Wrap-up of 2024 with eyes focused on 2025!

The year of 2024 is about to end and we at *SJOVS* are looking forward to publishing more of your scientific reports in 2025. It is hard to describe how much we appreciate your contributions (authors, readers, reviewers, editors and friends) to our journal and in 2024 we had many supporting our journal — a big thanks for that!

For this editorial we decided to mention a few highlights. The starting highlight goes to a report by The National Academies on Myopia. This comprehensive report of 337 pages makes many recommendations about the current and emerging problems related to myopia. For the full report, please follow the link in the reference list (National Academies of Sciences Engineering and Medicine, 2024). We decided to summarize the messages of the myopia report that was written for an American context. Readers, particularly those practicing in Scandinavia, should retain the messages that apply in their clinical and societal context. For some relevant studies in Scandinavia, see Bjørset et al. (2022), Demir et al. (2024), Demir et al. (2021), Demir et al. (2022), Hagen et al. (2023), Hagen et al. (2018), and Nilsen et al. (2023).

Here we provide you with key messages that are relevant for optometric practice:

- *comprehensive eye exams* should include cycloplegic drops for accurate refraction, especially in children. In addition, they should include axial length measurements and optical coherence tomography with regular follow-up.
- *vision screening* should continue and, whenever possible, be improved by utilising validated and reliable methods (e.g., photoscreeners) appropriate for the child's age, with clear referral criteria to increase adherence to recommendations. Professionals and authorities alike should work towards ensuring accessible testing for all children, especially those from disadvantaged backgrounds.
- *management of myopia* should be evidence-based using the best existing optical, pharmacological, and environmental options. It is important to understand the limitations of each management approach and potential rebound effects. Management is not a cure and that should be clear throughout the process.
- *clear communication* with patients and parents of young children is key while communicating test results and management plans to patients and families, emphasising the significance of compliance and ongoing care. Addressing barriers like costs, access, and cultural beliefs are relevant.
- *collaboration and standardised data collection* are required to improve understanding and to guide future development.

In short, the report stresses the importance of equitable access to care for all children given that costs associated with myopia detection and management can be a barrier to many. The report also emphasises the need for continuous data collection and updated evidence-based practice.

There are a few new publications that accompany this editorial in the final issue of 2024. This issue features a pilot study by Swiatczak and colleagues, demonstrating that repeated exposure to a "red in focus" digital filter on a computer screen over 12 days led to choroidal thickening and axial length shortening in myopic eyes, with partial recovery after two days. While the findings suggest a promising non-invasive approach to myopia control, the authors highlight the need for larger, long-term studies to confirm clinical applicability (Swiatczak et al., 2024).

In one original study Michielon and colleagues investigated light modulation LED mask MY MASK's effect on contact lens discomfort. The three-week observational study revealed that treatment significantly reduced contact lens discomfort symptoms by 43%, improved non-invasive tear film breakup time, and improved tear film lipid layer thickness. The authors recommend further research to confirm these findings (Michielon et al., 2024).

We also publish the abstracts of three conferences. The 16th Kongsberg Vision Meeting (Baraas, 2024), and the 2nd NorVIS Young Researchers Conference 2024 both organized by the University of South-Eastern Norway (USN) in Kongsberg (Falkenberg & Mathisen, 2024), as well as the 18th National Conference of the Italian Optometric Association (SOPTI) held in Riccione, Italy (Recchioni & Civiero, 2024).

As we step into 2025, our commitment to advancing vision science and optometric research across Europe and Scandinavia through publication of high-quality, impactful research remains unwavering. A heartfelt thank you for your continued support, and we look forward to an exciting year ahead!

We wish all authors and readers a Happy New Year,

Associate Editor António Filipe Macedo
Co-Editor-in-Chief, Karthikeyan Baskaran
Editor-in-Chief Rigmor C. Baraas

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Pilot study: simulating myopic chromatic aberration on a computer screen induces progressive choroidal thickening in myopes

Barbara Swiatczak,[1*] Lea Ingrassia,[1] Hendrik P. N. Scholl,[1,2] Frank Schaeffel,[1,3]

[1] Institute of Molecular and Clinical Ophthalmology Basel (IOB), Basel, Switzerland
[2] Department of Ophthalmology, University of Basel, Basel, Switzerland
[3] Section of Neurobiology of the Eye, Ophthalmic Research Institute, University of Tuebingen, Tuebingen, Germany

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* *Correspondence: barbaraswiatczak@gmail.com*

Abstract

The purpose of this study was to determine whether repeated exposure to a digitally simulated myopic chromatic aberration ("red in focus" filter) on a computer screen, can change axial length (AL) and choroidal thickness (ChT) in young human subjects.

Six myopic and four emmetropic subjects worked on a computer screen with a "red in focus" filter for 2 hours per day over 12 consecutive days (days 1–12). The treatment period was followed by 2 days of recovery where subjects performed computer work for 2 hours per day without filtering (days 13 and 14). Before and after each computer work episode, axial length and subfoveal choroidal thickness were measured in both eyes. Additionally, on days 1, 12, and 14, visual acuity and contrast sensitivity were measured in three luminance-matched light conditions: red, blue, and white light.

Myopic, but not emmetropic eyes showed progressive thickening of the choroid and shortening of the axial length over 12 consecutive days with the "red in focus" filter (AL: -31 ± 39 μm, $p < 0.01$; ChT: $+18 \pm 14$ μm, $p < 0.0001$) with significant recovery when compared to the last days of the treatment period (AL: $+10 \pm 26$ μm, $p < 0.05$; ChT: -16 ± 10 μm, $p < 0.001$). Visual acuity improved in both emmetropic and myopic eyes, under all light conditions, however, a significant difference was measured only in emmetropic eyes in red light (-0.03 ± 0.15 vs. -0.19 ± 0.14 LogMAR, $p < 0.05$). Contrast sensitivity did not significantly change during the entire experiment in emmetropic or myopic eyes.

Working on a computer screen with the "red in focus" filter may have an inhibitory effect on myopia progression since it causes progressive thickening of the choroid and associated shortening of axial length over 12 days. However, long-term studies with larger sample sizes are necessary to verify a general effect.

Keywords: myopia, emmetropisation, longitudinal chromatic aberration, myopic defocus

Introduction

The speed of light depends on the refractive index of a medium (dispersion). This is also valid for the ocular media. Short-wavelength light has a slower propagation speed in the ocular media than longer-wavelength light. According to Snell's law, it is, therefore, more deviated at intraocular refracting surfaces. Accordingly, cornea and crystalline lens have a shorter focal length in blue light, compared to red (longitudinal chromatic aberration, LCA). Since normal-sighted (emmetropic) eyes are in best focus in the mid-wavelength range, the image in the red is focused slightly behind the photoreceptor outer segments while the image in the blue is focused in front, imposing myopic defocus and related chromatic blur.

During postnatal development, the axial length of the eye is adjusted to its optical power, to achieve a close match of the focal plane and photoreceptor plane (emmetropisation). However, regardless of refractive errors (He et al., 2013; Suchkov et al., 2019) or higher-order aberrations (Vinas et al., 2015), the magnitude of LCA is nearly constant across the population (Howarth & Bradley, 1986). Depending on the range of wavelengths of the light spectrum in which measurements are done, LCA amounts to 1.5 to 2 D (He et al., 2013; Howarth & Bradley, 1986; Marcos et al., 1999; Thibos et al., 1990). A classical question of emmetropisation is how the retina might be able to determine the sign of defocus to generate the appropriate eye growth responses (discussion: Schaeffel and Wildsoet (2013)). A plausible strategy might be comparing image contrast in the red and the blue since it would provide a clear indication of the sign of defocus. Indeed, animals deprived of LCA by rearing them in spectrally narrowband light develop a wide range of refractive errors (e.g., tree shrew: Gawne et al. (2018) and She et al. (2023); chicken: Chun et al. (2023) and Wang et al. (2018); rhesus monkey: Hung et al. (2018) and Smith et al. (2015)). Recently it has been shown in tree shrews that chromatically simulated myopic defocus, produced by blurring the blue plane of the image, induced significant hyperopia by slowing axial eye elongation over 11 days of exposure (Gawne et al., 2022). At the same time, Swiatczak and Schaeffel (2022) found that bidirectional transient axial length changes were elicited in young human subjects when they watched movies with a myopic and hyperopic LCA simulated in real-time on a computer screen. The digital filter simulating myopic chromatic defocus (the "red in focus" filter) blurred the green and blue colour channels of the RGB display while keeping red pixels untouched. Conversely, the filter simulating hyperopic chromatic defocus (the "blue in focus" filter) blurred green and red pixels of the screen but kept blue pixels in focus (Swiatczak & Schaeffel, 2022). After 45 minutes of exposure, emmetropic eyes displayed significant elongation with the "blue in focus" filter, and eye shortening after exposure to the "red in focus" filter (Swiatczak & Schaeffel, 2022). The study provided evidence that emmetropisation uses chromatic cues to fine-tune the growth of the eye and this mechanism was still active in young adult human subjects. Surprisingly, in short-term experiments, there were no changes in eyes that were already myopic. To investigate whether myopic eyes were generally less responsive to LCA or whether they would just require longer exposure times, or repeated exposure to the simulated myopic chromatic defocus (the "red in focus" filter"), we asked young emmetropic and myopic human subjects to work on a computer screen with the "red in focus" filter implemented, for 2 hours per day on 12 consecutive days. Changes in choroidal thickness and axial length were monitored during the 12 days of treatment and 2 days of recovery.

Materials and Methods

Ten young (29 ± 4 years of age) human subjects were recruited to participate in our study. This group included four emmetropes (4 females, spherical equivalent (SE) OD: -0.1 ± 0.2 D, OS: -0.3 ± 0.4 D), and six myopes (3 females, SE OD: -3.6 ± 1.6 D, OS: -3.5 ± 1.7 D) who were asked to work on the computer with a digital filter implemented on the computer screen (25", 1920 × 1080 px) at 83 cm distance (the distance was determined to match the amount of defocus imposed in the previous study by Swiatczak and Schaeffel (2022) for 2 hours per day over 12 consecutive days (from day 1 to day 12). Before and after each exposure period, axial length (Lenstar 900 with autopositioning system, Haag-Streit, Switzerland) and subfoveal choroidal thickness (PlexElite OCT, Carl Zeiss AG, Germany) were measured in both eyes. Recovery was monitored for the subsequent two days (days 13 and 14) where subjects used the computer for 2

hours per day but without the digital filter. Moreover, to determine whether repetitive exposure to the digital filter may have subtle effects on visual functions, visual acuity (VA) and Weber contrast sensitivity (CS) were measured in all subjects on days 1, 12, and 14. Presenting VA test and CS (at angular letter size: 50 arcmin, line thickness 5.8 cyc/deg) measurements were done using the tumbling "E" procedure by using the free software "Freiburg Visual Acuity Test" (FrACT10, available online at https://michaelbach.de/fract/). Subjects were asked to perform the test monocularly, at a 2 m distance. To detect potential differences in VA and CS at the two ends of the visible light spectrum, two optical filters were used: a long-pass red filter (cut-off at 610 nm) and a short-pass blue filter (cut-off at 490 nm). Moreover, an attenuation-matched neutral density (ND) filter served as a control to normalise screen luminance to 72 cd/m^2. Both VA and CS tests were performed twice at each time point in each participant, therefore the presented results represent the average of two repeated measurements. Myopic participants wore their habitual corrections during the entire experiment. Prior to the experiment, each subject signed an informed consent form, which was approved by the Swiss Research Ethics Commission (EKNZ, reference 2023-01503). The study was conducted in agreement with the Declaration of Helsinki.

Digital "red in focus" filter

The "red in focus" digital filter was developed in Visual C++ and has been described in detail earlier by Swiatczak and Schaeffel (2022). Briefly, it separately low-pass filtered the RGB colour channels of the computer screen to simulate myopic longitudinal chromatic aberration in real time. To simulate the conditions in an uncorrected myopic eye, the "red in focus" filter left the red image (pixels) sharp, while green and blue images were blurred. The amount of blur was adjusted according to the longitudinal chromatic aberration function of the human eye for an average pupil size of 6.5 mm (Marcos et al., 1999).

Axial length measurements

Axial length was measured as the distance between the outer surface of the cornea and the retinal pigment epithelium (RPE). Three repeated measurements per eye were done at each time point with a standard deviation below 10 μm.

Choroidal thickness measurements

Choroidal thickness (see Figure 1, red arrow) was measured manually in the B-scan (Raster scan, HD Spotlight, 100 kHz) OCT images using software provided by the manufacturer (Carl Zeiss AG, Jena, Germany). Subfoveal choroidal thickness was defined as the distance between the choroidal-scleral border (see Figure 1, yellow line) and the RPE layer (see Figure 1, green line) under the foveal pit, which were marked manually in each scan. Only scans with visible choroidal-scleral border and ranked by the software as "good" or "very good" were accepted for further analysis. The hyperreflective point at the inner limiting membrane (ILM) and the central bouquet of cones were used as a coordinate to measure choroidal thickness in the same area in all scans. Two B-scans per eye were taken at each time point. The average of two consecutive measurements was used for further analysis.

Data Analysis

Statistical analyses were performed using R, a freely available software package for statistical analyses and graphics (R Core Team, R version 4.2.2-2022). Data are reported as mean ± standard deviation. Within-session repeatability of the choroidal thickness measurements was assessed using Bland-Altman and Pearson's correlation coefficient analysis of all data taken during the study. A repeated measures ANOVA with three within-subjects factors (weekends, time of day, and time) and three between-subjects factors (refractive group, age, sex) was performed for the daily delta values (daily delta = AL/ChT "after 2 hours of stimulation" – AL/ChT "before") and the daily baseline values (AL/ChT "before"). The effect of the recovery period on changes in axial length and choroidal thickness, as well as the effect of induced changes in visual acuity and contrast sensitivity of the right eyes, was assessed with paired t-tests. Post-hoc pairwise comparisons with Bonferroni correction were performed for any significant variables. A statistical power of 0.4 was obtained for axial length and 0.8 for choroidal thickness measurements adjusted to the significance level of 0.05.

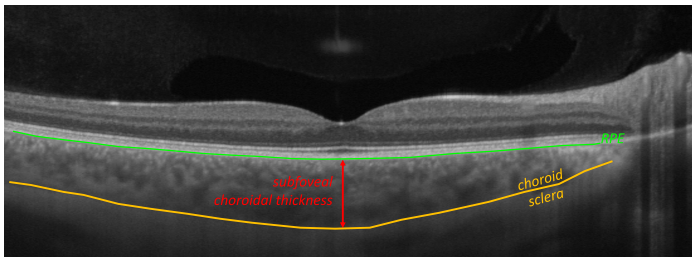

Figure 1: *Subfoveal choroidal thickness (red arrow) measured as the distance between the outer surface of the RPE layer (green line) and the choroidal-scleral border (yellow line) under the centre of the foveal pit.*

Results

Figure 2 shows linear correlations in induced changes in choroidal thickness and axial length between right and left eyes in myopic and emmetropic eyes. Myopic eyes showed a highly significant correlation in changes induced in choroidal thickness [$r(82) = 0.64$, $p < 0.0001$] and axial length [$r(82) = 0.83$, $p < 0.0001$] between the right and left eyes. Emmetropic eyes showed a similar trend in changes induced in choroidal thickness [$r(54) = 0.51$, $p < 0.001$], however, linear correlation in changes induced in axial length between both eyes did not reach statistical significance [$r(54) = 0.15$, $p = 0.26$].

