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Original Article

Normative values of Pelli Robson contrast sensitivity test in southeast Iran: A tropical area

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Abstract

Introduction: This study aimed to evaluate the distribution of contrast sensitivity (CS) using Pelli Robson test in normal individuals over seven years old living in Zahedan and examine its relationship with age, gender, and refractive errors.

Methods: In this cross-sectional study, simple sampling was performed on the patients aged over seven years and their attendants who had referred to Al-Zahra eye hospital in Zahedan. Complete ophthalmic examinations including vision and refraction assessment, biomicroscopy, and CS evaluation were carried out for all subjects. To evaluate CS, Pelli Robson chart was used at a distance of one meter. The logarithmic CS value of the last triplet in which the patient could accurately read two words was regarded as his/her CS value.

Results: Of the 150 patients (300 eyes), 70 (46.66%) were male. The mean age of the subjects was 34.56±16.15 years (ranged from seven to 78 years). The mean and standard deviation of the CS score in two modes of monocular and binocular vision were 1.45±0.19 and 1.57±0.19 log unit, respectively. The mean CS score was not significantly different between men and women ($P>0.454$), but it decreased significantly with the age ($P=0.000$). CS was higher in individuals with emmetropia than those with myopia and hypermetropia ($P=0.000$). There was also a significant correlation between cylinder magnitude and CS ($P=0.000$).

Conclusion: Although Pelli Robson test evaluates CS at low and constant spatial frequencies, its distribution is significantly different among different age groups and even among individuals with different values of refractive errors.

Introduction

Contrast sensitivity (CS) assessment is a valuable supplement to traditional visual acuity tests that ought to be integrated in the optometric examination of patients with normal vision.[1-3]

There is evidence suggesting that visual acuity might be quite normal in some ocular pathologies like optic neuritis, glaucoma, cataract, diabetes, and multiple sclerosis, despite a decrease in CS especially at middle or low spatial frequencies.[4,5] Moreover, it has been observed that dry eye syndrome negatively affects several aspects of visual function, including CS, even though one might have a normal visual acuity.[6] In fact, contrast tests can provide useful information about patient's visual function which is not dependent on visual acuity.[2]

Furthermore, CS examination is a key test after cataract and refractive surgery and is proposed as an indicator of surgical quality.[7,8] A decrease in CS can affect daily activities, such as driving, reading, walking, performing computer tasks, and recognizing faces. As a result, it impairs the overall quality of life.[9,10]

The Pelli Robson chart is a quick, repeatable, reliable, and most widely used CS test. It utilizes psychophysics of letter recognition and comprises printed letters of a fixed size but declining contrast. The reliability of this tool and its effectiveness and easy integration into regular optometric tests has been confirmed.[11,12]

The epidemiologic information regarding CS is limited. A variety of techniques are available for examining CS. This diversity could be recognized in previous studies on the normal distribution of CS in healthy people.[13-15] Additionally, there is insufficient normal age-related data on Pelli Robson test.[11,12] To determine whether a patient has reduced CS, normal values of the test have to be accessible for making necessary comparisons. Consequently, due to the fact that optical and neural characteristics of the visual system change considerably throughout one's lifetime,[14,16] this study aimed at collecting these data in various age groups with healthy eyes.

On the other hand, previous studies have shown that ethnic, racial, and geographical differences significantly affect the structure and function of eye,[17] as higher prevalence of cataract, dry eye syndrome, and pterygium is reported in tropical areas compared to other climatic

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conditions. Sistan and Baluchestan province is located in the tropical region[18] and given the importance of ethnicity and climate on the structure and function of eye,[17,19] we aimed to use Pelli Robson chart in order to, first, evaluate CS distribution in healthy people aged over seven years who live in Zahedan and, second, explore its relationship with age, gender, and refractive errors.

Methods

This is a cross-sectional study. Simple sampling was conducted among patients and the attendants aged seven and over who had referred to Al-Zahra eye hospital in Zahedan between October 2018 and June 2019. After explaining the purpose of the study and the procedure, a written consent was obtained from all participants or their legal guardians before the ophthalmic examinations. All patients were asked about their medical and ophthalmic histories prior to undergoing ophthalmic examinations. The exclusion criteria were history of diabetes, multiple sclerosis, and other systemic diseases affecting the visual system, history of glaucoma, cataract, strabismus, aphakia, amblyopia, pterygium, any ophthalmic surgery, spherical refractive errors greater than three diopters and cylinder above 2.5 diopters, inability to read English letters, and the withdrawal from the study. Finally, among qualified subjects, those with monocular and binocular best-corrected visual acuity of 20/20 were entered into the study.

