (1.8% for both eyes) or moderate (28.1% for the right eye and 21.1% for the left). The need of vision screening and care for the senior population is highlighted by the prevalence of visual impairment. Many of the respondents (87.7%) had normal color vision, while a smaller proportion (12.3%) exhibited abnormal color vision. This indicates that color vision defects are relatively uncommon among the study population. However, colour vision abnormalities according to age obtained from the study showed that, of the respondents, those in the 48-57years age range were more likely to have mild abnormalities than any other age group. While the difference between the mean age of respondents with impaired colour vision and those with normal colour vision (61.72 years) is not statistically significant (p=0.120), it is somewhat higher (69.00 years) for the former group. Chi-square tests indicate that there is a significant correlation (p=0.045*) between age and colour vision deficiency, indicating that advancing age with diabetes may be associated with an increased risk of defective colour vision. This correlates with former colour vision study using Farnsworth 100- hue test among 343 type 2 diabetics subjects recruited from follow-up cohort of Sankara Nethralaya diabetic retinopathy epidemiology and molecular genetics study and study by Gella et al.[14] Similarly, the previous publication by Lopez et al observed that the age of participants was a significant factor in colour vision abnormalities among diabetics.[15]

This study has few limitations. Majority of participants were walk-in patients who requested to be ‘‘fast-tracked’’. Therefore, only 57 persons consented to participate, which may not be entirely representative of the population and limit how widely the findings can be applied. Utilizing self-referred patients may have introduced selection bias since the study's generalisability to the broader diabetes community may be impacted by

participants who are already more health-conscious or symptomatic. Though less expensive than more sophisticated techniques, the Hardy-Rand-Rittler test might not identify all kinds of colour vision impairments or offer comprehensive information on the extent of impairments.[10] Other conclusive diagnostic techniques (such optical coherence tomography) may be required to confirm retinal abnormalities found by the Hardy-Rand-Rittler test. Therefore, future studies with the inclusion of control group maybe required to strengthen the evidence for adding colour vision tests to diabetic retinopathy screening procedures by addressing these shortcomings.

CONCLUSION

The research offers valuable perspectives on the studied population's glycemic values, colour vision, and demographic attributes. A possible age-related deterioration in colour perception is suggested by the association that appears to exist between age and colour vision impairments among the attendees of blood glucose monitoring appointments as evidenced by the incidence of unclassified mild and strong blue-yellow deficits using hardy randy rittler colour test. There may be no discernible correlations between the presence of diabetes or visual acuity in either eye or colour vision impairment however, these results suggest that age and diabetes may have an impact on colour vision and call for more research on age-related changes in vision among diabetics in this zone.

ACKNOWLEDGEMENTS

We would like to thank the Head of Department of Ophthalmology and all Ophthalmic Clinic Nurses of Enugu State University of Nigeria Teaching Hospital Parklane.

Funding: No funding sources
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee of Enugu State University of Science and Technology Teaching Hospital, Parklane, Enugu, Nigeria (ESUTHP/C-MAC/RA/034/179)

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Cite this article as: Ozioko NM, Eze GC. Assessment of colour vision among self-referred patients for glucose monitoring in ESUT teaching hospital, Parklane, Nigeria using Hardy-Rand-Rittler colour vision test. Int J Community Med Public Health 2024;11:4671-6.