The effect of a Computer Lens Filter on visual performance in subjects with retinitis pigmentosa

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Research article

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Abstract

Background Retinitis pigmentosa (RP) patients usually complain about nyctalopia and reduced dark adaptation which cause their visual discomfort. In this study we aimed to explore the effects of a UV reduction Computer Lens Filter (CLF) on contrast sensitivity (CS), reading speed for computer screen text and visual comfort in subjects with retinitis pigmentosa (RP) to find if a CLF is helpful for RP patients . Method: Twenty-two subjects diagnosed with binocular RP participated. Bright CS using the Mars test and reading speed for screen text were measured both with and without CLF wear. Subjective estimates of computer screen brightness and visual comfort were evaluated by Linkert self-report estimates. These functions were compared for the two conditions of filter wear and non-wear. Result Mean subject age was 38.2±7.5 years and mean logMAR VA was 0.505± 0.324. Wearing a CLF did not improve bright CS (t = 0.680, P=0.504) or increase reading speed (t =-0.223, P = 0.826). CLF wear was judged to reduce screen brightness (t = -5.412, P<0.0001) and improve visual comfort (t = 6.897, P<0.0001). Conclusion CLF wear did not improve RP subjects' CS or reading speed for screen text, but did reduce the appearance of screen brightness and improve subjects' reported visual comfort. Improvement in comfort alone may be sufficient justification for filter use as a vision aid for RP patients during vision rehabilitation.

Background

Retinitis pigmentosa (RP) is a bilateral retinal hereditary dystrophy. The most common symptoms for this disease are nyctalopia, reduced dark adaptation, reduced central VA, and blue-yellow channel dyschromatopsia [1]. The incidence of RP is about 1/4000 with millions of RP patients worldwide [2]. Vision impairment in RP is progressive with early symptoms including night blindness and constriction of visual fields. RP makes pedestrian orientation and mobility difficult, and together with reduced VA it impairs recognition of detail and slows reading rate [3]. Reading is the second most important near vision demand reported by low vision patients in China [4]. Our reliance on computers to execute work-related tasks has increased [5] resulting in more commonly reported visual fatigue[6] presumably due to the increased blue light emissions of LED-backlit liquid crystal displays[7] compared with previous-generation cathode ray tubes. Selected wavelength filters protect the retina and other ocular tissues against sunlight glare and contribute to ocular comfort in RP low vision patients [8, 9]. Filters are reported to improve the quality of vision by reducing recovery durations for light adaptation. They have been reported to increase retinal image contrast and decrease light dispersion and chromatic aberration inside the ocular media, improving visual comfort [10].

Previous studies have shown that wearing a blue UV filter during computer use reduces glare and visual fatigue [7, 11, 12]. However, these studies do not indicate whether an associated improvement in visual comfort with filter wear occurs for RP patients.

We analyzed bright CS, reading speed and the visual comfort of our RP subjects when reading text on a computer with and without CLF wear. We sought also to determine whether wearing a CLF improved visual comfort and warranted prescription as an effective low vision aid during vision rehabilitation.

Methods

Subjects

We recruited 22 patients who attended the Low Vision Rehabilitation Center in the Eye Hospital of Wenzhou Medical University from October to December in 2017 to participate. All had been diagnosed with binocular retinitis pigmentosa. The study was conducted in compliance with good clinical practice guidelines, institutional review board regulations and the tenets of the Declaration of Helsinki. All subjects were given a written explanation of the study and consented in writing to participate. Our consent form explained that enrolment in this study did not imply any risk to ocular health and provided the right of withdrawal from the study at any time.

Inclusion criteria were: 1) both eyes were diagnosed with retinitis pigmentosa according to its clinical manifestations, such as family history of night blindness, changes in visual field, changes in the fundus with typical pigment disorders, and ERG suggested retinitis pigmentosa dysfunction. 2) VA with best spectacle correction was better than 20/400.