Complete ophthalmic examinations including vision and refraction measurements, slit lamp biomicroscopy, and CS assessment were performed for all subjects. The E chart was used at a distance of six meters to record individuals' vision with and without refractive correction. Refraction was performed for all subjects using Auto-refractometer (KR-800 Auto Kerato/Refractometer, Topcon, Japan). The measurements were repeated three times for each eye, and the mean was recorded afterwards. Accordingly, subjective refraction was also administered for all participants. Then, patients' best corrected visual acuity was obtained. In the subjects under 15 years of age, cyclorefraction was carried out 30 minutes after applying the last drop of cyclopentolate 1% (3 times, every 5 minutes).

Pelli Robson chart was used at a distance of one meter to evaluate CS. This test consists of eight 6-letter rows, in which the letters of all rows have the same size and make a 2.8-degree angle with one eye at a distance of one meter. Each row includes two triplets with identical letter contrasts, gradually decreasing from the top left to the bottom right. The contrast loss in each triplet is 0.15 log unit, and the logarithm of CS (log CS) generally ranges from 0 to 2.25. According to the charts' manual, the last triplet from that a patient can correctly read two words is recorded as his/her CS score.[1] In the present study, both monocular and binocular contrast sensitivities were recorded for all patients. In patients with the presbyopia, according to the individual's age and test distance, an appropriate addition was used while measuring CS.

The results were analyzed in SPSS.16 software (SPSS for Windows, SPSS Inc., Chicago, IL, USA). The subjects were classified into seven age groups. Descriptive findings concerning the right eye, left eye, and both eyes of the participants were documented. However, in order to compare CS between different refractive error groups, all 300 eyes were considered in the analysis. Kolmogorov-Smirnov test was used to check the normality of data. Since data were normal, parametric tests were used to analyze the results. Independent *t* test and one-way ANOVA were applied to compare the mean CS in the two genders and across different age groups. Also, Pearson correlation test was employed to evaluate the correlation of quantitative variables. The level of significance was set to 0.05.

Results

A total of 169 cases were participated in this study, after the exclusion criteria were applied, 150 individuals were analyzed, of whom 70 (46.66%) were male and 80 (53.33%) were female. The age of the subjects ranged from seven to 78 years with a mean of 34.56 ± 16.15 years.

Table 1 shows the mean log CS in all individuals based on gender, age, and refractive errors. The results of independent *t* test revealed no significant difference between men and women in terms of CS in both monocular and binocular viewing conditions ($P > 0.454$).

On the other hand, one-way ANOVA analysis showed that CS was significantly different in various age groups

Table 1. Mean and SD values of Pelli-Robson contrast sensitivity test by age and sex

			OD	OS	OU
		N	Mean ± SD (range)	Mean ± SD (range)	Mean ± SD (range)
Total		150	1.45 ± 0.19 (1.05-1.80)	1.45 ± 0.19 (1.05-1.80)	1.57 ± 0.19 (1.20-1.95)
Gender	Male	70	1.44 ± 0.18 (1.05-1.80)	1.44 ± 0.19 (1.05-1.80)	1.56 ± 0.18 (1.20-1.95)
	Female	80	1.46 ± 0.19 (1.05-1.65)	1.46 ± 0.19 (1.05-1.80)	1.56 ± 0.18 (1.20-1.95)
Age	<10	11	1.62 ± 0.06 (1.50-1.65)	1.59 ± 0.07 (1.50-1.65)	1.71 ± 0.12 (1.50-1.95)
	11-20	21	1.61 ± 06 (1.50-1.65)	1.58 ± 0.07 (1.50-1.65)	1.68 ± 0.10 (1.50-1.95)
	21-30	26	1.63 ± 0.04 (1.50-1.65)	1.67 ± 0.08 (1.50-1.80)	1.76 ± 0.09 (165-1.95)
	31-40	37	1.43 ± 0.14 (120-1.65)	1.43 ± 0.13 (1.20-1.65)	1.55 ± 0.13 (1.35-1.80)
	41-50	25	1.34 ± 0.17 (1.05-1.65)	1.35 ± 0.14 (1.05-1.50)	1.49 ± 0.15 (1.20-1.65)
	51-60	17	1.23 ± 0.12 (1.05-1.50)	1.20 ± 0.14 (1.05-1.50)	1.35 ± 0.13 (1.20-1.65)
	>60	13	1.24 ± 0.12 (1.05-1.35)	1.24 ± 0.12 (1.05-1.35)	1.38 ± 0.12 (1.20-1.50)

Abbreviations: OD, oculus dexter (means right eye); OS: oculus sinister (means left eye); OU, oculus uterque (means both eyes).