Since exposure to the "red in focus" filter occurred binocularly, the average changes of both eyes are shown. There was no significant effect of sex, age, and weekends on the daily delta or daily baseline values recorded from the choroidal thickness and axial length measurements. Within a total of 140 data points (10 subjects × 14 days), 99 measurements were done in the morning and 41 in the afternoon. Both refractive groups had a similar number of measurements done in the morning (emmetropes 68%, myopes 73%) and in the afternoon (emmetropes 32%, myopes 27%). The repeated measures ANOVA revealed that there was a significant influence of time of day (morning/afternoon) when the experiment was performed on daily delta values in axial length ($p < 0.0001$) and choroidal thickness ($p = 0.0002$). However, this dependency was not detected in the daily baseline data of axial length and choroidal thickness measurements. Therefore, the data presented in Figure 3 represents daily baseline values relative to the day 1 baseline measurement of axial length and choroidal thickness.

Effects of repeated exposure to the "red in focus" filter

Subfoveal choroidal thickness

The mean difference in choroidal thickness between the measurements in two subsequent B-scans OCT was 1.0 ± 6.5 μm (Pearson's correlation coefficient $r(138) = 0.99$, $p < 0.0001$, see Figure 4A). A Bland-Altman analysis revealed that the 95% confidence interval limits for the average difference between the two measurements were −13.8 and 11.8 μm (see Figure 4B).

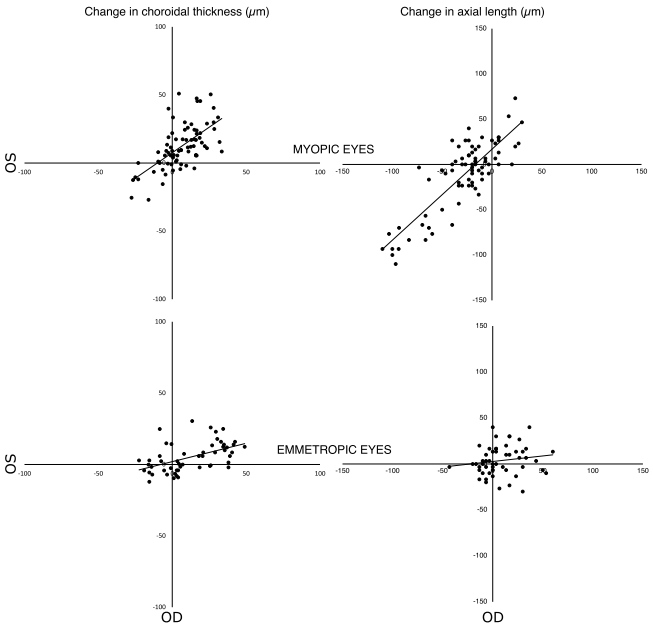

Figure 2: *Pearson's correlations between induced changes in choroidal thickness (left) and axial length (right) in the left and right eyes in myopic (top panel, n = 84) and emmetropic subjects (bottom panel, n = 56).*

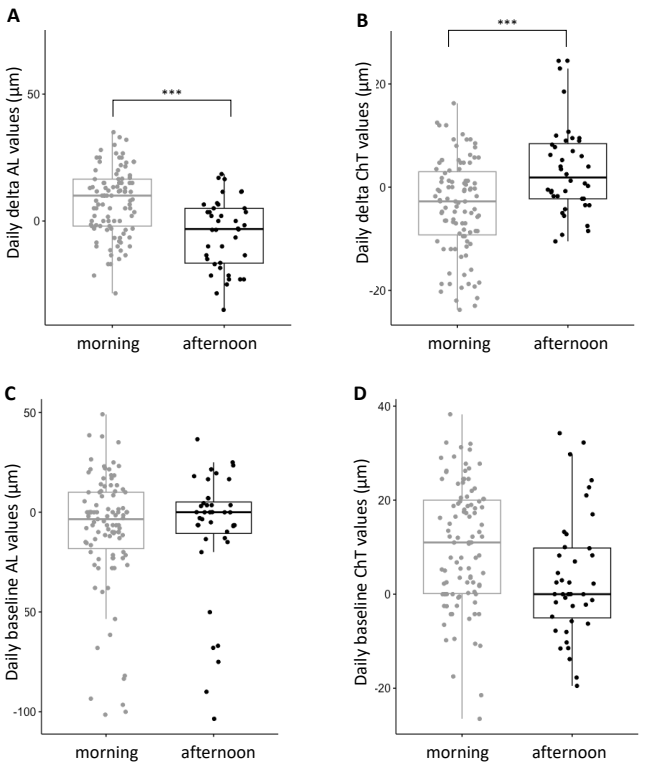

Figure 3: *Comparisons between measurements done in the morning (n = 99) and in the afternoon (n = 41) for all daily delta axial length (A), daily delta choroidal thickness (B), daily baseline axial length (C), and daily baseline choroidal thickness (D) values relative to the study baseline (day 1) for all 10 subjects. Daily delta = AL/ChT "after 2 hours of stimulation" – AL/ChT "before". Daily baseline = AL/ChT "before". Study baseline = 0 for each of the four panels. Significance level *** p < 0.001.*

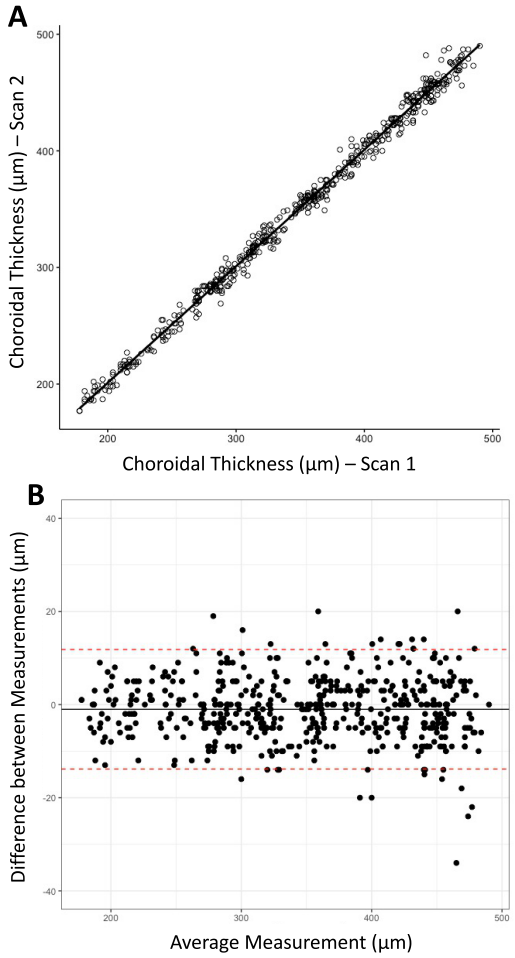

Figure 4: *A. Linear regression analysis of choroidal thickness measured in two subsequent scans (r(138) = 0.99, p < 0.0001, n = 140). B. Bland-Altman plot of two subsequent choroidal thickness measurements. The x-axis displays the average measurement of the two subsequent scans and the y-axis displays the difference between these two measurements. The black line represents the average difference in measurements between the two scans while the red dashed lines represent the 95% confidence interval limits for the average difference.*

There was a significant increase in subfoveal choroidal thickness in myopic, but not emmetropic eyes after 12 days when compared with the starting baseline (myopes day 1: 308 ± 81 vs. day 12: 346 ± 78 μm, average difference on day 12: $+18 \pm 13$ μm, $p = 0.03$; emmetropes day 1: 385 ± 39 μm vs. day 12: 373 ± 81 μm, average difference on day 12: $+10 \pm 16$ μm, *ns*). Choroidal thickness in myopic eyes progressively increased over 12 days (see Figure 5, top panel, $p < 0.0001$) while the changes in emmetropic eyes did not reach statistical significance.

Axial length

Changes in axial length were associated with changes in choroidal thickness. Axial length significantly decreased after 12 days of screen work with the "red in focus" filter in myopic, but not emmetropic eyes (myopes day 1: 24.94 ± 1.05 mm vs. day 12: 24.90 ± 1.06 mm, average difference on day 12: -31 ± 39 μm, $p = 0.03$; emmetropes day 1: 23.43 ± 0.26 mm vs. day 12: 23.43 ± 0.27 mm, average difference on day 12: $+5 \pm 24$ μm, *ns*). Axial length in myopic eyes decreased progressively over the 12 days of treatment (see Figure 5, bottom panel, $p = 0.003$) while changes in emmetropic eyes did not reach statistical significance. Repeated measures ANOVA revealed significant differences in the changes in axial length over time between emmetropes and myopes ($p < 0.0001$).

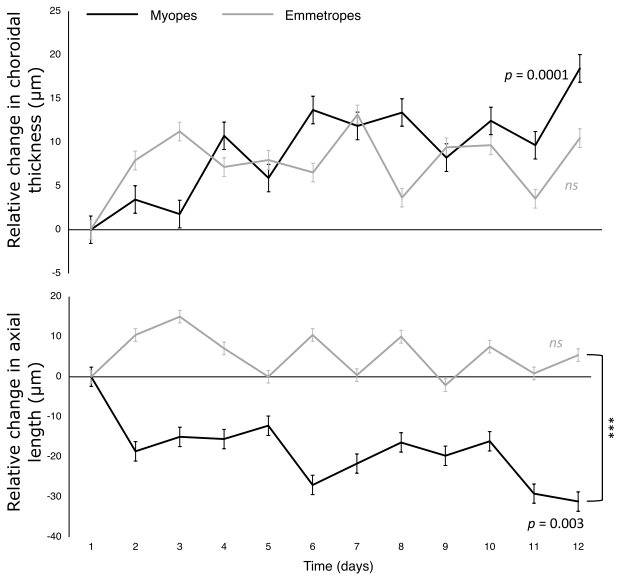

Figure 5: *Effects of repeated exposure over 12 consecutive days to the "red in focus" filter on subfoveal choroidal thickness (top) and axial length (bottom) in myopic (n = 6, black lines) and emmetropic (n = 4, grey lines) subjects. Significance level *** p < 0.0001. Error bars denote SEM.*

Visual acuity and contrast sensitivity

Results of the measurements of visual acuity and contrast sensitivity are summarised in Table 1. After 12 days of repeated exposure to the "red in focus" filter, both refractive groups showed a trend of improvement in their visual acuity under all light conditions (magnitude of logMAR visual acuity improvement in emmetropes: red 0.16, blue 0.02, ND filter 0.10 LogMAR; in myopes: red 0.06, blue 0.15, ND filter 0.08 LogMAR). However, the only statistically significant change in visual acuity was in emmetropic eyes in red light (-0.03 ± 0.15 vs. -0.19 ± 0.14 LogMAR, $p = 0.03$, see Figure 6). Contrast sensitivity was not significantly different after the treatment period, neither in emmetropic nor in myopic eyes under any of the lighting conditions (see Figure 6 and Table 1).

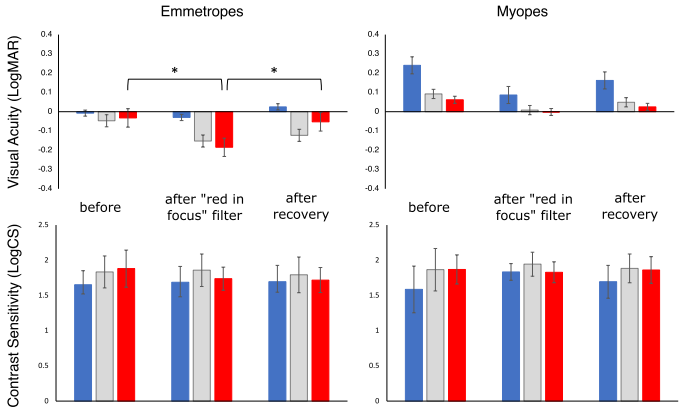

Figure 6: *Average visual acuity (top panel) and contrast sensitivity (lower panel) in emmetropic (left, n = 4) and myopic (right, n = 6) subjects before intervention, after 12 days of exposure to the "red in focus" filter, and after 2 days of recovery. Both variables were measured through a red (red bars), blue (blue bars), and ND (grey bars) filter. Error bars represent SD. Significance level * p < 0.05.*

Effects of a two-day recovery period

During the recovery period, all subjects worked on the computer for 2 hours per day, but without the "red in focus" filter. In myopic eyes, axial length increased (day 13: $+14 \pm 15$ µm, $p = 0.007$; day 14: $+10 \pm 26$ µm, $p = 0.04$, see Figure 7A) and choroidal thickness decreased (day 13: -10 ± 11 µm, p=0.006; day 14: -16 ± 10 µm, p=0.0003, see Figure 7B) towards the baseline values, compared with the last day of the treatment period (day 12). Emmetropic eyes did not show significant differences either in changes in axial length or choroidal thickness during the recovery period (AL day 13: -2 ± 15 µm, day 14: $+5 \pm 28$ µm; ChT day 13: -10 ± 11 µm, day 14: -16 ± 10 µm, all *ns*, Figure 7).

Visual acuity returned towards baseline in both emmetropic and myopic subjects (see Figure 6, top panel) but significance was achieved only in red light in emmetropic subjects (-0.19 ± 0.14 vs. -0.05 ± 0.10 LogMAR, $p = 0.01$). Contrast sensitivity did not change.

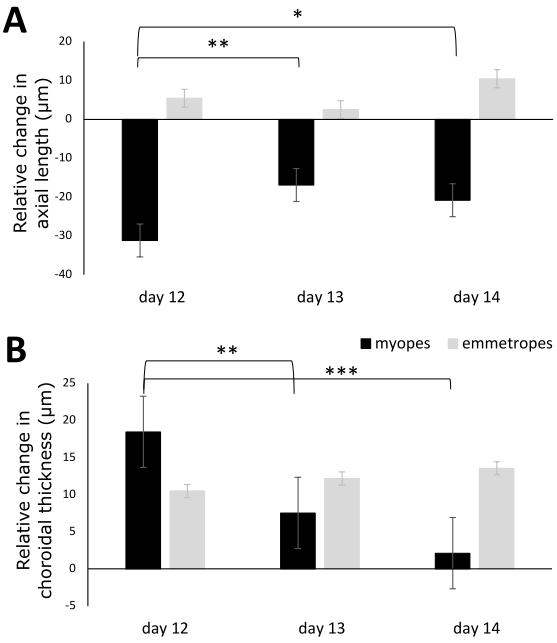

Figure 7: *The effect of the 2-day recovery period on axial length (A) and choroidal thickness (B) in myopic (black bars, n = 6) and emmetropic (grey bars, n = 4) eyes relative to the study baseline (day 1). Error bars denote SEM. Significance levels * p < 0.05, ** p < 0.01, *** p < 0.001.*

Table 1: *Mean and standard deviation of visual acuity and contrast sensitivity values for emmetropic (n = 4) and myopic (n = 6) subjects measured in red, blue, and dim light at baseline, after 12 days of repeated exposure to the "red in focus" filter, and after 2 days of recovery.*

			Emmetropes			Myopes		
			Baseline	After 12 days of treatment	After 2 days of recovery	Baseline	After 12 days of treatment	After 2 days of recovery
Visual Acuity (LogMAR)	Red	*M*	–0.03	–0.19	–0.05	0.06	0.00	0.03
		SD	0.16	0.14	0.11	0.20	0.13	0.14
	Blue	*M*	–0.01	–0.03	0.03	0.24	0.09	0.16
		SD	0.13	0.21	0.15	0.23	0.17	0.26
	ND filter	*M*	–0.05	–0.15	–0.12	0.09	0.01	0.05
		SD	0.08	0.18	0.15	0.20	0.17	0.22
Contrast Sensitivity (LogCS)	Red	*M*	1.88	1.74	1.72	1.87	1.83	1.86
		SD	0.26	0.16	0.18	0.21	0.15	0.19
	Blue	*M*	1.65	1.69	1.70	1.59	1.83	1.69
		SD	0.20	0.22	0.23	0.33	0.12	0.23
	ND filter	*M*	1.83	1.86	1.79	1.87	1.94	1.88
		SD	0.23	0.23	0.25	0.30	0.17	0.20

Discussion

In the present study, we found that repeated work on a computer screen with the "red in focus" filter, for 2 hours per day over 12 consecutive days, can progressively thicken the choroid and decrease axial length in myopic young adult subjects. No significant changes were induced in emmetropic eyes. Since the "red in focus" filter blurred the screen image in the blue and green channel, visual acuity was studied and found to be significantly improved in the red-light condition, and only in emmetropic eyes. Contrast sensitivity remained unchanged. Two days follow-up, with computer work without the "red in focus" filter, induced partial recovery in the measured variables, suggesting that induced effects were not long-lasting, and that repeated exposure would be necessary to achieve long-term effects.