Exclusion criteria were: 1) the presence of other diseases that affected VA, such as corneal ulcer, pterygium and cataract; 2) a history of eye surgery, such as laser surgery and cataract surgery; 3) other ocular fundus diseases, such as diabetic retinopathy, glaucoma, optic nerve disease, etc; 4) congenital color blindness, mental handicap, illiteracy, and 5) refusal to answer the Linkert self-report.

Patients were tested with their best correction for the distance being viewed. A normal age-matched control group of 22 subjects was used to provide a standard for the Linkert self-report section of the study.

Material and methods

1. **Computer Lens Filter**

We used a commercially available CLF from Fitovers (Jonathan Paul Eyewear Pty Limited) as blue-light blocking spectacle lenses. Specifications provided by the manufacturer are transmission spectrum (Figure 1) and specific filter parameters (Table 1).

2. **The computer display**

Our computer was a *Lenovo Small New 700*, with a 15.6 inch screen, a display resolution of and maximum screen luminance of 200 cd/m^2. Text was presented on the maximum background illumination level of 200 cd/m^2. Room luminance in the area of the computer was 90 to 120 cd/m^2.

3. **Reading content**

We selected reading content from the Chinese Reading Visual Acuity Chart written by Wang Chenxiao [13]. This chart contains three similar sentences, each with 30 characters, as shown in figure 2. Each subject chose a font size consistent with their VA demand for clear and comfortable reading at their habitual screen distance.

4. **Bright contrast sensitivity**

CS at near was measured monocularly using the Mars Numeral Contrast Sensitivity test, measured first without CLF, then with the filter. The examination room illumination illuminated the Mars chart to a luminance of 85 cd/m^2 and the test distance was 0.5 m. Examination commenced with the MARS first visual target and subjects were asked to identify targets one by one until two continuous errors occurred, at which stage the test was stopped and the result recorded.

5. **Reading speed test on computer**
6. RP subjects sat in front of the computer at their habitual reading distance. Using page E as the reading example, subjects adjusted font size until they could read clearly and comfortably. Reading test speeds were recorded by presenting Pages A and B both with and without the CLF but in random sequence. Words that subjects did not know or could not identify were skipped. Subjects were given a 5 minutes break between each test. The text is taken from the Reading content

7. **Linkert self-report**

Any subjective perception of change in visual comfort and brightness of the computer before and after wearing the CLF were recorded using a Linkert self-report. At the end of each reading test we asked subjects to grade comfort level and perception of screen brightness on linear scales from +10 to -10. 'Zero' was defined as the base line score for comfort level without the CLF. The higher the score, the more comfortable the task and brighter the text screen. Linkert scales are shown in figure 3. The Linkert scales do not indicate specific physical attributes and are not linked to a validated questionnaire. Therefore , an age-matched normal control group was used to be albe to compare the patients results with those of normal people.

Data analysis

Results were tabulated and comparisons tested using SPSS V23.0. Statistical significance was judged to be $P<0.05$.

Results

Patient characteristics

The average age of subjects was 38.364±7.650 years and the ratio of males to females was 6:16. Average logMAR visual acuity was 0.505 ± 0.324.

Linkert self-report

Wearing CLF both improved RP subjects' visual comfort and reduced computer screen brightness compared with the no-filter condition. Subjects rated visual comfort using the CLF as 4.045 *($t= 6.897, P<0.0001$)*, an improvement over the no-filter condition. The comfort rating for the age matched normal control group was 3.140±3.328, which did not differ from the RP group *($t=-0.988$, $P=0.329$)*. At the same time, subjects reported that CLF wear reduced screen brightness compared with the no-filter condition -2.820±2.442 *($t=-5.412$, $P< 0.0001$)*. This also did not differ from the control group -3.227±1.798 *($t=-0.633$, $P=0.531$)*. See table 2, figure 4.

Bright contrast sensitivity

Mean bright CS with CLF wear was 1.022±0.495 and 1.055±0.491 with no filter *($t=0.680$, $P=0.504$)*. CLF wear did not increase bright CS in our subjects. See table 2.

