A Comparative Study of Contrast Sensitivity among Hyperopic and Myopic Patients Visiting the Optometry Clinic in Aminu Kano Teaching Hospital Kano, Nigeria

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Abstract

Contrast sensitivity is an important component of visual function that affects real-world tasks such as driving, reading, and facial recognition, especially under low-light conditions. This study was a cross-sectional, hospital-based study to compare the contrast sensitivity performance between hyperopic and myopic adult participants attending the Optometry Clinic at Aminu Kano Teaching Hospital (AKTH), Kano, Nigeria. A total of 130 adult participants aged 18–50 years were recruited through simple random sampling. Participants had their refractive error assessment with an auto-refractor. Contrast sensitivity was measured using the Pelli-Robson chart. Data were analyzed using SPSS version 25. Independent t-tests, ANOVA, and Pearson correlation were used to compare contrast sensitivity between groups and determine the effect of age and refractive error severity. Hyperopic patients had slightly higher contrast sensitivity scores across monocular and binocular assessments, but the differences were not statistically significant ($p > 0.05$). Specifically, binocular contrast sensitivity was 1.65 ± 0.09 in hyperopic patients and 1.60 ± 0.09 in myopic patients. In myopes, contrast sensitivity improved with decreasing myopia (e.g., $r = 0.755$ for RE OD vs CS OU, $p < 0.001$). In hyperopes, contrast sensitivity declined with increasing hyperopia (e.g., $r = -0.713$ for RE OS vs CS OU, $p < 0.001$). This study revealed slightly higher contrast sensitivity in hyperopic patients, a non-significant decline with age, a strong correlation between refractive error severity and contrast sensitivity. These findings emphasize the importance of including contrast sensitivity testing in routine eye examinations to enhance clinical decision-making and patient care.

Keywords: Contrast sensitivity, Hyperopia, Myopia, visual function.

Introduction

Vision plays a central role in human interaction with the environment, with its quality being determined by various visual functions. Among these, contrast sensitivity stands out as an evaluating factor in assessing the ability to distinguish objects from their background under varying levels of contrast. Contrast sensitivity is an important measure of vision quality. Risk of falling injury is strongly associated with poor contrast sensitivity compared with poor near- and distance visual acuity[1]. Since good visual acuity is not necessarily associated with good visual performance in the "real world," it is important to consider contrast sensitivity when prescribing corrective lenses[2]. The prevalence of poor contrast sensitivity varies across the world. Vision and contrast sensitivity are closely related aspects of visual perception. Contrast sensitivity refers to the ability to distinguish between an object and its background[3].

Contrast awareness is a fundamental component of visual efficiency and is capable of performing tasks such as driving, reading, and navigation. For the calculation of refractive surgery results, contrast sensitivity is used[1]. Contrast is one of the most important requirements for healthy vision and can be influenced by many variables, unlike visual acuity[4]which measures sharpness of vision. Contrast sensitivity provides a broader understanding of visual performance, particularly in low-light or low-contrast conditions; measurement of contrast sensitivity provides vision quality[5]. A patient can have 20/20 visual acuity in many ocular diseases with loss of CS. Sometimes the loss of CS can be more psychologically disturbing than the loss of visual acuity[2].

Refractive error is one of the most common causes of vision impairment, accounting for 47% of all cases of vision impairment in high-income nations. Refractive error has a significant influence in developing countries, perhaps resulting in decreased economic production[6]. Refractive error, including hyperopia (farsightedness) and myopia (near-sightedness), is the most common cause of visual impairment. These conditions affect visual acuity and also influence contrast sensitivity. Hyperopia, marked by the eye's incapacity to focus on near objects, and myopia, associated with difficulty focusing on distant objects, may present with marked consequences on contrast sensitivity across different dimensional frequencies. For United States participants, non-Hispanic and Hispanic White races have a significantly higher risk of hyperopia in the 6 to 72-month age group[7]. Myopia and hyperopia are the most prevalent refractive errors affecting the population worldwide [6].

Contract sensitivity is reduced in variations of neurologic and ophthalmic conditions, including amblyopia, age-related macular degeneration (ARMD), glaucoma, multiple sclerosis, hypertension, glare, ocular cerebral lesions, myopia and dry eye [8].

Contrast sensitivity was also indicated as impaired in patients with early macular degeneration and cataract where visual acuity were nearly good [9]. A study on commercial drivers working in Rivers State found normal contrast sensitivity in 85% of participants, there is no general figures, and more research is required to establish prevalence 0f contrast sensitivity in the healthy Nigerian population[10].