Differences between myopic and emmetropic eyes and the impact of diurnal changes in axial length

In a previous study (Swiatczak & Schaeffel, 2022), short-term exposure to the "red in focus" filter (45 min) induced axial eye shortening only in emmetropic, but not in myopic eyes. In contrast, in the present study, repeated exposure over 12 days induced significant reduction in axial length in myopic, but not in emmetropic eyes. This contradictory finding can be explained by three factors: (1) changes induced by short-term exposure (45 min) are not confounded by diurnal fluctuations in axial length, with axial elongation in the morning and axial shortening in the afternoon which can amount to about 10 μm change in 3 hours (Chakraborty et al., 2011). In contrast, the effects of a 2-hour exposure are influenced by the time of the day. To reduce the impact of diurnal factors, results in the current study are presented as daily baseline measurements of axial length and choroidal thickness rather than the difference before and after the 2-hour exposure. The direct effect of a single 2-hour exposure could not be evaluated due to the diurnal fluctuations in axial length (see Figure 3). (2) It is possible that myopes are generally less responsive and need longer exposure time than emmetropes. Recently, differences were found in retinal processing and choroidal responses in myopic and emmetropic subjects. Using electroretinograms, Poudel et al. (2024) found that myopic eyes were less sensitive and responded slower to the ON retinal pathway stimulation, compared with emmetropic eyes. They also showed that the imbalance between ON and OFF retinal pathway activity is more pronounced in myopic eyes, which they attributed to a deficit in ON pathway function in the myopic retina. Also, Wagner and Strasser (2023) found decreased responses in the pattern ERG of myopic eyes when they combined the dead leaves stimuli (Panorgias et al., 2021) with inverted text contrast stimuli which overstimulate ON pathways (Aleman et al., 2018). Therefore, it is possible that myopic eyes, owing to reduced ON responses, may need prolonged visual exposure to display similar effects as emmetropic eyes. (3) That emmetropic eyes do not develop axial length and choroidal thickness changes in the long term can be considered a sign of functional emmetropisation. While exposure to the "red in focus" filter triggers short-term changes in axial length in those eyes, the oscillating data over time seen in Figure 5A may indicate that eye growth is always readjusted after removal of the defocus to maintain emmetropia.

Effects of the "red in focus" filter on visual acuity and contrast sensitivity

It has been previously shown that blurred visual targets induce contrast adaptation which may improve visual acuity, although mostly in defocused images (Mon-Williams et al., 1998; Ohlendorf & Schaeffel, 2009). Just 30 minutes of exposure to positive defocus can improve VA by about 0.12 LogMAR (Mon-Williams et al., 1998). This improvement was shown to be independent of developed refractive error (George & Rosenfield, 2004). Since the "red in focus" filter imposed blur mainly in the blue plane of the image, one would expect an increase in visual acuity only in the short wavelength range of the visible light spectrum. However, in both emmetropes and myopes, VA improved in blue and red light. It is worth mentioning, that emmetropes had a larger improvement in VA in red light (by 0.16 LogMAR, $p = 0.03$), while myopes contrarily in blue light (by 0.15 LogMAR, *ns*). None of the induced changes in contrast sensitivity reached statistical significance, however, there was a trend towards decreased CS in red light in emmetropes (by 0.14 LogCS, *ns*) and increased CS in myopes in blue light (by 0.24 LogCS, *ns*). There is no straightforward solid explanation for these effects at present, but it can be speculated that contrast adaptation is not selective for a spectral range.

Limitations of the study

There are four main limitations of our study. First, it is a small number of subjects. There is an obvious need to repeat the experiment in a larger population, however, our pilot study collected a large amount of data that shows highly significant longitudinal changes in choroidal thickness and axial length even in such a small group. Second, the proper control would be needed to be added to the study, which would include recording changes in choroidal thickness and axial length during 2 weeks of using a computer screen without the digital filter. Nevertheless, we could show significant differences between myopic and emmetropic subjects, as well as significant changes during the 2-day recovery period, which strongly suggests that the induced changes in eye length and choroidal thickness were caused by the exposure to the "red in focus" filter, rather than just working on the computer per se. Third, it must be kept in mind that simulating LCA on a computer screen interacts with the natural LCA in the eye. A more advanced approach would therefore be to first correct LCA in the eye with an achromatising lens and then add the simulated chromatic aberration on the screen. Such an approach was successfully implemented by Pusti et al. (2024), who showed similar results to those published by Swiatczak and Schaeffel (2022). The disadvantage of the optical correction of the natural LCA is that it is successful only on the optical axis of the achromatising system which severely limits eye movements and basically excludes work on a computer screen. Fourth, there was no specific time of day when all the measurements were done, thus they were performed in the morning or the evening depending on the availability of the subjects. Since diurnal fluctuations in axial length and choroidal thickness occur physiologically, they could significantly influence the results of the study. However, we found significant differences in the effect of repeated exposure to the "red in focus" filter between myopic and emmetropic subjects, even though the number of appointments scheduled in the morning and in the evening was similar in both refractive groups. Moreover, statistical analysis revealed that daily baseline measurements were not influenced by the time of day of the measurements, therefore we believe that our study represents an independent effect of the "red in focus" filter on axial length and choroidal thickness in young human subjects.

Conclusions

Our pilot study proposes a novel myopia control intervention that could be easily introduced into a patient's everyday life. Significant thickening of the choroid and a decrease in axial length over time can be induced by imposing myopic chromatic aberration on a computer screen and may have the potential to slow myopia progression and possibly inhibit myopia development in pre-myopic children.

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Pilotstudie: simulering av myopisk kromatisk aberrasjon på dataskjerm gir progressiv økning i årehinnetykkelse hos myope

Sammendrag

Hensikten med denne studien var å undersøke om gjentatt eksponering for digitalt simulert myopisk kromatisk aberrasjon ved å se på en dataskjerm med et «rødt i fokus» filter kan endre øyets aksiallengde (AL) og årehinnetykkelse (ChT) hos unge mennesker.

Seks myope og fire emmetrope deltakere utførte oppgaver på en dataskjerm med «rødt i fokus» filter i 2 timer per dag 12 dager i strekk (dag 1–12). Etter behandlingsperioden fulgte 2 dager hvor deltakerne utførte oppgaver på en dataskjerm i 2 timer per dag uten filter (dag 13 og 14). Aksiallengde og årehinnetykkelse ble målt på begge øyne før og etter hver 2-timers økt på dataskjermen. I tillegg ble visus og kontrastfølsomhet målt under tre belysninger: rødt, blått og hvitt lys med samme luminans som ble brukt på dataskjermen.

Myope, men ikke emmetrope, øyne hadde progressive økning i årehinnetykkelse og forkortning av aksiallengde i løpet av de 12 dagene de ble eksponert for «rødt i fokus» filter (AL: $-31 \pm 39\ \mu$m, $p < 0.01$; ChT: $+18 \pm 14\ \mu$m, $p < 0.0001$), med statistisk signifikant gjenoppretting sammenliknet med de siste dagene i behandlingsperioden (AL: $+10 \pm 26\ \mu$m, $p < 0.05$; ChT: $-16 \pm 10\ \mu$m, $p < 0.001$). Visus økte både for emmetrope og myope øyne under alle belysninger, men kun emmetrope øyne under rødt lys hadde statistisk signifikant bedring i visus (-0.03 ± 0.15 vs. -0.19 ± 0.14 LogMAR, $p < 0.05$). Det var ingen signifikante endringer i kontrastfølsomhet i løpet av studiet, hverken for emmetrope eller myope øyne.

Bruk av dataskjerm med «rødt i fokus» filter kan ha hemmende effekt på myopiprogresjon da det gir en fortykning av årehinnen og dermed en reduksjon av aksiallengden i løpet av 12 dager. Det er nødvendig med større studier over lengre tid for å bekrefte om dette er en effekt som er generaliserbar.

Nøkkelord: myopi, emmetropisering, kromatisk aberrasjon, myopisk defokus.

Studio Pilota: simulare l'aberrazione cromatica miopica sullo schermo di un computer produce aumento dello spessore coroidale nei miopi

Riassunto

L'obiettivo di questo studio era determinare se l'esposizione ripetuta ad un'aberrazione cromatica miopica ("filtro rosso a fuoco") simulata digitalmente sullo schermo di un computer, possa indurre cambiamenti di lunghezza assiale (AL) e spessore coroidale (ChT) in soggetti umani giovani.

Sei soggetti miopi e quattro emmetropi hanno lavorato su uno schermo di computer con un filtro "rosso a fuoco" per 2 ore al giorno per 12 giorni consecutivi (giorni 1-12). Il periodo di trattamento è stato seguito da 2 giorni di recupero durante i quali i soggetti hanno svolto lavoro al computer per 2 ore al giorno senza filtro (giorni 13 e 14). Prima e dopo ogni sessione di lavoro al computer, la lunghezza assiale e lo spessore coroidale subfoveale sono stati misurati in entrambi gli occhi. Inoltre, nei giorni 1, 12 e 14, l'acuità visiva e la sensibilità al contrasto sono state misurate in tre condizioni di luce con luminanza corrispondente: luce rossa, blu e bianca.

Gli occhi miopi, ma non quelli emmetropi, hanno mostrato un progressivo ispessimento della coroide e un accorciamento della lunghezza assiale nei 12 giorni consecutivi con il filtro "rosso a fuoco" (AL:$-31 \pm 39\ \mu$m, $p < 0{,}01$; ChT: $+18 \pm 14\ \mu$m, $p < 0{,}0001$) con un recupero significativo se confrontato con gli ultimi giorni del periodo di trattamento (AL: $+10 \pm 26\ \mu$m, $p < 0{,}05$; ChT: $-16 \pm 10\ \mu$m, p < 0,001). L'acuità visiva è migliorata sia negliocchi emmetropi che miopi, in tutte le condizioni di luce, tuttavia, una differenza significativa è stata misurata solo negli occhi emmetropi in luce rossa (−0, 03 ± 0, 15 vs.−0, 19 ± 0, 14 logMAR, p < 0, 05). La sensibilità al contrasto non è cambiata in modo significativo durante l'intero esperimento negli occhi emmetropi o miopi.

Lavorare su uno schermo di computer con il filtro "rosso a fuoco" può avere un effetto inibitorio sulla progressione della miopia poiché causa un progressivo ispessimento della coroide e un corrispondente accorciamento della lunghezza assiale in 12 giorni. Tuttavia, sono necessari studi a lungo termine con campioni di dimensioni maggiori per verificare un effetto generale.

Parole chiave: miopia, emmtropizzazione, aberrazione cromatica lon- gitudinale, defocus miopico

Contact Lens Discomfort (CLD) Treatment with MY MASK Light Modulation LED mask

Enrico Pavan Michielon,[1*] Pietro Gheller,[1,2] David Piñero,[3] Luca Stanco,[4]

[1] Department of Optics and Optometry, University of Padua, Padua, Italy
[2] Institute Benigno Zaccagnini, School of Optics and Optometry, Bologna, Italy
[3] Department of Optics, Pharmacology and Anatomy, University of Alicante, Alicante, Spain
[4] INFN, Department of Physics, University of Padua, Padua, Italy

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* *Correspondence: enricopm98@gmail.com*

Abstract

The purpose of this study was to understand how the use of the light modulation LED mask MY MASK affects Contact Lens Discomfort (CLD).

Forty-two (42) soft contact lens wearers with dry eye symptoms were recruited for a 3-week descriptive observational study. Treatment using the light modulation LED mask was applied three times, each lasting 15 minutes; on day 1, day 3 and after one week. Symptoms of CLD were quantified with the help of a specific questionnaire (CLDEQ-8) before and after treatment. Ocular surface and tear film measurements were conducted at baseline and 1 week after the last treatment.

Visual acuity remained stable (0.00 LogMAR ± 0.10). The number of symptomatic contact lens wearers decreased by 43% (18 out of 42 subjects), as indicated by the CLDEQ-8 scores (t-test= 5.14; $p < 0.001$) ($R^2 = 0.218$). Non-invasive tear film breakup time (NIBUT) improved significantly. Before treatment, 70% of eyes (59 out of 84) showed a NIBUT of less than 10 s; after treatment, 26% had values below this cut-off (t-test= 3.06; $p = 0.001$) ($R^2 = 0.241$). Meibography values did not change (t-test=1.17; p=0.121) (R^2=0.872). TearScope showed considerable improvement in tear film lipid layer thickness and the data obtained through the Gland Evaluator also demonstrated an improvement.

Treatment using light modulation LED mask could be an interesting option in improving the aspects that characterise CLD. Additional research is required to establish the reliability of the observed improvement and investigate the necessity of repeated treatments as a means of stabilising or sustaining satisfaction in contact lens wearers.

Keywords: contact lens, dry eye, discomfort, meibomian glands

Introduction

Contact lens discomfort (CLD) due to dry eye is the most common complication in soft contact lens wearers: more than three out of five wearers report dryness during the day (Ramamoorthy et al., 2008). Several recent studies estimate that the frequency of contact lens induced dry eye is roughly 50–79% globally (Inomata et al., 2020), with an afflicted population of 17 million individuals in the United States and 1 million in the UK (Richdale et al., 2007).

Ocular discomfort and dry eye symptoms are the main reasons for contact lens wear intolerance and discontinuation. It is generally accepted that there is an inflammatory component to dry eye disorders, which indicates that the body is responding to the irritants and distresses of daily life. Already in 2013, the International Workshop TFOS (Tear Film Ocular Surface) (Nichols et al., 2013) termed this phenomenon Contact Lens Discomfort (CLD), which frequently leads to contact lens dropout.

As reported by McMonnies and Ho (1986), contact lens wear is a provocative factor in marginal dry eye, which is associated with hyper-evaporation of the tear film and friction between the contact lens and the ocular surface (Dumbleton et al., 2013).

In this context, dry eye and discomfort can be multifactorial, but the growing clinical impression suggests that physiological changes in the eyelid and meibomian glands (MGs) are involved (Craig et al., 2013; Kojima, 2018). Scientific research has highlighted the central role of blinking, the lipid phase of the tear film, and MGs in the aetiology of this condition (Arita et al., 2009; Rohit et al., 2014; Siddireddy et al., 2018).

Practitioners can improve tear evaporation rate by treating the MGs. Historically, treatment of MGs has ranged from warm compresses and lid scrubs to topical or systemic pharmaceutical therapy (Geerling et al., 2011), though in recent years, several new devices/procedures have been designed to promote improved outflow of meibum. The light modulation LED mask is based on Low-Level Light Therapy (LLLT), one of the most advanced non-contact, effective and non-invasive systems (Giannaccare et al., 2023). This technology is based on heat production and photo-biomodulation, which stimulates mitochondrial energy production. Increased mitochondrial activity and ATP (adenosine triphosphate) consumption result in endogenous heat growth (internal heat) (D'Souza et al., 2022).

