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Research Article

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Assessment of Contrast Sensitivity in Cataract Simulation

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Abstract

Cataract is an opacification of the crystalline lens, lessening vision and eventually leading to blindness, if left untreated. Affects almost half of the population aged over 60s. Age-related type is a common reason for eye surgery in the elderly.

Contrast sensitivity is the visual ability to distinguish an object from its background and to discriminate between similar shades. It may be influenced by both ocular and neurological conditions.

Contrast sensitivity declines with age and eye disorders, like cataract or diabetic retinopathy. Although various charts have been designed for contrast sensitivity evaluation the Pelli-Robson chart provides a quick and reliable test in the clinical setting.

In current study, 12 healthy young people have been tested in simulated age-related cataract conditions, including three stages of severity. After statistical analysis, results illustrated much influence of contrast sensitivity at all states, reaching high level of decline in late stages, both monocular and binocular.

Keywords: Age-related cataract; Contrast sensitivity (CS); Pelli-Robson chart; Simulation

Introduction

Cataract is an eye condition where the environment looks blurry, hazy or less colorful [1-3]. Most age-related cataracts develop gradually. Vision experts cannot predict how quickly a person's cataract will develop [4].

Current studies estimated that 20 million people worldwide are blind due to bilateral cataracts. This number is supposed to rise to 32 million by 2020. More than half of all global blindness is cataract induced [5-8].

The prevalence of lens disorders makes the basic and clinical science of the lens an important subject in ophthalmologic training. Age-related cataract is not a single disease but rather three different types of lens changes, cortical, nuclear and sub capsular opacities [9]. All types have a significant impact on visual function. There are some proven effects of cataract on vision like monocular diplopia, astigmatism, reduced contrast sensitivity, sense of glare, change of colour perception, reduction of light transmission, visual field loss and reduced visual acuity [4,10,11].

Assessment of the overall cataract effect on visual function is probably a more appropriate way to determine visual performance than is visual acuity alone [12,13]. On the contrary, visual acuity reveals only the size of high contrast black and white letters that the individual is capable of seeing activities and living quality [14]. In everyday life, good contrast sensitivity is essential to distinguish a grey object on a heavy cloudy day, to detect unmarked steps in grey-cemented stairs, and to discriminate faint contours on people's faces to recognize them. People with low contrast sensitivity often lose the viewing image clarity and sharpness. The main procedure to compensate for this shortfall is to simply add some contrast to their environment, whenever possible [15,16].

Contrast sensitivity defines the threshold between the visible and invisible, which has obvious significance for basic and clinical vision science [17,18]. Threshold of contrast is the contrast required to see the target reliably. The reciprocal of threshold is called sensitivity [19,20]. Contrast sensitivity is better correlated with visual quality of life and notably may be impaired in neurodegenerative ocular pathologies even when acuity is unaffected [21]. A study of Pardhan and Gilhrist [22] demonstrated that at low spatial frequencies, where the monocular sensitivity difference was minimal, the binocular summation was obtained much better. As the sensitivity difference increased at higher spatial frequencies, the binocular contrast sensitivity decreased steadily until it reached a level below the sensitivity of the cataractic eye, demonstrating binocular inhibition [23]. Binocular contrast sensitivity depends on the contrast sensitivity differences between the two eyes. It is essential not only to assess contrast sensitivity monocular but also binocular [22]. A variety of special charts have been designed for the measurement of the contrast sensitivity function [12,24,25], especially in progressive eye disease.

A consideration of the methods to assess contrast sensitivity leads to the conclusion that, for a clinical test, letters are more suitable than gratings [25,26]. The Pelli-Robson contrast sensitivity test is a quick and reliable method. The chart consists of letters decreased in contrast but not in size. The letters are arranged in groups of three; successive groups decrease in contrast by a factor of 1√2 from a very high contrast down to a contrast below the threshold of normal observers. A subject's threshold is taken to be the lowest contrast for which at least two letters in a group are correctly reported [27].

The values of the test range from 0.00 log units to 2.25 log units. An Elliot's, et al. [28], research has shown that the majority of young subjects were found to have a CS of 1.80 log units or above. The majority of the older subjects were found to have a CS of 1.65 log units or above. In cataract, the Pelli-Robson score is lower than 1.25 log [29].

Cataract hinders health-related quality of life and is associated with increased difficulty with visual activities of daily living. Many studies conducted in simulation conditions have shown that cataract have a significant effect in night driving [30,31], reading [32-34] and generally, in low contrast conditions [35].

