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Effect of Diabetes Mellitus on Color Vision

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ABSTRACT

Background: Diabetic retinopathy, is a complication of diabetes, which damages the retina's blood vessels responsible for processing visual information, including color perception. The current study examines the effect of diabetes mellitus on color vision. **Objective:** The current study examines the effect of diabetes mellitus on color vision. **Method:** As part of our assessment, we employed the Ishihara color vision test to evaluate our patients' ability to perceive colors accurately. The Ishihara test is a widely used screening tool for detecting red-green color deficiency. It consists of multiple plates featuring variously arranged colored dots. Each plate displays numerals or symbols that individuals with normal color vision can readily identify. However, those with color blindness may have difficulty discerning or recognizing these numerals or symbols on the plates. **Results:** Among 300 patients, 162 are men (54%) and 138 are women (46%), all diagnosed with diabetes. Of the total patients, 105 individuals (35%) rely on medications to manage their diabetes, and 195 patients (65%) use insulin as part of their treatment. Furthermore, 125 patients (41.67%) have normal color vision, while 175 patients (58.33%) exhibit red-green color impairments. **Conclusion:** These findings suggest a possible link between diabetes and color vision issues. To establish the exact nature of this association, further investigation and analysis are essential. However, these results emphasize the possibility of shared underlying mechanisms between diabetes and color vision deficits, emphasizing the need for additional research and attention when caring for patients with these conditions.

Keywords: Color vision, Diabetes mellitus, Diabetic retinopathy

INTRODUCTION

Diabetes mellitus, a condition marked by elevated blood sugar levels, can result from either an absolute or relative deficiency in the production of insulin or its effectiveness [1]. Diabetes is currently classified into two major categories: type 1 diabetes (T1DM) and type 2 diabetes (T2DM) [2]. Type 1 diabetes, which impacts 5 to 10% of the population, is characterized by the immune system's attack on pancreatic beta cells as the root cause. Type 2 diabetes accounts for over 90% of diabetes cases and is influenced by a combination of genetic and environmental factors in its development [3]. In 2015, the international diabetes federation (IDF) reported that nearly 415 million individuals between the ages of 20 and 79 had diabetes mellitus. This number is projected to rise to 642 million by 2040, highlighting diabetes mellitus as a growing global public health concern [4]. Prolonged high blood sugar levels impact the walls of micro-vessels throughout the body, particularly in the eyes (retina), nerves, and kidneys, leading to their deterioration and subsequent dysfunction [5].

Diabetic retinopathy, a form of microangiopathy, is characterized by abnormal retinal meshwork and increased permeability brought about by prolonged hyperglycemia. This condition can lead to severe visual impairment. Over time, the damage can become severe enough to cause retinal vessels to become blocked and lose their functionality [6]. A study has revealed that among individuals with type 1 diabetes who were screened, 32.58% had diabetic retinopathy (DR). For those with type 2 diabetes, 23.04% of patients developed diabetic retinopathy [7].

Visual function refers to the eye's capacity to discern different shapes, colors, and levels of brightness, even in low-light conditions. This ability relies on the collaborative function of photoreceptors and the pigmented layer in the retina [8]. People with normal color vision (NCV) possess three distinct types of specialized retinal cells called cones, enabling them to perceive the colors red, green, and blue. Those with abnormal cones will experience altered color perception, leading to various forms of color vision deficiency (CVD). The three forms of dichromacy are protanopia, deuteranopia, and tritanopia. Reducing sensitivity to red, green, and blue is termed protanomaly, deuteranomaly, and tritanomaly, respectively. When one of the three cones is abnormal, it is referred to as anomalous dichromacy. Dichromacy occurs when a person has only two retinal cones capable of perceiving color, resulting in the complete loss of one color perception [9]. Tritan color vision impairment along the blue/yellow axis is associated with diabetes mellitus, consistent with many prior studies. These tritan abnormalities are believed to result from increased susceptibility of short-wavelength cones in the retina and early lens yellowing in diabetic eyes. However, some research suggests that individuals with diabetes may also experience a generalized color vision impairment affecting both the red/green and blue/yellow axes of discrimination. This deficiency is thought to be linked to an increase in inner retinal damage. The severity of diabetic retinal pallor or macular edema correlates with the overall color vision impairments when these conditions are present. Importantly, these impairments often become apparent before clinically evident retinal vein problems [10].