Pult (2020b) suggested that LLLT had a significantly higher heat effect than warm compresses or the like, while still being within the range recommended for the treatment of MGD (meibomian gland dysfunction). This technology allows heat to penetrate deeper into the eyelids than when using external heat (warm compresses or similar). The use of this non-invasive technology resulted in the removal of gland blockages, which facilitated the flow of lipids to achieve a complete tear composition (Pult, 2020a).

In a study by Stonecipher et al. (Stonecipher & Potvin, 2019; Stonecipher et al., 2019), a combination of LLLT and intense pulsed light therapy (IPL) was given to participants with dry eye who had previously failed with drops and oral medication. After the treatment, there was significant improvement in MG function, as well as in objective and subjective indicators of dry eye. The development of endogenous heat made the meibomian secretion less viscous, reducing inflammatory and neuropathic pain. Furthermore, it stimulated the parasympathetic nervous system and meibum production (Pult, 2020a; Stonecipher & Potvin, 2019; Stonecipher et al., 2019).

The proposed work evaluated how the light modulation LED mask can reduce discomfort due to dry eye (Gomes et al., 2017) during soft contact lens wear. In this descriptive observational study, patients using soft contact lenses and displaying associated dry eye symptoms underwent a cycle of treatments with the MY MASK light modulation LED mask. The impact on the CLD, tear film, and MGs was evaluated.

Methods

This multicentre investigation was conducted at three different practices: two based in Italy ("Studio Optica di Pietro Gheller" and "VisionOttica Pavan") and one based in Spain (David Piñero, University of Alicante). Patients who had used soft contact lenses for at least 3 years were recruited in the study. The Declaration of Helsinki's requirements were fulfilled, and each patient signed an informed consent form before the treatment was started. Forty-two subjects with CLD and a MG atrophy below stage 3 (≤ 3) on the Pult scale (Pult & Riede-Pult, 2012) were included in the study. CLD was defined by a Contact Lens Dry Eye Questionnaire – 8 items (CLDEQ-8) (Garza-Leon et al., 2019; Zeri et al., 2023)

score of 12 or more (Chalmers et al., 2016). The participants attended the clinic twice: at enrolment for baseline measurements, and 1 week after the last treatment for follow-up measurements. Between these two visits the subjects were treated with the MY MASK light modulation LED mask (Espansione Group) according to the instructions provided by the manufacturer: 15 min of treatment three times: on the first day, the third day and one week after enrolment (Stonecipher et al., 2020).

At the start of the enrolment visit, a clinician assessed the inclusion criteria and performed baseline measurements on both eyes of each participant before any treatment was administered. Following the treatment period, follow-up assessments were conducted at a time of day as close as possible to that of the initial enrolment visit to ensure consistency in the measurement conditions. To minimise the impact on tear film physiology for subsequent tests, measurements were performed in ascending order of invasiveness, always starting with the right eye.

Information about the participants' contact lens wear during the study was not recorded. Participants were permitted to wear their contact lenses regularly during the study period.

Monocular corrected visual acuity (VA) was assessed with a standard LogMAR chart.

The primary outcome measure was tear film lipid layer thickness employing the interferometer TearScope Polaris (CSO, Italy). The tear film lipid layer was graded according to the Guillon system (Mengher et al., 1985): grade 1: open meshwork; grade 2: closed meshwork; grade 3: wave or flow; grade 4: amorphous; grade 5: coloured fringes; grade 0: non-continuous layer (non-visible or abnormal coloured fringes) (cut-off 50–70 nm) (Guillon, 1998). Non-invasive tear film breakup time (NIBUT) was measured with the Placido disk topographer Antares (CSO, Italy) using automated detection of first breakup, while the subject maintained fixation and was requested to refrain from blinking. First breakup time was measured once (cut-off 10 s) (Wolffsohn et al., 2017). Infrared (IR) meibography was performed with the meibograph Me-check (Espansione Group, Italy), with the inferior eyelids everted in turn. From the captured image, the proportion of MGs visible within the tarsal area was graded according to the five-point Meiboscale (Pult classification, cut-off 3rd stage) (Pult & Riede-Pult, 2012) and the area of atrophy was automatically calculated by the software. The MG expression was evaluated using the MG evaluator TearScience Gland Evaluator (Johnson&Johnson, US). The flowing meibum was graded according to the 4-degree scale (cut-off 2nd stage) (Meadows, 2011).

Data analysis

The results obtained were described and evaluated by calculating the averages, frequencies and probability distributions. A linear regression analysis was developed to determine the data's dependencies and their compatibility. Various *t*-tests were performed to study the probability for observing any differences. The measurements from the left and right eyes were recorded as independent variables. Statistical analysis, performed separately for right eye (OD) and left eye (OS), did not reveal any significant differences between the eyes. Consequently, data from both the left and right eyes were combined for the overall analysis.

Results

The mean age ± *SD* of the 42 enrolled participants (27 females, 15 males) was 32 ± 12 years. Summary statistics of clinical measurements pre treatment, and 1 week post light modulation LED mask treatment are presented in Table 1.

Table 1: *CLDEQ-8 and clinical measurements pre-treatment (Pre), and 1 week post Light Modulation LED mask treatment (Post). Data are presented as mean ± SD or median (IQR). The p-values are reported.*

Parameter	Day	Mean ± *SD*	Range	*p*-value
CLDEQ-8	Pre	21.5±1.3	12.0–35.0	< 0.001
	Post	12.5±1.1	3.0–28.0	
Best corrected visual acuity (logMAR)	Pre	0.00±0.11	0.10–(-0.10)	1.000
	Post	0.00±0.10	0.10–(-0.10)	
Non-invasive tear film breakup time (s)	Pre	8.2±0.6	2.1–16.3	0.001
	Post	11.0±0.7	3.2–19.0	
Inferior eyelid meibography grade (% atrophy)	Pre	42.8±1.5	23.3–61.0	0.121
	Post	40.4±1.5	20.0–61.0	
Tear film lipid layer grade (out of 5)	Pre	3±0	2–4	< 0.001
	Post	4±0	4–5	
Meibomian gland expression (out of 4)	Pre	3±0	2–3	0.055
	Post	3±0	2–3	

Symptoms

When analysing the CLDEQ-8 questionnaire, a consistent trend of decreasing symptoms was observed when comparing the mean scores obtained for each individual question (items 1–8) pre and post treatment. Notably, there was a marked decrease in the overall mean score after treatment with the light modulation LED mask (see Figure 1).

To evaluate the total score on the CLDEQ-8, the average values and their associated standard deviations between the participants were calculated: pre treatment: 21.5 ± 1.3 and post treatment: 12.5 ± 1.2. The distribution of outcomes by scoring band is depicted by the graphs in Figures 2a and 2b. The probability areas of our samples were very roughly described by Gaussian curves, as illustrated.

After the use of the light modulation LED mask, dryness-related complaints were reported by only 57% of the wearers (24 out of 42 subjects) compared to 100% before the treatment. This indicated a reduction in CLD symptoms for nearly half of the participants to below the cut-off threshold. None of the individuals examined reported a worsening of their symptoms, and dryness symptoms decreased. Subsequent to the therapy, the results (linear regression and t-test) showed a significant improvement in CLD symptoms, with a statistical likelihood indicator of 100% (t-test$=5.14$; $p<0.001$) ($R^2=0.218$). The linear correlation of CLDEQ-8 questionnaire score pre and post treatment are illustrated in Figure 3.

Visual function and tear assessment

No effect on vision was noted as a result of the treatment and no adverse events were reported by participants during the study. No significant changes in visual acuity were observed following the light modulation LED mask sessions, with an average value of 0.00 LogMAR ± 0.11.

The objective tests revealed enhanced quality of the tear film after the treatment. Initially, 70% of the eyes (59 out of 84) had a NIBUT of less than 10 seconds. Following the treatment cycle, only 26% of the eyes had reduced NIBUT values, with the remaining 74% demonstrating a normal NIBUT value. This observation was statistically significant, with a t-test value of 3.06 ($p=0.001$) and an R^2 value of 0.240, as illustrated in Figure 4.

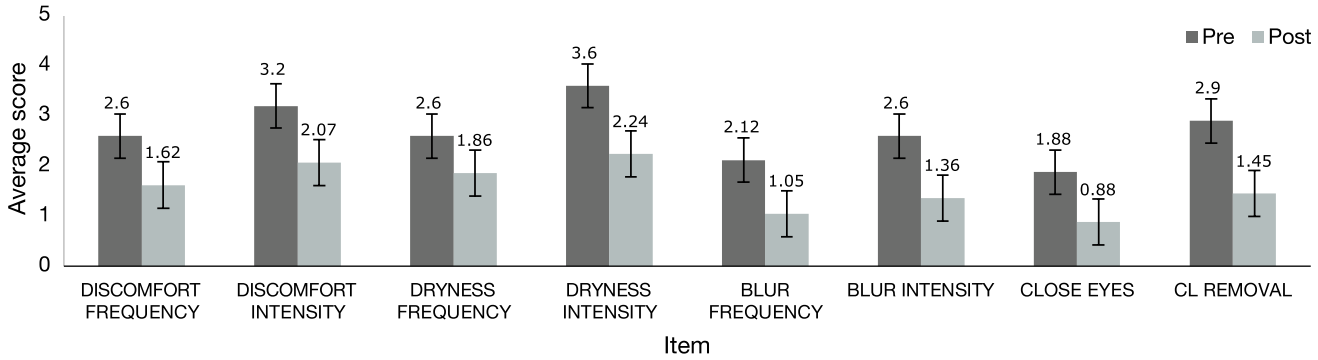

Figure 1: *CLDEQ-8 questionnaire average score for each item at baseline and one week after the light modulation LED mask treatment cycle. Each bar represents the average score. Error bars represent the standard deviation.*

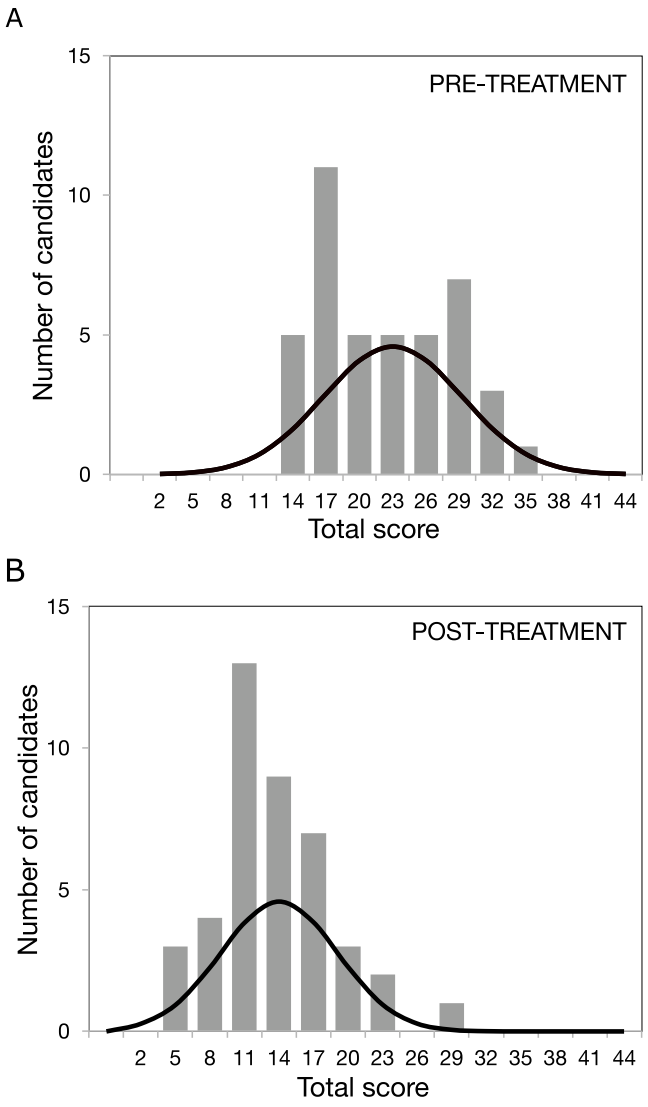

Figure 2: *The distribution of CLDEQ-8 questionnaire score pre and post treatment. The scoring bands reflect the frequency of participants who obtained a particular score on the CLDEQ assessment, while the Gaussian curve depicts the probability distribution of the sample scores.*

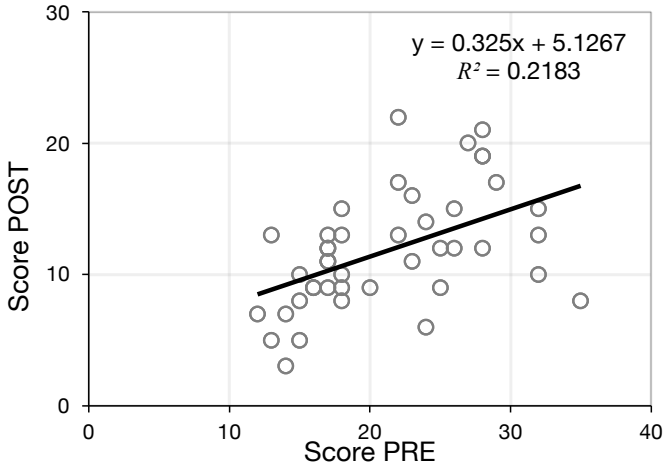

Figure 3: *The linear correlation of CLDEQ-8 questionnaire score pre and post treatment. The graph relates the scores obtained from the questionnaire by each subject before (x-axis) and after (y-axis) the LLLT treatment. The slope of the line indicates the correlation between the CLDEQ-8 pre and post treatment.*

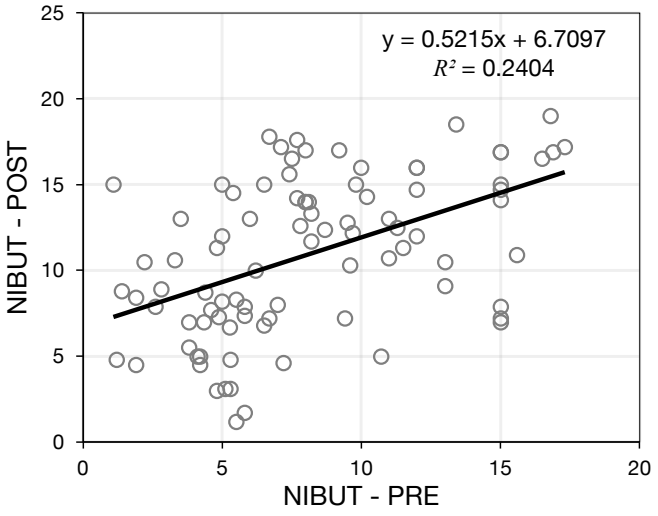

Figure 4: *The linear correlation of NIBUT before and after treatment.*

The TearScope data revealed variation among the participants with 26% of eyes having a lipid layer thinner than 50–70 nm before the treatment. However, post treatment every eye's lipid layer showed significant increase of at least one degree on the Guillon scale, from 3 ± 1 before to 4 ± 1 after the treatment (t-test=10.90).

In the meibography analysis, the sample of eyes investigated showed an initial decrease of atrophy in the area of the MGs, to almost below the third degree on the Meiboscale (Pult classification, cut-off 3rd stage) (Meadows, 2011; Pult & Riede-Pult, 2012). The mean atrophy area post-treatment was calculated to be 42.8 ± 1.5. However, exposure to light modulation LED mask did not

lead to a statistically significant change in meibography results, and changes were not always observed (t-test$=1.17$, $p=0.121$) ($R^2=0.872$) (see Figure 5).