Reading speed

CLF wear did not increase subjects' reading speeds. The average reading speed with CLF was 210.2±92.822 and without filter 209.1±95.011 (characters /min) *($t=-0.223$, $P=0.826$)*. See table2.

Discussion

Photophobia and light-induced interference with visual comfort and performance are the main complaints of RP patients [14, 15]. Discomfort is usually reported as glare, reflections, flicker and non-uniformity of illumination, all interfering with task performance [16]. Probable causes of these symptoms in RP patients are: (1) general photophobia caused by light scatter, since the retinal pigment epithelium can no longer absorb light normally. This causes poor adaptation to different illumination levels because of the lack of photoreceptor function [17, 18]. (2) increased levels of intraocular light scatter caused by posterior subcapsular cataracts that decrease retinal image quality [19, 20].

What is now termed the video terminal syndrome is a multifactorial condition with several potential contributory causes, such as uncorrected refractive error, especially astigmatism, presbyopia, and tear film abnormalities [21]. This experiment also takes into account that the refractive error will affect patient discomfort. Before the experiment, the patients were corrected for their refractive errors, and plus lens additions were added for the appropriate viewing distance for patients who needed. We then measured reading speed and comfort of RP patients in the most comfortable way, instead of testing the patients with their distance refractive correction. And in order to exclude the video terminal syndrome that includes prolonged tear film ruptures caused by long-term reading, the reading time of each reading session was interrupted for 5 minutes to reduce eye strain associated with computer use based on physiologic correlates of eye fatigue.

Carracedo et al. showed that only 11% of RP patients wearing a CPF-527 filter reported improvement in visual comfort for indoor activities of daily living [22]. In our study, 95% of subjects (21/22) wearing CLF reported improved comfort during computer use. Possible reasons for the difference between the two studies were the filter type and the visual task. Our CLF filtered 100% of wavelengths <400 nm and 71% of wavelengths between 400-500 nm, with a total luminance transmittance of 74.5%. The CPF-527 filter Carracedo et al. used removed 90% of the wavelengths <550 nm with a luminance transmittance of 21%. Total transmittance may be one contributing factor to visual comfort and an explanation for the difference. Second, we investigated visual comfort when RP patients read text on a computer screen that transmitted more blue light that might cause eye strain. Carracedo et al. studied the visual comfort during a broader range of their subjects' general daily activities. These are important differences between visual task conditions.

Declines in CS with progression of RP lead to difficulty in daily tasks [23, 24]. Van den Berg and Carracedo et al. found that RP patients wearing filters had improved CS [22, 25], while Cedron-Sanchez et al. showed that filters improved visual discrimination for their RP patients [15]. In our study, CLF wear did not enhance CS. Differences in spectral and luminance transmission of the various filters used in these studies may be a reason for these disparities in CS. Van den Berg and Carracedo et al, both used CPF-527 filters that filter out 98% the wavelengths below 527nm with an overall 32% transmittance.

Another reason for the discrepancies between studies may be the differences in contrast sensitivity tables. Gonzalo Carracedo et al,point out that contact filters improve contrast sensitivity at medium and high frequencies, while glass filters only improve contrast sensitivity at high frequencies. In our study, the Mars contrast sensitivity table was used. The visual Angle of each letter at 0.5m was 2°, corresponding to logMAR VA of 1.380. which is near the normal peak frequency of the CSF. Our RP patients had such good vision that they may have easily met the vision standard of 1.38. The finding of Colombo et al is also different from ours [24]. Although they also used Mars charts and selective blue-violet light filtering spectacle lenses, they included patients affected by retinal diseases other than RP.