It is true for many people with cataracts and other impairments the visual function experienced with these simulators is dramatically affected by the amount of available light and its direction relative to the wearer. According to researches, is remarkable that the presence of cataract and the relative decrease in contrast sensitivity, increases the risk of crash in elderly drivers [36]. One reason for the increase in accidents in people with cataracts is that the sensitivity of the contrast can affect the ability to understand risk, which increases the risk of conflict due to the reduction of the reflex reaction [37]. In fact, static visual acuity (on which almost all legal driving standards are based) is an incomplete measure of loss of visual function due to the presence of cataracts, leading many researchers to consider the need for contrast sensitivity assessment when assessing driving ability [31].

The only treatment of cataract is the surgical removal of the cataract lens. As reported in post-cataract surgery, there is a significant improvement in patients' vision as the sense of glare caused by cataract decreases, visual acuity is retrieved and the performance in contrast sensitivity significantly increases [35]. Improvement in vision performance is of major importance for the patient's functionality in daily activities [38-40] therefore, scholars suggest immediate treatment with surgical removal even at the beginning stages, although the early stage of the cataract does not cause significant disturbance to prevent significant effects on vision [41].

The Objectives of the Study

Main purpose of this study was to observe and evaluate the changes in contrast sensitivity by a simulated age-related cataract at different stages of the disease. The procedure was designed to determine contrast sensitivity scores for difference simulated cataract stages for early, medium or late age-related cataracts.

Methodology

Research design

A number of simulated cataract tests were applied to assess the visual performance of the participants. A Pelli-Robson contrast sensitivity test was used to evaluate the results. The cataract simulator utilized in controlled luminance conditions and under the supervision of an optometrist. Included the supply of 3 pairs of glasses, with lenses tinted in different shades of yellowness, as to provide a proper simulation of early, medium and late cataract level. At every change of vision performance, from fully sighted to visually impair, the participants took proper time to adjust for the new level of vision. The contrast sensitivity test evaluation for the effectiveness, relevance and capability of vision performance, included determination of how well the participants have achieved the goal to recognize the letter with the minimum contrast.

The methodology steps included the sample selection, the design of daily-light conditions in the examination room, the formation of cataract simulation glasses, the contrast sensitivity test using Pelli-Robson chart, the data recording and the final analysis of the results.

Respondents and sampling plan

The sample consisted of 30 participants, all undergraduate students (15 male and 15 female, aged 18-30) at the Department of Biomedical Sciences, University of West Attica in Athens. After the appropriate paperwork for the Ethics and nomination of participation, they went through a detailed ophthalmologic examination and complete record of their medical history. They filled out the specific forms and they evaluated for their refractive error inclusion criteria for the study.

Exclusion criteria incorporated the use of medications and the occurrence of allergies, any potential astigmatism over ±1.00 dpt or refractive error over ±2.00 dpt, family history of systematic diseases such as diabetes or other ocular diseases. After the evaluation of the initial 30 participants, finally the criteria met only 12 students aged 18 to 30 years old (5 male and 7 female). The recorded data of all individuals was protected, according the law for sensitive personal data, by giving them a corresponding number (from 1 to 12) to their names and identities (Table 1).

Simulation Cataract			
Stages	**n**	**Groups**	**n**
Normal	36	Right eyes	12
Early	36	Left eyes	12
Medium	36	Binocular	12
Late	36	Male	5
		Female	7

Table 1: Distribution of the Respondents.

Instrument and data gathering procedure

The experimental tests were performed in the visual inspection unit that included a room with dimensions of 8×5 m, which met the proper requirements of the study. A projector formed the daylight-simulated conditions and a photometer using a dimmer to adjust at 162lux, after had taken place a complete darkening of the surround area. To facilitate adjustment of the surrounding area brightness, the white disk of the photometer light sensor was facing the projector, in a steady position and at a distance equal to the distance between the examination chart and the individual at each test.

An original Pelli-Robson contrast sensitivity test (printed in UK) was placed at a distance of 3 meters from the participant (3 meters corresponds to spatial frequencies of 3c / deg). A Bailey-Lovie chart in Log-MAR scale in illuminated screen was placed at 4 meters distance from the individual, for the visual acuity test, which was conducted to assess the inclusion criteria. The chart was set to correspond at a 6 m distance of visual acuity assessment, which performed under scotopic conditions (0.003lux) and following standard optometric examination procedure.

The right eye was tested always first, secondly the left eye and finally the binocular test. Balancing the binocular vision with polarizing filters, the inclusion criteria for VA was 0,00 log for all subjects. After the visual acuity test, every subject was moved to a dark room with full eye coverage, using a sleep mask, for about 20 minutes in complete dark, to avoid fatigue during the assessment of contrast sensitivity. After this resting period of time, the sleeping mask was removed and the brightness of the room gradually changed in order to avoid the production of glare due to the sudden brightness change.

