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Prevalence of Myopia Among Public Schoolchildren in Brazil

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Prevalence of Myopia Among Public Schoolchildren in Brazil

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Abstract:

Purpose: Myopia has been recognized as a public health issue by the WHO since 2015. The prevalence of myopia is especially high in urbanized areas of east and southeast Asia, while Europe and the United States have doubled in prevalence compared to four decades ago. Little information about the prevalence of myopia in Latin America is available and this study aims to detect the prevalence of myopia in southern Brazil. Methods: this is a convenient sample cross sectional study which recruited 330 public schoolchildren enrolled between 2019 and 2021 (preschoolers to high school students, 5 to 21 years old). Individuals with severe neuro psychomotor developmental disorders who were unable to report visual acuity and/or subjects with congenital eye defects (congenital cataract, anophthalmic cavity, strabismus and congenital glaucoma) and contact lens wear on the date of the exam were excluded. Visual acuity, cycloplegic refraction, axial length measurements, corneal tomography, dilated fundus exam and slit lamp biomicroscopy were performed. A detailed questionnaire about demographics, use of near work devices, medical and family history was conducted. All statistical analysis was performed using SPSS version 18.0 software (SPSS, Chicago). The Pearson correlation coefficient, Kruskal Wallys and the Chi-Square Test were used to assess simple correlations and associations between variables. Results: Total prevalence of myopia was 17.4% and performed 31,3% of refractive errors. No statistically significant difference between male and female was found (p=0,7), with median myopia of -2.00D among females and -1.50D among males. The prevalence of high myopia was 4%, considering the cutt off of -6.00D. Conclusions: These are the highest rates ever published in a cycloplegic refraction study conducted in Brazil. Myopia prevalence seems to be rising and high myopia was surprisingly higher than expected.

Introduction:
Myopia was recently recognized as a public health issue by the WHO in 2015, and results in a significant number of complications and morbidity in the fourth decade of life, such as cataract, glaucoma, retina detachment and myopic maculopathy (1,2). East Asia has the highest prevalence exceeding that of any other region in the world, and alongside this, a growing prevalence of sight threatening myopia related pathologies Myopia is increasing worldwide (1,2). It is necessary for each country to have its own population health data in order to be able to create strategies for public health interventions (3).

The prevalence of myopia is especially high in urban East Asia (1,4-9). Japan, China, Singapore, South Korea and Taiwan are examples of countries in which 80% or more young adults are affected by the myopia epidemic (4,5,7,10). Europe and the United States have myopia rates of 30.6% and 25.4%, respectively, which rises to almost 50% if only the young population is considered (25 - 29 yo) (1,7,8). This is especially relevant when data referring to the preschool and school populations are collected. Recent studies demonstrate a pattern of greater involvement in this population segment, with a growing incidence of approximately 4% in Chinese children aged 3 to 6 years (4,5,6,8). The prevalence of myopia in less educated populations and underdeveloped countries seems to be much lower: 1.4 to 11.2% in Latin America and 3.4 to 11.2% in Africa (4,5,7). Nevertheless, a recent Brazilian study reports myopia prevalence in school children similar to Canada: 20.4% (3,11).

The increasing prevalence of myopia started to be a concern in Brazil in 2019. National data is scarce, the very few papers published have different methodology and not all used cycloplegia (4-7). Some studies taking place in Brazil reported the prevalence of myopia ranging from 9% to 20.4% (7,12-14). Yotsukura et al. (11) reported the prevalence of myopia and high myopia among schoolchildren in the equatorial region of Brazil as 20.4% and 1.4%, respectively. The ocular examinations included non-cycloplegic auto-refraction and axial length (AL)(7). Considering that the non-cycloplegic refraction may over minus, the prevalence of myopia may have been overestimated in this study. Garcia et al. reported the prevalence of myopia in Northeastern Brazil in 2001 was 13.3% in randomly selected students (13). Vilar et al. compared two studies conducted in the same ophthalmology hospital in Goiânia (Goiás) at different periods of time. The first study analyzed patients aged between 2 and 40 years old ,REF and the second study analyzed patients aged between 2 and 14 years old. REF In the evaluation carried out between 1995 and 2000, the prevalence of myopia was 3.6%. In 2014, the study found a prevalence of myopia of 9%. (13)

Brazil is a continental country with a large population, with cultural and ethnic differences as well as economic inequalities among regions. The country is comprised of 42.7% Caucasians and 56.2% Afro-descendants, most of them mixed, and only 9.4% blacks. Indians and Asians represent 1,1% of the total (15). Most of the schoolchildren do not reach high school and leave formal education in middle school (32.2%), 27.4% complete high school and only 17% obtain a university graduation (15).

The south of the country has winter (subtropical location), less illiteracy and mostly Caucasian than African genetic background compared to the other regions (78.3% Caucasians, 16.7% Afro-descendants, 0.7% of Asians and 0.3% of Indians) (15). The prevalence of myopia in Southern Brazil has never been studied. The authors performed a study on the prevalence of myopia in the region of Porto Alegre, capital of the State of Rio Grande do Sul, the southernmost Capital of the country.

Methods:
This convenience sample cross-sectional study aimed to identify the prevalence of myopia in children from public schools in the region of Porto Alegre, Rio Grande do Sul. The Hospital de Clínicas de Porto Alegre Ethics Committee approved this study, which adhered to the tenets of the Declaration of Helsinki.

Guardians of of the children provided written informed consent. A complete ophthalmologic evaluation was performed on all attending students, regardless of the presence or absence of previous ophthalmologic complaints or spectacles wear. A questionnaire on sociodemographic characteristics was also completed by participants..

Sampling:
The sample was composed of public schoolchildren in the region of Porto Alegre. The study was linked to a philanthropic activity of providing spectacles for refractive disorders. Sampled children were part of a charitable program. For this reason, the study subjects were sampled from schools referred by the Public Ministry. Children had no previous assessment of visual acuity and were not referred based on complaints. They were not previously screened.

Considering the prevalence of myopia as 20.4%, based on a recent study carried out in schoolchildren in northeastern Brazil (16) a sample size of 250 would be needed to achieve a 95% confidence level and confidence interval of 10%. The final number of participants required was 278 to allow for up to 10% of possible losses and refusals (7).

The study started in 2019, with assessment of students from public schools. The study was paused for two years due to the novel coronavirus pandemic and data collection was resumed in 2021. There were no public school activities from the period of May 2020 to August 2021.

Eligible children for the study were: schoolchildren (preschoolers to high school students) aged 5 years to 21 years. Individuals with severe neuro psychomotor developmental disorders who were unable to report visual acuity and/or subjects with congenital eye defects (congenital cataract, anophthalmic cavity, strabismus and congenital glaucoma) and contact lens wear on the date of the exam were excluded.

Outcomes and Cut Offs:
The primary outcome analyzed was the prevalence of myopia, defined as all cycloplegic spherical equivalent refraction equal to or less than -0.50D (3,17). Secondary outcomes were the identification and quantification of hyperopia and/or astigmatism. Spherical equivalent greater than or equal to +2.00D were defined as hyperopia20. Astigmatism was defined as -1.00 D cylinder less (20-21).

Two different high myopia prevalence rates were calculated based on two possible cut offs: the first, usually used for epidemiological studies, defines high myopia as spherical equivalent (SE) refraction equal to or less than -5.00D. The second is usually used for clinical studies, established as refraction equal to or less than -6.00D.

Measurements:
Assessments were carried out over three different weekend task forces: November 2019, August 2021 and September 2021. The exams were performed in 5 different medical centers in Porto Alegre: Hospital de Clínicas de Porto Alegre, Hospital Nossa Senhora da Conceição, Complexo Santa Casa, Centro de Olhos do Rio Grande do Sul and Instituto Ivo Correa Meyer. The examination was conducted by medical residents and staff members from the respective institutions following a standardized protocol. The questionnaire was applied by medical students.

A detailed ophthalmic examination was performed using a standardized protocol. All subjects had uncorrected visual acuity (UCVA), and best-corrected visual acuity (BCVA) measured and objective autorefraction. (HRK 7000 Huvitz, South Korea). In hyperopic patients, subjective dynamic refraction was performed prior to dilation. All students underwent corneal tomography using Galilei G4 (Ziemer, Germany) and ocular biometry using AL-100 biometer (Tomey, Japan) for axial diameter measurement. Schoolchildren

with visual acuity of 20/20 without complaints were not instilled with cycloplegic agents. Schoolchildren with visual acuity of 20/25 or worse, or 20/20 with visual complaints, were instilled with 1% tropicamide (1 drop in each eye, repeated 5 minutes later) and evaluated under cycloplegic effect after 25-30 minutes. Subsequent evaluation consisted of cycloplegic autorefraction, subjective refraction test under dilation, retinal mapping and slit lamp biomicroscopy.

A questionnaire about lifestyle, medical and family history for ocular and systemic diseases was answered by the students and their guardians. Itchy eyes, history of asthma, bronchitis or rhinitis, hours of daily screen time (including cell phone, tablet, television) and medications in use were investigated (Fig 1 and 2).

Statistics:
All statistical analysis was performed using SPSS version 18.0 software (SPSS, Chicago?). The Pearson correlation coefficient, Kruskal Wallys and the Chi-Square Test were used to assess simple correlations and associations between variables. Associations between the results of the ophthalmologic evaluation and all factors included in the questionnaire were analyzed in relation to the cut offs established for high myopia using the Generalized Estimating Equation model (GEE).

Results:
Six hundred and sixty eyes from 330 schoolchildren were evaluated. Mean age was 12.74 +/- 3.31 years and 48% were female. Ethnicity was 49% Caucasians and 51% were Afro descendants. Table 1 lists the proportion of children evaluated by each facility.

Table 1.
Hospital de Clínicas de Porto Alegre: 52%
Centro de Olhos Rio Grande do Sul: 13%
Hospital Nossa Senhora da Conceição: 12%
Complexo Santa Casa: 12%
Instituto Ivo Correa Meyer: 11%

UCVA was 20/20 bilaterally in 51% and 34.5% of the kids already used spectacles. Mean recreational screen time was 4.92+/- 3.95 hours daily; 63.4% rubbed the eyes but only 4% used eye drops; 26% had allergies (allergic conjunctivitis; rhinitis or asthma) and 28% used chronic medications for non ocular conditions.