Virgili et al. pointed out that reading difficulty for RP patients is closely related to progressive reduction of visual field, gradual loss of vision and significant reduction of high frequency CS [3]. Szlyk et al found statistically significant correlations between the clinical measures of vision such as CS and the functional performance of daily tasks, where better CS was associated with better reading performance [24]. We used random text sequences to eliminate any learning effect for accuracy of reading speed. The fact that CLF wear neither enhanced CS nor expanded the visual field of RP subjects [26] is one explanation for no change in reading speed with filter wear. Another reason may be that lens wear and transmittance of filters affect the visual acuity of RP patients differently. Visual acuity improved with refractive correction lens wear, while filter absorbance reduces luminance. The absorbance of the CLF alone is 74.5%. This can reduce visual brightness, but the contrast sensitivity is not expected to change with such a small luminance change. Thus, the eyeglass wear and CLF filter used in this study is consistent with the lack of effect of the CLF on vision and and reading speed.

Although CS and reading speed did not improve with filter wear, our subjects reported that their visual comfort improved. This finding suggests that patients with RP who experience photophobia when reading on a computer screen can be prescribed a CLF to improve their comfort and quality of life.

Conclusion CLF wear did not improve RP subjects' CS or reading speed for screen text, but did reduce the appearance of screen brightness and improve subjects' reported visual comfort. Improvement in comfort alone may be sufficient justification for filter use as a vision aid for RP patients during vision rehabilitation.

List Of Abbreviations

RP: Retinitis pigmentosa **CLF:** Computer Lens Filter

BCVA: best corrected visual acuity **CS:** contrast sensitivity

MAR: Minimum Angle of Resolution **LED:** Light Emitting Diode

Declarations

Ethics approval and consent to participate

This study was approved by the Human Research Ethics Committee of the Wenzhou Medical University, Eye Hospital [No. KYK[2018]02] and complied with the Declaration of Helsinki. Written informed consents were obtained from the patients.

Consent for publication

All authors approved the manuscript for publication, but there is not applicable of consent for the publication of identifying images or other personal or clinical details of participants that compromise anonymity.

Availability of data and materials

The datasets used during the current study available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

Conceptualization: ZMG,LZN ; Data Curation: ZMG; Writing – Original Draft: ZMG, LZN; Formal Analysis: ZMG; Project Administration: LZN, NL , YZ , LFJ; Supervision: Deng R, Lingzhi Ni; Writing –Review & Editing: ZMG , LZN DR. All authors have read and approved the manuscript for submission.

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Tables

Table 1 The specific filter parameters of CLF(Computer Lens Filter)

Glass filter	Main wavelengths filtered	Light transmission	Ultraviolet filtration rate	Blue light filtration rate
CLF	400-500nm	74.5%	100%	71%

Table 2. The results of logMAR, CS, reading speed, comfort level and brightness

		Without CLF	With CLF	t&	P&	t1#	p1#	t2#	P2#
logMAR	Control	-0.41± 0.0503	-	-	-	-7.819	<0.0001*	-	-
	RP	0.505±0.324	-	-	-				
Average of CS	Control	1.591±0.037	1.588±0.046	0.228	0.821	5.375	<0.0001*	5.542	<0.0001*
	RP	1.022±0.495	1.005±0.491	0.680	0.504				
Average Reading Speed(number of characters /min)	Control	319.0±51.215	309.6±59.052	1.341	0.194	4.774	<0.0001*	4.238	<0.0001*
	RP	209.1±95.011	210.2±92.822	-0.223	0.826				
Comfort level	Control	0	3.140±3.328	4.420	<0.0001	-	-	-0.988	0.329
	RP	0	4.045±2.751	6.897	<0.0001				
Brightness level	Control	0	-3.227 ±1.798	-8.421	<0.0001	-	-	-0.633	0.531
	RP	0	-2.820 ±2.442	-5.412	<0.0001				

&: Compare without CLF and with CLF;

1#: compare between control group and RP group without CLF;

2#: compare between control group and RP group with CLF;

*: the difference was statistically significant;

