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Assessment of Contrast Sensitivity in Myopic and Hyperopic Patients

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Abstract

To evaluate the potential effect of refractive error on visual acuity (VA) performance and contrast sensitivity function (CSF). We examined 240 eyes of the 120 participants, and they were divided into six groups (mild & moderate hyperopia, severe hyperopia, mild myopia, moderate myopia, severe myopia, and emmetropia) according to their spherical equivalent (SE). In severe myopia there was a statistically significant reduction in the contrast sensitivity function when the spherical equivalent is more than -10 diopters. Also, we found normal contrast sensitivity in hyperopic groups, mild & moderate myopic groups, and emmetropic groups. There was a negative correlation of contrast sensitivity functions with BCVA of studied participants whose correlation coefficient was r -0.566** & (P-value 0.000), while there was a positive correlation of contrast sensitivity function with SE whose correlation coefficient was r 0.310**& (P-value 0.000). VA and CS are two different but equally important metrics for assessing visual function. The VA defines visual performance in high-contrast settings, whereas CS testing examines visual function across a range of spatial frequencies and luminance. We noticed the visual performance impairment regardless of the optimum optical correction of high myopic participants.

Keywords: Contrast sensitivity**,** Visual acuity, Uncorrected visual acuity, Best-corrected visual acuity.

1. Introduction

Several types of assessments, such as visual acuity and contrast sensitivity function, have been developed throughout the years to assess visual processing in individuals [1]. The processing of visual information is referred to as visual perception. Object processing and spatial processing are the two types of processes [2]. Contrast sensitivity (CS) refers to the ability of the visual system to differentiate edges in a scene and effectively define the borders of objects [3]. So, contrast sensitivity testing is recommended for use in low vision clinics since it provides extra information on visual quality, and it can also be used to evaluate the results of refractive surgery

[4]. CS is also a helpful measure of visual function in evaluating patients with cataract, glaucoma, diabetic retinopathy, and macular degeneration which often impaired CS significantly [5]**.**

Visual acuity (VA) is the most commonly used psychophysical test, Standard visual acuity measurement is done with high contrast conditions. This does not provide any information about visual performance in many of the various activities, such as driving at night or reading in low light, and a patient's vision cannot be fully assessed by evaluating visual acuity alone [6]**.**

Contrast sensitivity is one of the most important aspects of good vision, and unlike visual acuity, it may be affected by many factors [7]**,** such as refractive errors and there is a relationship between the spherical equivalent and contrast sensitivity threshold [8].

There are numerous contrast sensitivity charts depending on the type of stimuli**.** The most commonly used are Sine-wave or periodic contrast sensitivity tests; Sinewave, periodic, or grating tests, consist of a repeated number of dark and light bars called cycles, Letter contrast sensitivity tests; Letter charts offer a large number of readily identifiable visual stimuli, Pelli Robson chart is one of the letter contrast sensitivity charts [9].

The Pelli Robson chart is probably the most commonly used chart, which is a quick, reliable, and repeatable means for studying contrast sensitivity. The chart presented with 59 x 84 cm letters at 1 meter (equivalent to 6/200) recommended a testing distance that corresponded to a spatial frequency of about 1 cycle per degree (cpd) [9].

It was composed of 16 different contrast levels, arranged in eight rows of two triplets each. The contrast of each triplet decreased by a factor of 0.15 log units. The contrast was tested to range from 100% to 0.56%. The size of the letters was 4.9 X 4.9 cm (2 X 2 inches). The letters on the left of the top line had the highest contrast, 100%, and the letters on the right of the bottom line had the lowest contrast, 0.6% [9].

The aim of the work was the assessment of contrast sensitivity (CS) in myopic and hyperopic patients.

2. Patients and Methods

This was a prospective, cross-sectional, observational, non-interventional study. It was carried out at the outpatient clinic of Al-Zahraa University Hospital, Faculty of Medicine (For Girls), Al-Azhar University.

2.1 Period of study

From June 2021 to December 2021.

2.2 The population of study

The study included 240 eyes from 120 patients.

2.3 All study participants were divided into six groups as follows

Group 1 (G1): Twenty mild to moderate hyperopic subjects (spherical equivalence (SE) within the range of +0.5 D to +2.5 D).
Group 2 (G2): Twenty severe hyperopic subjects (SE more than +2.5 D).
Group 3 (G3): Twenty mild myopic subjects (SE within the range of -0.5 diopter (D) to -2.5 D and with astigmatism not exceeding 0.5 D in either eye).
Group 4 (G4): Twenty moderate myopic subjects (SE within the range of -2.5 D to -5.0 D).
Group 5 (G5): Twenty severe myopic subjects (SE more than -5.0 D).
Group 6 (G6): Twenty emmetropic subjects (SE between -0.5 D & +0.5 D).

