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Contrast sensitivity : A test of visual performance in adapted contact lens wearers

Jayashree Vishwanath and Dr. John . J . Pole

Abstract:

Contrast sensitivity testing reveals visual deficits not detected by standard acuity tests, providing a more sensitive measure of visual performance. Sine wave contrast sensitivity functions were examined for spectacle and contact lens correction in well adapted lens wearers. Over the past decades, dozens of articles have been published that investigated the visual performance of soft contact lens wearers. Despite the large number of publications on this topic, there has been no consensus yet, on how contact lenses affect the visual performance in well adapted lens wearers. My article focuses on the effect of visual performance among well adapted contact lens wearers. I have included both soft lens and hard contact wearers and compared their visual performance with their habitual glasses.

Key words : Contrast sensitivity, soft contact lens, hard contact lens, Snellen, Spectacles.

The Snellen chart has historically been used to measure static visual acuity, using small objects at high contrast. These Snellen acuities and various related measures, derived from the ability to resolve fine detail at contrast ratios approaching 100%, have limited utility. There has been a trend towards refined and detailed measurement of visual performance using CSF. Contrast sensitivity determines the capability of the visual system to transmit or filter spatial and temporal information about objects seen. A CSF is obtained by measuring the sensitivity for the discrimination of sine-wave grating from a homogenous field at each of several spatial frequencies. Sensitivity is defined as the logarithm of the reciprocal threshold contrast, where threshold contrast is the difference between maximum and minimum grating luminance divided by the sum of the maximum and minimum luminance when the grating is barely visible.

Early studies on contrast sensitivity function with contact lens and spectacle correction, have contradicted each other. Applegate and Massof (1975), Woo and Hess (1979) and Mitra and Lamberts (1981) all reported a reduction in the CSF in contact lens wear compared to that of spectacle wear in some or all of their patients. Applegate and Massoff (1975) noted the contrast differences with spectacle and contact lenses to be greater at higher spatial frequencies.

In contrast, Bodrick (1981) and Woo and Hess subjects, report no significant difference between contact lenses and spectacles. The overview article by Kelly and Boots (1995) focused on contrast sensitivity testing among new soft contact lens wearers. Sheedy, Harris, Poon and Sakuda (1991) performed a clinical study to compare the task and vision performance with single vision contact lenses and spectacles. However, there were some inconsistencies in the sample selection, sample size and testing procedure in these studies.

The purpose of this study is to determine if there is any significant difference in the contrast sensitivity function among well adapted contact lens wearers. It is also to find if there is a significant difference due to the new advancement in science and technology to manufacture thinner and high quality contact lenses and spectacles as compared to the thicker soft lenses in the past.

Subjects : -

A random, unbiased cross sectional study was performed at the Michigan College of Optometry - Ferris state university. Thirteen well adapted contact lens wearers (11 Soft contact lens wearers & 2 Rigid gas permeable lens wearers) were selected for the study. All the thirteen included in this study have been wearing contact lenses at least an year and some for as long as 15 years. The subjects were pre presbyopic with age between 22 and 29 years old. All subjects met the following criterion for the study :

1. Atleast 10 hours of contact lens wear per day.
2. Good comfort with the contact lenses.
3. Acceptable to no clinically noticeable corneal response to contact lenses.
4. Visual acuity of 20/15 in each eye with their habitual spectacle correction and contact lenses.
5. Pre presbyopic.
6. No asthenopic symptom and no binocular vision problems.
7. Unremarkable ocular health.
8. No past history of eye infection, surgeries, trauma or any refractive surgical procedures.

Of the total thirteen subjects in the study, ten were wearing daily wear soft contact lenses; one was wearing soft Toric lenses and the remaining two subjects were wearing rigid gas permeable lenses. Their refractive errors ranged from +3.25 DS to -8.25 DS with cylindrical power of not more than -0.75 D for spherical lenses and -1.50 D for toric lenses. Subjects were wearing Bausch & Lomb Sequence II; Optima FW; Surevue; S.I; CSI Torisoft and rigid gas permeable lens- FP-60 and Boston 7. All the subjects had their complete eye exam with in the last year.
The subjects were pre informed about the testing date and were asked to bring in their updated spectacle lenses and their contact lenses. They were also given a questionnaire to be completed, that focuses on the subjective visual performance between contact lenses and spectacle lenses.