Chromatic sensitivity was assessed using the Color Assessment and Diagnosis (CAD) test, a quick and efficient method for gauging the extent of color vision (CV) loss. This test provides a precise evaluation of the reduction in chromatic sensitivity in both red-green (RG) and yellow-blue (YB) axes. Unlike many other color vision tests, which are primarily designed to detect congenital color deficiency, the CAD test accurately measures the degree of color vision loss [11]. The study aimed to assess the effect of diabetes mellitus on color vision.

MATERIALS AND METHODS

The research involved a cross-sectional study conducted at the Al Kubra Health and Eye Clinic, with a primary focus on investigating the effects of diabetes mellitus on color vision. The study was conducted with the approval of the ethical committee. Ethical considerations were upheld, ensuring that all participants provided informed consent, confidentiality was maintained, and patient privacy was safeguarded. This research aimed to shed light on the influence of diabetes mellitus on color vision in a specific demographic, ultimately contributing to our understanding of this critical health concern. A total of 300 cooperative respondents who met the inclusion criteria were included in the study. These criteria included patients diagnosed with diabetes mellitus, individuals aged between 25 and 50 years, and those with a diabetes history of 3-5 years. Exclusions involved patients below 20 years, individuals with coexisting conditions such as arthritis, hypertension, or other systemic diseases, autoimmune diseases, contact lens users, pregnant individuals, and those with other ocular pathologies. The data collection process took place in the designated medical facility, where subjects meeting the inclusion criteria were selected through convenient random sampling after providing informed consent. Medical history, ophthalmological history, and insulin usage data were recorded using a self-made questionnaire within one week of recruitment. Color vision was assessed using the Ishihara test, a recognized tool for identifying color deficiencies, particularly red-green deficiencies. Data collected in this study were analyzed using statistical software (SPSS-22), to perform relevant statistical tests and derive meaningful results. The chi-square test performed with a P-value ≤ 0.05 is considered significant.

RESULTS

Among the 300 individuals with diabetes, 54% are men and 46% are women. The majority (65%) manage their diabetes using insulin, while 35% use medicines (Table 1). Red-green color impairments, affecting the ability to distinguish between red and green colors, are prevalent in 58% of the patients, while 42% have normal color vision.

Table 1. Frequency of Insulin and Medicines.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	INSULINE	195	65.0	65.0	65.0
	MEDICINE	105	35.0	35.0	100.0
	Total	300	100.0	100.0	

Chi-square tests (Table 2) were conducted to assess the strength of the connection between diabetes mellitus and color vision. Several tests were employed, and the results demonstrated a strong relationship.

The "Pearson Chi-Square" test yielded a value of 36.927 with 1 degree of freedom, indicating a significant relationship (Table 2). The "Continuity Correction" test resulted in a value of 35.450 with 1 degree of freedom, further supporting the significant association (Table 2). The "Likelihood Ratio" test produced a value of 39.377 with 1 degree of freedom, again indicating a strong connection (Table 2). Additionally, a "Fisher's Exact Test" showed an exceedingly low chance (significance level of 0.000) that the observed results were random, for both two-sided and one-sided tests (Table 2). The "Linear-by-Linear Association" test scored 36.804 with 1 degree of freedom, reinforcing the strong relationship between diabetes mellitus and color vision (Table 2). It's important to note that all tests exhibited a minimal likelihood of the observed relationships occurring by chance.

The "N of Valid Cases" indicates that there were 300 valid cases included in the analysis. Furthermore, the message "0 cells (0.0%) have expected count less than 5" signifies that no cell in the table had an expected count less than 5, with the lowest expected count being 43.75. In summary, these test results underscore a clear and strong association between the variables (diabetes mellitus and color vision). Overall, the results of these tests indicate that there is a clear connection between diabetes mellitus and color vision.

Table 2. Chi-Square Tests.

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	36.927[a]	1	.000		
Continuity Correction[b]	35.450	1	.000		
Likelihood Ratio	39.377	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	36.804	1	.000		
N of Valid Cases	300				

DISCUSSION

The control variable comprises two groups: Insulin and Medicine. Meanwhile, the problem variable is categorized into two types: Normal Color Vision and Red Green Deficiency. Upon examination, we observe that for the insulin category, there are 106 cases with normal color vision and 89 cases with red-green deficiency. The total count for the insulin category is 195, encompassing both types. In the medicine control group, there are 19 cases with normal color vision and 86 cases with red-green deficiency. The total count for the medicine category is 105, encompassing both types within this group. By looking at the numbers at the end, we find that there were 125 times that NCV occurred and 175 times that RGD occurred in total. The total number of observations is 300, which includes all control categories.