Myopia prevalence was 17.4%. If considered UCVA 20/25 or worse, prevalence rose to 31.3%. Table 2 shows the prevalence of all ametropias. Astigmatism was the most prevalent ametropia because it can coexist with spherical ametropias. Table 3 contains myopia results under the two different cut points for high myopia.

Table 2. Cycloplegic refraction results
Hypermetropia ≥ +2.00 spherical diopters: 7.7%
Astigmatism ≤ -1.00 cylindrical diopters: 25.6%
Myopia ≥ -0.50 spherical diopters: 17.4%

Table 3. Myopia prevalence using a cut-off of ≤ -5.00D and ≤ -6.00D for high myopia:

With cut off point of -5.00D: 15%
With cut off point of -6.00D: 4%

There was no statistically significant difference between male and female (p=0.7), with median myopia of -2.00D among females and -1.50D among males. Considering the cut-off of -5.00D, mean Kmax was similar for low and high myopia (p=0.688), 44.97+/-1.91 for low and 45.86 +/- 2.1D for high myopia. Mean axial lengths were : 23.50 +/- 1.00 mm for low and 25.82 +/-1.39 mm for high myopic.

Considering the cut-off of -6.00D for high myopia, K max was different between low (45.1 +/- 2.00D) and high myopia (45.7 +/- 3.00D) with a p<0.01. However, we found no difference in keratometric keratoconus (kmax>47D) between groups (p=0.56). Axial length was also different between low and high myopia (23.58 +/- 1.03mm x 26.62 +/-1.01mm) with p<0.01. There was no difference between genders either.

Discussion

Data about myopia prevalence in Brazil is scarce and this is the first study on myopia prevalence in the south. Papers published in other regions did not have the same methodology (some without cycloplegia and/or retrospective delineation and/or adults included and/or patients from ophthalmology facilities) (4,7,13,14). The authors believe that data collected in Porto Alegre were surprisingly representative of public schoolchildren from all over the country in regard to ethnic issues, most likely because it was a segment of the population with lower purchasing power (the proportion of caucasians, mixed and blacks were similar to the national distribution)(15,22). The major difference is more insolation in the equatorial region, while the south is subtropical.

Public schools are similar in performance all over the country. Although Brazil spends about 5% of its GDP in public education, the number of hours and staff qualification and salaries are not enough and generally leading to weak academic results. Extreme poverty, major illiteracy and less access to schooling are more commonly found in the north and northeast of the country (15).

No private schoolchildren were included to avoid a possible bias, since they had online activities during the pandemic, have usually more hours of near work daily and a more demanding education. They are raised in families with more instruction and more intellectual activities, and they represent a small proportion of students in Brazil: 23% of all (23). The authors plan to perform another study in private schools.

The main possible bias of this study is the non-random sample. Nevertheless, no children were previously screened for ophthalmic complaints or visual acuity, neither at school nor in eye care facilities right previously to the study evaluation. Our study was also very detailed in obtaining information about refraction by performing dynamic and cycloplegic auto-refraction, followed by subjective cycloplegic refraction. The authors believe that the results are representative of Brazilian public schoolchildren in general and have a sustained external validity.

Most schoolchildren evaluated in this study had excellent uncorrected visual acuity. The authors did not find differences in prevalence between females and males, which differs from other regions (24,25). Total prevalence of myopia was equal to a study performed in Canada, which performed cycloplegic refraction and axial measurement and had with a diverse population of immigrants, most of them Asians (26).

Many schoolchildren complained of itchy eyes, allergy and rubbing the eyes is associated with keratoconus and may relate to chronic dry eyes for excessive near work activities, especially recreational screen use (27-30). Educating parents and children about the risks of rubbing the eyes should be considered as part of the eye examination routine.

It is difficult to compare these results to previous Brazilian studies, but our results suggest that myopia is increasing in total prevalence and also in incidence among ametropias in Brazil. The prevalence is small, but it has increased significantly over the last decade. Hypermetropia has always been the most common

refractive error in the country and myopia has been increasing from 9% in 2005 to 20.4% in 2021 (4,11,13,14). Since our public schools are not as demanding as in East Asia, it may be related to recreational screen time and less outdoor activities as the. High myopia prevalence was higher than expected (11,14).

Further studies understanding the prevalence of myopia in other parts of Brazil and South America, and the factors associated with it would be important to allow public health initiatives to be aimed at preventing myopia from increasing further. Authors are working to achieve this goal.

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The impact of uncorrected myopia on school-aged children, evidence from Kosovo

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- Purpose

Myopia is a major public health issue and a predominant vision disorder among school-age children. Poor vision caused by undiagnosed and uncorrected myopia can significantly affect children's learning and development. We designed an analytical observational study to assess the impact poor vision has on children before the provision of optical correction.

- Methods

The baseline study included 1091 children, aged 5-16 years, enrolled in four primary and lower secondary schools benefiting from an eye health program in Kosovo. The research sample compared Group A [TEST GROUP] of 494 (45%) children presenting uncorrected poor vision (VA<8/10) and Group B [CONTROL GROUP] of 597 (55%) children presenting good visual acuity (VA≥8/10). The analytical observational study design allowed us for an in-depth investigation of the two groups under an anonymized and quality-controlled data assessment. We defined an impact mapping and evaluated a set of thirty impact indicators categorized within the three major categories: 1) functional capacities, 2) learning capacities, and 3) behavioral capacities.

- Results

Among the screened population, 11% of children presented the need of (but did not own) vision correction. The baseline study evidenced a significant correlation between poor vision caused by uncorrected myopia and children's functional, learning, and behavioral capacities.

1) Functional capacities: the study provides evidence of the presence of vision-related issues among children and demonstrates that children with poor vision [Test Group] present a higher risk of developing incapacitating symptoms than children with good vision [Control Group]. Issues reported by children (N) are tired eyes (1 in 2), headaches (1 in 3), itching eyes (1 in 4), tearing eyes (1 in 4), eye pain (1 in 4), and burning eyes (1 in 5). Moreover, findings show that children with poor vision more often have to adjust their gestures and postures to overcome difficulties in the classroom and/or at home: squinting, rubbing their eyes, getting closer to the book, resting on the wrist/paper, getting closer to the board, sitting in the first desk.

2) Learning capacities: the study provides evidence that children with poor vision have their learning capacities affected more often than children with good vision, and they encounter more difficulties when playing or participating in sports. Issues reported by children (N) are difficulty in reading from the board (1 in 3), difficulty in reading a book (1 in 3), difficulty in writing and drawing (1 in 4), difficulty in doing homework (1 in 4), giving up on homework (1 in 4), difficulty in practicing sport (1 in 4), avoiding sport (1 in 5).

3) Behavioral capacities: overall, children feel well at school and are happy when socializing. However, 1 in 3 children feels uncomfortable when playing with others, and 1 in 4 feels frustrated when poor eyesight hinders the completion of homework.

- Conclusions

Poor vision caused by undiagnosed and uncorrected myopia is a public health concern having significant impacts on school-aged children. The study findings evidence a clear link between uncorrected poor vision and children's potential. With 80% of all learning occurring visually, these issues can have immediate and long-term consequences. The study shows the importance of early detection and treatment of vision problems in children. Regular screening in schools can dramatically reduce the rate of uncorrected refractive error, including myopia and its progression. This requires cooperation between the ministries of health and education, coupled with awareness campaigns and national eye-care plans that include school eye health. In Kosovo, there is a need for developing a sustainable roadmap and introducing adequate policies to ensure every child has access to universal eye care services. All stakeholders, parents, teachers, and eye care professionals have a role to play to guarantee children enjoy a good vision.

Estimates of myopia prevalence in UK 4-5 year olds from a large database of school vision screening

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Purpose
Myopia prevalence is increasing in the UK in teenagers, but little is known about younger children. We hypothesise that if the "myopia epidemic" is affecting young children, there will be increasing prevalence of bilateral reduced unaided vision (V) at vision screening at school entry. This was investigated in a retrospective serial cross-sectional study.

Methods
Retrospective anonymised data from computerised vision screening at age 4-5 years were analysed. Refractive error is not assessed in UK vision screening, so V was used to indicate myopia. Data were only included from schools that screened every year from 2015/16 to 2020/21. The criterion used was unaided LogMAR V worse than 0.2 in each eye. In selecting this criterion, we considered limitations of using V as a proxy for myopia. Use of >0.2 cut-off in each eye reduces the risk of including amblyopes but excludes unilateral myopia and bilateral low myopia. The decision not to set an inter-ocular difference criterion has the advantage of including aniso-myopes but also includes some amblyopes with reduced VA each eye from hyperopia/astigmatism.

Results
Anonymised raw data were obtained for 375,044 screening episodes from 2,118 schools. Once schools were excluded for which data were not available for every year and data were cleaned, the final database comprised 94,894 screening episodes. The proportion (%) failing the criterion from 2015/16 through 2020/21 are 7.6, 8.5, 7.8, 7.9, 8.7, and 8.6 respectively. A linear trendline shows increasing prevalence of reduced bilateral unaided vision, likely indicating increasing prevalence of myopia (Cochrane-Armitage test, p=0.020).

Conclusions
The result in 2016/17 is puzzling. Even at the young age of 4-5 years, there are signs of increasing myopia prevalence in the UK over the last 6 years. Further data when available from 2021/22 will be analysed to determine whether COVID lockdowns have affected this young age-group.

Strengths of this study include the large dataset from an unselected population. The main limitation is the use of V as a proxy for myopia.