Contrast sensitivity questionnaire :–

1. Do you find a significant difference in visual performance comparing contact lenses with your spectacles.
   Yes / No

2. Which of the two (contact lens or spectacles) gives good vision. CL/ Spectacles.

3. Any difference in visual performance with contact lens in day or dim light. Yes/ No

4. Grade the visual performance with contact lenses in a scale of :
   1-very bad; 2- bad; 3- no significant difference; 4- good and 5- excellent.
   Day light -
   Dim light-

Apparatus and stimuli :

The contrast sensitivity testing was performed using the B-vat monitor. The instrument was initially calibrated and was tested for reliability and repeatability of the readings. A standard acuity measure of 20/15 was kept constant for all subjects and the contrast was gradually decreased until the subject missed two or more letters with the minimum contrast threshold. The % minimum contrast threshold was directly read from the hand monitor.

Testing Procedure :

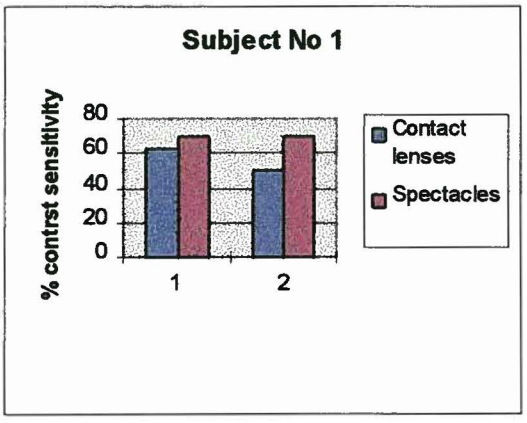
The subjects were initially taken to a standard exam room. A brief contact lens history consisting of the duration of lens wear, Lens type and material, Average daily wearing time, contact lens care system and the general and ocular health was obtained. Visual acuity for distance and near was measured using the standard Snellen chart with contact lenses and spectacles. The fitting of the contact lens and the ocular health was evaluated using the Haag-Strait slit lamp biomicroscope. The subjects were then taken to the special testing room for contrast sensitivity evaluation. The test distance of twenty feet was kept constant for all the subjects and the threshold contrast for 20/15 Snellen letter was measured. Each eye was tested separately first with contact lenses and then with spectacles lenses. The contrast of the 20/15 Snellen optotype was gradually decreased from 98% to 16% etc. (98% being the maximum contrast and 16% being the minimum contrast) until the subject missed two or more letters in the chart. These tasks were not timed. The testing process lasted 15-20 minutes.