Macular edema is a substantial contributor to vision loss in individuals with diabetes. According to the Wisconsin Epidemiological Investigation, the incidence of macular edema in the group with a younger onset of diabetes was determined to be 20.1% over 10 years. It's important to note that the risk of vision damage can be mitigated through photocoagulation therapy [12]. There is a consensus that acquired color vision impairment serves as a sensitive and early predictor of various neurotoxic and neurodegenerative diseases. While there has been a hypothesis suggesting a link between acquired color vision impairment and diabetic retinopathy, the relationship between acquired color vision impairment and diabetes in the absence of retinopathy remains unclear [13]. Considering that all diabetics are susceptible to color vision impairment due to the presence of retinopathy and the use of photocoagulation in its treatment, it becomes imperative to acknowledge this risk, particularly in individuals with retinopathy. Proper control of the condition is of utmost importance in preventing further vision loss in this group [14]. Diabetes is associated with vision impairments in both the red/green (protan) and blue/yellow (tritan) spectrum. In cases of overt diabetic retinopathy, individuals often exhibit increased protan and tritan color thresholds. Remarkably, even before indirect funduscopy can detect retinopathy, diabetic individuals experience alterations in their color perception. The underlying cause of these acquired color vision deficits in diabetes remains unknown. It is possible that abnormalities in color vision result from irregular retinal perfusion and ischemia, which develop early in diabetic retinopathy, possibly due to relative retinal oxygen desaturation [15]. Due to the natural process of physiological aging, yellow chromospheres steadily accumulate within the lens. This accumulation results in a denser color filter, which primarily diminishes the transmission of blue light to the retina. Age-related changes in color vision test performance, as well as changes observed in individuals with diabetes, most significantly impact the blue-yellow color vision axis [16]. Previous research has demonstrated that diabetes, whether accompanied by diabetic retinopathy (DR) or not, affects various aspects of vision function. This includes contrast sensitivity, impaired color vision, multifocal visually evoked potential, and multifocal electroretinogram. In a recent study, it was reported that 50% of patients participating in the Early Treatment Diabetic Retinopathy Study exhibited impaired color vision with abnormal hue discrimination. Color vision testing serves as an effective and accurate method for quantifying damage to the retina [17]. In one study, the prevalence of impaired color vision (ICV) was found to be 43% among its participants [18]. In another study, it was reported that twenty-two percent of the 849 eligible participants exhibited impaired color vision [19].

Chi-square tests were employed to determine the strength of the association between red-green deficiency and the control of diabetes through insulin and medicine. The initial test conducted was the Pearson Chi-Square test, which yielded a test statistic value of 36.927. This test was performed with 1 degree of freedom. The corresponding p-value, which signifies the strength of the relationship between the control and defect variables, was reported as 0.000, indicating a very strong relationship. Furthermore, the Continuity Correction test also demonstrated a strong connection, with a chi-square value of 35.450, and a negligible likelihood of the relationship occurring by chance (p-value = 0.000). These test results underscore a robust and significant association between the variables under study. The Likelihood Ratio test revealed a strong relationship between the variables, with a chi-square statistic of 39.377 and a highly significant p-value of 0.000. Fisher's Exact Test, employed when dealing with small sample sizes or when the assumptions of the chi-square test are not met, also produced significant results. The test indicated a significance level of 0.000 for both the two-sided and one-sided tests, further emphasizing the substantial relationship between the variables. The Linear-by-Linear Association test underscores a strong connection between the control and defect variables. The test generated a chi-square statistic of 36.804, and it is associated with a highly significant p-value of 0.000.

These findings lead to the conclusion that there is a distinct and significant connection between the variables under control and those exhibiting defects or problems. The chi-square tests highlight substantial variations in the number of defects across different control categories. In simpler terms, the choice of treatment (insulin or medicine) appears to influence the likelihood of experiencing specific problems (NCV or RGD). It's essential to note that the sample used for these tests comprised 300 individuals, as indicated by the "N of Valid Cases" value. This reinforces the reliability and credibility of the chi-square test results.

Conclusion

In summary, the chi-square test results confirm a strong and significant connection between the choice of control (INSULIN or MEDICINE) and the occurrence of RGD defect. The data indicate that the control variable significantly influences defect frequencies, with noticeable differences between the two control categories. The Pearson Chi-Square, Likelihood Ratio, Fisher's Exact Test, and Linear-by-Linear Association tests all yielded highly significant results, based on a sample size of 300 that met the test's assumptions. These findings have substantial implications, suggesting that optimizing control measures can reduce RGD in individuals with diabetes. This insight informs strategies to enhance the management of color vision impairment in this context.

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CONFLICT OF INTEREST

N/A

AUTHOR CONTRIBUTION

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