In a room luminance corresponding the daylight conditions, the CS test procedure begins by evaluating each eye separately. Those with refractive error used glasses with their refractive correction as revealed from the previous refractive test. At the beginning, CS was evaluated without the use of simulator lenses and then using simulating glasses, for each of the three stages of cataract simulation. This simulation was based on a modification of US. Patent 5,737,056 of Martin, et al. [42], entitled “Method for simulation of visual disabilities”, involving contact lenses, eye lenses and a pair of eyeglasses. Three different pairs of lenses were created corresponding to early level, medium and late stage of cataract. Individual pairs of glasses were used for each of the three levels. For the production of the lenses, initially was used a light yellow tint corresponding to an early cataract condition, darker yellow with light brown tint for the middle cataract stage and dark yellow with a darker brown tint for the level of the advanced cataract.

Pelli-Robson chart dimensions are 90 × 60cm (36 × 24 inches) and consist of 8 sets of different contrasting letters. Each line contains 6 letters or two triplets. The first three letters of each left triplet at any line have higher contrast than the three letters of the corresponding right triplet. The contrast also decreases downwards from line to line. The Letter size is 4.9 × 4.9 cm (2 × 2 inches). The first three left letters of the upper line have the maximum contrast (contrast = 1), and the right letters of the lowest line have the minimum contrast (contrast = 0.006). Contrast sensitivity is defined as the inverse analogue of contrast (CS = 1 / contrast). Each group of three letters is rated with 0.15 contrast sensitivity units [43]. For purposely accuracy of the results, the recorded values refer to each letter of the row and not to the entire triplet of letters, as defined by the designers of the test [28]. Incorrect responds for letters C and O were considered as faulse reading of the letter. Sensitivity values were tested monocular and binocular. Right eye was always examined first during the monocular test. During the monocular testing, a blocking cap was used in the non-examined eye. The binocular test was considered to be a bilateral cataract and the pair of simulator lenses was uniformly tinted on both sides of the lens, at all the simulated stages.

Results

Tables 2-4 illustrate the contrast sensitivity scores during the Pelli-Robson examination test for male and female individuals for right eyes, left eyes and binocular, in cataract simulation conditions for all stages (normal, early, medium, late). In normal stage CS scores recorded without simulation. For the male individuals, contrast sensitivity values in right eyes ranged from 1.75log for the normal to 0.45log for late cataract stage, for left eyes CS values ranged from 1.7log for the normal to 0.5log for the late, and in binocular test, values ranged from 1.9log for the normal to 0.55log for the late cataract stage. Correspondingly, for the female individuals, in right eyes contrast sensitivity values ranged from 1.65log for the normal to 0.25log for the late stage, in left eyes CS values ranged from 1.7log for the normal to 0.15log for the late, and the binocular CS values ranged from 2log in the normal stage to 0.3log in the late cataract stage.

	MALE				**FEMALE**			
	NORMAL	EARLY	MED	LATE	NORMAL	EARLY	MED	LATE
RIGHT EYES CS SCORE	1,55	1,35	1,05	0,65	1,6	1,55	1,25	0,55
	1,65	1,55	1,3	0,85	1,6	1,45	1,05	0,55
	1,75	1,55	1,25	0,65	1,55	1,5	1,2	0,35
	1,5	1,35	0,95	0,45	1,65	1,55	1,25	0,65
	1,55	1,3	1,05	0,45	1,5	1,35	0,95	0,25
					1,4	1,2	1,05	0,4
					1,65	1,5	1,25	0,5

Table 2: Pelli-Robson contrast sensitivity scores (log) for right eyes for male and female individuals with cataract simulation in all stages (normal, early, medium, late).

	MALE				**FEMALE**			
	NORMAL	EARLY	MED	LATE	NORMAL	EARLY	MED	LATE
EFT EYES CS SCORE	1,7	1,55	1,2	0,95	1,55	1,5	1,15	0,65
	1,7	1,6	1,35	0,95	1,25	1,25	1	0,6
	1,6	1,45	1,3	0,7	1,7	1,6	1,15	0,25
	1,55	1,4	1	0,5	1,55	1,5	1,15	0,55
	1,55	1,25	0,85	0,5	1,7	1,4	0,85	0,15
					1,4	1,2	0,95	0,45
					1,45	1,3	1,15	0,55

Table 3: Pelli-Robson contrast sensitivity scores (log) for left eyes for male and female individuals with cataract simulation in all stages (normal, early, medium, late).