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Prevalence of myopia in the current young generation in the Netherlands

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Background: The prevalence of myopia is increasing all over the world, but estimates of the prevalence in the current young generation in Europe are scarce.
Purpose: To estimate the prevalence of myopia in the Dutch population-based birth-cohort study Generation R at various ages as the children grow up.
Methods: Study participants (n=5711 at baseline) completed eye examinations at ages 6, 9, and 13 years. The current round at age 17 years is still ongoing, but n=1000 have already been examined. The eye examination included best-corrected LogMAR visual acuity using ETDRS method; automated refraction in cycloplegia with cyclopentolate or tropicamide using Topcon RM-A2000 autorefractor; and measurement of eye biometry using Zeiss IOL-master 500. Myopia was defined as spherical equivalent ≤-0.5D.
Results: The prevalence of myopia was 2.4% at age 6; 11.6% at age 9; 22.5% at age 13; and 40% at age 17. Females had a slightly higher risk of myopia from age 13 onwards (HR 1.18 95% CI 1.06; 1032).
Conclusions: The prevalence of myopia in the current young generation in the Netherlands has doubled during the last century. Nevertheless, the prevalence appears somewhat lower than expected by extrapolation of former trends.

Epidemiology of premyopia among children aged 6-8 in Shanghai

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Purpose To understand the distribution and progress of premyopia among children aged 6-8 in Shanghai, and to analyze the related influencing factors to provide a theoretical basis for the prevention and control of myopia among children and adolescents in China.
Methods The data for this study are from the Shanghai Time Outside to Reduce Myopia (STORM) study, a prospective school-based study conducted in Shanghai, China. Using random cluster sampling method, a 2-year follow-up study was conducted among 2037 students in grades one and two from 8 primary schools in 8 districts of Shanghai. At baseline and annual follow-up, ophthalmological examinations such as visual acuity, cycloplegic autorefraction and axial length were performed, and questionnaires on related factors were collected. The epidemiological characteristics of premyopia were analyzed, and the influencing factors of incident myopia in premyopic and hyperopic children were analyzed by multivariate logistic regression.
Results The prevalence of overall premyopia at baseline, first-year follow-up, and second-year follow-up were 26.2%, 37.3%, and 41.3%, respectively. Among them, the prevalence of premyopia in children aged 6, 7, and 8 at baseline were 20.7%, 37.0%, and 42.6%, and in children aged 8, 9, and 10 at the second-year follow-up were 31.5%, 38.3%, and 41.4%. There was no statistical difference between boys and girls ($\chi 2$=0.01~2.66, all P>0.05). The incidence of myopia in children with premyopia at baseline was 31.5% after 1 year of follow-up, and the cumulative incidence of myopia after 2 years of follow-up was 62.0%, which was much higher than that in children with hyperopia (0.6% and 9.0%). Multivariate analysis showed that premyopia at baseline [OR=15.892 (11.651-21.677)], female [OR=1.961 (1.404-2.738)], owning 2 myopic parents [OR=2.662 (1.818-3.899)], and AL at baseline [OR=1.319 (1.029-1.691)] were negatively associated with incidence of myopia at 2 years of follow-up (all P<0.05).
Conclusions Premyopic children are at high risk of incidence of myopia within 2 years and are a priority group for surveillance and myopia prevention interventions.

Following Prevalence of Myopia in a Large Swiss Military Cohort over the Last Decade - Where is the European "Myopia Boom"?

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Purpose: Myopia incidence and prevalence is increasing globally, with highest rates found in Asia. Data from European countries is scarce. The purpose of this analysis was to investigate whether the prevalence of myopia is rising in our meridians.

Methods: Retrospective analysis of refractive status in male Swiss Army recruits. Recruits` data for the recruitment period of 2008 – 2017 were included in the study. Among others, the following variables were available in the dataset: year of recruitment, recruits' birth year, visual acuity, refractive status (spherical equivalent), spectacle wear (yes/no). Ethical approval of the local ethical committee was obtained.

Results: The dataset contained data of a total of 355'657 male soldiers who had been recruited in the years 2008 to 2017. The mean number of recruits per year was 35'566 (Md=35'440, Sd=1'249), reaching a minimum number of 33'998 recruits in 2017 and a maximum of 37'594 in 2011. Mean age at recruitment was 19.7 years (Md=19.0y, Sd=1.1y). Overall, the number of recruits wearing spectacles remained stable over the observation time; on average 29.6% (n=10'540; Md=10'472; Sd=492) of recruits wore glasses at recruitment. Of 21.8% (n=77'698) of recruits data on the refractive status was available: Mean spherical equivalent for right eyes was -2.3D (Md=-2D, Sd=2.4D) over the entire time period. No decrease of mean spherical equivalent per recruitment year was noted over the observation time period.

Conclusion: In summary, no change in spherical equivalent refractive errors of male Swiss army recruits has been found for the years 2008 to 2017. Equally, the percentage of spectacle wearers has not significantly increased during the same time.

Improving population-level myopia monitoring via mixture distributions

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PURPOSE Sampling and describing distribution of refractive error in populations is critical to understanding factors affecting myopia development and progression. Researchers most commonly report prevalence at specific refractive cut-points, and sometimes describe refractive distribution using summary statistics, usually limited to mean and standard deviation. We investigate the accuracy of single versus multiple-mixed normal models for describing refractive distributions.
METHODS Component distributions can be combined via weighting to describe an observed distribution. Mixing symmetric distributions can model an asymmetric distribution. We used the MixR package in R to fit published refractive data from diverse populations with 1-6-component-mixed normal distributions. We used chi-square goodness-of-fit, Bayesian Information Criterion, and bootstrapping Likelihood Ratio Test to determine relative fitting accuracy of various mixes. We also tested accuracy of myopia prevalence estimates derived from each model.
RESULTS Fitting accuracy improved significantly from 1- to 2- to 3-component models describing ≥12yo US National Health and Nutrition Examination Survey (NHaNES), 19yo Korean military and 40-69yo UK BioBank refractive data. Fitting accuracy was similar for 3- to 6- component models – i.e. 3-component, all-normal mixture models were optimal for describing distribution of refractive error across these datasets. The component means, standard deviations and relative weights were unique to each population. Given the normal distribution of component refractive structures, and recognition of myopia, emmetropia and hyperopia as meaningful groups, it makes intuitive sense that 3 normal component distributions can add to create the skewed, kurtotic refractive distributions commonly observed in populations. Crude prevalence of myopia in the raw NHaNES data was 38.5% for ≤-0.50D and 4.3% for ≤-5.00D; in comparison, the 1-component model predicted 50.5% and 1.7%, the 2-component model predicted 38.4% and 4.0%, while the 3-component model predicted 36.2% and 4.6%.
CONCLUSIONS Mixture models offer an innovative approach to accurately describe distribution of refractive error. Refractive distribution studies would benefit from publication of full datasets (as per US NHaNES). If that is not possible, then modelling using a 3-normal-component mixture distribution provides an adequate description, while mean, standard deviation, skewness AND kurtosis provide a minimum standard

FROM HYPEROPIC RESERVE TO MYOPIA: A NARRATIVE REVIEW

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Purpose:
The dominant theory of refractive development is emmetropisation, initially postulated to explain the shift during childhood from neonatal hyperopia towards emmetropia and myopia. Later work on experimental myopia demonstrated that imposed hyperopic defocus accelerated axial elongation and myopic shifts in refraction, whereas imposed myopic defocus slowed both processes. This led to a model of emmetropisation in which hyperopic defocus drove refractions towards 0D, while emerging myopic defocus slowed the subsequent development of myopia, tending to maintain emmetropia. The aim of this analysis is to rigorously compare these models with data on human refractive development.
Methods:
PubMed was searched using the key word "myopia." Abstracts of all papers were scrutinised for relevant data, and further references were located through scrutiny of reference lists.
Results:
In most populations of children, refractive errors cluster in the mild hyperopia range, from 1.0-1.5D at the time of first school enrolment. Longitudinal data suggest that in this early developmental period, hyperopic shifts in refraction are often seen, apparently in an attempt to maintain mild hyperopia. Longitudinal data also show that the increased rates of myopic shifts in refraction, typically seen in myopes, first appear once refractions drop out of this range, supporting the recently defined refractive category of premyopia, in which children are at high risk of developing myopia. Attaining this state is a risk factor for the development of myopia, and there is no evidence of the operation of a mechanism for maintaining emmetropia. Myopic shifts in refraction prior to the onset of myopia appear to be driven by environmental exposures, rather than by ageing itself.
Conclusions:
The evidence is more consistent with a model that involves development of mild hyperopia (1.0-1.5D) by the start of schooling, than with emmetropisation. Myopia subsequently develops if refraction is driven into the premyopia range by environmental exposures, until declining refractive plasticity with age brings myopisation to a close. Paradoxically, while there is no evidence for a role of myopic defocus signals during human refractive development, their existence is supported by the efficacy of clinical devices for controlling the progression of myopia.

Regional variations in human macular choroidal thickness changes in response to blue light stimulation of the optic nerve head

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Purpose:
Eye growth is known to be associated with changes in choroidal thickness (ChT), and evidence from animals and humans suggests a potential contribution of short-wavelength sensitive melanopsin signalling via intrinsically photosensitive retinal ganglion cells (ipRGCs) to the regulation of ChT. This study aimed to examine the regional variations in the ChT response to brief blue light stimulation of the melanopsin-expressing axons of ipRGCs at the optic nerve head (ONH) in a group of healthy emmetropes and myopes.
Methods:
The ONH of both eyes of 10 emmetropes and 10 myopes (age 28 ± 6 years) was stimulated locally for 1 min with a flickering short-wavelength blue light using a virtual reality headset. Enhanced depth imaging optical coherence tomography was used to measure the foveal, parafoveal, and perifoveal ChT of the left eye, before and over 60 mins post-stimulation. As a control condition, the left eye's regional ChT response to no light stimulation was examined on a separate day at a similar time of day. A linear mixed model analysis was used to examine the main effects and interactions of light, time, eccentricity, and refractive group upon changes in ChT.
Results:
An eccentricity-dependent increase in ChT was observed over the 60 min period following the 1 min stimulation of the ONH with blue compared to no light in emmetropes, while myopes showed no significant changes in ChT (interaction $p < 0.001$). In emmetropes, a significant increase in foveal ChT was found immediately after (mean ± SEM, 3 ± 2 µm), and later at 10 (3 ± 2 µm), 20 (5 ± 2 µm), 30 (8 ± 2 µm), and 60 mins (10 ± 2 µm) following blue compared to no light stimulation to ONH (all $p < 0.05$), with this increase in ChT attenuated in the parafovea and perifovea. Emmetropes exhibited greater choroidal thickening compared to myopes at 30 (8 ± 2 vs 1 ± 2 µm) and 60 mins (10 ± 2 vs 4 ± 2 µm) post-stimulation in the fovea (both $p < 0.01$), but this difference also diminished in the parafovea and perifovea.
Conclusion:
This refractive error- and region-dependent thickening of the choroid that sustained over 60 mins following brief blue light stimulation of the ONH suggests the involvement of ipRGCs in the regulation of ChT, potentially more so in the foveal than extra-foveal regions. It is speculated that the short-term choroidal thickening associated with blue light stimulation of the ONH may have implications for longer term control of eye growth.