($P = 0.000$), with the highest CS occurring in people aged 21-30. Also, Pearson's correlation coefficient revealed a significant negative relationship between age and CS, where CS decreases with the increase of age ($P < 0.000$, $R \leq -0.714$).

Based on the results of one-way ANOVA, different refractive errors are associated with significantly different contrast sensitivities ($P = 0.000$), as CS is higher in people with emmetropia compared to those with myopia and hypermetropia. There was also a significant correlation between magnitude of cylinder and CS, where the CS score was significantly lower in those with cylinders exceeding half a diopter than those whose cylinder was below this value ($P = 0.000$). Table 2 represents mean ± SD of the CS scores based on the refractive errors.

The repeated ANOVA analyses confirmed that CS differs significantly in monocular and binocular viewing conditions ($P < 0.001$, $F = 196.51$). Table 1 presents the mean the log CS values in different viewing conditions. Pairwise comparison with the Bonferroni correction demonstrated that the log CS is greater in binocular than monocular condition. The mean difference and the confidence interval for the difference of the log CS in monocular and binocular viewing conditions are presented in Table 3.

Discussion

The results of the present study showed the normal distribution of CS value using Pelli-Robson test under monocular and binocular viewing conditions and represent its relationship with age, sex and refractive error. The mean, minimum, and maximum CS scores were 1.45, 1.05, and 1.80 log unit under monocular viewing condition and 1.57, 1.20, and 1.95 log unit under binocular viewing condition, respectively. CS dropped significantly with the age increase. Additionally, comparing CS among different refractive error groups revealed that CS score is lower among ametropic patients (myopic and hyperopic subjects) and those whose astigmatism exceed 0.5 diopters. Elliott et al reported that the mean CS score in normal subjects with the mean age of 22.5 ± 4.3 and 70.2 ± 6.7 years was 1.88 and 1.75 log unit, respectively.[11] These scores are clearly higher than the mean log CS obtained in the present study. They recommended 1.65 as the lower limit of Pelli-Robson test in the dominant eye of young subjects and 1.5 in the elderly. According to the results of the present study, in the monocular viewing condition, the minimum log CS was 1.50 in the age group of 20-30 years and 1.05 in those over 60 years old, which are lower than the values reported by Elliott et al for both groups (especially the elderly). Regarding the effect of age on CS, as observed in the previous studies[11,20] and the present research, we compared CS in different age groups, separately. Accordingly, the mean log CS was lower in the present research compared to that of previous studies in all age groups; therefore, age variation of subjects cannot account for the differences observed in the results of these studies.

One of the reasons for the observed lower CS in the present study can be correlated with the people aged over 60 years (who comprised part of our samples) who show some degree of lens opacity, although we have excluded those with a history of cataract and pterygium and enrolled patients who had a 20/20 vision. It is previously reported that even the slightest degrees of cataract can reduce optical function and cause age-related neural deterioration.[21] On the other hand, tropicality of the study area and the higher prevalence of cataract and superficial eye problems such as dry eye in these areas could justify the lower CS in our study population.[22,23] The results of the research by Szczotka-Flynn et al concerning the effect of dry eyes on visual outcome showed that although people with lacrimal film instability may have normal visual acuity and do not exhibit a symptom of dry eye syndrome, they still could experience reduced CS.[6]

Similar to previous reports and as expected, a decline in CS with the age also occurred in the current study. Most previous studies have showed the CS reduction at all spatial frequencies, especially high ones, with the increasing age.[14,16,20] Nonetheless, this suggestion is still a matter of controversy. Whereas, some have concluded that the increasing age does not influence CS at spatial frequencies below 2 cycle/degree (cpd),[24] there are also studies supporting a CS decrease at the spatial frequency of 1.5 cpd.[14] The present study found a reduction in CS with the increasing age even at the low spatial frequency (1 cpd). The causes of CS decline with age include the decreased pupil size,[25] the increased high-order aberrations,[26] the decreased cone cells density,[27] and the other age-related optical and neural changes.

The results of the present study showed no significant difference with regard to CS in men and women. The impact of gender on CS has not been adequately studied

Table 2. Pelli-Robson contrast sensitivity test results based on refractive error among all 300 evaluated eyes

Type of refractive errors	No.	Mean ± SD	Min.	Max.
Emmetropia (-0.5 D < ES < +0.5 D)	167	1.50 ± 0.16	1.05	1.80
Myopia (ES < -0.5 D)	84	1.39 ± 0.21	1.05	1.65
Hypermetropia (ES > +0.5 D)	49	1.38 ± 0.22	1.05	1.80
Pure astigmatism < 0.5 D	189	1.50 ± 0.17	1.05	1.80
Pure astigmatism > 0.5 D	111	1.36 ± 0.20	1.05	1.65

ES, equivalent sphere.