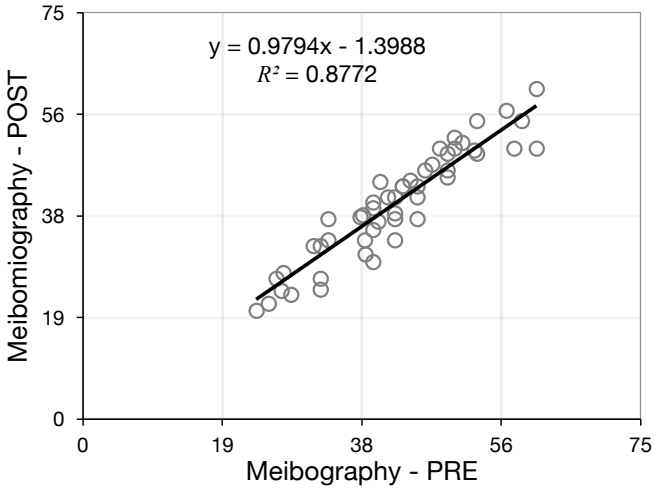

Figure 5: *The linear correlation of meibography before and after treatment.*

In the MG expression evaluation, all eyes were classed as grade 2 or 3 on the selected 4-degree scale (TearScience Gland Evaluator [Johnson&Johnson, US]). The majority of eyes (65%) presented normal secretion, which is characterised by a clear liquid secretion. Before the light modulation LED mask treatment, 35% of the observed glands (29 out of 84 eyes) showed slightly altered expressibility, which is characterised by opaque liquid. After treatment, this had decreased to 11% (9 out of 84) (t-test$=1.61$; $p=0.055$).

Discussion

The results of the present study show that a two-week course of treatment with a light modulation LED mask led to a significant improvement in CLD symptoms and tear film measurements. The questionnaire responses indicated that almost half of the participants experienced a reduction in CLD and dry eye symptoms to below the cut-off level. All contact lens wearers reported improvement in symptoms such as dryness, burning, itching, and stability of vision. The overall trend of improvement observed in the study population suggested that there was better tolerance to the use of contact lenses after the treatment.

Within a short period of time, treatment with the light modulation LED mask improved tear stability, tear film lipid layer thickness, and MG expression. The treatment was even effective in tear film previously considered unstable due to the absence of homeostasis. Quantity and quality of flowing meibum was assessed following compression of the MGs (Chalmers et al., 2016). Despite most of the participants being within the normal range when entering the study, significant improvement in this parameter was observed after the treatment and an ideal condition was achieved. Furthermore, following the treatment, TearScope data indicated an increase of more than one degree in lipid layer thickness according to the Guillon scale. The expression of natural meibum is associated with improvement in tear film stability, as it strengthens the integrity of the surface lipid layer, which is necessary for inhibiting aqueous tear evaporation. Consequently, NIBUT values improved to above the cut-off of 10 s for almost all participants. The decrease of evaporation ensured the maintenance of the aqueous component of the tear film.

This data could also have included blink frequency and other factors to better understand their effect on contact lens comfort. This study cannot establish that improvement in tear film performance directly influences dryness symptoms associated with contact lens wear. We are also aware that CLD is affected not only by the quality of the tears but also by the chemical-physical characteristics of the contact lens surface (Richdale et al., 2007).

Moreover, it is difficult to determine whether the effects detected in the current study might be due to the transient natural changes in tear film stability, which are recognised to be highly variable. The follow-up time of one week was also insufficient to demonstrate long-term effects.

Other limitations are that the study design can be subject to various sources of bias that can limit the interpretation of this findings. Furthermore, this study cannot establish causality. Unlike randomised controlled trials (RCT), observational studies do not involve randomly assigning participants to different treatment groups, so it is difficult to determine whether a particular exposure is truly responsible for an outcome (Pinquart, 2019). In addition, longer follow-up periods are required in future studies, further research is needed to determine the duration of improvements, and whether repeat treatments can stabilise or improve contact lens wear satisfaction.

However, based on this study, it is possible to argue that in the group of subjects analysed there was a general improvement such as to significantly reduce the CLD preliminary condition. LLLT treatment with the light modulation LED mask MY MASK device has proved to be an interesting option in improving the aspects that characterise CLD.

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Behandling av ubehag i forbindelse med kontaktlinsebruk med MY MASK Light Modulation LED-maske

Sammendrag

Målet med denne studien var å undersøke hvordan behandling med LED-maske (MY MASK) påvirker ubehag i forbindelse med kontaktlinsebruk.

Førtito myklinsebrukere med symptomer på tørre øyne deltok i en tre uker lang studie. De ble behandlet med LED-masken tre ganger à 15 minutter; på dag 1, dag 3 og etter 1 uke.

Symptomer på ubehag i forbindelse med kontaktlinsebruk ble målt ved hjelp av et spørreskjema (CLDEQ-8) før og etter behandling. Øyets overflate, inkludert målinger av tårefilmen, ble undersøkt ved begynnelsen av studien og 1 uke etter siste behandling.

Visus var uendret (0.00 logMAR $\pm$ 0.10). Antall symptomatiske linsebrukere var redusert med 43% (18 av 42 deltakere), i henhold til score på spørreskjemaet CLDEQ-8 (t-test=5.14; $p<0.001$) ($R^2=0.218$). Tårefilmstabilitet målt med "non-invasive tear film breakup time" (NIBUT) hadde signifikant bedring. Før behandling hadde 70% (59 av 84) av øynene NIBUT mindre enn 10 sek; etter behandling hadde 26% verdier lavere enn denne grenseverdien (t-test=3.06; $p=0.001$) ($R^2=0.241$). Meibografi viste ingen endring av øyelokkskjertlene (t-test=1.17; $p=0.121$) ($R^2=0.872$). TearScope viste betydelig økning tykkelsen på tårefilmens lipidlag og data fra Gland Evaluator viste også forbedring.

Behandling med LED-maske kan være et interessant alternativ for å redusere ubehag i forbindelse med kontaktlinsebruk. Det kreves ytterligere forskning for å fastslå grad av pålitelighet og undersøke nødvendigheten av gjentatte behandlinger for å stabilisere og sikre varighet av komfort hos linsebrukere.

Nøkkelord: kontaktinse, tørre øyne, ubehag, meibomske kjertler

Trattamento del Discomfort da Lenti a Contatto (CLD) con la Light Modulation LED mask MY MASK

Riassunto

Lo scopo di questo studio è comprendere come l'uso della Light Modulation LED mask (MY MASK) influisca sul Discomfort da Lenti a Contatto (CLD).

Quarantadue (42) portatori di lenti a contatto morbide con sintomi di occhio secco sono stati reclutati per uno studio osservazionale descrittivo della durata di 3 settimane. Il trattamento con la Light Modulation LED mask è stato applicato tre volte, ciascuna sessione della durata di 15 minuti: il primo giorno, il terzo giorno e dopo una settimana. I sintomi di CLD sono stati quantificati mediante un questionario specifico (CLDEQ-8) prima e dopo il trattamento. Sono state inoltre effettuate misurazioni della superficie oculare e del film lacrimale all'inizio dello studio e una settimana dopo l'ultimo trattamento.

L'acuità visiva è rimasta stabile (0.00 logMAR $\pm$ 0.10). Il numero di portatori di lenti a contatto sintomatici è diminuito del 43% (18 su 42 soggetti), come indicato dai punteggi CLDEQ-8 (t-test= 5.14; $p<0.001$) ($R^2=0.218$). Il tempo di rottura del film lacrimale non invasivo (NIBUT) è migliorato in modo significativo. Prima del trattamento, il 70% degli occhi (59 su 84) presentava un NIBUT inferiore a 10 secondi; dopo il trattamento, solo il 26% aveva valori inferiori a questa soglia (t-test=3.06; $p=0.001$) ($R^2=0.241$). I valori della meibografia non hanno mostrato cambiamenti (t-test=1.17; $p=0.121$) ($R^2=0.872$). I dati ottenuti tramite TearScope hanno evidenziato un notevole miglioramento dello spessore dello strato lipidico del film lacrimale, e anche i dati ottenuti attraverso il Gland Evaluator hanno mostrato un miglioramento.

Il trattamento con la Light Modulation LED mask potrebbe rappresentare un'opzione interessante per migliorare gli aspetti che caratterizzano il CLD. Sono necessarie ulteriori ricerche per stabilire l'affidabilità del miglioramento osservato e indagare la necessità di trattamenti ripetuti come mezzo per stabilizzare o mantenere la soddisfazione nei portatori di lenti a contatto.

Parole chiave: lenti a contatto, occhio secco, discomfort, ghiandole di Meibomio

NorVIS 2nd Young Researchers Conference 2024: Abstracts

The second NorVIS Young Researchers Conference was held at the University of South-Eastern Norway (USN) in Kongsberg on the 28th of May, 2024. This year, it was a hybrid conference with digital attendance from Sweden and Bergen to accommodate those unable to travel. The primary goal was to share knowledge, experiences and projects for researchers in the start of their careers and to stimulate to more vision and brain research. Further, it is an arena for discussing clinical problems and research ideas, and to network with other professionals working in the field (Mathisen et al., 2023). The one-day meeting had presentations including study protocols, masters' projects, PhD and post-doctoral clinical research from a variety of professionals. The interdisciplinary professions included a neuropsychologist, a specialised nurse, occupational therapists, a speech therapist and optometrists. After the presentations, Jan Johansson and Helle K. Falkenberg shared their tips and experiences on writing abstracts for papers and conferences. The meeting was organised by Torgeir S. Mathisen and Helle K. Falkenberg from USN and was partly financed by the NorVIS network, www.synogslagnett.no. The abstracts from contributed authors are listed in the order of presentation.

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Vision assessment of patients with acquired brain injury — occupational therapists' experience with the KROSS tool

Katrine Ekeberg-Malmli[1,2] Torgeir S. Mathisen[1] Helle K. Falkenberg[1*]

[1] National Centre for Optics, Vision and Eye Care, Department of Optometry, Radiography and Lighting design, University of South-Eastern Norway, Kongsberg, Norway

[2] Sunnaas Rehabilitation Hospital, Nesoddtangen, Norway

Corresponding author: helle.k.falkenberg@usn.no

Abstract

Vision problems are common after acquired brain injury (ABI) and affect quality of life, independence, and participation in meaningful activities and everyday life. Healthcare professionals lack experience, knowledge, and routines to secure effective vision care as part of the patient pathway (Falkenberg et al., 2020; Rowe, 2017). This study assessed the experiences of occupational therapists (OT) with the KROSS vision assessment tool (Falkenberg & Mathisen, 2024; Falkenberg et al., 2016) in a specialist healthcare unit for rehabilitation.

Six OTs participated in the project. First, they were given a short introduction to the most common vision problems caused by ABI and trained in using the KROSS tool. They participated in a focus group interview before, during and after using the KROSS tool for three months. Data were analysed using thematic analysis. Four main themes were identified: 1) Determinants for implementation; 2) Vision assessment should be included in the activity analysis; 3) Difficult, but useful, to assess vision in ABI patients and 4) We have identified a vision problem; Now what?

Despite their lack of expertise in and knowledge of vision problems after ABI, OTs found the KROSS tool beneficial for performing vision assessments, leading to more appropriate follow-up plans. They felt uniquely positioned to identify vision issues due to their focus on activity and participation. However, they noted limited and unclear guidelines within their unit and the healthcare system, emphasising the need for leadership, training, and easy-to-use tools. The KROSS tool increased their understanding and focus on vision problems, boosting their confidence in working with patients and caregivers, and ensuring quicker follow-up. The study highlighted the need for a structured patient pathway for vision rehabilitation and pointed out the systemic lack of competence in handling vision problems in healthcare services.

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The effect of coloured overlays for adults with acquired brain injury or post Covid-19

Kajsa Gode, Sarah Weström*

Rehabilitation Medicine University Clinic Stockholm, Brain Injury Rehabilitation Daycare, Danderyds Hospital AB, Stockholm, Sweden

Corresponding author: sarah.westrom@sll.se

Abstract

Reading difficulties are common after neurological conditions such as acquired brain injury or Covid-19. Visual stress is a possible cause of reading disturbances and is associated with symptoms of eyestrain, headaches and distortions of visual perception when viewing striped patterns, including lines of text.

There is evidence suggesting that coloured overlays can alleviate symptoms of visual stress and improve reading speed. An increased reading speed of 5% is predicting a long-term use of the overlay. The purpose of this study was to study the effects of coloured overlays on word fluency and reading experience. Two Swedish studies investigated the effect of overlays in patients with neurological symptoms and reading difficulties after acquired brain injury ($n = 30$) and Covid-19 ($n = 30$).

The overlays used in these studies were developed in the UK. The impact of the individually chosen overlay was measured using the Wilkins Rate of Reading test. All patients were assessed for mental fatigue, visual discomfort, and visual functions.

Preliminary results showed a significant increase in reading speed by 6.5% with the overlay of choice compared to reading without ($p < 0.001$). Most participants with post Covid-19 chose overlays with blue and purple shades (blue, purple, lilac, and aqua). A majority of the patients (83.3%) experienced positive visuo-perceptual effects when using the overlay. Visual discomfort correlated positively with mental fatigue ($r = 0.67$, $p < 0.001$). Overlays showed promise as an aid for patients with reading-related problems after ABI or Covid-19. Current findings and planned progress of the studies will be discussed in the presentation.

Assessing vision after acquired brain injury — a survey of current healthcare practice in Sweden

Hilda Holmström, Helle K. Falkenberg*

National Centre for Optics, Vision and Eye Care, Department of Optometry, Radiography and Lighting design, University of South-Eastern Norway, Kongsberg, Norway

Corresponding author: helle.k.falkenberg@usn.no

Abstract

Many suffer from acquired brain injury (ABI) every year. The visual system is complex, involving many areas in the brain. Therefore, an injury to the brain often causes visual problems such as blurred vision, visual field loss, hypersensitivity to light and glare, double vision, visual inattention and other visual perceptual problems (Hepworth et al., 2021). Visual impairments (VI) cause reduced participation in activities in daily life and social activities, and patients often report reduced quality of life. It is therefore important to assess vision after ABI to identify vision related difficulties and offer appropriate care and rehabilitation (Berthold Lindstedt et al., 2019; Falkenberg et al., 2020; Johansson et al., 2020). In the Swedish healthcare system there are no common guidelines for assessing vision after ABI and little is known about current healthcare practice.

The primary aim of this study was to describe the current practice for assessing vision after ABI in Swedish healthcare. As part of a Nordic study, we translated a Norwegian and Danish survey (Schow et al., 2024) to Swedish. The web survey was sent to key persons and occupational therapists (OTs) in Swedish neurorehabilitation care settings. Information about the survey was also shared using social media and work networks. The questionnaire contained 24 questions concerning routines and teamwork, assessment tools and perceived barriers, and the target group was healthcare personnel of various professional categories meeting ABI patients in the Swedish healthcare. ABIs caused by concussion and Covid-19 were excluded.

Forty-three surveys were returned in full, representing all six Swedish healthcare regions. Most respondents (56%) were OTs, 11 (26%) had a routine for identifying VI at their workplace, while 16 (37%) stated that vision assessment was part of the general medical examination. Assessment was mostly carried out by OTs and physicians, and 9 (21%) reported that their workplace had a specialised interprofessional team identifying VI. Only 8 (19%) routinely assessed visual function in all patients with ABI, 21 (49%) examined vision when VI was suspected. Many did not use standardised tests (49%) or questionnaires (61%). Respondents who had a routine for identifying VI used standardised tests and questionnaires more often than those without ($p = 0.001$). Two thirds of the OTs stated that limited knowledge and skills in identifying VI was very challenging.

The results of this study confirmed the lack of clear guidelines and showed that practices for identifying VI vary greatly across Sweden. The lack of routinely performed structured assessments leads to unequal access to adequate care and rehabilitation after ABI. The study also revealed that OTs often were responsible for assessment and rehabilitation after ABI. Further, there is a need for more knowledge and competence in VI, across disciplines.

