The prevalence of dyschromatopsia in an open population in Puebla, Mexico

Prevalencia de discromatopsia en una población abierta en Puebla, México

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DOI http://dx.doi.org/10.28960/revmeduas.2007-8013.v15.n3.004

Recibido 01 de mayo 2025, aceptado 23 de junio 2025

RESUMEN
Objetivo: Determinar la prevalencia de discromatopsia en una población abierta en la ciudad de Puebla y del municipio de Chalchicomula de Sesma. **Materiales y métodos:** Estudio observacional, descriptivo de corte transversal, se estableció la presencia de deuteranopia y protanopia a través de la prueba Ishihara. **Resultados:** La muestra fue de 358 sujetos, encontrando 8 casos de alteraciones en la percepción cromática. Obteniendo que el 2.23% (8) de los participantes presentaron alteración en la visión de colores. Nuestros resultados muestran que no hay una asociación estadísticamente significativa entre el sexo (p=0.228), horas de pantalla por día (p= 0.453), y la presencia de Protanopia/Deuteranopia, sin embargo, la edad media de los participantes con discromatopsia fue significativamente mayor que la de los participantes sin discromatopsias (p = 0.043). **Conclusiones:** Al identificar la presencia de deficiencias en la percepción del color, se subraya la necesidad de mayor atención en el diagnóstico temprano y en el diseño de estrategias educativas y laborales inclusivas para mejorar la calidad de vida de las personas afectadas.
Palabras clave: Defectos de la visión del color; Deuteranopia; Protanopia; Prevalencia; Prueba de vision.

ABSTRACT
Objective: To determine the prevalence of dyschromatopsia in an open population in the city of Puebla and the municipality of Chalchicomula de Sesma. **Material and methods:** Observational, descriptive cross-sectional study, the presence of deuteranopia and protanopia was developed through the Ishihara test. **Results:** The sample was 358 people, finding 8 cases of alterations in color perception. Obtaining that 2.23% (8) of the participants presented alterations in color vision. Our results show that there is no statistically significant association between sex (p=0.228), hours of screen time per day (p=0.453) and the presence of Protanopia/Deuteranopia, however, the mean age of participants with dyschromatopsia was significantly higher than that of participants without dyschromatopsia (p=0.043). **Conclusions:** By identifying the presence of deficiencies in color perception, the need for greater attention to early diagnosis and the design of inclusive educational and work strategies to improve the quality of life of affected people is highlighted.
Keywords: Color Vision Defects; Deuteranopia, Protanopia, Prevalence, Vision Test.

Introduction

Dyschromatopsy is a disorder manifested by the deficiency, inefficiency or absence of photopigments in the cones and rods of the retina[1]. This disorder has an incidence of 5% in men and 0.7 % in women in the general population[2]. Dyschromatopsy comprises of any of the following: 1) Protanopy: absence of red photoreceptors, where the wavelength neutral point is 392 nm distinguishing it as white. 2) Deuteranopy: absence of the green photoreceptor, where the wavelength neutral point is 499nm perceiving it as white and 3) Tritanopy: absence of the blue photoreceptor, where for tritanopes the wavelength neutral point is 570nm, distinguishing it as white[3,4].

Diagnosing dyschromatopsy can be complex. However, there is the Ishihara test, a practical instrument used to evaluate color vision. The

original Ishihara test is composed of 38 pseudoisochromatic plates, where perception depends on the chromatic differences between the stimulus target and the background. It is made up of images of dots and circles of different sizes and colors that form numbers or figures visible to people with normal color vision[5]. Those with color vision problems can only identify numbers to a limited extent, and some numbers can only be seen by those with a color vision defect, while they are invisible to those with normal vision[6].

Regarding the accuracy of the Ishihara test, a study conducted in the United Kingdom evaluated the accuracy of the Ishihara test compared to the Hardy-Rand-Rittler (HRR) plates, using a sample of 486 trichromat patients. The results showed that the Ishihara test is sensitive and effective in identifying mild anomalous trichromats, with results superior to those obtained by using the HRR plates[7].

A study that was conducted in the metropolitan area of Mexico City in 2019 analyzed the prevalence of congenital and acquired dyschromatopsies of a sample of 1,646 people using ordination and pseudoisochromatic tests. The author found a prevalence of 5.65% of congenital color dyschromatopsies in men, with anomalies related to the green color being the most common[8]. The prevalence of color blindness was assessed in 243 children from three localities in Bogotá in 2012 using both the Ishihara and Fransworth tests. The prevalence in the first locality was 6.7% using Ishihara and 14.6% using Fransworth; in the second, it was 2.4% and in the third, 2.9% using Ishihara and 10% using Fransworth. The authors concluded that the higher prevalence was related to the localities and not to the differences between the tests used[9].