Investigating myopia control using ChromaBlur

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Purpose: One of the fundamental unanswered questions in myopia research is how the retina detects the sign of defocus. A study by Cholewiak et al. demonstrated that the addition of chromatic fringes to an image, called ChromaBlur (CB), was effective in driving accommodation and perceived depth.[1] It is proposed that investigating the effect of CB on the short-term axial length (AL), a putative biomarker for long-term refractive development, and accommodation of the eye may aid in understanding underlying mechanisms of optical control for myopia. This study aimed to test the effect of CB and compare it with the effect of optically induced defocus blur (OB).
Method: In each visit of the study, young subjects watched a movie for 40 minutes, which was rendered to produce either CB or OB conditions at one of the four levels (±1.5 and ±3.0 D), while AL (by Lenstar) and accommodation (by COAS) were measured five times at 10-minute intervals in the same (left) eye. Two "no blur" (NB) conditions - screen focus at 1.5 D vergence (NBN) and far focus (NBD) were also tested as the control for CB and OB, respectively. The CB movies were altered to provide one of the four levels of CB, while a "clear" unaltered version of the 40-minute movie was used for OB and NB conditions. The order of testing the 10 conditions was randomized for each subject. A 2-way linear mixed model was used to analyze accommodation and AL changes for different types and levels of blur conditions over time.
Results: Twenty subjects (age 20-35 years) completed the study. CB induced a small bidirectional accommodative response. The largest mean (SD) difference in accommodative change responses for CB conditions compared to NBN was 0.27 (0.27) D observed at 20-minutes with +3.0 D CB ($p<0.05$). There was little difference in the magnitude of the accommodation response between 1.5 and 3.0 D of CB of the same sign. There were no significant differences in AL changes between any of the CB conditions and the NBN control ($p>0.05$). In contrast, 40 minutes of OB conditions led to the expected AL changes corresponding to the sign and magnitude of the OB.
Conclusions: ChromaBlur stimulated accommodation in the predicted direction, however, the magnitude of change was small. ChromaBlur did not significantly change the AL of the eye within the time limits of 40 mins of exposure.

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Myopia can be controlled by intervention in scleral endoplasmic reticulum stress

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Purpose: Increased demand for protein synthesis for tissue remodelling results in a state of stress on the endoplasmic reticulum (ER), i.e. ER stress. Since scleral remodeling has been reported to be involved in the onset and progression of myopia, we hypothesized that endoplasmic reticulum stress in the sclera may play a role in myopia progression and aimed to test this hypothesis.

Methods: Male C57BL/6J mice (3 weeks old, n=24) were subjected to minus lens-induced myopia (LIM) for 3 weeks. After LIM, eye balls (n=4) were enucleated and fixed by 2.5 % glutaraldehyde in PBS to be prepared for ultra-thin sections, and observed with transmission electron microscopy (TEM). Western blotting (n=12) and qPCR (n=8) were performed using control and LIM sclera. To validate whether endoplasmic reticulum (ER) stress associate with myopia development, 0.2% or 2% of 4-phenylbutyric acid (4-PBA) or tauroursodeoxycholic acid (TUDCA; 100 mg/kg body weight) was administrated by intraperitoneally or topically during LIM period (n=5~6, respectively). For ER stress induction, tunicamycin (TM; 50 µg/mL) or thapsigargin (TG; 10 µM) solution was instilled in C57BL6J mice. The refraction and the axial length were measured using a refractometer and a SD-OCT system in both eyes before and after LIM or TM/TG instillation.

Results: Mice with LIM demonstrated ER stress in scleral fibroblasts. Attenuation of ER stress by systemic or topical administration of 4-PBA suppressed pathological but not physiological axial elongation. Pharmacological ER stress induction in the sclera was sufficient to induce axial elongation. LIM dramatically changed the expression of scleral collagen genes responsible for ER stress. Furthermore, collagen fibre thinning in LIM was ameliorated by 4-PBA administration, concomitant with the collagen gene expression pattern. We demonstrated that scleral ER stress controls axial elongation only during myopia development.

Conclusion: We demonstrated that scleral ER stress controls axial elongation only during myopia development. Thus, scleral ER stress controls can be a promising therapeutic target for addressing axial elongation during myopia development

RNA-Seq Analysis Reveals an Essential Role of the Tyrosine Metabolic Pathway and Inflammation in Myopia-Induced Retinal Degeneration in Guinea Pigs

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Purpose: To illustrate the mechanism of action underlying retinal degeneration caused by myopia with a model of myopia-induced early-stage retinal degeneration in guinea pigs.

Methods: Two- to three-week-old guinea pigs were randomly assigned to two groups (n = 30/group): form deprivation and naïve nontreatment controls. In the form-deprivation group, the right eyes were occluded with nontoxic balloons as translucent masks for 15 weeks. The left eye remained untreated and served as a self-control. Another group of untreated age-matched animals was used as naïve controls. The refractive error and ocular biometrics were measured at 3, 7, 9, 12 and 15 weeks post-FDM induction. Visual function was evaluated by electroretinography. Retinal neurons and synaptic structures were examined by confocal microscopy of immunolabelled retinal sections. The total RNAs were extracted from the retinas and processed for RNA sequencing analysis.

Results: The FDM eyes presented a progressive axial length elongation and refractive error development. After 15 weeks of intervention, the change of refractive power was -6.33±2.05 D in the FDM eyes, -0.15±1.37 D and 1.11±1.05 D in the self-control and naïve control eyes, respectively. The change of axial length was -1.27±0.28 mm in the FDM, 0.78±0.19 mm and 0.89±0.14 mm in the self-control and naïve control eyes, respectively. The a-wave amplitude was significantly lower in FDM eyes and these eyes had a significantly lower number of rods, secretagogin+ bipolar cells, and GABAergic amacrine cells in selected retinal areas. RNA-seq analysis showed that 288 genes were upregulated and 119 genes were downregulated in FDM retinas compared to naïve control retinas. In addition, 152 genes were upregulated and 12 were downregulated in FDM retinas compared to self-control retinas. The Kyoto Encyclopedia of Genes and Genomes (KEGG) enrichment analysis showed that tyrosine metabolism, ATP-binding cassette transporter (ABC transporters) and inflammatory pathways were upregulated, whereas tight junction, lipid and glycosaminoglycan biosynthesis were downregulated in FDM eyes.

Conclusions: The long-term (15-week) FDM in the guinea pig models induced an early-stage retinal degeneration. The dysregulation of the tyrosine metabolism and inflammatory pathways may contribute to the pathogenesis of myopia-induced retinal degeneration

A comparison of indoor and outdoor light exposures

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Purpose: Several studies have shown that an increased outdoor light exposure reduces the chance on myopia incidence, spherical equivalent refraction (SER) and axial length (e.g. Xiong, 2017; Ho, 2019), and myopia progression (Jin, 2015). Outdoor related factors that may contribute to myopia prevention are the high illuminance levels, spectral composition, reduced peripheral hyperopic defocus, release of dopamine, relaxed accommodation, and higher spatial frequency content in the visual scene (Thakur, 2017.) We here take a closer look at the differences in intensity and spectral composition of natural (outdoor) and artificial (indoor) light. While indoor lighting solutions are predominantly static and lately mainly based on energy-efficient LED spectra, natural daylight varies with geographical latitude, month, day of month, time of day and atmospheric (weather) conditions. Therefore, a general advice to spend a specified amount of time outdoors will have a variable effect on the prevention of myopia development, depending on the factors mentioned.

Method: To quantify this variability, we take solar spectral irradiance data from a publicly available tool (Diffey, 2015) as a starting point, which applies to solar irradiance on a horizontal surface at sea level. To estimate corneal irradiance, the contributions from direct sunlight and diffuse skylight are combined, after conversion from horizontal to vertical irradiance. While in principle this can be done for any location on earth, we select 50° N latitude (≈ Brussels) as a working example.

Results: The average vertical irradiance between 8.00 a.m. and 8.00 p.m. – a time window in which children can be expected to play outside - varies between 4 klux (winter) and 17 klux (summer) when accounting for average cloudiness of the sky (peak levels from 20 klux (winter) to 30 klux (summer)). The average vertical outdoor irradiance values are at least 25 times higher than indoor illuminance levels required in schools (300-500 lux horizontal, ≈ 150-250 lux vertical). Spectrally, there are also large differences between indoor and outdoor light exposures. Comparing normalized daylight spectra with LED spectra with correlated color temperatures ranging between 3000 K and 6500 K, it becomes clear that the two wavelength regions on the borders of the visual range are under-represented in standard indoor lighting. These are wavelengths below 400 nm and above 650-700 nm. On the short-wavelength part, natural daylight provides radiant energy in the range 350-400 nm while it is completely lacking in standard LED light, the same wavelength region where neuropsin (OPN5) is activated. In mice, neuropsin has been shown to be related to dopamine, which is involved in the regulation of eye growth (Jiang, 2021). On the long-wavelength part, natural light extends into the near infrared range, while indoor LED light typically has low emission beyond 650 nm. Recent studies with repeated long wavelength light interventions in children (635 and 650 nm) have shown beneficial effects for myopia control (Jiang, 2021b; Zhou, 2022). A third wavelength region, 450-500 nm, is also of interest because of the 'cyan gap' that is usually present in LED light. In this wavelength region melanopsin (OPN4) is stimulated, and might be related to refractive development (Chakraborty, 2022).

