Article • Spectral Transmission of Sunglasses from Patients with Various Inherited Retinal Diseases

Chloe M. Vezinaw, OD • The Chicago Lighthouse • Chicago, Illinois

Gerald A Fishman, MD • The Chicago Lighthouse • Chicago, Illinois

Chloe M. Vezinaw, OD
Chicago, Illinois

Optometrist with Rosin Eyecare

Fellowship studying inherited retinal diseases and electrophysiology at the Pangere Center within the Chicago Lighthouse, 2018-2019

Illinois College of Optometry, 2018

Bradley University, Biology major, 2014

ABSTRACT

Background: Light comprised of ultraviolet and blue wavelengths is known to cause potential damage to the retina after chronic exposure. Those with already compromised retinas are potentially at a greater risk of experiencing damage from this light exposure. Subsequently, it is likely important that such patients wear the most optimal sun protection to try and diminish this potential risk. As such, we sought to determine the effectiveness of their sunglass lenses for filtering blue and ultraviolet wavelengths of light in a group of patients with compromised retinas.

Methods: Forty subjects with various inherited retinal diseases were included in the study. We inquired by a simplified questionnaire how patients selected their most recent sunglasses and how satisfied they were for reducing their discomfort from light exposure. The light transmission quality of their selected lenses was measured with a spectral transmission lensometer.

Results: The average percentage of blue light transmitted from subjects' measured lenses was 13.9% (range 0-60%) and that most (70.0%) subjects' lenses blocked all UVB and UVA light. Most (82.5%) subjects were either very satisfied or satisfied with the protection of their current sunglasses from discomfort during light exposure. Their sunglasses were mainly selected due to a recommendation by an eye care professional (35.0%) or by fashion (30.0%).

Conclusion: Most subjects were satisfied with the comfort afforded by their sunglasses although, on the whole, they did not provide ideal protective qualities in reference to filtering blue light. Eye care providers and fashion made the most contributions towards sunglass selection.

Keywords: blue light exposure, inherited retinal diseases, retinal toxicity, sun protection

Introduction

Photons of light are absorbed by photoreceptors within the human retina resulting in retinal phototransduction and facilitation of the retinoid cycle. When the rod and cone photoreceptors absorb light, they are potentially subjected to damage depending on the characteristics of the exposing light. These characteristics include: wavelength, intensity, and duration of exposure.[1,2]

Ultraviolet (UV) light has been defined as light within the 100-400 nanometer spectrum[1] and blue light has been defined as light within the 400-500 nanometer spectrum.[3] Studies show that light comprised of these wavelengths can cause retinal damage.[3,4] Thus, it is important that people with already compromised retinas, such as patients with inherited retinal diseases, be protected from these potentially most harmful wavelengths. Studies conducted on mouse models mimicking autosomal dominant retinitis pigmentosa showed exposure to white light accelerated the progression of the condition.[5,6] Similarly, studies conducted on mouse models mimicking Leber congenital amaurosis demonstrated acceleration of disease progression following exposure to white light comprised of 350-700 nanometers.[7] Further studies conducted on rats with retinitis pigmentosa and those with albinism have led scientists to recommend elimination of blue light transmission in sunglasses.[3,8,9] It has been determined that if all wavelengths of light under 500 nm are completely filtered, then the risk of phototoxicity to the retina is reduced by 98%.[10] Hence, an optimally protective lens would be one in which all UV and blue light wavelengths were filtered.

Sunglasses have a role in providing comfort and likely some degree of ocular protection from potentially harmful wavelengths of light. However, their potential protective quality can vary greatly between brands. Transmission of UV light has been found to vary from 1.5% to 40% in sunglasses.[11] Further, it is probably less likely that a majority of people consciously select sunglasses based upon their perceived light transmission quality, or reducing the threat of retinal damage, but rather on other factors such as their appearance, comfort, or cost. In this study, we sought to understand how patients with various inherited retinal diseases were selecting their sunglasses and the potential protective quality of their sunglasses, particularly for the filtering of ultraviolet and blue light.