	MALE				FEMALE			
	NORMAL	EARLY	MED	LATE	NORMAL	EARLY	MED	LATE
BINOCULAR CS SCORE	1,7	1,55	1,2	1,1	1,7	1,5	1,25	0,75
	1,9	1,65	1,35	1,05	1,5	1,4	1,1	0,65
	1,8	1,6	1,35	0,8	1,9	1,65	1,25	0,3
	1,8	1,45	1,15	0,55	2	1,65	1,2	0,85
	1,75	1,4	1,25	0,6	1,95	1,55	1	0,3
					1,75	1,25	1,1	0,5
					1,9	1,6	1,3	0,55

Table 4: Pelli-Robson binocular contrast sensitivity scores (log) for male and female with cataract simulation in all stages (normal, early, medium, late).

Data analysis

The data gathered in this study were computer-processed using Statistical analysis Package for Social Science (SPSS) Version 17. For the analysis of the results, the researcher used the frequency count and percentage, mean, and standard deviation for descriptive analysis and the non-parametric tests for inferential analysis.

The mean was used to determine the statistically significant difference between the independent groups using One way ANOVA (analysis of variance) method followed by Games-Howell post hoc with a 0.05 significance level, Wilcoxon signed-rank test was used to determine the means difference between right eyes and left eyes group, the Mann-Whitney U test was run to determine if there is a statistically significantly difference between male and female contrast sensitivity scores in simulation cataract conditions. The obtained mean ratings were interpreted and described using the following scales and descriptions.

Interpreting the descriptive measures

ANOVA/Games-Howell post-hoc test of variance analysis was performed, with multiple comparisons between groups (right eyes, left eyes, binocular) and stages (Normal, Early, Medium, Late) of simulated cataract (Tables 5-8). This post hoc test provides confidence intervals for the differences between group means and shows whether the differences are statistically significant. Post-hoc tests attempt to test the experimental error rate (usually alpha = 0.05).

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
RIGHT	NORMAL	12	1,5792	,09160	,02644	1,5210	1,6374	1,40	1,75
	EARLY	12	1,4333	,11934	,03445	1,3575	1,5092	1,20	1,55
	MEDIUM	12	1,1333	,12851	,03710	1,0517	1,2150	,95	1,30
	LATE	12	,5250	,16167	,04667	,4223	,6277	,25	,85
	Total	48	1,1677	,42695	,06162	1,0437	1,2917	,25	1,75
LEFT	NORMAL	12	1,5583	,13953	,04028	1,4697	1,6470	1,25	1,70
	EARLY	12	1,4167	,14035	,04051	1,3275	1,5058	1,20	1,60
	MEDIUM	12	1,0917	,16214	,04680	,9887	1,1947	,85	1,35
	LATE	12	,5625	,23944	,06912	,4104	,7146	,15	,95
	Total	48	1,1573	,42238	,06097	1,0346	1,2799	,15	1,70

BINOCULAR	NORMAL	12	1,8042	,13728	,03963	1,7169	1,8914	1,50	2,00
	EARLY	12	1,5208	,12515	,03613	1,4413	1,6004	1,25	1,65
	MEDIUM	12	1,2083	,10624	,03067	1,1408	1,2758	1,00	1,35
	LATE	12	,6583	,24199	,06986	,5046	,8121	,30	1,05
	Total	48	1,2979	,45721	,06599	1,1652	1,4307	,30	2,00

Table 5: Descriptive measures for CS scores, right eye, left eye, and binocular in each stage of cataract simulation, normal values, early stage values, medium stage values and late stage values.

ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
RIGHT	Between Groups	7,849	3	2,616	160,311	,000
	Within Groups	,718	44	,016		
	Total	8,567	47			
LEFT	Between Groups	7,034	3	2,345	76,387	,000
	Within Groups	1,351	44	,031		
	Total	8,385	47			
BINOCULAR	Between Groups	8,677	3	2,892	110,862	,000
	Within Groups	1,148	44	,026		
	Total	9,825	47			

Table 6: Statistically significant differences were observed, in all groups, right eye, left eye and binocular values, $p = 0.000 < 0.05$. Contrast sensitivity score was statistically significantly different between different groups, Right eyes $F(3,44) = 160.311$, $p < 0.05$, Left eyes $F(3,44) = 76.387$, $p < 0.05$, Binocular $F(3,44) = 110.862$, $p < 0.05$.

Robust Tests of Equality of Means					
		Statistic[a]	df1	df2	Sig.
RIGHT	Welch	133,276	3	23,995	,000
LEFT	Welch	57,770	3	24,118	,000
BINOCULAR	Welch	84,282	3	23,877	,000
a. Asymptotically F distributed.					

Table 7: Welch test of equality of means. Right eyes group Welch's F (3,23.995) =133.276, p<0.05, Left eyes group Welch's F (3, 24.118) =57.770, p<0.05, Binocular group Welch's F (3, 23.877) =84.282, p<0.05.