2.4 Inclusion criteria:

All participants had with-the-rule astigmatism less than ± 2.00D, clear lens and no eye diseases other than refractive error. Age ranged from 20 to 60 years old. Both sexes were included.

2.5 Exclusion criteria:

The patients excluded from the study were: A best-corrected distance VA (BCDVA) less than 6/60 in either eye. Patients having macular pathology like Cystoid macular edema (CME), Central serous retinopathy (CSR), diabetic maculopathy and Age related macular degeneration (ARMD). Patients with a history of recent ocular surgery that could possibly interfere with the interpretation result, cataract, Contact lens wearers and Severe dry eye.

2.6 Ethical consideration

This study was approved by the ethics committee of Faculty of Medicine for Girls Al-Azhar University. Informed consent was obtained from each participant after explaining the purpose of the study.

2.7 Study design

2.7.1 Demographic data

History taking (Age, gender, history of Diabetes Mellitus, Hypertension, past history of any ocular surgery, refractive surgery or ocular trauma).

2.7.2 Full ophthalmological examination

Included slit lamp biomicroscopy of the anterior and posterior segments with pupillary dilation was performed to identify any eye diseases in each subject prior to enrollment using TOPCON slit-lamp (TOPCON Corporation, Tokyo, Japan). All participants had with-the-rule astigmatism no greater than ± 2.00D and no eye diseases other than refractive error. The interocular difference in refractive error of each subject was less than 1.00D.

2.7.3 Assessment of refractive error:

Cycloplegic refractions were achieved with the installation of three drops of Cyclophrine 1% eye drop (cyclopentolate 1%+phenylephrine 10%, producing company: Alcon) separated by 5 minutes before enrollment using a NIDEK autorefractometer (NIDEK corporation, Gmagori Aichi, Japan). Cycloplegic refraction measurement commenced 30 min after the first drop of Cyclophrine.The spherical equivalent refraction (SER) was the algebraic addition of the spherical power and half the cylindrical power.

2.6.4 Assessment of VA

Measurement of uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA) using Landolt's broken ring chart. All types of VA were converted to LogMAR VA chart for statistical purposes.

2.6.5 Assessment of Contrast sensitivity

CS function was assessed with the Pelli Robson chart (figure 1). It was administered at one (1) meter and all patients had to wear their correction with an addition of +0.75 DS for the shortened working distance.
We examined each eye separately (monocular) and then both eyes together (binocularly).
The contrast sensitivity was done in photopic conditions.
The logarithmic contrast sensitivity value of the last triplet of which at least 2 letters were correctly seen was marked as the result. We used the Pelli-Robson scoring sheets to determine the contrast sensitivity scores (figure 2).
A Pelli-Robson score of 2.0 indicates normal contrast sensitivity of 100 percent. Scores less than 2.0 signify poorer contrast sensitivity. Pelli-Robson’s contrast sensitivity score of less than 1.5 is consistent with visual impairment and a score of less than 1.0 represents visual disability.

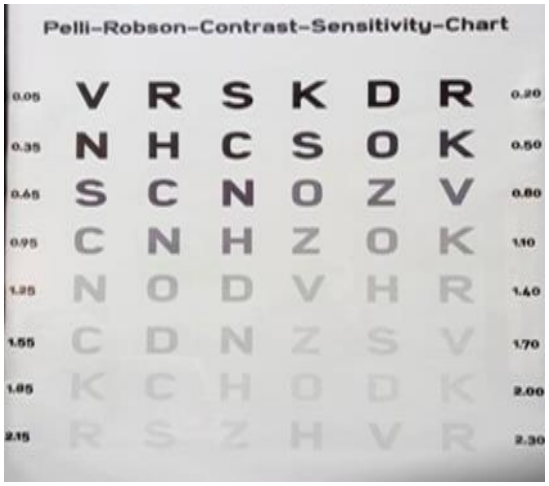

Figure (1): Pelli Robson contrast sensitivity chart.