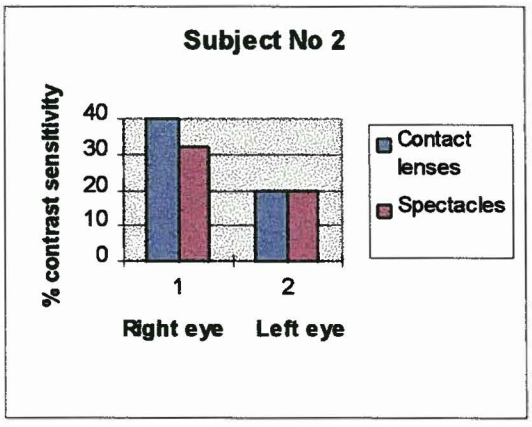
Patient Number	Spectacle Rx	Power of CL	Duration CL wear Yrs	ADW hrs.	V.A. CL/ Spec	Lens Type	% C.S. with CL	% C.S. with Spec
1	OD -2.75-0.75x150	OD -2.50 D			20/15	B & L	63	70
	OS -2.25-0.75x180	OS -2.50 D	12	9 to 12	20/15	Optima FW	50	70
2	OD -2.75 D	OD -2.75 D			20/15	B & L	40	32
	OS -2.50 D	OS -2.50 D	6	15	20/15	Medalist	20	20
3	OD -4.75-0.25x146	OD -5.00 D			20/15	Surevue	40	32
	OS -4.75-0.50x042	OS -5.00 D	7	14 - 16	20/15		50	32
4	OD -1.25 D	OD -1.50 D			20/15	Surevue	40	50
	OS -1.50 D	OS -1.50 D	2	12 to14	20/15		32	50
5	OD -2.75 D	OD -2.75 D			20/15	B & L	40	63
	OS -3.25 D	OS -3.25 D	9	16	20/15	Optima FW	40	63
6	OD -4.25-1.00x41	OD -4.25 D			20/15	B & L	40	50
	OS -8.00 DS	OS -7.50 D	2	12	20/15	Optima FW	40	50
7	OD -2.00-1.00x015	OD -2.25 D			20/15-	B & L	40	50
	OS -2.75-0.75x170	OS -2.75 D	15	10 to 15	20/15-	Optima FW	50	63
8	OD -5.75-0.25x135	OD -5.00 D			20/15	B & L	10	25
	OS -6.75-0.25x035	OS -6.00 D	4 to 5	16	20/15	Seequence	20	40
9	OD -5.25-1.75x015	OD -4.50 D			20/15	DW - RGP	20	40
	OS -7.25-1.00x165	OS -6.75 D	10	16	20/15 RGP		20	32
10	OD -7.75-0.25x015	OD -6.75 D			20/15-	S.I	50	63
	OS -7.50 DS	OS -6.75 D	11	13	20/15		63	63
11	OD -4.50-0.75x100	OD -4.50 D			20/15-	Surevue	63	50
	OS -5.00-0.75x070	OS -5.25 D	14 - 15	10	20/15-		50	40
12	OD -4.00 DS	OD -4.25 D			20/15+	DW - RGP	20	32
	OS -4.00 DS	OS -3.75 D	7	12	20/15+ RGP		25	50
13	OD +2.50-1.00x145	OD Toric			20/15-	CSI Tori	63	50
	OS +3.25-1.50x009	OS Toric	9	12 to 14	20/15-	Soft	50	50

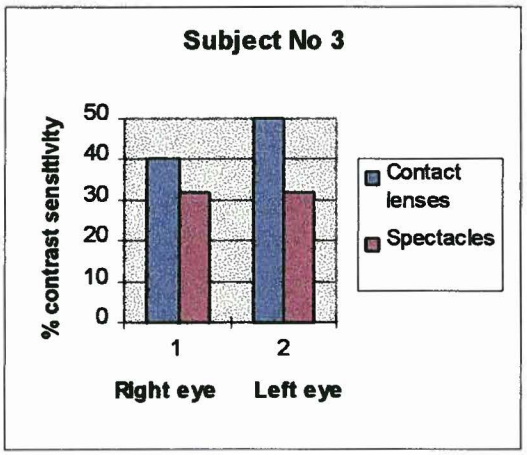
Results :

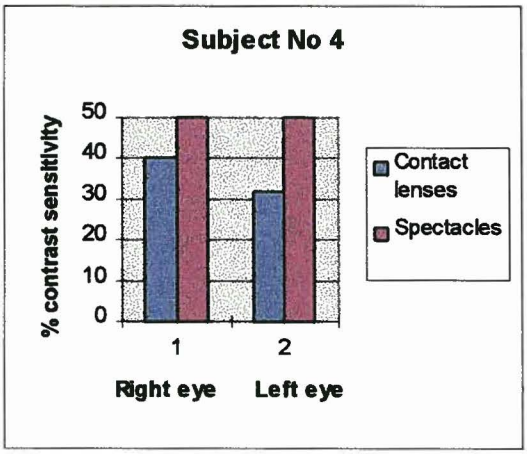
The % contrast threshold for each eye was compared with their contact lenses and the spectacle lenses. The values are summarized in the table below. The threshold values are graphically represented for each subject, comparing contact lens with spectacle for each eye. Of the Twenty six eyes tested (13 subjects) to evaluate the contrast sensitivity function, we found that nineteen eyes had better contrast threshold with contact lenses than with spectacles; four eyes had contrast sensitivity threshold better with glasses than with contact lenses and three eyes had no difference in contrast sensitivity between contact lenses and spectacles.