In 2016 an analytical cross-sectional study was conducted in three randomly selected primary schools within a district in Ethiopia with the aim of determining the extent of congenital dyschromatopsy. Ishihara plates were used in 850 students aged 8 to 18 years, of whom 452 were male and 398 females. The results showed 36 cases of color vision defects with 27 males and 9 females. Of these 36 cases 15 were deuteranopes; 7 protanopes and the rest were undifferentiated. A prevalence consistent with epidemiological studies worldwide of 4.24% was found[10].

The aim was to determine the prevalence of dyschromatopsy in an open population in the city of Puebla and the municipality of Chalchicomula de Sesma, Puebla.

Methods

The population of this study is an open population, comprising patients who attended ophthalmological consultations and those who voluntarily agreed to participate. A non-probabilistic convenience sampling was used. 358 patients (229 women and 129 men) were evaluated with ages

averaging 26.38 ± 6.41 years, and a range between 18 to 72 years. 68% of the population fall between 19.97 and 32.79 years of age. The Ishihara test was administered during the months of February and March 2024 in the city of Puebla and in the municipality of Chalchicomula de Sesma, Puebla. The study adheres to the principles of the Declaration of Helsinki and was approved by the ethics and research committee of the university Universidad de las Américas Puebla (158-09-202). Signed informed consent was required from all subjects evaluated.

Chromatic perception was determined with the use of the Ishihara pseudoisochromatic plates[11]. The Ishihara test is designed to have the person examined at a distance of 75 cm and the plate at a right angle to the line of sight in indirect sunlight. Three seconds are allowed for the reading of each of a total of 17 plates. A correct reading of 13 or more plates is considered normal color vision; a correct reading of 10 to 12 is considered anomalous and 9 or fewer plates read correctly is considered deficient color vision.

Sociodemographic variables were recorded on a spreadsheet and used for descriptive statistics and calculations of means; standard deviations; frequencies and percentages.

Results

Of the 87.4% (358) evaluated subjects included, 313 are from Chalchicomula and 12.6% (45) from the city of Puebla. Women predominate at 64% (229) versus men at 36% (129).

Participants' daily screen time was grouped in intervals with a mean of 5.33 ± 3.56 hours per day. The majority spent 6 to 10 hours per day viewing screens (Figure 1).

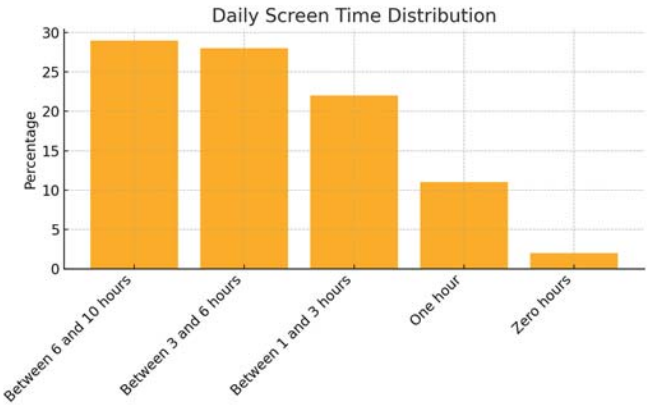

Figure 1. Daily screen time distribution (self-reported).

Color vision ranking

Chart 1 contains the results of the Ishihara test showing 8 people with color deficiency for which they are considered dichromatic; 87% (312) classify as normal and 10% (36) classify as anomalous.

Chart 1. Results of the Ishihara test classification

Classification	Results	Freq.	Percentage
Normal Vision	13 or more correct	314	87.7%
Color Deficiency	9 or fewer correct	8	2.23%
Anomalous	Between 10 and 12 correct	36	10.07%
Total		358	100%

The classification of protanopy or deuteranopy is obtained from the response to plates 16 and 17 of the Ishihara Test (see Chart 2). There was an incidence of 5 people with mild protanomaly; 2 with strong protanomaly; 5 with strong- and 2 with mild deuteranopy.

Chart 2. Results of the Ishihara Test clasiffication for protanopy or deuteranopy

Classification	Results	Frecuency
Protan (strong)	Result according to the answer key (No. 16: 6; No. 17: 2).	2
Protanomaly (mild)	Result according to the answer key (No. 16: (2) 6; No. 17: (4)2.	5
Deutan (strong)	Result according to the answer key (No. 16: 2; No. 17: 4).	5
Deuteranomaly (mild)	Result according to the answer key (No. 16: 2 (6); No. 17: 4 (2).	2

Association between sex and color vision deficit (protanopy/deuteranopy vs. normal vision)

Of the 8 cases with color deficiency 62.5% (5) were male and 37.5% (3) were female. A Chi-square test was performed to evaluate whether there was a significant association between sex and the presence of protanopy or deuteranopy. The p-value (0.228) indicated that there is no statistically significant association between sex and the presence of protanopy/deuteranopy in the data.

