Evidence base for the efficacy of blue blocking spectacle lenses for visual comfort and as protection against macular disease[*]

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Light falling within the blue region of the electromagnetic spectrum (400 – 500nm) is potentially phototoxic to the retina and could also lead to a variety of visual symptoms including (but not exclusively) changes to visual acuity or contrast sensitivity, colour discrimination, glare and visual fatigue/discomfort. Blue blocking spectacle lenses are claimed to offer benefit for retinal protection. They are also claimed to reduce eye fatigue following intensive visual tasks and improve sleep quality following the use of electronic devices at night.

The College of Optometrists' "Using Evidence in Practice" series provides a reliable source of evidence-based information to support optometrists in their practice. The recommendation to practitioners for prescribing blue-blocking spectacle lenses to alleviate symptoms of eye fatigue, improve visual performance and sleep quality based on current best evidence is:

There is a lack of high quality clinical evidence to support prescribing blue-blocking spectacle lenses for the general population to improve visual performance or sleep quality, alleviate eye fatigue or preserve macular health.

The level of evidence was considered to be 'low' or 'very low' for visual performance, eye fatigue and sleep quality. (*GRADE: Grading of Recommendations Assessment, Development and Evaluation*[†]). As a result little confidence can be ascribed to the overall outcome formed from the included studies.

The strongest evidence for the efficacy of any therapeutic intervention is obtained from 'randomised controlled trials' (RCTs) in which patients with the target condition are randomised to receive either the treatment under investigation or a comparator (e.g. placebo, no treatment or 'standard care'). Ideally, neither the patient nor the treating clinician should be aware of which therapy was received. Although it is not always possible to mask the patient in a trial investigating blue-blocking spectacle lenses, the clinician assessing the outcome should be masked in order to reduce the potential for bias. When considering the evidence for the use of blue-blocking spectacle lenses, four questions were addressed:

1. Are blue-blocking spectacle lenses effective in improving visual performance?
2. Are blue-blocking spectacle lenses effective in alleviating the symptoms of visual fatigue or discomfort?
3. Are there any structural changes in the macula following the intervention?
4. Are blue-blocking spectacle lenses effective in improving sleep quality?

A systematic literature review was undertaken as part of the development process for this guideline (search date 02.05.17). Three studies that met the inclusion criteria were identified (see characteristics of included studies table).

A small RCT[1] investigated the change in sleep and mood in 20 participants who subjectively reported sleep difficulty defined as sleep-onset insomnia, mild-sleep insomnia and terminal insomnia.

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[*] This article is based on the following systematic review: Lawrenson JG, Hull CC and Downie LE. The effect of blue-light blocking spectacle lenses on visual performance, macular health and the sleep-wake cycle: a systematic review of the literature. *Ophthalm Physiol Opt*. 2017

[†] http://www.gradeworkinggroup.org/

Subjects were randomly allocated to receive either amber glasses (intervention) or the yellow-tinted "safety" glasses (placebo) with 10 subjects in the experimental and control groups respectively. Transmission spectra reported by the authors confirmed that the amber glasses blocked light below 550nm whereas the yellow safety glasses (placebo) blocked light below 465nm. It is noteworthy that the placebo glasses would also attenuate some blue wavelengths given the UVA band extends from 315 – 400nm so its upper limit is some way below the 465nm 50% transmission value of the yellow-safety glasses used as the placebo. The participants were blinded to the hypothesis that amber glasses improve sleep quality. Outcomes were measured using a sleep diary and Positive Affect and Negative Affect Scale (PANAS) mood scale upon waking each morning. Compliance was not systematically assessed. For the first week, baseline measures were obtained with no lenses worn. During the subsequent two weeks either the intervention or control was worn for 3 hours immediately prior to bedtime. The study reported a significant difference in sleep quality and positive affect on the mood scale between intervention and control groups with a statistically significant interaction between sleep quality and intervention and positive affect on mood and intervention. However, the conclusions that can be drawn from this study are limited by differences in baseline and lack of a validated tool for assessing sleep quality. The authors also note the limitation of the placebo (control) condition where the lenses would also have affected the blue light input into the circadian system given they reduce transmission of wavelengths below 465nm as already noted. Re-analysis of the data using mean differences confirms a small improvement in sleep quality for those wearing amber lenses with a mean difference of 1.4 and confidence limits 0.17 to 1.43.