Multiple Comparisons							
Games-Howell							
Dependent Variable	(I) STAGE	(J) STAGE	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
RIGHT	NORMAL	EARLY	,14583*	,04343	,015	,0246	,2671
		MEDIUM	,44583*	,04556	,000	,3183	,5734
		LATE	1,05417*	,05364	,000	,9021	1,2063
	EARLY	NORMAL	-,14583*	,04343	,015	-,2671	-,0246
		MEDIUM	,30000*	,05063	,000	,1594	,4406
		LATE	,90833*	,05801	,000	,7461	1,0705
	MEDIUM	NORMAL	-,44583*	,04556	,000	-,5734	-,3183
		EARLY	-,30000*	,05063	,000	-,4406	-,1594
		LATE	,60833*	,05962	,000	,4421	,7746
	LATE	NORMAL	-1,05417*	,05364	,000	-1,2063	-,9021
		EARLY	-,90833*	,05801	,000	-1,0705	-,7461
		MEDIUM	-,60833*	,05962	,000	-,7746	-,4421

LEFT	NORMAL	EARLY	,14167	,05713	,091	-,0170	,3003
		MEDIUM	,46667*	,06175	,000	,2949	,6384
		LATE	,99583*	,08000	,000	,7694	1,2223
	EARLY	NORMAL	-,14167	,05713	,091	-,3003	,0170
		MEDIUM	,32500*	,06190	,000	,1528	,4972
		LATE	,85417*	,08012	,000	,6274	1,0809
	MEDIUM	NORMAL	-,46667*	,06175	,000	-,6384	-,2949
		EARLY	-,32500*	,06190	,000	-,4972	-,1528
		LATE	,52917*	,08348	,000	,2948	,7635
	LATE	NORMAL	-,99583*	,08000	,000	-1,2223	-,7694
		EARLY	-,85417*	,08012	,000	-1,0809	-,6274
		MEDIUM	-,52917*	,08348	,000	-,7635	-,2948
BINOCULAR	NORMAL	EARLY	,28333*	,05362	,000	,1343	,4323
		MEDIUM	,59583*	,05011	,000	,4560	,7357
		LATE	1,14583*	,08031	,000	,9181	1,3736
	EARLY	NORMAL	-,28333*	,05362	,000	-,4323	-,1343
		MEDIUM	,31250*	,04739	,000	,1806	,4444
		LATE	,86250*	,07865	,000	,6382	1,0868
	MEDIUM	NORMAL	-,59583*	,05011	,000	-,7357	-,4560
		EARLY	-,31250*	,04739	,000	-,4444	-,1806
		LATE	,55000*	,07629	,000	,3303	,7697
	LATE	NORMAL	-1,14583*	,08031	,000	-1,3736	-,9181
		EARLY	-,86250*	,07865	,000	-1,0868	-,6382
		MEDIUM	-,55000*	,07629	,000	-,7697	-,3303
***. The mean difference is significant at the 0.05 level.**							

Table 8: Multiple comparisons between stages statistically significance was observed in all stages, p = 0.000. Right eyes p = 0.015 between normal and early stage, left eyes p=0.091 between normal and early stage. In binocular group, p=0.001 between normal and early stage, in the other stages p=0.000<0.005.

Test Statistics[a]	
	CS
Mann-Whitney U	1000,500
Wilcoxon W	2596,500
Z	-,890
Asymp. Sig. (2-tailed)	,374
a. Grouping Variable: GENDER	

Descriptive Statistics					
	N	Mean	Std. Deviation	Minimum	Maximum
CS	96	1,1630	,42154	,15	1,75
GENDER	96	1,58	,496	1	2

Ranks				
	GENDER	N	Mean Rank	Sum of Ranks
CS	MALE	40	51,49	2059,50
	FEMALE	56	46,37	2596,50
	Total	96		

Table 9: Non-Parametric Mann-Whitney U test for males (mean rank=51.49) and females (mean rank=46.37) U=1000.500, z=-0.890, p=0.374.

Test Statistics[b]	
	LEFT - RIGHT
Z	-,727[a]
Asymp. Sig. (2-tailed)	,467
a. Based on positive ranks.	
b. Wilcoxon Signed Ranks Test	

Ranks				
		N	Mean Rank	Sum of Ranks
LEFT - RIGHT	Negative Ranks	22[a]	25,30	556,50
	Positive Ranks	22[b]	19,70	433,50
	Ties	4[c]		
	Total	48		
a. LEFT < RIGHT				
b. LEFT > RIGHT				
c. LEFT = RIGHT				

Table 10: Wilcoxon Signed Rank Tests (n=48, -0.0104 ± 0.123), left (mean rank=25.30), right (mean rank=19.70), z=-0.727, p=0.467.