Conclusion: In sum, natural daylight and artificial light differ in both lux level and spectral composition. However, these two factors are usually confounded. We propose to systematically investigate the separate roles of light intensity and spectral content to clarify their potential roles in controlling myopia onset/progression with indoor lighting solutions. Just replicating outdoor intensities and spectral composition will not be a viable possibility because of the sustainability impact that it will bring.

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Role of VEGF secreted from Retinal Pigment Epithelium in Choriocapillaris and Axial Length Maintenance

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Purpose: The prevalence of myopia has risen dramatically in recent decades while the onset mechanism of abnormal axial length (AL) elongation remains unclear, to identify how RPE and/or choroid influence eye growth may contribute to new explanations and new interventions for myopia. We tested our hypothesis that RPE may be essential for proper physiological ocular development by using 3 types of conditional knockout and lens-induced myopia (LIM) mice.

Methods: Best1-Cre mice were mated with Lrp2 floxed/floxed, Vhl floxed/floxed, or Vegf floxed/floxed mice to obtain RPE specific conditional KO mice (Lrp2 RPE KO, Vhl RPE KO Vegf RPE KO). Chx10-Cre mice were mated with Lrp2 floxed/floxed mice to obtain neural retina specific conditional KO mice (Lrp2 Retina KO). Floxed mice without the Cre transgene were used as control littermates. Refraction statuses were measured by an infrared photorefractor and AL and choroidal thickness were measured by an OCT. Morphological changes were observed by immunohistochemistry and real-time PCR were performed to elucidate the pathophysiology of myopia at molecular level.

Results: 8 weeks old Lrp2 RPE KO mice showed extremely enlarged eyes compared with control mice (Control vs KO: 3.56±0.038mm vs 4.58±0.02mm, P<0.0001) and Lrp2 Retina KO mice (Lrp2 RPE KO vs Lrp2 Retina KO: 4.58±0.02mm vs 3.58±0.015mm, P<0.0001). Real-time PCR revealed a significant decrease of Vegf expression in RPE cells (Control: 0.96±0.04 vs Lrp2 KO: 0.52±0.15, P<0.001) and choriocapillaris degeneration were observed in Lrp2 RPE KO mice. Besides, Vegf RPE KO mice showed abnormal choriocapillaris development and AL elongation, with features similar to those of the lens-induced myopia (LIM) mouse model, whereas VEGF overexpression by knocking-out von Hippel–Lindau (VHL) specific to the RPE expands the choriocapillaris and shortens the AL.

Conclusions: VEGF derived from RPE is necessary for choriocapillaris development and maintenance, which is essential for overall ocular size development and maintenance. The development of emmetropic eyes requires VEGF derived from RPE to promote the development of choriocapillaris and maintain their physiological thickness.

Change in visual performance with multifocal contact lenses through a fixed pupil size

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Purpose: With the increasing use of multifocal contact lenses (MFCLs) for myopia control, it is important to understand how these lenses affect visual performance. We previously reported changes in visual performance with center-distance MFCLs without controlling for differences in pupil size. Here, we report changes in visual performance through a standardized pupil size to better isolate the effects of multifocal optics on vision.

Methods: Participants (n=13) with spherical refractive error between -1.00 to -6.00D and astigmatism less than 1.00D (corneal plane) were enrolled. Participants were masked to lens type and fitted in random order with a single vision contact lens (SVCL; Biofinity sphere) and a center-distance MFCL (Biofinity D +2.50) in their right eyes only. Over-refraction was performed to optimize distance visual acuity (VA). The pupil was then dilated, and visual performance with each lens was measured through a unit magnification telescope that imaged a 5mm aperture onto the geometric center of the subject's pupil. A 5mm aperture was chosen to match the mean photopic pupil size of myopic children reported in the BLINK Study. High- and low-contrast logMAR VA (HCVA and LCVA), and contrast sensitivity (CS) at 3, 6, 12, and 18 cycles per degree were measured with the M&S Clinical Trial Suite through the fixed artificial pupil. Paired t-tests were used to test for differences in VA and area under the log contrast sensitivity function (AULCSF) between lens types (MFCL minus SVCL). RM-ANOVA was used to analyze CS by spatial frequency and lens type.

Results: Mean (± SD) age and right eye spherical equivalent refraction were 24.5 ± 1.2 years and -2.70 ± 1.15 D respectively. There was no difference in HCVA between the two lens types ($p = .48$), but LCVA was about 1.5 lines worse with the MFCL compared to the SVCL (mean ± SE = 0.14 ± 0.04 logMAR, $p = .004$). Reductions in CS between lenses did not depend on spatial frequency ($p = .47$). Across spatial frequencies, the mean (± SE) reduction in CS with MFCLs was -0.12 ± 0.05 (main effect, $p = .019$), and AULCSF was reduced by about 10% with MFCLs vs. SVCLs (-0.11 ± 0.03, $p = .005$).

Conclusion: When controlling pupil size, MFCLs cause reductions in LCVA and CS. The MFCL optics cause reductions in vision that are not captured by HCVA and go beyond what is measured by LCVA. Additional work is needed to determine whether these reductions in visual performance change under different standardized pupil sizes.

Peripheral blur orientation provides the eye with a cue for the sign of defocus

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Purpose: The mechanism by which the eye detects the sign of defocus for controlling emmetropization remains a question of great interest. This study investigated the relationship between ametropia and the odd-error cues of peripheral image quality. The sign and shape of peripheral blur provides an optical "odd-error" cue for the sign of defocus, potentially playing a role in emmetropization.

Methods: The population average of optical quality, specifically the peripheral refraction and higher order aberrations, has been previously published [1]. Zernike coefficients across retinal eccentricity (0, 10, 20 and 30 deg horizontal visual field) were used to compute the monochromatic modulation transfer function (MTF) at 555 nm for a 4 mm pupil. Two-dimensional MTF was computed at each retinal eccentricity, through-focus (from -3 to +3 D in steps of 0.1 D) and was subsequently used to define two metrics of image quality: (1) overall image quality, defined as the volume under the MTF (vMTF) and (2) blur anisotropy, defined as the ratio of the horizontal to vertical meridians of the MTF (HVRatio).
[1] Romashchenko, D, R. Rosén, and L. Lundström. "Peripheral refraction and higher order aberrations." Clinical and Experimental Optometry 103.1 (2020): 86-94.

Results: Across the horizontal visual field (at 10, 20, 30 deg), through-focus vMTF revealed best focus (max vMTF) was within +0.3 D of the retina in emmetropes (-0.3, -0.3, 0.0 D, respectively). Myopes' best focus was behind the retina (-0.1, 0.4, 1.5 D, respectively) and hyperopes in front of the retina (-0.5, -0.6, -0.6 D). Emmetropes, myopes and hyperopes exhibited peripheral blur anisotropy beyond 10 degrees. At 0.0 D (on the retina), emmetropes and hyperopes both exhibited radially elongated blur, whereas myopes had circumferentially elongated blur (HVRatio = 0.3, 0.7 and 2.8, respectively, at 30 deg eccentricity). In all groups, peak vMTF (best focus) coincided with radially elongated blur.

Conclusions: Optical blur in the peripheral retina is anisotropic and dominated by so-called "odd-error" blur signals, primarily due to oblique astigmatism. The orientation of peripheral blur (e.g. radial vs circumferential) provides the eye with an optical cue for the sign of defocus and may play a role in mechanisms of accommodation and emmetropization. All subject groups had peripheral anisotropic blur: myopes exhibited a circumferentially elongated peripheral blur, whereas emmetropes and hyperopes exhibited radial blur. These differences may be due to the interaction between peripheral wavefront aberrations and field dependent axial length (i.e. globe shape).

P176: Exploring the perspectives of myopia risk factors and outdoor time among parents of South Indian children – A qualitative study

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Purpose: Outdoor time is an effective strategy to reduce myopia development in children, and it is to be promoted as a public health initiative. The lack of literature on current perceptions about myopia and outdoor time among parents has resulted in deficits in culture-specific myopia prevention strategies. In this study, we aimed to explore the perspectives of parents concerning myopia risk factors and specifically their thoughts on the benefits and barriers of outdoor activities for children, through qualitative research.
Method: Thirty-seven parents of school-going children (median age of children: 11 years (6-16)) participated in either in-depth interviews or focus group discussions. Parents were residents of Tamil Nadu, India, and from diverse socioeconomic status and living conditions. Parents of children with any ocular or systemic abnormality or under myopia control measures were excluded. Interviews with a semi-structured interview guide gathered parents' perspectives on myopia and its risk factors; specifically, their thoughts on benefits and barriers to engaging children outdoors, and feedback on overcoming the same. The interviews were conducted until thematic saturation was achieved. The interviews were audio-recorded, transcribed verbatim, coded using the inductive and deductive approaches, and analyzed iteratively using a method of constant comparison.
Results: Four themes surfaced: i) Perceptions of myopia risk factors: Parents were unaware of the potential benefits of outdoor time in relation to myopia prevention and attributed myopia mainly to screen time, due to its proximal working distance, and emission of powerful rays from the gadgets. Other factors stated were heredity and lack of a healthy diet. ii) Benefits of outdoor time: Parents' definitions of outdoor time deviate from what is recommended for myopia prevention. When asked specifically about the benefits of outdoor play, parents attributed its importance to physical fitness and healthy social behavior rather than myopia prevention. Some felt it improves eye health as it reduces screen time and eye strain. None related outdoor time to myopia risk or prevention. iii) Barriers to engaging children outdoors: The identified challenges in engaging children outdoors were time constraints for parents and children due to work/study load, lack of same-age peers or space, and reluctance to allow girls to play outdoors due to safety concerns. Other factors like allergies, fear of getting hurt, and bad company were mentioned. Parents felt COVID-19 lockdown had imposed smartphone addiction, restricting outdoor play. iv) Strategies to encourage time outdoors: The parents' suggested activities like outdoor morning school assembly, terrace gardening, playing games in parking lots, secured community areas, or vehicle-free zones. Parents proposed that they should dedicate outdoor time for children. Importantly, outdoor time was not equated to exposure to sunlight, leading to suggestions for shopping, and visiting family/friends for outdoor time.
Conclusion: The benefit of outdoor time for myopia prevention is not a common knowledge among parents. The misconceptions, challenges, and barriers in outdoor time implementation identified by this study should be considered when planning myopia awareness programs and prevention strategies.