Contrast sensitivity is an important component of visual function that influences daily activities, such as driving, reading, and recognizing faces especially under low-light or low contrast conditions. While visual acuity tests remain the gold standard for diagnosing in visual performance that significantly affect quality of life. This study will provide insight into the functional vision impairments associated with each condition, also to enhance diagnostic and management protocols by incorporating contrast sensitivity testing into routine eye examination. Contribute to academic literature and inform future research in refractive error management within the Nigeria healthcare context. Our study was planned to address these concerns by comparing the contrast sensitivity function of hyperopic and myopic participants attending the Optometry Clinic of Aminu Kano Teaching Hospital (AKTH).

Methodology

The study was carried at the optometric clinic of Aminu Kano Teaching Hospital (AKTH), Kano, within the period of 6 months (January to June, 2025). Aminu Kano Teaching Hospital (AKTH) is a tertiary hospital located in Tarauni LGA, in Kano state. It is a referral center for various eye conditions and general medical cases in Northern Nigeria.

This is a descriptive cross-sectional study designed to evaluate and compare the contrast sensitivity function in hyperopic and myopic patients, using simple random sampling techniques. The descriptive cross-sectional study design was chosen because it allows for the assessment of contrast sensitivity at a single point in time among a defined population.

The study population was patients attending an optometry clinic, examined and diagnosed with myopia and hyperopia who were between the age of 18 and 50 years. All participants had no other eye condition other than refractive error (myopia and hyperopia) based on the information retrieved from their hospital folders. The study procedure was explained to the participants. The population in this study included adults diagnosed with hyperopia or myopia, with best-corrected visual acuity (BCVA) of 6/6 (20/20) or better, who showed willingness to participate and provide informed consent. Those excluded had a history of ocular trauma or surgery, other ocular conditions, systemic conditions affecting vision such as diabetes, elderly patient due to a combination of impaired cognitive function, sensory deficits (like vision loss from their refractive status) and unwillingness to participate and provide informed consent, physical limitations affecting participation and difficulties with understanding complex information. These will hamper their ability to make a decision based on comprehensible details and the ability to reason, which are keys of informed consent.

The sample size was calculated using Cochran's formula, from the prevalence reported by a study in Kano, Nigeria[11].

The sample was calculated using Cochran's formula:

$$N = \frac{Z^2 \times P \times (1-P)}{D2}$$

Where;

n = the desired sample size (when population >10,000)

z = Standard error of the mean, which corresponds to a 95% confidence level (1.96)

p =prevalence of myopia (0.09 for myopia prevalence in Kano[11].

q = 1 − p

d = Precision with which P is determined, 0.05

$$n = \frac{(1.96)^2 \times 0.09 \times (0.91)}{(0.05)^2}$$

$$n = \frac{(3.8416 \times 0.0819)}{(0.0025)}$$

$n = 125$

With an attrition factor of 10% which is 5.9

Total sample size=125 + 13

$n = 138$

Instruments used were Snellen charts to confirm visual acuity, ophthalmoscope, slit lamp biomicroscope, Pelli-Robson, Auto-Refractor for objective refraction, trial lens box and patients hospital folder. The data collected were the age, gender, visual acuity, type and degree of refractive and ocular health (to exclude those associated ocular conditions like cataract, retinitis pigmentosa, etc) of the participants,

Participants were given a detailed explanation of the study and asked to sign a written informed consent form before proceeding. The illuminated Snellen chart (literate and illiterate) was used measure the visual acuity and the best-corrected visual acuity at 6 meters; external and internal examinations were carried out using pen torch for external examination while an ophthalmoscope and a slit lamp were used for internal examination to rule out ocular conditions (glaucoma, hypertensive retinopathy, cataract, age related maculopathy, etc) that influence contrast sensitivity. An auto-refractor was used to measure the participant's objective refraction; while subjective refraction was performed using trial lenses and trial frame to confirm the type and degree of refractive error of the participants. In this study, myopia was defined as a spherical equivalent (SE) of −0.5 diopter (D) or less, and hyperopia was an SE of 0.5D or more. Further classifications in degree included low, moderate, and high myopia as an SE of −0.5 to less than −3.0D, −3.0D to less than −6.0D, and less than −6.25D, respectively. To classify hyperopia, we used SE ranges of

+0.5 to less than +3.0D, +3.0D to less than +6.0D, and less than +6.25D for low, moderate, and high hyperopia, respectively.

The contrast sensitivity was measured using Pelli-Robson. The test was conducted in a well-lit room with standardized illumination. Participants were positioned at a 1-meter distance from the chart while wearing their best corrected prescriptions. This helped us to determine the effect of contrast sensitivity on corrected hyperopia and myopia. Participants were asked to read the letter on the contrast sensitivity chart from top to bottom. The letters gradually become less visible (lower contrast) as the participants move down the chart. The lowest contrast level at which the participant can correctly identify two out of three in a triplet were recorded as their contrast sensitivity score.