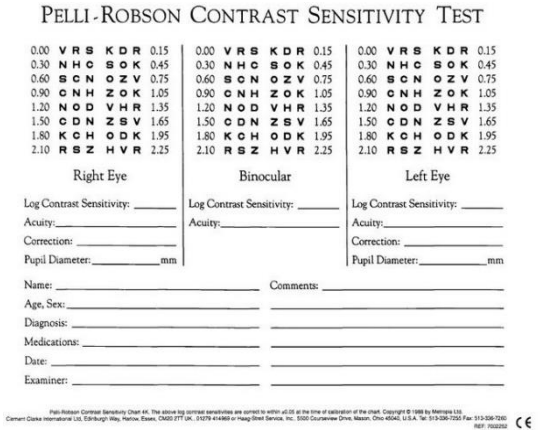

Figure (2): Pelli Robson contrast sensitivity scoring sheet.

2.7 Statistical Analysis

Data were collected, revised, coded and entered to the Statistical Package for Social Science (SPSS) version 23; released 2015 for IBM Corporation, Armonk, New York, United States.

The quantitative data were presented as mean, standard deviations and ranges when parametric. Also, qualitative variables were presented as number and percentages. The comparison between groups with qualitative data was done by using Chi-square test. The comparison between two groups with quantitative data and parametric distribution were done by using independent t-test. The comparison between more than two groups with quantitative data and parametric distribution were done by using One Way ANOVA test.; while the comparison between more than two groups with quantitative data and non-parametric distribution was done by using Kruskall Wallis test. Spearman correlation coefficients were used to assess the correlation between two quantitative parameters in the same group. The confidence interval was set to 95% and the margin of error accepted was set to 5%. So, the p-value was considered significant as the following: $P > 0.05$: non-significant. $P < 0.05$: Significant. $P < 0.01$: Highly significant.

3. Results

As shown in table 1 a total of 120 subjects with a mean age of 30.04 ± 7.00 years (range 20–48 years) were enrolled. The hyperopic group mean age was 30.78±6.57 (range 23 – 47), the myopic group mean age was 28.20±6.56 (range 20 – 48), and the emmetropic group mean age was 31.05±7.88 (range 20 – 43). There was no statistically significant difference regarding age between the three studied groups with (p-value 0.103). Females in hyperopic groups accounted for 82.5%, while males accounted for approximately 17.5% of the total, females made up 51.7%, whereas males made up 48.3% of myopic groups and the emmetropic group had 90.0% females and 10.0% males. There was a statistically significant difference found between the groups studied regarding uncorrected visual acuity & BCVA with (P-value 0.000).

3.1 Refractive errors

As shown in Table .2, There was a statistically significant difference found between studied groups regarding SE with (P-value 0.000).

3.2 Contrast sensitivity (Cs)

As shown in table 3 There was a statistically significant difference between the myopic and hyperopic groups compared with the emmetropic group with (p-value 0.014) when examined each eye

separately, while there was no significant difference between the hyperopic group and the myopic group, and there was no statistically significant difference between studied groups regarding the contrast sensitivity function of both eyes together

3.3: One Way ANOVA test

As shown in table 4 There was a statistically significant difference found between studied subgroups regarding the contrast sensitivity function of the right and left eyes of studied patients separately (monocular) with (p-value 0.000) while there was no statistically significant difference found between studied groups regarding the contrast sensitivity function of both eyes together (binocular) with (p-value 0.421).

3.4 Relationship of refractive errors, VA and CSF

There was a negative correlation of contrast sensitivity functions with BCVA of studied participants whose correlation coefficient was **r -0.566**** & (P-value 0.000), while there was a positive correlation of contrast sensitivity function with SE whose correlation coefficient was **r 0.310****& (P-value 0.000). There was no correlation of contrast sensitivity function with age, VA

Table (1): Assessment of uncorrected visual acuity (Log Mar) & BCDVA (Log Mar) in the study groups.

		Mild and moderate hypermetropia	Severe hypermetropia	Mild Myopia	Moderate Myopia	Severe Myopia	Emmetrope	Test value‡	P-value
		No. = 40	No. = 40	No. = 40	No. = 40	No. = 40	No. = 40		
UCVA	Mean ± SD	0.33 ± 0.19	0.55 ± 0.28	0.33 ± 0.24	0.62 ± 0.50	0.82 ± 0.56	0.05 ± 0.08	94.347	0.000
	Range	0 – 0.778	0 – 1.3	0 – 0.778	0 – 1.3	0.178 – 1.477	0 – 0.176		
BCVA	Mean ± SD	0.07 ± 0.11	0.08 ± 0.14	0.01 ± 0.04	0.03 ± 0.09	0.31 ± 0.15	0.00 ± 0.00	121.391	0.000
	Range	0 – 0.301	0 – 0.477	0 – 0.176	0 – 0.477	0 – 0.477	0 – 0		

P-value >0.05: Non-significant (NS); P-value <0.05: Significant (S); P-value< 0.01: highly significant (HS) ‡: Kruskal Wallis test

Table (2): The SE measurements among the study groups.