P184: Myopia management need in Germany

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Purpose
Although myopia is a public health issue worldwide, less is known about the real need for myopia management in young kids. The purpose of this study is to evaluate how many kids need myopia management per month and per shop in Germany.
Methods
Real world data collected from 408 optician shops by Euronet Software AG was used for the evaluation. The data was longitudinal and was collected within the last 20 years. The number of individuals evaluated were 80.941 and ranged from age 6 to 16 years. The annual progression of the spherical equivalent refractive error was calculated and grouped per age, namely, 6 to 9 years, 10 to 12 years and 13 to 16 years. The need of myopia management was defined as the number of individuals per shop and per month at which the annual progression of spherical equivalent reached values below or equal to -0.5D.
Results
The number of individuals that need myopia management per shop and per month at age 6 to 9 years, 10 to 12 years and 13 to 16 years were 1.2, 2.5 and 3.0 individuals, respectively.
Additionally, the distribution of spherical equivalent refractive error as a function of the age group showed a shift towards myopia.
Conclusions
The increase on the number of kids in need for myopia management as a function of the age, together with the shift of spherical equivalent towards myopia for older kids might be an indicator on the need to proactively start myopia management at earlier ages.

Acknowledgement: With kind support of the Market Research Division of Euronet Software AG

P9: Communication between ECP and parents of Myopic Child

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Abstract For IMC 2022

Purpose:
The purpose of this presentation is to enlighten the Eye Care Practitioner (ECP) on how to communicate with the parents of a myopic child. Defining myopia, discussing the chances that the child's myopia will increase, the dangers of high myopia and the treatment options. Explaining how to show the parents the means to predict their child's myopia progression. Show this by means of all the different prediction charts, or calculators.
Methods:
All that is explained in the presentation will be evidence based, referring to articles cited. The prediction charts are: PREMO
BHVI
Age of onset prediction chart
Coopervision Simulator

This is not a study that was conducted but rather a literature review. This presentation will illustrate what must be told to the parents including the possible adverse effects of wearing contact lenses but also put the dangers into the correct context.
Conclusions:
The main conclusion being that "every dioptre matters" (Bullimore & Brennan, 2019), and that the ECP and the parents of the myopic child, must do everything possible to retard the child's myopia progression.

P55: Moving optometry forward to accepting the changing approach to myopia from a prescribing lens only to looking at myopia as a disease entity: WCO's role

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Introduction/Purpose
The mission of the World Council of Optometry (WCO) is to facilitate the development of optometry around the world and support eyecare providers (ECPs) in promoting ocular health and vision care as a human right through advocacy, education, policy development and humanitarian outreach. In the past decade, the emergence of myopia is seen as a growing public health problem through evidence of the growing epidemic. The expansion of research on myopia as a disease entity demonstrates that it can lead to vision threatening conditions. Improved methods to monitor changes in vision and orbital structure have been documented and there has been development of multiple methods to prevent, control and treat myopia. For these reasons WCO is working to actively advocate for updated and expanded diagnosis and treatment of the myopia.

Methods
WCO has teamed with CooperVision, a leader in the field of vision care, to develop a Standard of Care for Myopia Management by Optometrists (2021) designed to shift the profession of optometry from the concept of simply correcting myopia to understanding how to mitigate, measure and manage the disease and provide patients with the most up to date and evidence-based tools.

Conclusions
Many optometrists do not have the time to search all the plethora research published in multiple journals. WCO and CooperVision are engaged in reviewing the science and providing clinicians with needed information to best serve their patients through virtual presentations, published articles and a website with documents that provide succinct guidance to mitigate, measure and manage their myopic patients with current interventions. WCO is a global optometric organization designed to help the clinician stay abreast of the best evidence-based means to provide quality, affordable and equitable care for their patients.

P186: The progression of spherical refractive error for myopic and emmetropic kids in Germany

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Purpose: Myopia is a health issue worldwide. To fight myopia, the estimation of its progression and eventual risk assessment is crucial. The purpose of this study is to generate percentile curves that reflect the progression of the spherical equivalent refractive error (SE) of German young individuals, aiming to serve as help to guide on the risk assessment in the field of Myopia Management.

Methods: Data collected by Euronet Software AG from opticians all over Germany was used for the evaluation. More than 130,000 individuals were included in the analysis. Individuals with SE ≤0.5D and age between 3 to 16 years were considered for the evaluation. The annual progression of the spherical equivalent refractive error was calculated. A quantile regression was used to generate the progression percentile curves.

Results: A clear difference on the SE progression was observed before and after the age of 8 years. Despite the percentile group, all values for the SE annual progression decreased as a function of the age until the age of 8 years. Afterwards, the values for the SE progression increased. Moreover, the change between positive and negative SE progression was found between the 75th and 90th percentile.

Conclusion: When longitudinal data of individuals is available, an estimation of the eventual refractive error progression can be done using these findings. Additionally, the percentile curves can guide the eye care professionals to better estimate the risk for German kids to develop myopia. It further needs to be analyzed if links to possible confounding factors (such as initial SE) exist.

Acknowledgements: With kind support of the Market Research Division of Euronet Software AG.

P113: Adult Myopia Progression

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Purpose
Assessment of adult myopic progression is complicated by slow progression and a paucity of studies on those aged 20 to 40 years. Reports have also concentrated on proportions of subjects progressing more than a certain threshold over relatively short time periods rather than long term change. Here, we analyze accumulating evidence for myopic refractive shift between the ages of 20 and 50 years by systematic review.

Method
We identified 4 papers with potentially useful long-term adult refractive progression data. Vitale et al. (2009) provide US population-based refractive prevalence data for those aged 18 to 24 years in 1971-72. This population is aged 45 to 57 years in 1999-2004; conveniently, the authors provide data for a comparable group (45 to 54 years of age) at this time. Plotting log of the odds ratio of prevalence against refractive error allows estimation of refractive progression in this group. German clinical data from Goldblum et al. (2013) with 5 to 10 year progression were extracted and analyzed but a discount of 30% applied to account for methodological limitations. A paper by Ducloux et al. (2021) using French clinical data did not allow detailed analysis but general trends were considered. Takeuchi et al. (2022) provide 5-year progression rates averaged for 5-year age intervals and initial refractive error in a Japanese clinical population.

Results
Estimates of progression between age 20 and 50 for the given studies were: Vitale; -1.1, -1.4 and -1.9D for baseline refractive errors of -1, -3 and -6D respectively: Goldblum; -1.0, -1.1 and -1.0D for low, medium and high myopes: Takeuchi; -1.00D for males and -0.85D for females with, perhaps surprisingly, progression being higher among those with lower initial myopia. In all studies, average progression rates continue to fall with increasing age, with the majority of the progression occurring between 20 and 30 years of age. Small hyperopic shifts from age 50 to 60 are apparent. Ducloux showed trends of myopic shift consistent with the data from the other studies.

Conclusion
There is consistent evidence that myopes continue to progress after teenage years through to age 50 by an average of about 1D or more. Since disease prevalence predictions with myopia tend to be based on patients older than 60 years, using prevalence rates from late teenage years may underestimate future morbidity of myopia.

P15: Assessing Effectiveness of a Clinical Algorithm for Myopia Progression (CAMP) Treatment Strategies for Pediatric Myopia in Real-World Practice Settings

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Purpose: Limited evidence currently exists to display the impact of modified therapeutic interventions using a defined protocol on the efficacy of myopia management. We performed a 3-year retrospective cohort analysis to investigate and evaluate the effectiveness of a clinical treatment algorithm for myopic progression (CAMP) for children in a real-world clinical setting.

Setting: Two pediatric myopia management centers

Method: De-identified EHR data were analyzed for all patients presenting to Treehouse Eyes (Bethesda, MD and Tysons Corner, VA) from Aug 2016-Sept 2019. A total of 1487 records were reviewed for all children and visits during that timeframe, and records were retrieved for 342 children completing at least 1 annual visit. Data were grouped into treatment modalities prescribed at initial visit: orthokeratology (OK), OK+atropine (OK+A), soft multifocal contact lenses (SMF), SMF+atropine (SMF+A), Atropine of any concentration (ATR). Changed modality or treatment added after 1M were excluded. Measuring parameters included cycloplegic spherical equivalent refractive error (CSER), and axial length (AL). Data presented are Mean (SE) with $p < 0.05$ set for statistical significance.

Participants: A total of 342 children with myopia (girls, 53%; individuals of Asian ethnicity, 45%; and individuals with at least one parent showing myopia, 91%; mean (SE) age, 10.84 (0.13) years).

Main outcome measures: Changes in cycloplegic autorefraction spherical equivalent refractive error (CSER) and axial length (AL) in the right eye over periods of one, two, and three years, respectively.

Results: Baseline characteristics were as follows (Mean, SE): CSER, −4.01 (0.15) diopters (D); AL, 24.97 (0.07) mm. Patients treated with CAMP approach demonstrated change in AL of 0.16 (0.01) mm, 0.17 (0.02) mm, and 0.09 (0.02) mm in years one, two, and three, respectively. Change in CSER (excluding orthokeratology) was -0.29 (0.11) D, −0.46 (0.12) D, and −0.45 (0.18) D over the same period. At baseline, 188 (55%) children showed at least one atypical ocular finding, with the mean (SE) AL of 25.19 mm (0.09; range: 22.62–29.55; 95% CI: 25.00–25.40), indicating that the cohort was of significant risk for myopia. Changes in CSER and AL were lower in the CAMP group ($p < 0.001$) than in an age- and ethnicity-matched myopic virtual control group. A cumulative absolute reduction of axial elongation (CARE) value was calculated to be 0.29 mm over three years, projecting a 0.86 D (58%) decrease in CSER change and 34% decrease in AL change over this period. Over up to three years, 63% and 60% of subjects displayed minimal refractive progression (≤−0.25 D/year) and minimal axial elongation (0.10 mm or less/year). Children prescribed with orthokeratology and soft multifocal contact lenses generally showed the least myopia progression over time, whereas children prescribed with atropine required treatment modifications during the course of treatment. Continuous monitoring of CSER progression (>0.25 D) and axial length elongation (>0.1 mm) indicated over six months was observed to be an effective approach for myopia management.