The study data were analyzed and managed using SPSS (version 25). Descriptive statistics for summarizing demographic data, an independent t-test was used to compare contrast sensitivity between hyperopic and myopic groups. ANOVA was used to evaluate differences in contrast sensitivity across spatial frequencies. A p-value <0.05 will indicate statistical significance. The results were presented using tables, graphs, and charts for clarity.

Ethical approval was obtained from the research ethics committee of Bayero University Kano, Health Research Ethics Committee (NHREC/BUK-607/10/2311), by the tenets of Helsinki. Informed consent was obtained from all participants before the study began. The confidentiality of participants' data was ensured, and they have the right to withdraw from the study at any point.

Results

A total of 130 adult participants aged 18–50 years, with a male to female ratio of 1:1.2. They comprised 50 myopia patients with a mean ± standard deviation age of 36.14 ± 9.87 and 80 hyperopia patients with a mean age of 35.59 ± 9.34. (Tab.1) The age distribution was between 18 and 50 years. The participants between the ages of 31-40 have the highest frequency [myopia 16(12.3%) and hyperopia 31(23.9%) respectively] among the participants. (Tab.1) Majority of the Participants had low degrees of severity of myopia 30(23.1%) and hyperopia 50 (38.5%). (Tab.1)

Table 1: Demographic data of the participants for myopia and hyperopia cases.

	Myopia Frequency	**Hyperopia Frequency**
Gender		
Male	24	35
Female	26	45
Total	50	80
Age Group		
18-20	5	9
21-30	9	14
31-40	16	31
41-50	20	26
Total	50	80
Degree of severity		
Low (±0.25 D to ±3.00 D)	30	50
Moderate (±3.25D to ± 6.00 D)	15	19
High (≤±6.25 D)	5	11
Total	50	80

Table 2 shows contrast sensitivity performance in adult myopic and hyperopic participants, which indicates no significant difference ($p < 0.05$). There was no significant difference ($p < 0.05$) between the age groups and contrast sensitivity performance in myopic and hyperopic participants. (Tab.3)

Table 2: Contrast sensitivity performance in adult myopic and hyperopic participants

Variables	CS Right Eye	CS Left Eye	CS Both Eye
Myopia	1.55 ± 0.09	1.55 ± 0.08	1.60 ± 0.09
Hyperopia	1.60 ± 0.09	1.59 ± 0.10	1.65 ± 0.09
t-value	-3.144	-2.666	-3.138
p-value	0.899	0.165	0.954

Values are mean ± standard deviation (SD).

Values with $p>0.05$ are not significant

CS: Contrast Sensitivity

Table 2: Contrast sensitivity of the age groups in myopic and hyperopic participants

	Myopia			Hyperopia		
Age Groups	CS of OD	CS of OS	CS of OU	CS of OD	CS of OS	CS of OU
18-20	1.55 ± 0.07[b]	1.54 ± 0.07[b]	1.60 ± 0.07[b]	1.60 ± 0.07[b]	1.61 ± 0.08[b]	1.65 ± 0.07[b]
21-30	1.59 ± 0.06[b]	1.57 ± 0.08[b]	1.64 ± 0.06[b]	1.60 ± 0.09[b]	1.58 ± 0.09[b]	1.65 ± 0.09[b]
31-40	1.55 ± 0.11[b]	1.55 ± 0.09[b]	1.60 ± 0.10[b]	1.59 ± 0.10[b]	1.57 ± 0.10v	1.64 ± 0.10[b]
41-50	1.54 ± 0.08[b]	1.53 ± 0.09[b]	1.59 ± 0.08[b]	1.61 ± 0.09[b]	1.60 ± 0.10[b]	1.66 ± 0.09[b]
p-value	Right eye	Left eye	Both eyes			
	0.088	0.215	0.100			

Values are mean ± standard deviation (SD).

Values with p>0.05 are not significant
Values with the same superscript are not statistically different from each other (p>0.05)
CS: Contrast Sensitivity

The association between Refractive Error (RE) and Contrast Sensitivity (CS) indicated a significant positive correlation (p = <0.001) in myopic participants, while a strong significant negative correlation (p = <0.001) existed between Refractive Error (RE) and Contrast Sensitivity (CS) in hyperopic participants. (Tab.4)

Table 4: Correlation between the degree of refractive error and contrast sensitivity