In a second RCT[2], Leung and co-workers recruited 80 computer users into a pseudo-randomised controlled trial that used a crossover design. The participants were split equally between young adults aged 18-30 years and middle aged adults aged 40-55 years to allow for the reduction in visual function in middle age. The trial compared blue-blocking anti-reflection coated lenses (which work by reflecting blue light), brown tinted lenses (absorption) and a clear, anti-reflection coated control lens. The reported blue light transmittance values of these lenses were 82.2%, 77.5% and 90% respectively. The primary outcomes were contrast sensitivity under standard and glare conditions (Mars letter contrast sensitivity test) and colour discrimination (Farnsworth-Munsell 100 Hue). Following baseline assessments participants were randomly allocated to one of the three lens types, which they had to wear for a minimum of 2 hours per day over a month. The results did not show any difference in log contrast sensitivity or total error score on the Farnsworth-Munsell 100-Hue between the two blue-blocking lenses and the control lens. These results were not dependent on age. A 13 item questionnaire was also used to evaluate the subjective performance of the different lenses. There were a high proportion of no change responses for both interventions. The items showing the largest number of responses (37-40%) reporting improvement were antiglare, vision on a computer and vision on a mobile digital screen. It should be noted that in the same categories about 18% reported a decline in performance. In contrast to Burkhardt and Phelps, Leung and co-workers found no difference in sleep quality for both blue-blocking lenses compared to the clear lens. Re-analysis in terms of mean differences to allow comparison with other studies where different measures have been used confirmed this result for the blue anti-reflection lenses (MD=0.04; CI -0.26 to +0.18) and brown tint (blue absorbing) lenses (MD=0.00; CI -0.23 to +0.23)

In the final study that met the inclusion criteria, Lin and co-workers[3] recruited 36 subjects who were randomly allocated to one of three groups to compare a high blue blocking, low blue blocking and non-blue blocking lens. All participants undertook a 2 hour computer task and had their critical fusion frequency (CFF) measured as a surrogate of eye fatigue as well as answering a 15-item questionnaire designed to assess eye strain. There was no change in CFF between the low and no blocking lens groups and a statistically significant negative change when high blue blocking and no block/low blue blocking lenses were compared indicating a reduction in eye strain. A difference in CFF score at baseline could affect these results but a post hoc analysis by the authors led them to

maintain their assertion that high blue-blocking lenses attenuate eye fatigue associated with computer use. The authors pooled data from the non-blocking and low block lens groups since there was no statistical difference between them and compared them to the high block group using a questionnaire to assess eye strain. Questions asking about pain around the eye, eyes feeling heavy and eyes feeling itchy were reported to have a statistically significant difference from baseline. The analysis, assuming a continuous outcome variable was questionable given the dichotomous responses to the questions and so we have re-analysed the data using the risk ratio, which compares the proportion of those demonstrating improvement in the high block group to the proportion showing improvement in the non-blocking/low block group and is the recommended method for such variables when carrying out systematic reviews. As a result, the only question that showed a statistically significant difference from baseline was "my eyes feel itchy," which we don't consider relates to eye strain. In fact a review of the questions in the questionnaire showed very few questions that could reasonably be considered to directly relate to eye strain.

Although a further twelve studies[4-15] were identified as addressing the outcome criteria for our review, they were excluded as not meeting our pre-stated inclusion criteria. In a majority of cases they were not randomised controlled trials or did not report their primary or secondary outcomes. No studies were found that addressed the effect of blue-blocking spectacle lenses on macular health. One of the benefits of systematic review methodology is that it seeks and evaluates the highest possible levels of scientific evidence. Inclusion of non-randomised controlled trials was not considered to meet this requirement in providing evidence for this Using Evidence in Practice article.

In conclusion, the best scientific evidence currently available does not support the use of blue-blocking spectacle lenses to improve visual performance, alleviate the symptoms of eye fatigue or visual discomfort, or improve sleep quality.