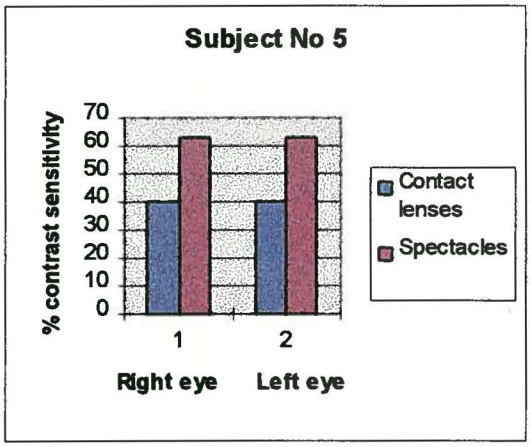
Among the nineteen eyes with contact lenses, the improvement in contrast sensitivity varied from 7% to as high as 25%. There was a variation from 8% to 13% among the four eyes with contrast sensitivity better with spectacles. In other words, 73% of the sample showed improvement in contrast sensitivity with contact lenses, 15.4% with spectacles and 11.5% showed no difference. Assuming that all subjects in the sample were wearing similar quality contact lenses and spectacles, there seems to be a significant difference in contrast sensitivity while wearing contact lenses.

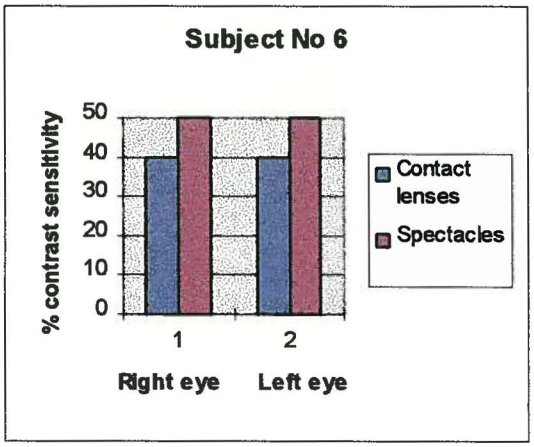


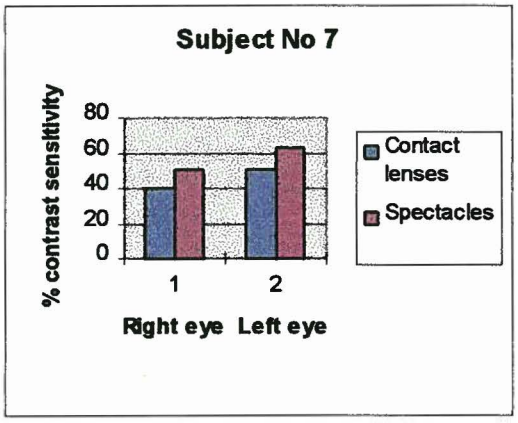


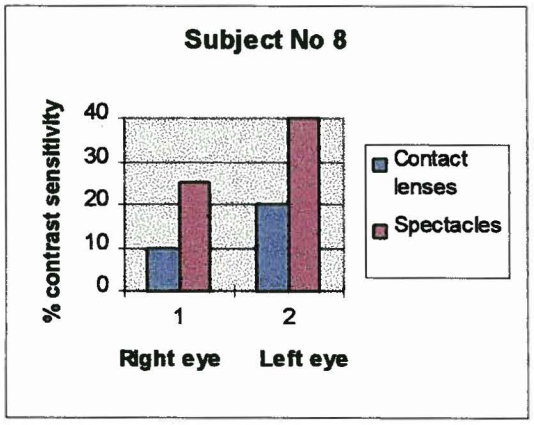

Subject No 3
% contrast sensitivity
50
40
30
20
10
0
1
2
Right eye
Left eye
Contact lenses
Spectacles