Discussion

The one-way Welch ANOVA was conducted to determine the difference between the simulated cataract stages. Three groups named right, left and binocular were classified in four simulation stages, normal, early, medium and late. There were no outliers, as assessed by boxplot (Figures 1-6); data was normally distributed for all groups, as assessed by Shapiro-Wilk test (p>0.05). Homogeneity was violated in binocular group, as assessed by Levene's Test of Homogeneity of Variance (p=0.023). Data is presented as mean ± standard deviation. Contrast sensitivity score was statistically significantly different between stages of simulated cataract.

For right eyes group Welch's F (3,23.995) =133.276, p<0.05, Contrast sensitivity score was decreased from normal 1.57 ± 0.09, to early 1.43 ± 0.12, to medium 1.13 ± 0.13, to late 0.53 ± 0.16. For left eyes group Welch's F (3,24.118) =57.770, p<0.05. Contrast sensitivity score was decreased from normal 1.56 ± 0.14, to early 1.41 ± 0.14, to medium 1.09 ± 0.16, to late 0.56 ± 0.23. For binocular group Welch's F (3, 23.877) =84.282, p<0.05. Contrast sensitivity score was decreased from normal 1.80 ± 0.14, to early 1.52 ± 0.13, to medium 1.21 ± 0.11, to late 0.66 ± 0.24.

Games-Howell Post-Hoc analysis revealed that the mean with 95% CI, decreased in right eyes group from normal to early stage 0.15, [0.025 to 0.27], p=0.015<0.05, from early to medium 0.3, [0.16 to 0.44], p=0.000<0.05, from medium to late 0.61, [0.44 to 0.77], p=0.000<0.05. Nevertheless, from normal to late stage 1.05, [0.91 to 1.20], p=0.000<0.05. In left eyes group the mean decreased from normal to early 0.14, [-0.02 to 0.30], p=0.091>0.05, was not statistically significant in this stage for left eyes group. The mean with 95% CI, also decreased from early to medium stage 0.33, [0.15 to 0.49], p=0.000<0.05, from medium to late stage 0.53, [0.29 to 0.76], p=0.000<0.05. In sum, the mean decreased from normal to late stage for left eyes group 0.99, [0.76 to 1.22], p=0.000<0.05. In binocular group the mean reduced from normal to early stage 0.28, [0.13 to 0.43], p=0.000<0.05, from early to medium stage 0.31, [0.18 to 0.44], p=0.000<0.05, from medium to late stage 0.55, [0.33 to 0.77], p=0.000<0.05. Briefly, the CS mean in binocular group decrease from normal to late stage 1.15, [0.92 to 1.38], p=0.000<0.05. All results were statistically significant (p<0.05) for all stages in all groups, except the early stage in left eyes group that was not statistically different (p=0.091), probably due to a learning effect during the examination procedure.

A Mann-Whitney U test (Table 9) was run to determine if there were differences in contrast sensitivity scores between male and female individuals. Distributions of CS scores for both genders were not similar, as assessed by visual inspection. Sensitivity scores for male (mean rank=51.49) and female (mean rank=46.37) were not statistically significantly different, U=1000.500, z=-0.890, p=0.374.

A Wilcoxon signed-rank test (Table 10) was run to determine if there were differences in contrast sensitivity scores between right and left eyes of the participants. There was not a statistically significant median (n=48, -0.0104 ± 0.123), for left (mean rank=25.30), and for right (mean rank=19.70), z=-0.727, p=0.467.

Normal contrast sensitivity values calculated and compared with contrast sensitivity values in simulated cataract conditions to evaluate the effect of cataract in three stages of severity. Results demonstrated that the contrast sensitivity decreases even in the early stages of cataract, which allows us to consider contrast sensitivity control as being of particular importance for patients with cataract, as the reduced contrast sensitivity is likely to have a significant effect on their daily activities since contrast sensitivity is also a valuable predictor of "real-world" vision. Contrast sensitivity influences the ability to recognize faces and objects as well as road signs, obstacles, and pedestrians while driving. Contrast sensitivity is more important determinant of generic quality of life [44-46]. Acuity was less important than CS for activity and the importance of contrast sensitivity over acuity has been suggested with the rationale that the environment contains more low- than high-contrast visual stimuli [12].

Conclusions

Present study illustrates that simulated cataract affects the contrast sensitivity at all stages, for both monocular and binocular, for male and female individuals. Statistical analysis illustrates much influence of contrast sensitivity at all states, with maximum decline in late stage. The results do not show statistically significant differences between the eyes. Statistical analysis of gender contribution showed that there are no statistically significant differences between male and female individuals.