Relationship between age and protanopy/deuteranopy

A variance analysis was conducted (ANOVA) to compare age between groups with and without protanopy/deuteranopy. Chart 3.

Chart 3. Mean age of participants with and without protanopy/deuteranopy

Group	Age mean	Standard deviation	N
W/O protanopy/deuteranopia	34.45	12.61	350
With Protanopia/Deuteranopia	49.75	18.41	8

The variance analysis indicates a significant difference in the mean age between the groups (F (1. 274) = 4.14, p= 0.043). The mean age of the participants is significantly greater among those with protanopy/deuteranopy.

Association between screen time and protanopy/deuteranopy

Chart 4 presents the analysis of the relationship between daily screen time and the occurrence of protanopy/deuteranopy using logistic regression.

Chart 4. Logistic regression of daily screen time vs. presence of protanopy/deuteranopy

Variable	Regression coefficient	p-value	Odds Ratio (CI 95%)
Daily screen time hours	-0,041 (CI 95%: -0,104 to 0,022)	0.453	0,959 (CI 95%: 0,896 to 1,027)

No significant association was found between daily screen time and the probability of having protanopia/deuteranopy (p= 0.453). The regression coefficient (-0.041) indicates that for each

additional hour of screen time per day, the probability of having protanopy/deuteranopy decreases by 4.1%, but this effect is not statistically significant.

Discussion

This study assessed the prevalence of dyschromatopsy in an open population of Puebla, revealing a significant majority of participants from Chalchicomula de Sesma at 87% (312), which may reflect a greater willingness of individuals from this community to take part in the research.

The findings of this study using the Ishihara test are noteworthy in that among a total of 358 individuals, 87% (312) exhibited normal vision, while 2.23% (8) demonstrated color deficiency, categorizing them as dichromats. It is estimated that around 350 million people globally have some red-green color blindness as dichromats [12]. Prevalence data in Mexico are relatively scarce. A study carried out in the metropolitan area of Mexico City indicates a prevalence of color blindness of 4.13% in this region[13]. The difference presented in the above cited study may be due to the sample size, which is larger with 500 participants. In addition, this study results indicate that 10.07% of participants are classified as "anomalous", which suggest a subcategory of deficiencies that, although not qualifying as dichromatic, could require special attention. Additional research may be necessary to explore whether these individuals experience difficulties in specific contexts such as color perception in work or in educational settings.

Regarding the prevalence of color vision deficiency by gender, this study is consistent in showing a higher proportion of men as dichromatic (62%) compared to women. Studies such as that of Alarifi et al. indicate a significant difference in the prevalence of dyschromatopsia between men and women. This study showed a prevalence of dichromats of 2.6% in men and 0.38% in women, evidencing that men have a considerably higher risk of presenting this condition[14].

The low incidence of protanopy found in this study (1.4% for mild cases and 0.6% for severe cases) and deuteranopy (0.6% for severe cases and 0.4% for mild cases) is in line with existing literature on color vision deficiency (CVD). The overall prevalence of CVD is typically reported to be around 5% in men and 0.7% in women, with red-green color deficiencies—such as protanopy and deuteranopy—constituting approximately 95% of cases[15, 16].

The findings reveal a significant difference in average age between the groups with and without protanopy/deuteranopy indicating an association between these visual impairments and older age among participants. This aligns with earlier studies that have investigated the connection between age and color perception while noting

that the prevalence of color vision deficiencies may rise with age. Thus, age-related changes in visual perception could increase these disorders in older adults[17]. This phenomenon is linked to the degeneration of retinal cones in some cases, which impacts color perception over time. A study published in 2011 suggests that hereditary conditions contribute towards protanopy and deuteranopy as the population ages, since the ability to compensate for color vision deficits tends to diminish with age[18]. This suggests a higher expected frequency of these conditions among older versus younger adults.

The variance analysis shows a significant effect ($p = 0.043$), which supports age as an important factor to consider in studies of visual impairment. This finding supports understanding how aging affects not only overall visual perception but also specific conditions like protanopy and deuteranopy. Nevertheless, it is essential to acknowledge that the sample of participants with protanopy/deuteranopy was limited compared to the sample of participants without protanopy/deuteranopy, thus necessitating future studies with larger and more representative samples to validate these findings.

Although the results of this study provide valuable insights into the prevalence of dyschromatopsia in Puebla, the limitations related to sample size and study design must be acknowledged. These limitations underscore the need for further research involving larger and more representative samples to validate these findings. Additionally, future studies should investigate the practical implications of dyschromatopsia for eye health across diverse demographic groups and age ranges. To facilitate early detection, periodic eye examinations in schools and workplaces are strongly recommended.

Future research on color perception that explore variables such as diabetes mellitus along with other degenerative diseases that can affect the retina and influence the prevalence of dyschromatopsy is warranted.

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