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Measures and rehabilitation of visual field deficits for driving — protocol for an intervention study

Marte F. Rosenvinge[1*] Per Olof Lundmark[1] Grethe Eilertsen[2,3] Helle K. Falkenberg[1,3]

[1] National Centre for Optics, Vision and Eye Care, Department of Optometry, Radiography and Lighting design; Faculty of Health and Social Sciences, University of South-Eastern Norway, Kongsberg, Norway

[2] Faculty of Health and Social Sciences, University of South-Eastern Norway, Drammen, Norway

[3] USN Research group of Older Peoples' Health

Corresponding author: marte.f.rosenvinge@usn.no

Abstract

Driving is crucial for people's sense of independence in both daily life and societal activities. The loss of a driver's licence is associated with reduced quality of life, depression, and mortality (Falkenberg et al., 2020; Mathisen & Eilertsen, 2016; Sand et al., 2018). Stroke and glaucoma, the most common causes of visual field deficits, often lead to individuals not fulfilling the driving standard regulations. However, people can learn to compensate for their visual field loss but need rehabilitation to adopt efficient strategies. Despite this, visual rehabilitation is not part of Norwegian health services. Further, many perceive the Driving Licence Regulations as problematically strict, arguing that the standard static method for measuring the field of vision does not reflect the ability to drive safely (Harper et al., 2022; Sudmann et al., 2022). There is a need for innovative tests or biomarkers that can measure any experienced improvements in the functional visual field after vision rehabilitation.

The purpose of this study is to gain knowledge of the experiences, and measured effects, of vision rehabilitation for visual field loss after stroke or glaucoma. The study aims to define markers for the ability to compensate for visual field deficits. Additionally, we will examine the experience of living with visual field loss related to traffic situations. Here we will present parts of the protocol for this mixed-method intervention study. We plan a controlled clinical intervention with data collection before and after the intervention, and at 6 months after the intervention. We aim to recruit 50 persons with the following inclusion criteria: age 30–75, diagnosed with glaucoma or stroke; lost their driver's licence solely due to visual field loss in the last 12 months, motivated to participate in the vision rehabilitation. Ten participants will be asked to participate in two qualitative individual interviews about their experience of compensating for visual field deficits and functioning in traffic, as well as their motivation and experience before and after visual rehabilitation. Recruitment will be carried out over 18 months via patient organisations, stroke units, sub-acute rehabilitation units, NorVIS network and optometrists.

The intervention will be person-oriented visual rehabilitation or standard clinical follow-up (control), using block randomisation with a cohort size between 2 and 6. Data collection before and after the intervention will include standardised methods in

optometry, neuropsychology, and rehabilitation. Standard optometric assessments will include, visual acuity, visual field (Octopus 900), innovative VR-technology (BulbiCAM), reading (IReST), ADL and quality of life-related tests and self-reporting questionnaires. The interviews will be analysed using thematic analysis.

This study has potential benefits for the individual person, for the stroke and glaucoma population, and for optometrists and other healthcare professionals. Identification of relevant biomarkers can be used to inform further studies on how we understand and measure visual field, particularly related to driving. Further, it will give important insight into the experience of compensating for visual field loss and how it impacts losing one's driving license, and participation in vision rehabilitation.

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Public knowledge of visual stroke symptoms: a systematic literature review

Irene Langeggen,[1*] Janne Dugstad,[2] Torgeir S. Mathisen,[1] Grethe Eilertsen,[3] Helle K. Falkenberg[1]

[1] National Centre for Optics, Vision and Eye Care, Department of Optometry, Radiography and Lighting design, University of South-Eastern Norway, Kongsberg, Norway

[2] Centre for Health and Technology, Faculty of Health and Social Sciences, University of South-Eastern Norway, Drammen, Norway

[3] Department of Nursing and Health Science, University of South-Eastern Norway, Drammen, Norway

Corresponding author: irene.langeggen@usn.no

Abstract

A quick response time to treatment is essential for improving outcomes after a stroke. The public stroke symptoms campaign, known as FAST, which stands for Facial mimic (F), lifting Arms (A), Speaking (S), and Time (T), does not include vision (Rioux et al., 2022). However, approximately 30% of stroke patients do not recognise sudden visual problems as a symptom of stroke. This lack of knowledge causes unnecessary delays in contacting emergency stroke care services. Enhancing knowledge could promote greater awareness and encourage appropriate action among the public. The aim of this systematic literature review was to explore public knowledge of visual stroke symptoms.

The literature review followed PRISMA guidelines. The authors searched Medline, Scopus, CINAHL and comparable electronic databases. Blinded evaluation of title and abstracts were done by three researchers, including IL and HKF, and discrepancies were solved by a fourth. Articles inclusion criteria were: English or Nordic language, informants age >18 years, results presented public, or stroke survivors' knowledge of vision symptoms related to stroke. STROBE reporting guideline was used to assess the quality of reporting in the papers. This study is part of a larger updated review, and preliminary results are presented.

The search identified 574 articles, where 21 articles met the inclusion criteria and authors' STROBE quality evaluation. The articles represented 480 548 informants from 13 countries across the world. Most studies assessed knowledge through interview or self-administrated questionnaires. Preliminary analysis showed that the knowledge of vision symptoms of stroke was low. Further, vision symptoms and visual problems were described in many different terms, including blindness, blurry vision and tired eyes. The results suggest that there is a need for more precise and uniform communication on how to identify and act on stroke related vision symptoms to the public. In order to improve vision and stroke related health competencies in the public, a clear set of symptom descriptions that accurately identify the most frequent visual stroke symptoms, and a strategy to implement this knowledge in public health campaigns are required.

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Sensitivity and specificity of the Norwegian KROSS tool for vision assessment after stroke

Torgeir S. Mathisen,[1,2] Irene Langeggen,[1,2] Ragnhild Munthe-Kaas,[3] Marianne Råen,[4] Grethe Eilertsen,[2,5] Helle K. Falkenberg[1,2*]

[1] National Centre for Optics, Vision and Eye Care, Department of Optometry, Radiography and Lighting design, University of South-Eastern Norway, Kongsberg, Norway

[2] USN Research group of Older Peoples' Health

[3] Kongsberg Hospital, Vestre Viken Hospital Trust, Kongsberg, Norway

[4] Vikersund Rehabilitation Centre, Vikersund, Norway

[5] Department of Nursing and Health Science, University of South-Eastern Norway, Drammen, Norway

Corresponding author: helle.k.falkenberg@usn.no

Abstract

Over 60% of stroke survivors have visual problems (Rowe et al., 2019). These include central vision issues, visual field defects, eye movement deficits, and visual perception problems. It is crucial to assess vision post-stroke for rehabilitation, but this is not routine in Norwegian stroke care. Here we will present the results of a study aimed to validate the KROSS tool, developed for identifying post-stroke vision problems (Falkenberg & Mathisen, 2024; Falkenberg et al., 2016; Mathisen et al., 2021). The KROSS tool, created with Norwegian stroke and rehabilitation services, has 21 items related to symptoms, observations, and assessments of visual acuity, field, movements, and inattention. All are scored binary (problem present or not). Sixty-seven stroke survivors were assessed twice: first by a healthcare professional without formal vision competence, then by an optometrist/KROSS specialist within two days. Sensitivity, specificity, predictive values, and inter-rater reliability were calculated using Kappa values and Gwet's Agreement Coefficient.

The KROSS tool demonstrated high sensitivity (98%) and specificity (83%), excellent reliability (AC1 > 0.86/Kappa > 0.83), and observer agreement (93%). Vision problems were identified in 64% of cases, with 44% of patients reporting vision symptoms. The tool had high positive and negative predictive value and negative predictive values (> 0.9). High specificity scores (> 70%) were observed for all items, with most showing excellent or substantial agreement (AC1 > 0.7/Kappa > 0.6). Almost all patients were referred to an optometrist for further follow-up.

The KROSS tool exhibited high levels of sensitivity, specificity,

and reliability. The high agreement scores suggest that non-vision specialists without formal vision competence could effectively assess and identify the presence of a vision problem. The results also indicate that most patients with newly identified, or inadequately managed known vision problems could be referred to an optometrist for further assessment and rehabilitation. Vision assessment should be integrated into stroke care, serving as an indicator of high-quality service delivery for stroke survivors.

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SOPTI Meeting 2024: Abstracts

The 18th National Conference of the Italian Optometric Association (SOPTI) was held in Riccione on April 14–15, 2024. The title of the conference was "*Focus on Errors, Unexpected Events and Complications*", and it was structured into three thematic sessions. The conference was organised by Gabriele Civiero and the programme featured a diverse array of activities, including lectures, workshops, a photo competition, and a poster session. The keynote speaker, Dr Matjaž Mihelčič (ECOO Past President), delivered a lecture about "*How to Manage Non-Adaptation to Ophthalmic Lenses*". The abstracts of the accepted posters and free papers are presented in this collection.

Correspondence for all abstracts: gab.civiero@gmail.com.

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Comparison between optometric measurements and subjective satisfaction after photobiomodulation for dry age-related macular degeneration

Bianca Marini[1], Virginia De Marco[1], Andrea Bedei[2], Laura Boccardo[1,3]

[1] Department of Optics and Optometry, University of Florence, Italy

[2] Eye Clinic Pietrasanta, Lucca, Italy

[3] Institute for Research and Studies in Optics and Optometry (IRSOO), Vinci, Italy

Abstract

Maculopathy is a degenerative disease of the retina that causes irreversible and profound vision loss, primarily affecting central vision in individuals over 60 years of age. Age-related macular degeneration (AMD) can present in two main forms: exudative (wet) and atrophic (dry). Photobiomodulation involves the use of light from the visible spectrum to near-infrared (NIR) (500–1000 nm), produced by laser or non-coherent light sources such as light-emitting diodes (LEDs) applied to the body to produce beneficial cellular effects. The treatment is performed in an eye clinic using the Valeda Light Delivery System (LumiThera). It lasts about 4 minutes and can be administered to one eye or both consecutively and it consists of nine sessions over 30–45 days, which can then be repeated after 6 months.

The purpose of this study is to evaluate the correlation between visual functions, such as visual acuity and contrast sensitivity, and the degree of subjective satisfaction in patients undergoing photobiomodulation therapy for dry AMD.

To assess the visual performance of each patient, data on visual acuity and contrast sensitivity were collected both pre- and post-treatment. One month after treatment, patients were asked to evaluate their overall visual improvement in daily life, compared to their initial condition, on a scale from 0 (no perceived improvement or even worsening compared to before treatment) to 10 (significant improvement). Each patient was treated using the Valeda Light Delivery System, through transconjunctival irradiation.

The study was conducted on 43 patients (34 females) aged between 56 and 91 years (median 81). Results from the one-month follow-up visit revealed an average improvement in best-corrected visual acuity from 0.28 ± 0.22 to 0.24 ± 0.22 LogMAR (t-test, $p < 0.001$) and in contrast sensitivity from 0.94 ± 0.38 to 1.06 ± 0.38 LogSC (t-test, $p < 0.001$). The average score of the questionnaire was 3.49 ± 2.80. Analysis of the results indicates a weak correlation between optometric measurements and subjective evaluations.

The average improvement in visual acuity is statistically significant but clinically negligible, whereas the improvement in contrast sensitivity, although small, can be considered clinically significant. These improvements are poorly correlated with the subjective satisfaction rating provided by the patients. Therefore, for a comprehensive assessment of the treatment, it is important to evaluate the patient's subjective satisfaction, integrating psychometric measures with subjective evaluations.

The role of reading in childhood: relationship between visual skills, gender and age

Irene Catena, Marina Serio, Silvio Maffioletti

Department of Optics and Optometry, University of Torino, Italy

Abstract

The visual system is subjected to great demands for both close and distant tasks from an early age, and taking care of it and acting promptly to remedy any problems is vital for a child's overall wellbeing. In paediatric optometry, the collaboration between the eye specialist and the teacher plays a fundamental role in the early detection of vision-related disorders.

With this thesis we aim to investigate the role of visual skills in the process of reading and similar tasks, differentiating the sample by gender and age. This research considers a sample of 40 children at the beginning of their school career, specifically 20 second grade (average age 7.2 ± 0.8 years) and 20 third grade (average age 8.3 ± 0.6 years) children. Each child underwent a screening, consisting of several tests, to assess visual acuity, the quality of binocular vision and the efficiency of visual skills during one of the most important phases of schooling: learning to read and write. Previous studies examined the correlations between optometric variables and visual research tests and with this thesis we want to compare their results.

Specifically, the three macro-areas investigated by the tests carried out were: visual tracking with the Groffman test; the recognition of a figure with the interference of the crowding phenomenon with the BReViS test; the evaluation by means of the DEM test of speed and accuracy in the execution of a task similar to reading but with numerical symbols, which proposes to correlate reading skills with a sustained level of attention, recognition and naming of numbers and a correct orientation of Visual Spatial Attention. It was verified that visual skills influence the test results mainly in terms of errors differently for the two ages, while no differences were found in terms of gender.

Validation of a questionnaire for assessing visual function in cataract and refractive surgery patients

Virginia De Marco[1], Bianca Marini[1], Andrea Bedei[2], Laura Boccardo[1,3]

[1] Department of Optics and Optometry, University of Florence, Italy

[2] Eye Clinic Pietrasanta, Lucca, Italy

[3] Institute for Research and Studies in Optics and Optometry (IRSOO), Vinci, Italy

Abstract

Cataract and refractive surgeries are increasingly common and continuously evolving procedures, highlighting the need for studies that assess their effectiveness and impact on patients' lives. In

this context, psychometric questionnaires are a key tool for describing visual abilities and vision-related quality of life, providing healthcare professionals with valuable data to improve treatments. The psychological impact of these interventions is important, as the primary goal is to ensure that the patient experiences improved vision compared to their previous condition, offering not only functional benefits but also perceptual and psychological advantages. This study aims to evaluate the validity of a self-assessment questionnaire on vision quality following these two types of interventions.

Demographic and refractive data were collected from patients at an eye clinic in Pietrasanta (Lucca). Refractive data, along with uncorrected visual acuity (UCVA) and best-corrected visual acuity (BCVA), were recorded both before and after surgery. During the follow-up visit, patients completed a psychometric self-assessment questionnaire on visual function and perceived improvement following cataract or refractive surgery. The questionnaire was developed by one of the authors to internally monitor patient satisfaction with the procedures performed at his clinic. It focuses on assessing the patient's visual function and is completed during the postoperative check-up. The questionnaire consists of 11 questions, each referring to everyday activities. For each question, five levels describe the patient's perception of their vision while performing the listed activities, with each level corresponding to a specific score.

The study was conducted on 102 patients (71 females), of whom 80 had cataract surgery, 11 had FemtoLASIK, six had PRK treatment, two had SMILE treatment and three had phakic IOL implantation for refractive purposes. Age ranged from 21 to 93 years (median 72). After surgery, UCVA and BCVA were 0.12 ± 0.18 and 0.05 ± 0.09 LogMAR, respectively. The mean improvement of UCVA and BCVA was 0.62 ± 0.41 and 0.30 ± 0.26 LogMAR, respectively. The questionnaire score showed a median value of 3.7 (range 1.8–4.0) on a scale of 0 to 4 (see Figure 1). Regarding the Rash analysis, the reliability index of the questions is good (0.92) while that of the subjects is low (0.49); the separation index between the items is good (3.42) while for the subjects it is low (0.99).

The patients are highly satisfied with the results of the intervention, achieving good scores across all activities tested in the questionnaire. Data analysis shows no clinically significant correlation between visual acuity and the questionnaire scores, which may be due to the clustering of scores at very high levels. To continue with the validation of the questionnaire, it will be necessary to include a sample with greater variability in responses, by administering the questionnaire both before and after the intervention, and by testing for repeatability.