The result of the study is significantly useful in addressing the needs of investigation between control and elderly groups, in order to identify its strengths and weaknesses, and the relevance of its competencies to the daily activities. Based on the findings of the study the following conclusions were drawn.

Control of contrast sensitivity is considered as a necessary diagnostic part for the clinical assessment of visual function. It has been recognized in numerous studies that it offers more accurate information about the patient's visual performance. In all grades of age-related simulated cataract, a decreased sensitivity is revealed.

Recommendations

Based on the findings and conclusions of this study, the researchers recommend the following:

- Use a sample with cataract patients to perform a contrast sensitivity test in patients used as a control group with different types of cataracts
- Use a sample with cataract patients measuring contrast sensitivity scores using blue and yellow filters in order to investigate the short wave visual pathway.
- Strengthen the linkage between cataract grade and daily activities and gender segregation.

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References

1. De Waard PW, IJspeert JK, Van De Berg TJ, De Jong PT (1992) Intraocular Light Scattering in Age-Related Cataract. Investigative Ophthalmology & Visual Science 33: 616-625.
2. Hess R, Wood G (1978) Vision through cataracts. Investigative Ophthalmology & Visual Science 17: 428-435.
3. Mellerio J (1987) Yellowing of the human lens:nuclear nad cortical contributions. Vision Research 27: 1581-1587.
4. Michael R, Bron A (2011) The ageing Lens and Cataract: a model of normal and pathological ageing. The Royal Society, Biological Sciences.
5. Bourne R, Flaxman S, Braithwaite T, Cicenelli M, Das A, et al. (2017) Magnitude, temporal trends and projections of the global prevalence of blindness and distance and near vision impairment:a systematic review and meta-analysis. Lancet Glob Health 5: 888-897.
6. Pascolini D, Mariotti PS (2012) Global estimates on visual impairment in the year 2010. British Journal of Ophthalmology 96: 614-618.
7. Pizzarello L, Abiose A, Ffytche T, Duerksen R, Thulasiraj R, et al. (2004) VISION 2020:The right to sight, A global inivitive to eliminate avoidable blindness. Arch Ophthalmology 122: 615-620.
8. Resnikoff S, Pascolini D, Kocur I, Etya'ale D, Pararajasegaram R, et al. (2004) Global data on visual impairment in the year 2002. Bulletin of the worl health organization 82: 844-851.
9. Delcourt C, Carriere I, Ponton-Sanchez A, Lacroux A, Covacho M-J (2000) Light exposure and the risk of cortical,nuclear and posterior subcapsular cataracts: the pathologiew oculaires Liees a l'age (POLA) study. Archives of ophthalmology 118: 385-392.
10. Bahrami M, Hoshino M, Pierscionek B, Yagi N, Regini J, et al. (2015) Refractive index degeneration in older lenses: A potential functional correlate to structural changes that underlie catarct formation. Experimental eye Research 140: 19-27.
11. Campbell C (1999) Observations on the optical effects of a cataract. Cataract Refractive Surgery 25: 995-1003.
12. Datta S, Alexander F, Matthew G, Richard G, Anwar Z, et al. (2008) The Importance of Acuity, Stereopsis, and Contrast Sensitivity for Health-Related Quality of Life in Elderly Women with Cataracts. Investigative Ophthalmology & Visual Science 49: 1-6.
13. Taylor RH, Misson GP, Moseley MJ (1991) Visual acuity and contrast sensitivity in cataract: summation and inhibition of visual performance. Eye 5: 704-707.
14. Bodis-Wollner I (1972) Visual acuity and contrast sensitivity in patients with cerebral lesions. Science 178: 769-771.
15. Alghwiri AA, Whitney SL, Baker CE, Sparto PJ, Marchetti GF, et al. (2012) The Development and Validation of the Vestibular Activities and Participation Measure. Archives of Physical Medicine and Rehabilitation 93: 1822-1831.
16. Lundstrom M, Fregell G, Sjoblow A (1994) Vision related daily life problems in patients waiting for a cataract extraction. British Journal of Ophthalmology 78: 608-611.
17. Blackwell H (1952) Studies of psychophysical methods for measuring visual thresholds. Journal of the Optical Society of America 42: 606-616.
18. Pelli D, Farell B (2010) Psychophysical methods. In C. e. M.Bass, Handbook Of Optics:Vision and Optics (Vol. Vol.III, pp. 3.1-3.12). New York: McGraw-Hill.
19. Fechner G (1860) Elemente der Phsychophysik. Leipzig: Breitkopf und Hertel. New York: Holt, Rinehart and Winston.
20. Pelli DG, Bex P (2013) Measuring contrast sensitivity. Vision Research 90: 10-14.
21. Owsley C (2003) Contrast sensitivity. Ophthalmology Clinics of North America 16: 171-178.
22. Pardhan S, Gilhrist J (1991) The importance of measuring Binocular and Monocular contrast sensitivity in Unilateral cataract. Eye 5: 31-35.
23. Bex P, Makous W (2002) Spatial frequency,phase,and the contrastnof natural images. Journal of America 19: 1096-1106.
24. Arditi A (2005) Improving the design of the letter contrast sensitivity test. Investigative Ophthalmology & Visual Science 46: 2225-2229.
25. Haymes SA, Roberts KF, Cruess AF, Nicolela MT, LeBlanc RP, et al. (2006) The letter contrast sensitivity test: Clinical Evaluation of a new design. Investigative Ophthalmology & Visual Science 47: 2739-2745.
26. Pelli D, Robson J (1991) Are letters better than Gratings. Clinical Vision Sciences 6: 409-411.
27. Pelli D, Robson J, Wilikings A (1988) The design of a new letter chart for measuring contrast sensitivity. Clinical Vision Sciences 2: 187-199.
28. Elliot D, Whitaker D, Bonette L (1990) Differences in the legibility of letters at contrast threshold using the Pelli-Robson Chart. Ophthalm. Physiol.Opt 10: 323-326.
29. Mantyjarvi M, Laitinen T (2001) Normal values for the Pelli-Robson contrast sensitivity test. Journal of Cataract & Refractive Surgery 27: 261-266.
30. Horswill M, Plooy A (2008) Reducing contrast makes speeds in video-based driving simulator harder to discrimates as well making them appear slower. Perception 37: 1269-1275.
31. Shelby MA, Horswill MS, Wood JM (2008) The effect of simulated cataract on driver's hazard perception ability. Optometry and Vision Science 85: 1121-1127.
32. Fine E, Rubin GS (1999) The effects of simulated cataract on reading speed with normal vision and simulated central scotoma. Vision research:Elsevier:Pergamon 39: 4274-4285.
33. Koch DD (1989) Glare and contrast sensitivity testing an cataract patients. Journal of Cataract and Refractive Surgery 15: 158-164.
34. Patel B, Elliot DB, Whitaker D (2001) Optimal reading speed in simulated cataract:development of a potential vision test. Ophthal.Physiol. Opt 21: 272-276.
35. Mennemeyer ST, Owsley C, McGwin JrG (2013) Reducing oldeer driver motor vehicle collisions via earlier cataract surgery. Accident Analysis and Prevention: Elsevier.
36. Owsley S, Stalvey B, Wells J, Sloane M (1999) Older Drivers and Cataract: Driving Habits and Crash Risk. Journal of Gerontology: MEDICAL SCIENCES 54: M203-M211.