Figures

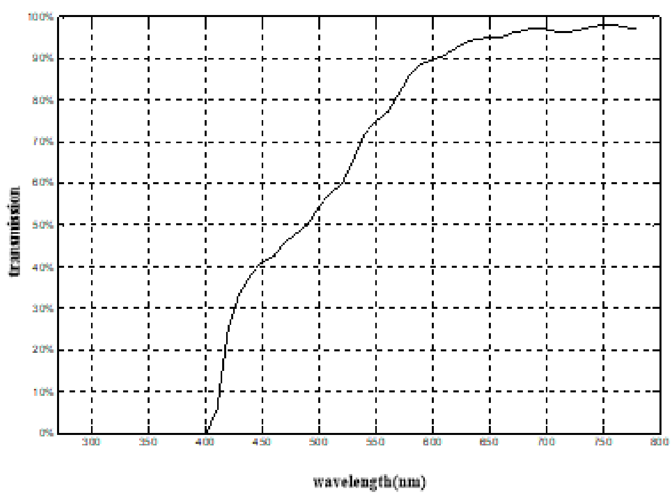

Figure 1

the spectrogram of CLF (Computer Lens Filter) of Fitovers

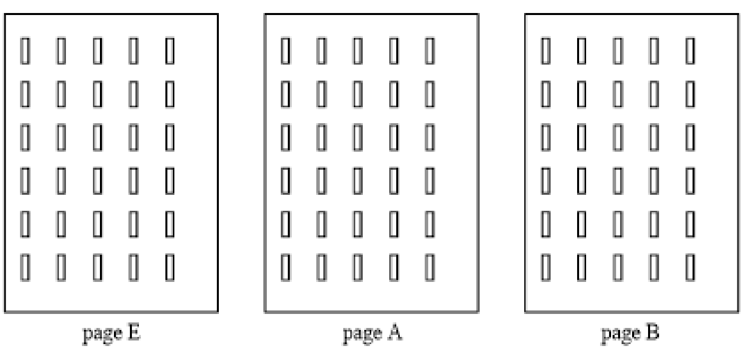

Figure 2

reading content

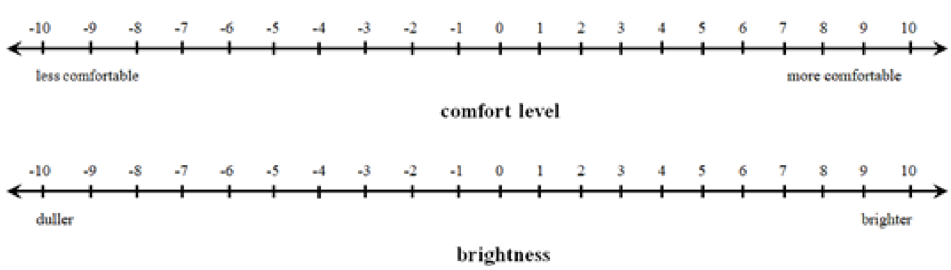

Figure 3

The questionnaire of comfort level and brightness

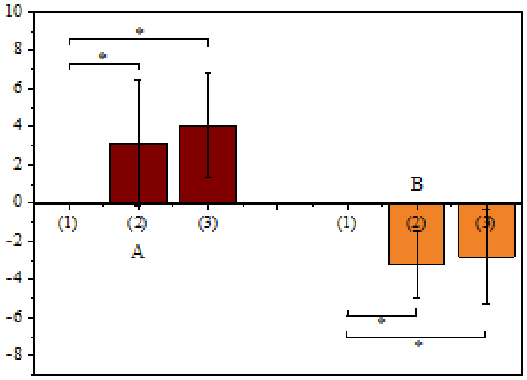

Figure 4

Results of comfort and brightness. A(1) without filter, the mean of comfort level is 0. A(2) with filter ,the mean of comfort level of control group is 3.140±3.328, P<0.0001. A(3). with filter, the mean of comfort level of RP patients is 4.045±2.751, P<0.0001.B(1) without filter, the mean of brightness level is 0. B(2) with filter, the mean of brightness level of control group is -3.227±1.798, P<0.0001.B(3) with filter, the mean of brightness level of RP patients is -2.820±2.442, P<0.0001. *: the difference was statistically significant compared with that without CLF

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