Methods

Subject Selection

Forty patients seen at the Pangere Center for inherited retinal diseases in Chicago, IL were randomly selected. All scheduled patients were requested to bring their sunglasses to their upcoming appointment. Patients without inherited retinal diseases were excluded. Further, patients who were unable to evaluate the satisfaction of their sunglasses due to recent purchase and minimal wear-time were excluded (N=2). Patients with more than one pair of sunglasses were asked to supply the pair that they wear most frequently (N=9). Subject demographics are summarized in Table 1.

Table 1. Summary of subject demographics and various retinal diseases

Sex	
Males	17 (42.5%)
Female	23 (57.5%)
Age (years)	
Mean	46.2
Range	18-78
Ethnicity	
Caucasian	29 (72.5%)
Hispanic	6 (15%)
African American	5 (12.5%)
Condition	
Retinitis Pigmentosa	14 (35%)
Stargardt Disease	14 (35%)
Cone-Rod Dystrophy	6 (15%)
Cone Dystrophy	2 (5%)
Late-Onset Retinal Dystrophy	1 (2.5%)
Familial Drusen	1 (2.5%)
Myopic Degeneration	1 (2.5%)
X-Linked Retinoschisis	1 (2.5%)

Table 2. List of questionnaire inquiries

1. How satisfied with your current sunglasses are you for protecting your eyes against light exposure?
a. Very satisfied
b. Satisfied
c. Unsure
d. Dissatisfied
2. On what basis did you select your current pair of sunglasses?
a. Fashion
b. Cost
c. Recommendation by eye care professional
d. Other (please list)
3. How long have you worn your current pair of sunglasses?
a. A few days
b. A few weeks
c. A few months
d. A year or more
4. Are the sunglasses you provided today the only pair you wear when a sunglass is necessary?
a. Yes
b. No
c. Unsure

Procedure

This study was approved by the Western Institutional Review Board and was in accordance with HIPAA regulations as well as the tenets of the Declaration of Helsinki. Subjects who agreed to participate were informed of the nature of the study as well as any risks or benefits of participating. All subjects signed a consent form. A simplified, multiple-choice questionnaire (Table 2) was administered. The sunglass transmission properties were measured using a Humphrey Lens Analyzer 360 Auto Lensometer (ZEISS, New York, USA). The lensometer measured percent transmission of UVB, UVA, and visible light. Percent transmission of blue light was determined by taking the peak transmission spectrum between 400-475nm. This range was selected because the blue spectrum begins at 400nm[5] and it has been found that photoreceptors may be damaged by wavelengths of 475nm or less.[12] To determine if the spectral transmission differed between sunglasses provided by subjects who selected their sunglasses on the basis of a recommendation by an eye care provider or those who selected on the basis of fashion or cost, a two-sample t-test assuming equal variances was performed. To determine if the spectral transmission differed between sunglasses provided by subjects who were dissatisfied or unsure if they were satisfied with their current sunglasses for protecting their eyes against discomfort during light exposure verse satisfied subjects, a two-sample t-test

assuming equal variances was performed. Statistical significance was determined by having a p-value less than 0.05. Subjects were informed of the results and counseled on optimal sunglass selection.

Results

Questionnaire

Most subjects (82.5%) felt that they were very satisfied or satisfied with the effectiveness of their current sunglasses for facilitating less light discomfort. The reasons subjects selected their sunglasses were as follows: recommendation by an eye care professional (35.0%), fashion (30.0%), cost (17.5%), or comfort (17.5%). A majority of subjects (62.5%) had worn their sunglasses for a year or more. Most subjects (77.5%) provided sunglasses that were the only pair they wore when a sunglass was needed.

Spectral Analysis

Transmission data are summarized in Table 3. Seventy percent of subjects selected lenses that blocked all UVB and UVA wavelengths. The average percent of blue light transmitted was 13.9% with a range of 0%-60.0% and a median value equal to 12.0%. The average percent of visible light transmitted was 16.5% with a range of 1.0%-66.0% and a median value equal to 14.0%. Table 4 shows that there was no statistical difference in the spectral transmission of UVB, UVA, or violet light between sunglasses provided by subjects who selected their sunglasses on the basis of cost/fashion or recommendation by an eye care provider (all p-values greater that 0.05). There was a statistical difference in the transmission of blue light (p-value=0.03). Sunglasses provided by subjects that selected them due to a recommendation by an eye care provider had a statistically lower percent transmission of blue light than subjects who selected their sunglasses on the basis of fashion/cost. Table 5 shows that there was no statistical difference between the spectral transmission of UVB, UVA, blue or ultraviolet light from sunglasses worn by subjects who were dissatisfied or unsure if they were satisfied with their current sunglasses for protecting their eyes against discomfort during light exposure versus satisfied subjects (all p-values greater than 0.05).