Conclusion: The CAMP treatment protocol demonstrated excellent control of the CSER and axial elongation in a diverse group of high-risk, young patients with progressive myopia, as compared to age- and ethnicity-matched virtual myopic control group, over a period of up to three years. Optical interventions (OK and SMF) generally demonstrated a lower amount of myopic CSER progression and axial elongation than low-

dose ATR therapy. The CAMP treatment protocol was successful in identifying initial instances of poor or no response, as well as modifying the treatment approach to achieve effective control of myopic progression through three years of follow-up. It offers a practical, realistic, and clinically relevant model that can be applied in other clinical settings.

P33: Adolescents Onset Accommodative Spasm Misdiagnosed as Myopia and Treated with Orthokeratology-lens

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Background: Accommodative spasm (AS) has been reported to be a rare cause of an acquired visual loss, occurring in children, adolescents, and yong adults. They are often misdiagnosed as amblyopia or retrobulbar optic neuritis. This presentation documents an AS case misdiagnosed as myopia ,and treated with Orthokeratology lens. We discuss the presentation, clinical investigations, management, response to treatment, and 3-year follow-up.
Case Report: We described a unique case of AS in a 10-year-old healthy male patient with sudden onset of blurred vision. Presenting visual acuities were 20/100 in each eye. Refractive error by retinoscopy was -9.00 diopter sphere (DS) in the right eye and -8.00 DS in the left eye. Refractive error with cycloplegia revealed low hyperopia in each eye. He was treated with cycloplegic medications and vision function training. The condition resolved following 3 years and there has been no recurrence.
Conclusion: AS can be the cause of acquired visual loss. AS responds favorably to cycloplegic medications but may need a longer course of treatment for successful resolution and stability.

P37: Binocular function changes produced in response to wearing overnight orthokeratology with intermittent exotropia

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Purpose To observe and analyze the binocular vision changes in myopic children with intermittent exotropia after they switched from spectacles to orthokeratology (ortho-k) lenses.
Methods A prospective, longitudinal study on young adult subjects with low to moderate myopia with intermittent exotropia 30 subjects was carried out. General information was gathered, and examinations were performed at baseline and at 1, 3, 6, and 12 months after switching to ortho-k lenses.Binocular function was assessed by the following sequence: Distance and near horizontal phoria (Von Graefe technique), distance and near horizontal vergence ranges (Risley rotary prisms), accommodative convergence/accommodation (AC/A) ratio (gradient method) and the near point of convergence (standard push-up technique).
Results After the children switched to ortho-k lenses, distance and near ocular alignment showed no obvious exophoric shift (distance: $p > 0.05$, near: $p > 0.05$), and the horizontal vergence range decreased by different degrees (convergence: distance blur point ($p <$
0.05), distance break point ($p < 0.05$), near blur point ($p < 0.05$), near break point ($p > 0.05$); divergence: distance break point ($p < 0.05$), distance recover point ($p < 0.05$), near recover point ($p < 0.05$). The stereopsis ability no changes.
Conclusion The subjects showed no obvious distance and near exophoric shifts after switching to ortho-k lenses;No improvements in stereopsis, and ocular motility; and a decrease in the binocular horizontal vergence range. No obvious near exophoric trend over the short-term period. Further investigations were required.

P99: Comparison of accuracy and precision between smartwatch and outdoor diary for recording outdoor activity

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Purpose: This study aims to evaluate the performance of a smartwatch in recording outdoor status comparing with the form of outdoor diary.
Methods: A total of 28 students in grade 3 from Shanghai Chess Experimental Primary School participated the study. Three sources of data were collected simultaneously in each student. Firstly, the smartwatch collected data and discriminated the state between "outdoor" and "indoor". One piece of data collected by the smartwatch consists of time, luminance (lx), ultraviolet light intensity, count of steps, weather, and wearing status in 1 minute. Then, the status of each data piece was classified as “outdoor” and “indoor” using support vector machine (SVM) algorithm. Secondly, students were asked to complete the outdoor diary to record their outdoor and indoor status to the minute. Thirdly, direct observation was conducted by research staff. The collected data served as the gold standard. The data recorded by both smartwatch and the outdoor diary were screened for analysis afterwards. Finally, the accuracy and precision of the smartwatch and the outdoor diary for recording outdoor time were estimated against the gold standard.
Results: The direct observation recorded 39060 pieces of data. The smartwatch and the outdoor diary recorded 33372 and 27943 pieces of data, accounting for 85.4% and 71.5% of the result of direct observation. After filtering the data recorded by both smartwatch and outdoor diary, 23812 pieces of data were finally analyzed. For the accuracy of recording outdoor/indoor status, in the entire observation time, the smartwatch was more sensitive than the outdoor diary (91.1%; 95% CI, 89.8%-92.5% vs. 83.2%; 95% CI, 81.5%-85.0%; $P < 0.001$). The Youden index showed that the smartwatch displayed better validity than the outdoor diary (0.82 vs. 0.79). The receiver operating characteristic (ROC) curves shows that the smartwatch was more accurate than the outdoor diary as well (AUCs, 0.91; 95% CI, 0.91-0.91 vs. 0.89; 95% CI, 0.89-0.90; P=0.005). For the precision of recording outdoor/indoor status, in different hours of the observation time, the indicators showed that the smartwatch was more stable than the outdoor diary (sensitivity, range 91.1%-91.4%, rate difference 0.4%; 95% CI, -3.3%-4.0% for the smartwatch vs. range 62.7%-90.9%, rate difference 28.2%; 95% CI, 22.4%-33.9% for the outdoor diary; specificity, range 86.6%-93.5%, rate difference 6.9%; 95% CI, 5.3%-8.5% for the smartwatch vs. range 67.8%-100.0%, rate difference 32.3%; 95% CI, 30.2%-34.3% for the outdoor diary; agreement rate, range 87.2%-90.7%, rate difference 3.5%; 95% CI, 2.4%-4.6% for the smartwatch vs. range 75.6%-95.8%, rate difference 20.2%; 95% CI, 18.5%-21.8% for the outdoor diary; AUCs, range 0.889-0.91, rate difference 0.02 for smartwatch vs. range 0.79-0.89, rate difference 0.10 for outdoor diary).
Conclusions: The smartwatch displayed better accuracy and precision than the outdoor diary, indicating that the smartwatch has great potential to be widely used in research on the relation between myopia and outdoor activity and as myopia prevention and control management.

P53: Parent and child attitudes to myopia, myopia management, and myopia research

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Purpose: Despite the development of effective myopia interventions, less than 4% of soft contact lenses prescribed to children in the UK are for myopia management purposes. The current public perceptions of myopia, its management, and participation in relevant research, are not fully understood. Therefore, to explore key barriers towards myopia management and research we sought to gather the attitudes of children and parents in this cross-sectional, qualitative study.
Methods: A patient and public involvement (PPI) event was organised for parents of at risk, or myopic, children. Participants were recruited using flyers, local authority notices and press releases into the national community. A two-hour event was scheduled to include a presentation about myopia, options of myopia management available in the UK, and an example of a Participant Information Sheet (PIS) for a myopia intervention trial, for discussion. Both parents and children were invited to participate. Two independent researchers transcribed the data and it was analysed thematically.
Results: The PPI event took place online in April 2022, including both parents and children. Several key themes became apparent. A primary concern was a lack of communication from eyecare practitioners (ECPs) at the time of myopia diagnosis, and a resultant lack of information about progression, possible pathology, and management options. Consequentially, parents expressed frustration at having to turn to other, possibly unreliable sources of information, elevating feelings of apprehension. Parents were open to the various optical management options available. The choice of treatment may depend on the parents' experience of intervention modality, perceived safety, and the age of the child, although further discussion alleviated most concerns. Parents described barriers to increasing time spent outdoors as the UK weather, child safety, and children's enthusiasm for technology. COVID-19 lockdowns were also mentioned as a contributing factor. Regarding myopia management research, parents expressed particular concern about being assigned to a non-intervention group, although frequent visits were perceived as a benefit as any rapid progression could be identified sooner. Parents indicated including this point in a PIS could provide a more favourable view of participation.
Conclusion: The current lack of communication from ECPs about myopia is troubling. Confounding information sought from unregulated sources can lead to misconceptions and heighten feelings of concern. There is a clear need to educate patients on implications of myopia and myopia management options, optical or lifestyle. PPI events involving the public in the design of research trials can highlight barriers to recruitment and continued participation, which can inform and improve the approach to research to minimise these effects.

P89: Near working distance may lead to myopia in ultra-Orthodox men

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Purpose:
The Israeli Jewish male population provides a unique opportunity to study contributions of genetic, environmental, and behavioral factors in myopia due to differences in prevalence among different groups and diverse behaviors. Ultra-Orthodox adolescent boys have been shown to have a significantly higher prevalence of myopia than non-ultra-Orthodox. The purpose of this study was to use an objective, continuously measuring range finding device to examine near work viewing behaviors in ultra-Orthodox and non-ultra-Orthodox young adults.

Methods:
Healthy Jewish men aged 18-30 years were included in this study. Subjects were categorized as ultra-Orthodox (n = 20) and non-ultra-Orthodox (n = 26) based on the school system where they studied in primary school and on still self-identifying with that category. Visual acuity and autorefraction were measured. Myopia was defined as average spherical equivalent in both eyes of ≤-0.50 D. Viewing distance was assessed using the Clouclip during four 10-minute tasks, including (a) passive reading and (b) active writing on paper, and (c) passive viewing and (d) active engagement on an iPad.