37. Plainis S, Murray I (2002) Reaction times as an index of visual conspicuity when driving at night. Ophthalmic.Physiol.Opt 22: 409-415.

38. Denoyer A, LeLez M-L, Majzomb S, Pisella P-J (2007) Quality of vision after cataract surgery after Tecnis Z9000 intraocular lens implantation: Effect of contrast sensitivity and wavefront aberration improvements on the quality of daily vision. Journal of Cataract & Refractive Surgery 33: 210-216.

39. Elliot D, Patla A, Furniss M, Adkin A (2000) Improvements in clinical and functional vision and quality of life after second eye cataract surgery. Optom.Vis.Sci 77: 13-24.

40. Shuttleworth G, Luthisi E, Harrad R (1998) Do patients with age related maculopathy and cataract benefit from cataract surgery? British Journal of Ophthalmology 82: 611-616.

41. Lam C, Sundaraj K, Sulaiman M (2012) Virtual simulation of eyeball and extraocular muscle reaction during cataract surgery. Procedia Engineering, Elsevier 41: 150-155.

42. Martin NF, Robinson TW, Robinson HN (1998) Patent No. US5737056A. USA.

43. Robson J (1993) Contrast Sensitivity:One hundred years of clinical measurement. In Human Contrast.Sensitivity and its clinical measurements. Boston : MIT press.

44. Niemeyer J, Paradiso M (2017) Contrast sensitivity, V1 neural activity, and natural vision. Journal of Neurophysiology 117: 492-508.

45. Elliot D, Gilchrist J, Weatherill J, Whitaker D (1989) Contrast sensitivity and glare sensitivity changes with three types of cataract morphology:are these techniques necessary in a clinical evaluation of cataract? Ophthalmic and Physiological Optics 9: 25-30.

46. Guthauser U, Flammer J (1988) Quantifying visual field damage caused by cataract. American Journal of Opthalmology 106: 480-484.