Cases	Variables	Pearson Correlation coefficient (r)	p-value	N	Interpretation
Myopia	RE OD vs CS OD	0.748**	<0.001	50	Strong significant positive correlation
	RE OD vs CS OS	0.708**	<0.001	50	Strong significant positive correlation
	RE OD vs CS OU	0.755**	<0.001	50	Strong significant positive correlation
	RE OS vs CS OD	0.751**	<0.001	50	Strong significant positive correlation
	RE OS vs CS OS	0.712**	<0.001	50	Strong significant positive correlation
	RE OS vs CS OU	0.758**	<0.001	50	Strong significant positive correlation
Hyperopia	RE OD vs CS OD	-0.712**	<0.001	80	Strong significant negative correlation
	RE OD vs CS OS	-0.657**	<0.001	80	Strong significant negative correlation
	RE OD vs CS OU	-0.712**	<0.001	80	Strong significant negative correlation
	RE OS vs CS OD	-0.713**	<0.001	80	Strong significant negative correlation
	RE OS vs CS OS	-0.661**	<0.001	80	Strong significant negative correlation
	RE OS vs CS OU	-0.713**	<0.001	80	Strong significant negative correlation

RE: Refractive Error, CS: Contrast Sensitivity, OD: Right Eye, OS: Left Eye, OU: Both Eye
***. Correlation is significant at the 0.01 level (2-tailed).*

Discussion

Refractive errors are one of the known factors of decline in contrast sensitivity among patients[12]. Improvement of a patient with sharp vision, refractive error plays an important role in his/her quality of life[13, 14]. The findings of the current study revealed that although hyperopic participants had slightly higher contrast sensitivity scores than the myopes across monocular and binocular testing; these differences were not statistically significant. This outcome is in agreement with a previous research that found no significant difference in contrast sensitivity among different types of refractive errors after correction[1] and observed that mild and moderate degrees of refractive error tend to show normal contrast sensitivity when adequately corrected [15].

Our study agreed with another study conducted in Pakistan[16], reported slightly higher contrast sensitivity in hyperopes, particularly in binocular measurements, though without statistical significance. The slight elevation in contrast sensitivity scores among hyperopes could be ascribe to retinal adaptation mechanisms or well organized cortical processing in hyperopia under full correction, but the findings across studies remain indecisive.

This study showed no significant difference ($p < 0.05$) between the age groups and contrast sensitivity performance in myopic and hyperopic. Majority of our participant were below forty years and so cannot be generalised. While a study carried out in China [17], reported that age is a major factor affecting contrast sensitivity performance, regardless of refractive status. Contrast sensitivity is imparted by age as seen in many studies, which reported a generally lower contrast sensitivity function in older populations [17, 18]. This may be due to decreased pupil size[19], decreased cone cell density[20] with age, the other age-related optical and neural changes, and increased high-order aberrations [21].

The most prominent finding in the analysis was the strong and statistically significant correlation between refractive error severity and contrast sensitivity:

In myopic participants, a positive correlation was found, showing that contrast sensitivity improves as the refractive error becomes less severe (closer to emmetropia). This means that as the eye's focusing ability becomes less myopic, contrast sensitivity, or the ability to distinguish between subtle differences in brightness of color, tends to increase according to some vision studies[12].

This result aligns closely with another study in India[19], which reported that higher degrees of myopia are associated with significantly poorer contrast sensitivity. Similarly, a study conducted at the New England College of Optometry[23]found out that peripheral contrast sensitivity decreases more in myopes under attentional demand, which may reflect neural adaptation or structural elongation effects.

In hyperopic patients, a negative correlation was observed, meaning contrast sensitivity worsens with increasing hyperopia. Both hyperopia and contrast sensitivity tend to move in opposite directions to ward as the degree of hyperopia increases; contrast sensitivity decreases, and vice versa. Our findings were similar to those carried out in India and Lahore, Pakistan [12, 16]. The current findings reinforce that higher refractive error magnitudes negatively affect retinal image quality and visual processing efficiency, even when acuity appears corrected on a Snellen chart.

Limitations of the study

Factors such as lighting conditions and testing protocols could influence the outcomes, and also the severity of the condition, such as patient with high myopia and high hyperopia were difficult to find, this is the reason why they have the least number in this research. This study depends on specific populations and may not be generalizable (excluding pediatrics and geriatric participants).

Conclusion

This study indicated that hyperopic participants had slightly higher contrast sensitivity scores across monocular and binocular assessments, but the differences were not statistically significant ($p > 0.05$). The association between Refractive Error (RE) and Contrast Sensitivity (CS) indicated a significant positive correlation ($p = <0.001$) in myopic participants, and a strong significant negative correlation ($p = <0.001$) in hyperopic participants. Myopic participants showed improvement in contrast sensitivity with low degree of severity of myopia. Binocular contrast sensitivity was congruously excessive than monocular sensitivity across both refractive. In this study, there was no significant difference ($p <0.05$) between the age groups and contrast sensitivity performance in myopic and hyperopic participants which may be due to age limit of the participants. These findings emphasize the importance of including contrast sensitivity testing in routine eye examinations to enhance clinical decision-making and patient care.

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