		Mild and moderate hypermetropia	Severe hypermetropia	Mild Myopia	Moderate Myopia	Severe Myopia	Emmetrope	Test value	P-value
		No. = 40	No. = 40	No. = 40	No. = 40	No. = 40	No. = 40		
SE	Mean ± SD	1.34 ± 0.43	3.23 ± 1.04	-1.31 ± 0.62	-3.39 ± 0.93	-11.45 ± 4.76	-0.07 ± 0.34	230.681	0.000
	Range	0.75 – 2.5	1.75 – 5.75	-2.5 – 0	-5 – -0.75	-17.75 – -6.5	-0.5 – 0.5		

P-value >0.05: Non-significant (NS); P-value <0.05: Significant (S); P-value< 0.01: highly significant (HS): Kruskal Wallis test

Table (3): The contrast sensitivity function assessment of the studied groups.

		Hypermetropia group	Myopia group	Emmetrope group	Test value•	P-value	Sig.
		No. = 80	No. = 120	No. = 40			
CST	Mean ± SD	2.22 ± 0.14	2.16 ± 0.23	2.25 ± 0.00	4.370	0.014	S
	Range	1.55 – 2.25	1.55 – 2.25	2.25 – 2.25			
CST both eye	Mean ± SD	2.25 ± 0.00	2.25 ± 0.01	2.25 ± 0.00	0.496	0.610	NS
	Range	2.25 – 2.25	2.25 – 2.3	2.25 – 2.25			

P-value >0.05: Non-significant (NS); P-value <0.05: Significant (S); P-value< 0.01: highly significant (HS)

Table (4): The contrast sensitivity function assessment of the studied subgroups.

		Mild and moderate hypermetropia	Severe hypermetropia	Mild Myopia	Moderate Myopia	Severe Myopia	Emmetrope	Test value•	P-value
		No. = 40	No. = 40	No. = 40	No. = 40	No. = 40	No. = 40		
CST	Mean ± SD	2.21 ± 0.16	2.23 ± 0.11	2.25 ± 0.00	2.25 ± 0.00	1.99 ± 0.34	2.25 ± 0.00	16.498	0.000
	Range	1.55 – 2.25	1.55 – 2.25	2.25 – 2.25	2.25 – 2.25	1.55 – 2.25	2.25 – 2.25		
both eye	Mean ± SD	2.25 ± 0.00	2.25 ± 0.00	2.25 ± 0.00	2.25 ± 0.00	2.25 ± 0.00	2.25 ± 0.00	1.000	0.421
	Range	2.25 – 2.25	2.25 – 2.25	2.25 – 2.25	2.25 – 2.25	2.25 – 2.25	2.25 – 2.25		

P-value >0.05: Non-significant (NS); P-value <0.05: Significant (S); P-value< 0.01: Highly significant (HS). •: One-way ANOVA test.

Table (5): The correlation of contrast sensitivity function in each eye with age, VA, BCVA& SE.

	CST	
	r	**P-value**
Age	-0.060	0.518
Visual acuity	0.034	0.605
BCVA	-0.566**	0.000
SE	0.310**	0.000