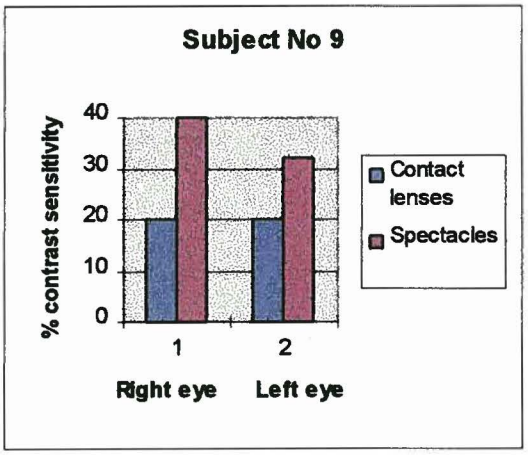

Subject No 4
% contrast sensitivity
50
40
30
20
10
0
1
2
Right eye
Left eye
Contact lenses
Spectacles

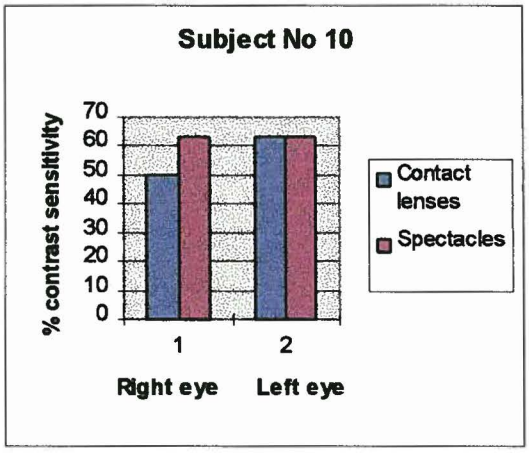

Subject No 5
% contrast sensitivity
70
60
50
40
30
20
10
0
1
2
Right eye
Left eye
Contact lenses
Spectacles

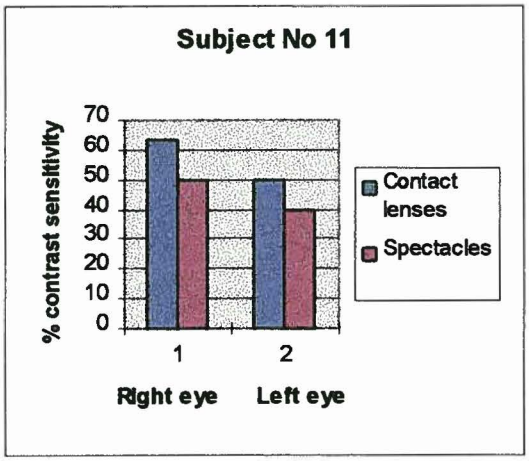

Subject No 6
% contrast sensitivity
50
40
30
20
10
0
1
2
Right eye
Left eye
Contact lenses
Spectacles

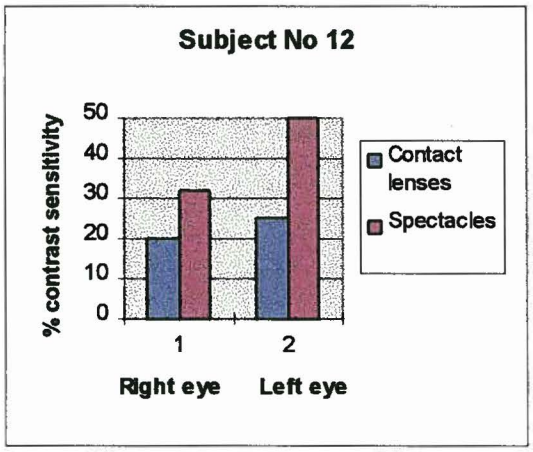

Subject No 7
% contrast sensitivity
80
60
40
20
0
1
2
Right eye
Left eye
Contact lenses
Spectacles

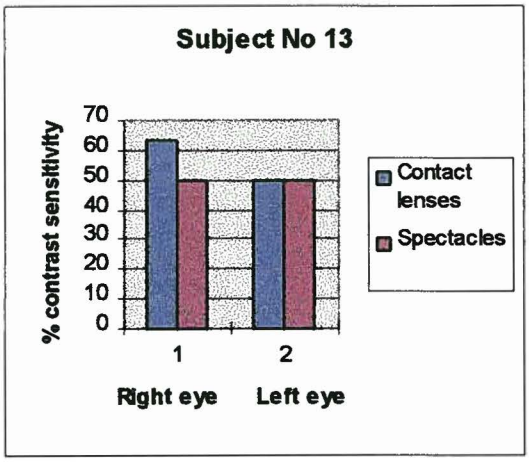

Subject No 8
% contrast sensitivity
40
30
20
10
0
1
2
Right eye
Left eye
Contact lenses
Spectacles