Table 3. The mean difference and the confidence interval for difference of the log CS in monocular and binocular viewing conditions

	Mean difference	*P* value	95% Confidence interval	
			Lower bound	Upper bound
OU - OD	0.121	<0.001	0.105	0.137
OU - OS	0.125	<0.001	0.107	0.143
OD - OS	0.004	>0.990	-0.014	0.022

so far, and the few related studies have applied different tools to investigate CS.[28-30] Similar to our results, Solberg and Brown observed no significant variation in CS between the two genders.[30] However, contrary to our results and the study of Solberg and Brown, Hashemi et al, analyzing normal individuals aged 40-64 using CSV-1000 test, indicated the higher CS in males than females at spatial frequencies of 3 and 6 cpd. The authors did not provide any specific justification for their finding.[28] Meanwhile, unlike Hashemi et al, Solberg et al found no sex differences in CS.[29] In general, given the exclusion of people with eye problems and those with a history of systemic illnesses affecting the visual system in the present study, the relatively equal proportion of CS in the two genders is expected.

In the present study, although the refractive errors of the subjects were less than 3 diopters, CS in patients with myopic and hyperopic refractive errors even with the best optical correction was less than that of emmetropic patients. However, no significant difference was found between myopic and hyperopic patients. Unlike previous studies suggesting that Pelli Robson chart is not sensitive to refractive errors and that even individuals with uncorrected refractive errors may display a good performance based on this instrument, the present research supports the occurrence of reduced CS in patients with corrected refractive errors compared to the emmetropic individuals. It is to note that these responses were achieved even when the range of refractive errors of the subjects was low and they had adequate visual acuity as assessed by Snellen chart. Similar to the present study, Hashemi et al observed a lower CS in myopic and hyperopic patients compared to the emmetropic individuals, using the CSV-1000 test.[28]

Similar to the previous studies, the present research found a decrease in CS in the people with the astigmatism.[28,30] The lower CS in the patients whose cylinders exceed half a diopter, compared to those with a lower cylinder, can be attributed to the meridional minification caused by the cylindrical lenses which lead to the uneven changes in the retinal images.[30]

Also, the results of the present study supported that of previous studies which had showed higher log CS under binocular rather than monocular viewing condition. Unless, there is an asymmetry between the two eyes due to cataract or other factors, which leads to a greater visual performance of binocular vision rather than monocular vision (binocular summation).[31] Since the people with the cataract or the other visual problems such as amblyopia and high refractive errors were excluded from the present study, the higher CS under binocular viewing condition observed here is in the agreement with the previous reports.

Pelli-Robson chart is one of the most common CS tests used in the ophthalmic research. One of the restrictions of this test relates to the performing CS examinations at a fixed and low spatial frequency.[1] Nevertheless, in order to compare the results obtained by this method in several studies, it is necessary to have a normal distribution of CS by using this test.

Study Highlights

What is current knowledge?

- It is necessary to know the normal distribution of contrast sensitivity for each region according to ethnicity and race. At present, there are few studies that have reported the normal distribution of contrast sensitivity using Pelli Robson test in different ethnicities.

What is new here?

- The results of the present study provide relevant information about the normal distribution of contrast sensitivity in a sample of people living in a tropical area and the influence of age, gender, and refractive errors on it.

The results of the present study provide relevant information about the normal distribution of the log CS and the influence of age, gender, and refractive errors on CS. The low sample size and the lack of population-based sampling were two limitations of the present study. Therefore, it is recommended that future studies be designed based on more specific populations and larger sample sizes. On the other hand, considering the high prevalence of superficial eye problems in tropical areas and the association of dry eye syndrome with CS,[6] it is suggested that appropriate examinations be conducted to screen people living in these places with regard to these two issues.

Conclusion

Although Pelli-Robson test evaluates CS at low and constant spatial frequencies, its distribution is significantly different among different age groups and even among individuals with different values of refractive errors.

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Authors' contribution

All the authors have contributed sufficiently in the intellectual content, conception and design of this work.

Ethical Approval

This project was approved by Zahedan University of Medical Sciences (Ethic code: IR.ZAUMS.REC.1398.449)

Conflict of Interest

No conflicting relationship exists for any author.

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