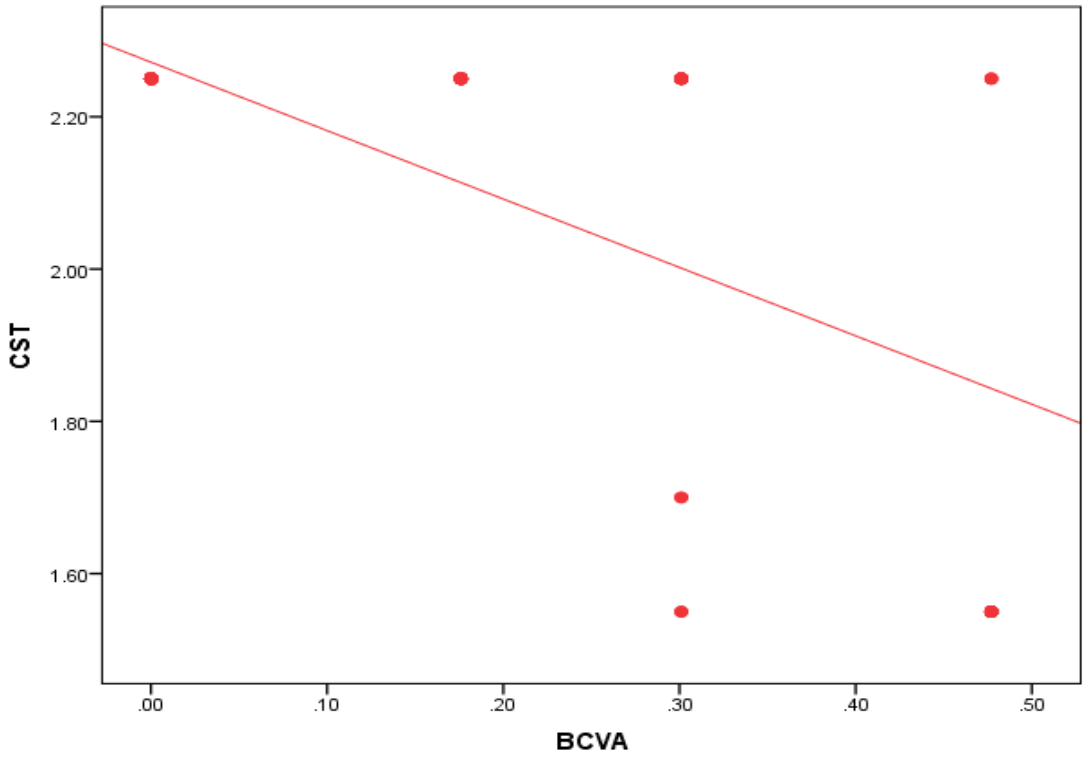

Figure (2): Shows the correlation between CST & BCVA.