Table 3. Percent spectral transmission data of measured lenses

UVB	
Mean	0.18
Range	0-1
Median	0
UVA	
Mean	0.45
Range	0-11
Median	0
Blue Light	
Mean	13.9
Range	0-60
Median	12.0
Visible Light	
Mean	16.5
Range	1-66
Median	14.0

Table 4. The statistical difference between the spectral transmission data of sunglasses provided by subjects who selected their sunglasses on the basis of a recommendation by an eye care provider versus fashion/cost.

Spectral Transmission Range	P-value
UVB	0.96
UVA	0.21
Blue	0.03
Visible	0.09

Table 5. The statistical difference between spectral transmission data from sunglasses being worn by subjects who were dissatisfied or unsure if they were satisfied with their current sunglasses for protecting their eye against discomfort during light exposure versus satisfied subjects.

Spectral Transmission Range	P-value
UVB	0.81
UVA	0.62
Blue	0.43
Visible	0.92

Discussion

Retinal damage as the result of blue light exposure has been considered as controversial. While some have questioned whether blue light can damage the retina, the weight of the evidence regarding potential harm warrants a recommendation to reduce exposure of UV and short-wavelength light. There are studies conducted on rhesus monkeys that determined cone photoreceptors were damaged by exposure to blue light of 463 nm.[13,14] It has been determined that rhesus monkeys serve as a model for similar human tolerance in regard to retinal light toxicity.[15,16] Another concern is that nearly 90% of blue light is transmitted through the cornea, lens, and vitreous humor.[17] As such, the photoreceptors are exposed to much of the offending light. In patients with certain inherited retinal diseases, their photoreceptors are already degenerating. The RPE is damaged by blue light and the already impaired photoreceptors may be subjected to even further damage from the compromised RPE function that is necessary for the survival of photoreceptor cells.[18]

Our questionnaire results showed that most sunglasses were selected due to either a recommendation by an eye care professional or fashion. A potential selection bias might occur if an individual visual practitioner recommended a specific sunglass tint as traditionally occurs with one of the authors (GAF), who recommends brown-tinted sunglass lenses that are known to poorly transmit blue light.[19] Additionally, the questionnaire results showed 77.5% of subjects had only one pair of sunglasses that they wore regularly. Further, most lenses were worn for a year or more, and subjects were overall satisfied with the comfort that their sunglasses provided from light exposure. Question 1 of our survey asked subjects to rate their satisfaction with their lenses for protection against light exposure. This question was intended to ascertain the protection from light discomfort during exposure to light. It does not address protection from retinal tissue damage that could be independent from the level of discomfort.

The spectral transmission results showed that most subjects were wearing sunglasses that filtered UV light and transmitted, on average, 16.5% of visible light (up to 66%) and 13.9% of blue light (up to 60%). Statistical analysis showed that recommendations by eye care providers resulted in subjects selecting sunglasses that filtered out more blue light than those who selected sunglasses on the basis of fashion/cost. There was not a statistical difference in the spectral transmission of sunglasses from subjects that were satisfied or dissatisfied with their sunglasses for protecting their eyes against light exposure.

Our study underpins the observation that in our cohort of patients, the participants, unknowingly, were selecting sunglasses that were not comprehensively filtering blue light. This finding suggests that visual practitioners should practice due diligence when advising patients as to the selection of their sunglasses.

It is of relevance to note that various factors other than the spectral transmission of sunglasses could impact upon light exposure to the retina, such as, the frame design of the sunglasses, presence of a nuclear sclerotic cataract, and whether or not a brimmed hat was worn.

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Correspondence regarding this article should be emailed to Chloe M. Vezinaw OD, at CVezinaw@eyedoc.ico.edu.

Vezinaw CM, Fishman GM. Spectral transmission of sunglasses from patients with various inherited retinal diseases. Optom Vis Perf 2020;8(1):39-42.