Subject No 9
% contrast sensitivity
40
30
20
10
0
1
2
Right eye
Left eye
Contact lenses
Spectacles


Subject No 10
% contrast sensitivity
70
60
50
40
30
20
10
0
1
2
Right eye
Left eye
Contact lenses
Spectacles


Subject No 11
% contrast sensitivity
70
60
50
40
30
20
10
0
1
2
Right eye
Left eye
Contact lenses
Spectacles


Subject No 12
% contrast sensitivity
50
40
30
20
10
0
1
2
Right eye
Left eye
Contact lenses
Spectacles


Subject No 13
% contrast sensitivity
70
60
50
40
30
20
10
0
1
2
Right eye
Left eye
Contact lenses
Spectacles

Results of the Subjective response- questionnaire

Difference in visual performance between Spectacle and contact lenses =	5/ NO	8/ YES
Good vision with Contact lenses / Spectacles =	8/ CL	
Difference in visual performance in Day/ Dim light with contact lenses =	3/ YES	10/NO

Grade visual performance with contact lenses =

Day =	6/grade 4	7/ grade 5	
Dim =	2/ grade 3	5/ grade 4	6/ grade 5

Among the thirteen subjects, eight found significant difference in visual performance with contact lenses. Ten of the thirteen did not find any subjective difference between day and dim light with contact lenses. This supports my earlier observation.

Discussion :

My study results contradict the study performed by Applegate and Massoff (1975), Woo and Hess (1979) and Mitra and Lamberts(1981) all report a reduction of contrast sensitivity function in contact lens wear compared to that of spectacles in some or all of their patients.

The difference from Applegate and Massoff may be explained by the presence of residual astigmatic refractive error in contact lens wearers. A difference does exist between the results obtained here and those of Mitra and Lamberts (1981), who showed an inferior contrast sensitivity function with soft contact lenses. It is probable that, this is due to the composition of the subject groups, Performance in psychophysical methodology, the different levels of sensitivity obtained in the statistical analyses, or in the type of contact lens correction employed. In a literature review performed by Kelly and Boots (1995) they found a reduction in contrast sensitivity of unadapted soft lens wearers with in the first few hours of lens wear.

These results may be due to the availability of different soft contact lens material, initial adaptation to contact lens wear and the time elapsed between the initial dispense of the soft contact lens and the time visual performance is measured. Lens parameters such as center thickness, water content, the time of contrast sensitivity measurement , refractive error and the astigmatism are important variables to affect visual performance. Thus the authors concluded that the reduction in contrast sensitivity must be attributed to both the optical properties of soft lenses and the corneal changes soft contact lenses induced.

Sheedy, Harris, Poon and Sakuda (1991) found no significant difference in the performance for timed visual tasks between contact lenses and spectacles for both rigid gas permeable or soft contact lenses. Although none of the error performance differences were statistically significant, it is note worthy that 17 to 63% more errors were made on each occupational task with soft contact lenses as compared to spectacles. They attributed the poorer visual acuities with soft contact lenses to be due to larger residual refractive errors.

Bernstein and Brodrick (1979) found no systematic differences between soft contact lenses and spectacles or any systematic changes over the 18 hour period of testing. These results stand in apparent conflict with the results performed in my study. One possible ground for reconciliation is improvement in the quality of soft contact lenses available today.

Limitation :

1. Only pre presbyopic subjects were included in the study.
2. All subjects were Caucasians.
3. Sample size may be too small.
4. Most of the subjects were wearing soft contact lenses.
5. Contrast sensitivity measured with B-Vat does not give the exact %. For example any percentage greater than 80% will be shown as 98%. This cause some error will comparing percentages between two experiments.

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