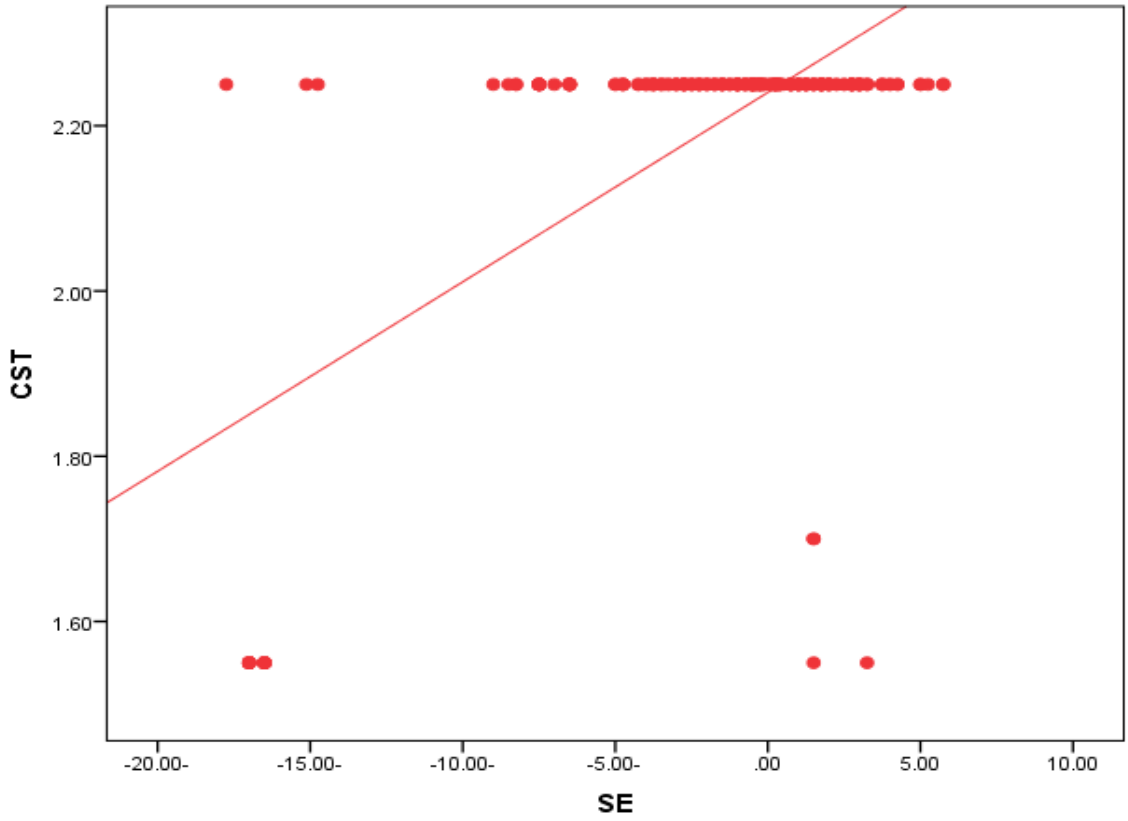

Figure (3): Shows the correlation between CST & SE.

4. Discussion

Contrast sensitivity (CS) is an important measure of visual function; it is the ability to detect a difference between the luminance of an object and its background. However, the varying levels of contrast presented in a CS test more accurately represent variations common to everyday visual experience [10]. The current study was designed to evaluate the effects of refractive errors on contrast sensitivity function. This study proved that in severe myopia there was a reduction in the contrast sensitivity function when the spherical equivalent is more than -10 dioptres. Also, we found normal contrast sensitivity in hyperopic groups, mild & moderate myopic groups, and emmetropic groups.

Because numerous ophthalmological disorders impair the contrast sensitivity function, all individuals in our study had a negative medical history and were free of pathological eye conditions.

When we tested the contrast sensitivity function with the best correction of the participants, we found that there is impairment in the CS in high myopic participants with a mean SE (-11.45 ± 4.76) range (-17.75 – -6.5), while a mean BCVA (0.31 ± 0.15) range (0 – 0.477), which the mean contrast sensitivity values (log units) in these participants were (1.99 ± 0.34) range (1.55–2.25) which was statistically significant with (p-value 0.000).

Our results were similar to those done by Bilal et al. [8] who recorded that despite excellent visual acuity corrections, myopic eye show a decreased sensitivity to contrast compared with emmetropes, also, these results were matched with Ang et al. [11] who reported the association between refractive error with reduced BCDVA and CS in a large population with high myopia. And in accordance with our result Hashemi et al. [12] The contrast sensitivity function was worse in high myopes.

On the contrary, Habiba & Hussain. [13] showed that the Contrast sensitivity was affected more in hyperopic anisometropic patients than in myopic anisometropia patients. Patients with mild to moderate myopia had normal contrast sensitivity, while those with severe myopia had impaired contrast sensitivity but hyperopes have reduced contrast sensitivity as compared to myopes.

Also, Li et al. [6] showed that contrast sensitivity was likely reduced in hypermetropia compared to the other refractive statuses. However, Zocher et al. [14] found hyperopic eyes had lower contrast sensitivity than myopic eyes, but this was due to increasing hyperopia with age in the population, so age was the predominant factor rather than hyperopia.

On other hand, Sun et al. [15] found there was no statistically significant difference in CS scores between myopes with correction, emmetropes, and hyperopes with correction. Additionally, Xu et al. [16] showed that myopes and emmetropes had identical contrast sensitivity functions.

Finally, our findings proved that the functional performance of myopic eyes decreased compared with hyperopic & emmetropic eyes, in which BCDVA and CS decreased with increasing myopia.

These findings can be used as a guide for determining contrast sensitivity in the general population of people aged 45 to 60. Contrast sensitivity, as a measure of visual quality, deteriorated in high myopes.

The current study's limitations include a small sample size, but it serves as a foundation for a larger, more conclusive sample size. Another limitation is that most of the high myopic participants have astigmatism more than 2 but our study should include participants with cylinders of no more than 2. There were also some people who were not educated enough to understand the letter's contrast sensitivity chart (Pelli Ropson chart) when we applied it.

5. Conclusion

VA and CS are two different but equally important metrics for assessing visual

function. The VA defines visual performance in high-contrast settings, whereas CS testing examines visual function across a range of spatial frequencies and luminance, and it's a good way to figure out what the visual system can do. Many clinical researchers, on the other hand, are prone to neglect CS. Regardless of the optimum optical correction of high myopic participants, we recognized the visual performance impairment so more research is needed to establish an up-to-date reference of the candidate population in need of CSF testing, particularly for those whose CSF levels are low while BCDVA is normal.

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Conflicts of interest:

There is no conflict of interest.

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