Factors affecting pupil diameter

Francesco Adami,[1] Laura Boccardo[1,2]

[1] Department of Optics and Optometry, University of Florence, Italy

[2] Institute for Research and Studies in Optics and Optometry (IRSOO), Vinci, Italy

Abstract

Understanding pupil size is highly relevant in refractive surgery, multifocal contact lens fitting, and orthokeratology. The purpose of this study is to evaluate the factors that may affect pupil size, such as light conditions (photopic, mesopic, and scotopic), refractive error, light sensitivity, eye colour, corneal diameter, and axial length.

WAM 5500 Open Field Binocular Autorefractometer (Grand Seiko) and Osiris-T Aberrometer (CSO) were used to measure objective refraction. Lenstar 900 biometer (Haag-Streit) was used for axial length measurement. Light sensitivity measurement was performed with Lumiz 100 (Essilor). Pupillary and corneal diameters were measured with the Osiris-T topographer (CSO). All examinations were performed without refractive correction.

The sample included 64 subjects, equally divided between males and females, aged 19 to 52 years (mean 26.5). The results show that luminance is the factor that mostly affects pupillary diameter. The mean pupillary diameter of the sample was: 3.96 ± 0.83 mm in photopic condition, 5.03 ± 0.94 mm in mesopic condition, and 6.12 ± 0.81 mm in scotopic condition (ANOVA: $P < 0.001$). There is evidence of a decrease in pupillary diameter as age increases, and this correlation, although moderate, is statistically significant ($R = -0.36$, $p < 0.05$). The sample was composed of 30 myopic subjects (< -0.50 D), 28 emmetropic subjects, and 11 hyperopic subjects (> +0.75 D). At low luminance levels, myopes tend to have larger pupils (mesopic: 5.41 mm; scotopic: 6.42 mm) than hyperopes (mesopic: 4.77 mm; scotopic: 5.85 mm) ($p < 0.05$). The difference was not statistically significant at the photopic level. In our sample, 45 subjects had dark eyes and 14 had light eyes (blue, green, or grey). No statistically significant differences in pupil diameter were found based on eye colour. In all lighting conditions, no significant correlation was observed between pupil diameter and anatomical parameters of the eye, such as axial length and corneal diameter.

Among the factors analysed, those influencing pupillary diameter are environmental luminance, age, and uncorrected refractive error. Luminance is the factor with the greatest effect. The study shows that refractive error affects pupil diameter, as subjects with hyperopia had smaller pupil diameters than those with myopia. This difference may be due to the fact that our measurements were taken without correction, thus not excluding the influence of accommodative miosis. The results indicate that the other factors examined (light sensitivity, eye colour, axial length, corneal diameter) do not affect pupil diameter.

Are online myopia calculators reliable?

Alessia Bellatorre,[1,2] Silvia Di Benedetto,[1,2] Claudia Colandrea[1,2]

[1] Department of Optics and Optometry, University of Torino, Italy

[2] Istituto Benigno Zaccagnini, Milano, Bologna, Italy

Abstract

Retrospective study comparing the evolution of myopia using two web calculators: Myopia Care Web (MCW) and Myopia Calculator BHVI (MCBHVI). The main aim is to verify the accuracy of the predictions from these tools compared to the actual results observed in a group of myopic subjects.

The studied sample includes 417 eyes of Caucasian subjects, aged between 7 and 25 years, with a maximum follow-up of 6 years. The subjects did not use specific corrections to slow down the progression of myopia, except for a group that used orthokeratology lenses. The results showed that MCW tends to overestimate myopia in 69% of cases compared to MCBHVI, with an average difference of -0.46 D. Furthermore, MCBHVI tends to underestimate myopia compared to the actual values.

The statistical analysis, performed with the Wilcoxon test, revealed a significant difference between the two calculators. The greatest discrepancy was observed in subjects with a starting age of around 11 years and initial myopia of -2.45 D. The conclusions suggest that, although the calculators may be useful for an initial indication, professionals should be cautious about basing their decisions solely on these tools, given the individual variability of risk factors.

Control of myopia progression and orthokeratology – a 10 year case study

Charles Di Benedetto

Department of Optics and Optometry, University of Florence, Italy

Abstract

Myopia has been increasing exponentially, and in recent years, many optical companies have developed and commercialised solutions for its management. Orthokeratology has been a pioneering solution for controlling myopia progression and remains one of the most effective non-pharmacological optical strategies today. This study presents a 10-year case report of a 22-year-old female myopic patient, who has been using orthokeratology lenses since she was 12.

The patient's myopia had progressed to -2.00 D when orthokeratology treatment was started in March 2014, and it has been closely monitored ever since. From November 2021, regular axial length measurements were performed to track myopia progression alongside the traditional method of spherical equivalent measurement. The contact lenses used for this patient have always been Contex OK lenses (Bausch & Lomb).

Over the 10-year period (from February 2014 to March 2024), the patient's myopia increased by -1.25 D in the right eye and -1.00 D in the left eye. Axial length increases from November 2021 to February 2024 were minimal: 0.05 mm in the right eye and 0.04 mm in the left. No complications related to visual health or eye safety were observed during this period. Throughout the years of lens use, there were no visual or ocular health complications. This was ensured by the regular follow-up appointments, which the patient consistently adhered to.

These periodic check-ups helped maintain a strong professional-patient relationship, fundamental for the success and continuity of the treatment, as well as for preventing and managing any potential complications. The patient continues to be satisfied with the treatment, engaging in sports without needing glasses or traditional contact lenses. When compared with published literature, this case shows effective long-term control of myopia, particularly given the patient's young age at the start of the treatment.

Preschool visual screening: update on guidelines and procedures

Luca Beccari, Silvia Di Benedetto, Claudia Colandrea, Stefano Spataro

Department of Optics and Optometry, University of Torino, Italy

Abstract

Visual screening at preschool age allows us to prevent visual developmental anomalies in advance, offering the possibility to intervene before problems worsen. The aim of this work is to present a worldwide survey of visual screening protocols and to compare them with a model analysed in Italy. The implementation of a visual screening programme is now of crucial importance for the public health of children. Here, we propose how to update the guidelines for the implementation of effective and efficient vision screening in our country. First, the approach and screening methods used internationally were evaluated by selecting information from 30 articles in the literature. The extrapolated data were then compared with the data collected in the present study carried out in Italy (Ottica Zoldan – Belluno in collaboration with orthoptists and ophthalmologists).

The Italian model was found to be complete in comparison with the international literature and could be implemented as a possible programme in our country. The model proves to be very reliable due to the wide range of tests covered; in fact, it shows excellent results compared to the international panorama and boasts a better preschool visual screening programme. The implementation of a visual screening programme would be very important for the public health of children today, as shown by the analysis of the 30 articles from different parts of the world. These studies found that on average 20% of children fail the screening test due to visual impairment, a figure that should not be underestimated.

Refractive errors in school age children: a study with the portable autorefractometer

Giorgia Meneghel, Allessia Bellatorre, Michela Greco

Department of Optics and Optometry, University of Torino, Italy

Abstract

The aim of this research was to investigate the visual situation in school age children through the use of a portable autorefractometer (VIVS100S-B Welch-Allyn) and analyse the incidence of refractive errors detected. The sample consisted of a group of 125 children aged between 6 and 9 years, from the primary school "Santorre di Santarosa" in Torino.

Three optometric tests were used to carry out this investigation: measurement of the refractive error using the portable autorefractometer, a tool that provides an objective estimate of the refractive defect; cover test, one of the fundamental tests for investigating the quality of binocular vision; Lang test II, useful for evaluating binocular and stereoscopic vision and identifying any early defects.

To study the reproducibility of the measurements made with the portable autorefractometer, repeated measurements were performed on a subject and compared with the data of a fixed autorefractometer.

The results obtained highlight the importance of the screening test and show the need to further study the reliability of the instrument.

Kongsberg Vision Meeting 2024: Abstracts

Kongsberg Vision Meeting was held at the University of South-Eastern Norway in Kongsberg, for the 16th time, on October 24–25, 2024. The meeting was organised as a two-day event focusing on clinical optometry and vision research. Vibeke Sundling, Ann Elisabeth Ystenæs, Lotte-Guri B. Steen, Tove Lise Morisbakk, Helle K. Falkenberg and Rigmor C. Baraas organised the meeting. The theme this year was related to advancements in primary eye care. Keynote speakers were António Filipe Macedo, Linnæus University, Sweden; Mhairi Day, Glasgow Caledonian University, Scotland; Tony Pansell, Karolinska Institutet and St Erik Eye Hospital, Stockholm, Sweden; Fiona Stapleton, University of New South Wales, Australia; and Maria Liu, UC Berkeley Herbert Wertheim School of Optometry & Vision Science, Berkeley, USA. The abstracts from the other invited and contributed talks on the different days are presented in the order they were given.

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Neovascular age-related macular Degeneration: The patient's journey

Antonio Filipe Macedo

Department of Medicine and Optometry, Linnaeus University, Kalmar, Sweden

antonio.macedo@lnu.se

Abstract

In this talk I will share the results of an ongoing research project which aims to characterise the journey of patients with neovascular age-related macular degeneration (nAMD). The project deals with patients' perceptions of several aspects of their life and their vision together with clinical aspects like treatment response in a real-world setting. In the first part I will focus on the patients' perspective by sharing results of standard measures of mental health and vision related quality of life. In the second part I will share longitudinal, functional and structural outcomes and pilot data on explorative blood markers for disease relapses. Finally, I will make a connection between all the aspects by mentioning the touching points and how these can be used to improve management and quality of life for those affected by nAMD.

The effectiveness of optical myopia management interventions

Mhairi Day*, Stephanie Kearney

Department of Vision Sciences, Glasgow Caledonian University, Glasgow, UK

* Correspondence: m.day@gcu.ac.uk

Abstract

Clinical trials show that widely commercially available optical myopia management interventions significantly reduce the progression of axial length (AL) to mean values of 0.1–0.26 mm/year compared to controls (0.20–0.36 mm/year), a mean reduction of between 0.1–0.175 mm/year (Bao et al., 2022; Chamberlain et al., 2019; Huang et al., 2016; Lam et al., 2020; Liu et al., 2023; Ruiz-Pomeda et al., 2018). Clinical trials have set durations (e.g. 1, 2, 3, 6 years); selected subjects are within a set age bracket (e.g. 8 to 12 years) and have a specific range of spherical equivalent refractive errors (SER, sphere power + 0.5*cylinder power; e.g. -1 to -5 D), and many are conducted in subjects with a Chinese ethnicity. Additionally, the final outcomes reported in clinical trials do not include the results of subjects who have dropped out during the studies.

Using a variety of methods, previous research investigating effectiveness of interventions in a UK clinic population in a small case series showed that, on average, 30% of patients had successful outcomes with the intervention (Kearney et al., 2022). This study aims to extend this case series, including analysis on myopia management spectacle lenses, to investigate the response to optical myopia management interventions in a UK clinic setting.

In this study, data collected from patient clinical records from the myopia clinic, Glasgow Caledonian University, included age, axial length (AL) and intervention method (DIMs, orthokeratology (OK), dual focus (DF) and multifocal (MF) contact lenses)). If data were available, effectiveness was evaluated by three methods: 1) Mean Efficacy Method using the reduction in AL mean values from literature as a target, 2) Emmetropic Growth Method using emmetropic AL growth as a target, 3) Responder/non-responder, a responder demonstrating progression <0.11 mm/year (Prieto-Garrido et al., 2021).

Sixty-three patients were included (DIMs: 28, DF: 15, MF: 11, OK: 8). Results show that at commencement of intervention, mean $\pm$ SD SER was -4.56 $\pm$ 2.10 DS and AL 25.04 $\pm$ 0.95 mm. The AL growth rate before intervention was 0.34 $\pm$ 0.26 mm and the mean $\pm$ SD AL growth rate during intervention was 0.15 $\pm$ 0.12 mm/yr with a significant mean reduction of 0.19 $\pm$ 0.27 mm/year.

Across all methods and intervention types, interventions showed success in 39% of patients. Across all interventions, there was success in 49% of eyes using the mean efficacy method, 29% success with the emmetropic growth method and 42% were classed as responders. The average success across the three methods of measurement for each intervention was: DIMS: 44%; DF: 25%; MF: 45%; OK: 33%.

In conclusion, approximately half of patients will not meet the mean AL effectiveness values from clinical trials and the effectiveness of interventions varies greatly across individuals. As optical interventions are a considerable time and monetary investment for patients, the effectiveness of interventions should be discussed with patients in a balanced way and AL measured to accurately evaluate efficacy. Practitioners should consider monitoring the AL before starting an intervention to ensure interventions are offered in an appropriate manner to myopes demonstrating AL progression and to allow for success to be evaluated using methods such as the Mean Efficacy Method.

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Vision and dizziness

Tony Pansell

Institution for Clinical Neuroscience, Karolinska Institute, Stockholm, Sweden

tony.pansell@ki.se

Abstract

Dizziness is a common complaint and might indicate severe illnesses in the body or brain that need further clinical investigation. There is also non-serious dizziness that the optometrist should handle. In this talk, I will present a framework for investigating and correctly handling patients suffering from dizziness. Particular focus is given to vision motion hypersensitivity, also called visual vertigo.

Exploring the association between virtual reality technologies, oculomotor function and postural control

Ieva Krastina*, Rigmor C. Baraas, Ellen Svarverud, Stuart J. Gilson, Lene A. Hagen

National Centre for Optics, Vision and Eye Care. Faculty of Health and Social Sciences, University of South-Eastern Norway, Kongsberg, Norway

* Correspondence: ikra@usn.no

Abstract

The use of virtual reality (VR) technologies has the potential to provide benefits and advancements in various areas, from entertainment and leisure activities to education and work life. Some of these benefits include increased engagement in learning, the ability to repeat life-like training scenarios as often as needed in safe conditions, as well as enabling efficient long-distance, real-time collaboration.

Despite its benefits, VR presents challenges, particularly regarding vision and oculomotor functions that are critical for depth perception, navigation, and adaptation to natural and virtual environments. In a VR environment, human vision encounters oculomotor challenges such as the vergence-accommodation conflict: a disconnect between vergence and accommodation. Furthermore, vision is one of three sensory systems used to maintain bodily balance. The increased demand on human vision in VR, including the vergence-accommodation conflict, may affect postural control during and immediately after immersion in VR. However, the understanding of the interaction between human vision, postural control and VR technologies, and the role that human vision plays in a VR environment, remains limited. Knowledge about the vergence-accommodation conflict raises the question of how important the function of accommodation and vergence is for continuous and comfortable VR use. Also, how does VR use affect oculomotor function and postural control?

This study examined the association between oculomotor functions, specifically accommodation and vergence, and performance, comfort, and postural control during and after VR gameplay. Also, it explored potential risks and benefits that VR may pose for oculomotor function and postural control. The study included 120 upper secondary school students aged 16–18 years. Comprehensive vision testing was conducted to characterise each participant's visual status, and a set of tests was carried out before and after the VR gameplay to evaluate possible changes in oculomotor function and postural control.

The results suggest that both vergence and accommodation might be important indicators for predicting postural instability after VR gameplay. The findings offer valuable insights into the importance of oculomotor function for more comfortable and effective use of VR. They also explore its potential impact on postural control, informing more inclusive design practices in VR technologies.