References

1. Burkhart K, Phelps JR. Amber lenses to block blue light and improve sleep: a randomized trial. Chronobiol Int 2009;26:1602-12.
2. Leung TW, Li RW, Kee CS. Blue-Light Filtering Spectacle Lenses: Optical and Clinical Performances. PLoS One 2017;12:e0169114.
3. Lin JB, Gerratt BW, Bassi CJ, Apte RS. Short-Wavelength Light-Blocking Eyeglasses Attenuate Symptoms of Eye Fatigue. Invest Ophthalmol Vis Sci 2017;58:442-7.
4. Figueiro M, Rea, M.S. The impact of self-luminous displays on evening melatonin levels. 27th Annual Meeting of the Associated Professional Sleep Societies, LLC. SLEEP 2013.; Baltimore, MD United States. , abstract no. 38, p. A184.
5. Figueiro MG, Wood B, Plitnick B, Rea MS. The impact of light from computer monitors on melatonin levels in college students. Neuro Endocrinol Lett 2011;32:158-63.
6. Hammond BR. Attenuating Photostress and Glare Disability in Pseudophakic Patients through the Addition of a Short-Wave Absorbing Filter. J Ophthalmol 2015;2015:607635.
7. Hovis JK, Lovasik JV, Cullen AP, Kothe AC. Physical characteristics and perceptual effects of "blue-blocking" lenses. Optom Vis Sci 1989;66:682-9.
8. Ide T, Toda I, Miki E, Tsubota K. Effect of Blue Light-Reducing Eye Glasses on Critical Flicker Frequency. Asia Pac J Ophthalmol (Phila) 2015;4:80-5.
9. Kaido M, Toda I, Oobayashi T, Kawashima M, Katada Y, Tsubota K. Reducing Short-Wavelength Blue Light in Dry Eye Patients with Unstable Tear Film Improves Performance on Tests of Visual Acuity. PLoS One 2016;11:e0152936.
10. Lee JE, Stein JJ, Prevor MB, Seiple WH, Holopigian K, Greenstein VC, et al. Effect of variable tinted spectacle lenses on visual performance in control subjects. CLAO J 2002;28:80-2.

11. Luria SM. Vision with chromatic filters. Am J Optom Arch Am Acad Optom 1972;49:818-29.
12. Sasseville A, Paquet N, Sevigny J, Hebert M. Blue blocker glasses impede the capacity of bright light to suppress melatonin production. J Pineal Res 2006;41:73-8.
13. Thomas SR, Kuyk TK. D-15 performance with short wavelength absorbing filters in normals. Am J Optom Physiol Opt 1988;65:697-702.
14. van der Lely S, Frey S, Garbazza C, Wirz-Justice A, Jenni OG, Steiner R, et al. Blue blocker glasses as a countermeasure for alerting effects of evening light-emitting diode screen exposure in male teenagers. J Adolesc Health 2015;56:113-9.
15. Wood B, Rea MS, Plitnick B, Figueiro MG. Light level and duration of exposure determine the impact of self-luminous tablets on melatonin suppression. Appl Ergon 2013;44:237-40.

Characteristics of included studies

Study	Methods	Participants	Interventions	Outcomes	Risk of bias
Burkhart & Phelps 2009	Parallel group randomised controlled trial	20 subjects subjectively reporting sleep difficulty	High blue-blocking glasses (wavelengths below 550nm) for 3hrs prior to bedtime compared to low blue-blocking glasses (below 465nm) for 3hrs prior to bedtime	• Sleep quality rated using a sleep diary and 10-point Likert scale from very poor to very good • Mood rated using the PANAS (Positive and Negative Affect Schedule) mood scale	High
Leung, Li & Kee 2017	Pseudo-randomised cross-over trial	80 subjects with a refractive error	Blue-filtering anti-reflection coated lens (intervention 1), brown tinted lens (intervention 2) compared against a clear AR coated lens. Each lens is worn for 1 month	• Contrast sensitivity with and without glare (Mars letter contrast sensitivity test) • Colour discrimination (F-M 100 hue) • Subjective lens performance using a 13-item questionnaire	
Lin, Gerratt, Bassi & Apte 2017	Parallel group randomised controlled trial	36 between the ages of 21 and 40	25% blue light blocking lens (intervention 1), 60% blue light blocking (intervention 2) and a clear lens (comparator) used for a 2 hour computer task	• Critical fusion frequency before and after intervention • Symptoms of eye strain using a 15-item questionnaire	