Vision and cognitive function in healthy Norwegian school children

Tina R. Johansen, Hilde R. Pedersen, Rigmor C. Baraas, Trine Langaas*, The SNOW Study Group

National Centre for Optics, Vision and Eye Care. Faculty of Health and Social Sciences, University of South-Eastern Norway, Kongsberg, Norway

* Correspondence: trine.langaas@usn.no

Abstract

Anecdotally, when asking teachers or parents if they believe that having good vision is important for a child's academic performance, many will nod in agreement. Consistent with such a view, a growing body of evidence shows that several aspects of visual functions are associated with academic performance. Visual acuity is shown in numerous studies to be linked to academic performance (Hopkins et al., 2020; Schmitz et al., 2023). Similar trends have been reported for refractive error status (Mavi et al., 2022), and binocular- and accommodative-functions (Shin et al., 2009), but with some degree of uncertainty (Hopkins et al., 2020).

There are several methods to measure academic performance in children, where the most obvious one is looking at their school grades. However, research has shown that, by testing children's cognitive function (such as working memory, inhibition and processing speed), the outcome can predict future academic performance (Roebers et al., 2014).

Therefore, in addition to measuring children's visual status as a part of a school vision program, the SNOW study has also measured their cognitive function (working memory and processing speed) to investigate the possible associations between visual and cognitive functions in a healthy population of Norwegian schoolchildren aged 7–16 years. Preliminary results will be discussed in the context of previously published research.

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Exploring the effects of natural dark/light exposure on myopia — insights from animal models

Solveig Arnegard[1*] Rigmor Baraas[1] Andreas Zedrosser[2]

[1] National Centre for Optics, Vision and Eye Care. Faculty of Health and Social Sciences, University of South-Eastern Norway, Kongsberg, Norway

[2] Department of Natural Sciences and Environmental Health, University of South-Eastern Norway, Bø, Norway

* Correspondence: solveig.arnegard@usn.no

Abstract

Numerous studies suggest that spending time outdoors protects humans against developing myopia (Morgan et al., 2021; Rose et al., 2008). However, it is unknown if and how exposure to daylight and darkness in natural outdoor habitat regulates eye growth and protects against developing myopia in mammals. Myopia research generally uses laboratory animal models like guinea pigs, tree-shrews, monkeys, domestic chicken, and mice. Studies on laboratory animals are commonly conducted under regulated lighting conditions, where the animals are typically raised under conditions with a given number of hours of artificial daylight and darkness (Troilo et al., 2019). It remains unclear how transferable these animal models are for humans living in both artificial and natural environmental conditions.

This presentation will provide a preliminary analysis on refractive errors and eye growth in animals, comparing individuals that grew up in laboratory conditions with individuals that live in natural outdoor lighting conditions

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Does method matter? A comparison of a vision-generic and a disease-specific questionnaire in assessing vision-related quality of life in persons with keratoconus

Eilin Lundanes[1*] Helle Kristine Falkenberg[1] Lena Leren[2] Vibeke Sundling[1]

[1] National Centre for Optics, Vision and Eye Care. Faculty of Health and Social Sciences, University of South-Eastern Norway, Kongsberg, Norway

[2] Centre for Health and Technology, Department of Nursing and Health Sciences, Faculty of Health and Social Sciences, University of South-Eastern Norway, Drammen, Norway

* Correspondence: eilin.lundanes@usn.no

Abstract

The purpose of this study was to explore the differences between the vision-generic National Eye Institute Visual Functioning Questionnaire (NEI VFQ-25) (Jelin et al., 2019; Mangione et al., 2001) and the disease-specific Keratoconus Outcomes Research Questionnaire (KORQ-NO) (Khadka et al., 2017) in assessment of vision-related quality of life (VR-QoL) in persons with keratoconus. Persons with keratoconus aged 18 years and older were recruited through social media. A digital platform was utilised to collect self-reported data on VR-QoL using the KORQ-NO and NEI VFQ-25 questionnaires. Additionally, data from a clinical study was included. The psychometric properties of the questionnaires were assessed by Rasch analysis using RUMM2030+ (Andrich & Marais, 2019), complimented by a qualitative comparison of the content of the questionnaires. The "Activity limitations" and "Symptoms" subscales of KORQ-NO were analysed independently.

In total, 165 participants completed the two questionnaires. 48.5% were females, and median age was 41 (range 19–72). The "Symptoms" subscale of KORQ-NO demonstrated excellent targeting with mean persons location of 0.35 [*SD* 1.17], suggesting that the symptoms covered by the questions are relevant to persons with keratoconus. The questions were well separated and distributed along the logit scale, capturing and differentiating most persons with various levels of severity of symptoms. Except for two questions on pain and discomfort, NEI VFQ-25 does not consist of questions related to symptoms.

The "Activity limitations" subscale of KORQ-NO exhibited excellent targeting with mean persons location of -0.07 [*SD* 1.66]. Again, the questions were well separated and distributed along the logit scale, differentiating persons with various vision-related activity limitations, suggesting a scale that is valid, accurate, and sensitive to persons with keratoconus. For NEI VFQ-25, Rasch analysis showed multidimensionality (% of statistically significant *t*-tests = 18.79), poor targeting (mean persons location = -2.28 [*SD* 1.23]) and flooring effect.

Both the KORQ "Activity limitations" subscale and NEI VFQ-25 contain questions covering similar dimensions on limitations due to vision, such as distance vision, near vision, and driving. However, KORQ "Activity limitations" covers more aspects of distance vision, as well as interference of oncoming lights and seeing in poor light, whereas the NEI VFQ-25 covers dimensions such as general health, social functioning, mental health, role difficulties, and dependency.

The most relevant NEI VFQ-25 item was found to be "How often do you worry about your vision?". In general, wording and content of the NEI VFQ-25 questions indicate targeting towards persons with low vision. Several of the questions had item locations higher than any persons, including questions related to distance and near vision, colour vision, social functioning, dependency and mental health, suggesting irrelevance to persons with keratoconus.

The disease-specific KORQ-NO is more accurate, valid, and reliable compared to the vision-generic NEI VFQ-25 in the assessment of vision-related quality of life in persons with keratoconus. This supports the use of a disease-specific questionnaire in future assessments of VR-QoL in persons with keratoconus.

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Assessment of a novel protocol for image acquisition of corneal subbasal nerve plexus by laser in vivo confocal microscopy

Siv A. Sandvik,[1*] Eilin Lundanes,[1] Emanuele Käser,[2] Neil Lagali,[3] Tove Lise Morisbakk,[1] Vibeke Sundling[1]

[1] National Centre for Optics, Vision and Eye Care. Faculty of Health and Social Sciences, University of South-Eastern Norway, Kongsberg, Norway

[2] FHNW University of Applied Sciences and Arts Northwestern Switzerland, School of Engineering, Institute of Optometry, Olten, Switzerland

[3] Department of Biomedical and Clinical Science, Linköping University, Linköping, Sweden

* Correspondence: siv.a.sandvik@usn.no

Abstract

Neuropathy and other neurodegenerative processes significantly impact both systemic and ocular health. Examination of the peripheral nerve fibres in the transparent cornea can provide an important window into the nerve status in relation to both health and disease. However, non-invasive direct imaging and assessment of nerve fibres remains challenging.

In vivo confocal microscopy (IVCM) generates *en face* high-resolution images of the corneal layers from epithelium to endothelium using a confocal point scanning technique (Patel & McGhee, 2007). IVCM has been used to image corneal subbasal nerves in multiple diseases such as diabetes (Roszkowska et al., 2020), dry eye disease (Chiang et al., 2023), Parkinson's (Che & Yang, 2020), keratoconus (Flockerzi et al., 2020), acanthamoeba- and fungal keratitis (Moshtaghion et al., 2023), and other non-neurological diseases (Gu et al., 2022). The technique has the potential for monitoring peripheral nerve fibre degenerations by a more feasible method than the existing skin biopsy (Lagali et al., 2018). Previously addressed challenges using IVCM to assess the corneal subbasal nerves plexus include the small image size, 400×400 μm, and the inhomogeneous distribution of the corneal nerve fibres (Marfurt et al., 2010; Patel & McGhee, 2005; Winter et al., 2016). Both introduce methodological biases to the results.

Even though studies have demonstrated good repeatability in capturing individual images (Kalteniece et al., 2017; Ostrovski et al., 2015), challenges persist in establishing consistent normative values for the most reported outcome parameter, corneal nerve fibre length (CNFL). In fact, CNFL shows significant variability even among healthy individuals (Parissi et al., 2013; Tavakoli et al., 2015). There are published protocols for IVCM image acquisition, but no standardised imaging protocol exists (Köhler et al., 2016; Schaldemose et al., 2017; Tavakoli & Malik, 2011).

We have developed a novel imaging acquisition protocol, aiming for clinically feasible and repeatable image acquisition of a consistent region of interest. The purpose of this pilot study was to assess a novel method of image acquisition of the corneal subbasal nerve plexus.

The protocol uses an automated moving fixation target in front of the non-examined eye. The image acquisition starts at the structural landmark, the inferior whorl, acquiring approximately 800 images in total. Mosaics are created from the acquired images, and subsequently, the predefined region of interest is analysed.

The pilot study included 25 eyes (13 subjects) from healthy young adults aged 20–30 years. Two operators performed, in total, three examinations per eye, allowing for the calculation of both inter- and intra-repeatability. The method shows promising preliminary qualitative results and has potential for improvement in terms of both time consumption and clinical feasibility.

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The impact of environmental conditions on the ocular surface: TFOS Lifestyle Report

Fiona J. Stapleton,[1*] M. Alves,[2] P. Asbell,[1,3] M. Dogru,[1] G. Giannaccare,[4] A. Grau,[5] D. Gregory,[6] D. H. Kim,[7] M. C. Marini,[8] W. Ngo,[9] A. Nowinska,[10] I. J. Saldanha,[11] E. Villani,[12] T. H. Wakamatsu,[13] M. Yu[14]

[1] Faculty of Medicine and Health, UNSW Sydney, Kingsford, Australia

[2] Department of Ophthalmology and Otorhinolaryngology, University of Campinas, Campinas, Brazil

[3] Department of Bioengineering, University of Memphis, Memphis, USA

[4] Department of Ophthalmology, University Magna Graecia of Catanzaro, Cantanzaro, Italy

[5] Department of Ophthalmology, Pontifical Catholic University of Chile, Santiago, Chile

[6] Department of Ophthalmology, University of Colorado School of Medicine, Colarado, USA

[7] Department of Ophthalmology, Korea University College of Medicine, Seoul, South Korea

[8] Department of Ophthalmology, Hospital El Cruce, Buenos Aires, Argentina

[9] School of Optometry & Vision Science, University of Waterloo, Waterloo, Canada

[10] Clinical Department of Ophthalmology, Faculty of Medical Sciences in Zabrze, Medical University of Silesia, Katowice, Poland

[11] Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore, USA

[12] Department of Clinical Sciences and Community Health, University of Milan, Eye Clinic, San Giuseppe Hospital, IRCCS Multimedica, Milan, Italy

[13] Department of Ophthalmology and Visual Sciences, Paulista School of Medicine, Sao Paulo Hospital, Federal University of Sao Paulo, Sao Paulo, Brazil

[14] Sensory Functions, Disability and Rehabilitation Unit, World Health Organization, Geneva, Switzerland

* Correspondence: f.stapleton@unsw.edu.au

Abstract

Environmental risk factors likely to have an impact on the ocular surface were reviewed and associations with age and sex, race/ethnicity, geographical area, seasonality, prevalence and possible interactions between risk factors were assessed. Environmental factors can be either climate-related or related to outdoor and indoor pollution. Temperature affects ocular surface homeostasis directly and indirectly, precipitating ocular surface diseases and/or symptoms, including trachoma. Humidity is negatively associated with dry eye disease (DED). High altitude and ultraviolet light exposure are associated with pterygium, ocular surface degenerations and neoplastic diseases. Pollution is associated with DED and conjunctivitis. Living within a potential zone of active volcanic eruption or with indoor pollution is associated with eye irritation. Most ocular surface conditions are multifactorial, and several environmental factors may contribute to specific diseases. The pandemic and pandemic-mitigating measures generally increased symptoms of ocular surface disease. A systematic review was conducted to determine: "What are the associations between outdoor environment pollution and signs or symptoms of DED?". DED is associated with air pollution (from NO_2) and soil pollution (from chromium). These findings can help inform the multifactorial nature of ocular surface diseases and assist with their management.

Advanced therapeutics for ocular allergy management

Maria Liu

School of Optometry, UC Berkeley, Berkeley, USA

marialiu75@berkeley.edu

Abstract

Ocular allergies are common and can significantly impact patients' quality of life. Optometrists must understand the spectrum of ocular allergy presentations, pathophysiology, and evidence-based treatment options for effective management. This session provides a comprehensive approach to diagnosing and treating ocular allergies, focusing on practical strategies for addressing both common and challenging cases.

Ocular allergies include conditions such as seasonal allergic conjunctivitis (SAC), perennial allergic conjunctivitis (PAC), vernal keratoconjunctivitis (VKC), and atopic keratoconjunctivitis (AKC). This presentation will discuss how to differentiate between these conditions and perform a thorough diagnostic assessment, including case history, slit-lamp examination findings, and in-office testing.

The therapeutic approach will focus on pharmacological options, including dual-action antihistamines/mast cell stabilisers (e.g., olopatadine), corticosteroids (e.g., loteprednol), and immunomodulatory agents (e.g., cyclosporine). Each class of drugs will be discussed in terms of their mechanism of action, indications, dosing, and side effects, particularly focusing on how to balance treatment efficacy with minimising risks, such as corticosteroid-induced intraocular pressure increases.

Non-pharmacological strategies will also be emphasised, including allergen avoidance, environmental modifications, and adjunctive therapies like artificial tears and cold compresses for symptomatic relief. Practical management tips will be provided, including tailoring treatment to specific patient populations, such as contact lens wearers and paediatric patients.

The session will conclude with real-world case studies to reinforce key concepts and provide practical tools for managing ocular allergies in daily clinical practice. By the end of the course, participants will be equipped with the knowledge needed to provide tailored, evidence-based care for patients with ocular allergies.

Latest insights into managing low and moderate hyperopia

Julie-Anne Little

Centre for Optometry and Vision Science, Biomedical Sciences, Ulster University, Coleraine, Northern Ireland, UK

ja.little@ulster.ac.uk

Abstract

Uncorrected refractive error (URE) is the primary cause of childhood vision impairment, affecting approximately 13 million children aged 5–15 years globally. A review and meta-analysis reported significant variation in the prevalence of clinically significant hyperopia across different age groups, and populations. Among children aged 5–15 years, the prevalence of clinically significant hyperopia, based on cycloplegic automated refraction, has been reported to range from 1.6% to 26.0%.

Hyperopia in schoolchildren has been shown to be associated with poorer binocular near VA and larger lags of accommodation. We conducted the first systematic review to demonstrate that uncorrected hyperopia has been shown to have an impact on educational performance, with other studies also reporting this association. However, it remains difficult to identify those hyperopes that would benefit from correction, and thus there is a lack of clinical consensus regarding when and how to correct hyperopia. Furthermore, vision screening programmes are primarily designed to

detect reduced distance vision, and it is difficult to detect hyperopia and determine its magnitude without employing cycloplegic refraction techniques.

This talk will review our current scientific knowledge and consider the other pertinent visual functions that are important to measure in the context of hyperopia. Recent research from our group will be presented, evaluating the impact of uncorrected hyperopia on sustained near tasks. The accommodative behaviour of schoolchildren with and without hyperopic correction while they conducted a reading task for 15 minutes, and watched a movie for 15 minutes was investigated using eccentric infrared photorefraction. We found that refractive correction significantly improves the accuracy of naturally hyperopic children's accommodative responses when undertaking near viewing tasks, but there was no correlation with other near visual function measures. This talk will discuss the implications of this work and other evidence relevant to clinical practice, helping to empower clinicians to decide when there is value to intervene with hyperopic spectacle correction.

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