Results:
Most of the participants were myopic (76%, n = 35), with no significant difference in the prevalence between ultra-Orthodox (80%, n = 16) non-ultra-Orthodox (73%, n = 19, p = 0.73). However, ultra-Orthodox participants had significantly more myopic refractive error than non-ultra-Orthodox participants (-4.29 ± 4.44 D vs -1.49 ± 2.08 D, p<0.02). For all subjects, mean viewing distances significantly differed by task (passive reading: 39.11 ± 8.47 cm; active writing: 33.19 ± 8.00 cm, passive viewing on iPad: 43.34 ± 9.99 cm; active engagement on iPad 39.72 ± 9.50 cm, p<0.001).
Ultra-Orthodox participants had significantly shorter working distance compared to non-ultra-Orthodox for passive reading of printed material (35.65 ± 5.94 vs 41.77± 9.24 cm, p<0.02). No differences were observed between the groups for passive viewing (40.72 ± 9.56 vs 45.36 ± 10.03 cm, p=0.10), active writing (31.56 ± 8.73 vs 34.44 ± 7.31 cm) and active engagement iPad (37.36 ± 9.39 vs 41.52 ± 9.37 cm, p>0.08).
Conclusions:
Ultra-Orthodox men demonstrated significantly shorter working distances for reading of printed material compared to non-ultra-Orthodox men, which may be due to the small text font used in the ultra-Orthodox school system. The shorter working distance may contribute to observed increases in myopia observed in this population compared to non-Ultra-Orthodox men.

P49: Time to maximum cycloplegia following the instillation of proxymetacaine 0.5% and cyclopentolate 1% in White 12-13-year-olds

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Purpose: The current procedure for paediatric cycloplegic refraction is to wait for 30-minutes post-instillation of a cycloplegic before measuring spherical equivalent refraction (SER). We tested the hypothesis that the clinical guideline may be changed from 30 to 20-minutes with the pre-instillation of proxymetacaine hydrochloride 0.5% (Minims, 0.5% w/v, Bausch & Lomb, UK), hence reducing the time patients spend in practice.
Methods: A clinical observation study was performed to determine whether there was a clinically significant difference in SER at 20 & 30-minutes post drop instillation. The data was collected from 99 Ireland Eye Study participants (White 12-13-years-olds) between September-October 2016 for a total of 198 eyes. One drop of proxymetacaine hydrochloride followed two minutes later by one drop of cyclopentolate hydrochloride (Minims, 1% w/v, Bausch & Lomb, UK) was instilled per eye. Participants were advised to gently close their eyes, and pressure was applied to the inner canthi to reduce systemic absorption. SER was measured by autorefraction (Dong Yang Rekto ORK-11 Auto Ref-Keratometer) at 20 & 30-minutes post-instillation. Anonymised data were analysed using Statistical Package for Social Sciences V.28.0. Paired t-testing, correlations, and linear regression analysis were performed.
Results: The results indicate strong statistical agreement between SER readings at both time points ($t(197) = 1.096$, $p = 0.275$). The agreement indices were as follows: Accuracy=0.999, Precision =0.981, Concordance =0.980. The mean difference between the time points was small ($\mu = 0.022$D, $\sigma = 0.277$D, 95%CI=-0.060 – 0.017D, SEM=0.020). In 94.4% of eyes in this study, the measurements of SER at 20 & 30-minutes differed by ≤0.50D. In 99% of eyes, the difference was <1D.
Conclusions: There is no clinically significant difference in SER, and hence, the level of cycloplegia at 20 & 30-minutes in most participants. Further studies are required to determine if these results persist in younger children with more robust accommodative systems. However, initial findings suggest that clinical guidance may be reviewed on the latent time between drop instillation and the measurement of refractive error in 12-13-year-old White children.

P29: Factors affecting the lifetime cost of myopia and the impact of anti-myopia treatments

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PURPOSE Informed decisions on myopia management require an understanding of financial impact. We describe a methodology for estimating lifetime myopia costs, explore the major influences on cost, and compare across management options.

METHODS We demonstrate a process for modelling lifetime costs of traditional myopia management (TMM = full, single-vision correction) and a number of active myopia management (AMM) options. Evidence-based, location- and ethnicity-specific progression data can be used to determine the likelihood of all possible refractive outcomes. Myopia care costs can be collected from published sources and key informants. Refractive and ocular health decisions can be based on standard clinical protocols that responded to the speed of progression, level of myopia and associated risks of pathology and vision impairment. The progressions, costs, protocols and risks can be used to estimate and compare lifetime cost of myopia under each scenario. The effect of zero, 3% and 5% annual discounting, which adjusts future costs to 2020 value, can also be evaluated.

RESULTS Examples of lifetime myopia cost using TMM and applying 3% annual discounting are US$7,437 (confidence interval US$4,953 – US$10,740) in Australia, and US$8,006 (US$3,026 – US$13,707) in China. The lowest lifetime cost options with 3% discounting were anti-myopia spectacles (US$7,280, US$5,246 – US$9,888) in Australia, and low-dose atropine (US$4,453, US$2,136 – US$9,115) in China. The most significant influences on lifetime myopia cost include the risk of a child reaching high myopia, effectivity of AMM options over extended periods, discounting, input costs, and clinical protocols followed.

CONCLUSIONS Financial investment in AMM during childhood may be balanced or exceeded across a lifetime by reduced refractive progression, simpler lenses, and reduced risk of pathology and vision loss. Our methodology can be applied to estimate cost in comparable scenarios.

REFERENCE Fricke TR, Sankaridurg P, Naduvilath T, Resnikoff S, Tahhan N, He M, et al. Establishing a method to estimate the effect of antimyopia management options on lifetime cost of myopia. Brit J Ophthalmol, published online ahead of print 2022.

P155: Myopia prevalence and risk factors in school children in Madrid, Spain

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Purpose. The increasing prevalence of myopia in some countries is leading to a growing concern about the effects of this visual condition. The aim of the study was to determine the refractive status, myopia prevalence rates and risk factors of myopia of a sample of school-age subjects in Madrid, Spain.

Methods. We carried out a cross-sectional descriptive epidemiological study of 1st, 6th and 8th grades children of 3 schools in Madrid. Retinoscopy, and far visual acuity (VA) with their usual correction were performed. Data of right eye was used. Refractive error was classified by the spherical equivalent (SE) in those with a cylinder <1.50D. Myopia was considered as a SE ≤-0.50D and a VA in far vision ≥0.1 LogMAR in those without correction and a SE ≤-0.50D in those with previous correction. Low myopia was considered between -0.50D and ≥-3.00D; moderate myopia was considered from -3.00D up to -6.00D and ≤-6.00D was considered high myopia. A questionnaire was carried out to determine risk and protective factors for myopia.

Results. 447 children (149 of 1st grade, 189 of 6th grade and 109 of 8th grade) participated in the study (79.9% male). Mean age was 6.45±0.38; 11.55±0.44 and 13.63±0.48 years in 1st, 6th and 8th grades, respectively. 18 subjects were excluded because they had astigmatism ≥1.50D. Myopia prevalence was 3.52% in 1st grade; 9.83% in 6th grade and 15.54% in 8th grade. Low myopia was found in 3.52% of 1st grade children, 8.74% of 6th grade and 14.57% of 8th grade; while moderate myopia was present in 1.06% of 6th grade children and in 0.97% of 8th grade. No cases of high myopia were found. Mean SE was 0.621 ± 0.711 D in 1th grade; 0.305 ± 0.869 D in 6th grade; and 0.021 ± 0.893 D in 8th grade. Refraction was significantly different between grades (p=0,001).
Children were 2.054 times more likely to be myopic if the mother was myopic (p=0.025), but we did not found a relationship with father´s myopia (p= 0.105). We found that myopic subjects spent more time studying (p=0.008), doing near vision activities (p=0.003) and working with screens (p=0.001) than non-myopic. On the other hand, myopic children spent less time in outdoor activities (p=0.016) than non-myopic.

Conclusions. The prevalence of myopia tends to increase with age, reaching values in line with other European countries. It was not found a high prevalence of myopia in children in Madrid region, Spain. Near work appears to be a risk factor for myopia, while more time outdoors may be a protective factor.

P153: Prevalence of myopia in Madrid subway drivers

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PURPOSE
There are not many data on the prevalence of myopia in adults from many Western countries. Our goal has been to determine the prevalence of myopia in a group of adults whose work is not done at near distance. A cross-sectional descriptive epidemiological study was carried out in a randomized sample of Madrid subway drivers.
METHODS
The study was conducted at the Optometry Clinic of the Complutense University of Madrid, Spain. Refraction was determined by autorefraction and refined by subjective refraction. Myopia was defined as the spherical equivalent ≤ -0.5 D; and high myopia as the spherical equivalent ≤ -6 D. A total of 370 people, aged between 27 and 65, participated in the study.
RESULTS
The prevalence of myopia in the entire group was 29.7%, and of high myopia of 1.4%. Most myopic subjects had myopia less than -3D (25.1%), and only 3.2% had myopia between -3 and -6D.
The sample was divided by age, in intervals of 10 years. The prevalence of myopia in subjects under 40 years of age was 36%; in the forties of 27.8%, in the fifties of 31.6% and in the sixties of 9.1%.
The prevalence of high myopia was 0.9% in those under 40 years of age, 1.7% in subjects of the forties, 1.9% in subjects of the fifties and no cases were found in those over 60 years of age.
The mean refractive error in the whole group was -0.5D ± 1.36 and the median was -0.25D. In the different age groups, the mean refractive error was -0.63 ±1.3; -0.63 ±1.26; -0.22 ±1.6 and 0.51 ± 0.99 from the group of under 40 years to the sixties respectively.
Refractive error was found to be different between age groups (p=0.008). It was the same in those under 40 years of age and the group of the forties (p=0.92). It was also the same in the 50 and 60 age groups (p=0.14). However, there was a significant difference between those under 50 and those over 50 (p=0.01), with the most myopic refractive error in those under 50.
CONCLUSIONS
The prevalence of myopia in this sample of adults is similar to that obtained in other Western countries. Most myopic subjects have a myopia of low magnitude and the prevalence of high myopia is low. Refractive error was found to be higher in younger generations.

P97: Are pupillary and accommodative responses linked for near tasks?

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Purpose:
Visual tasks at close range are believed to engage the near triad, i.e., an increase in accommodation, convergence, and pupil constriction. Near work is considered a major risk factor for myopia and the role of accommodation in myopia has been extensively researched. However, there is little understanding of the role of the pupil, it's interaction with accommodation and relation, if any with onset and progression of myopia. We aimed to determine the impact of various near based activities such as reading and cognition on pupil and accommodative responses.

Methods:
Twenty-one participants (15 myopes, mean age 19.6 ± 1.4 yrs, SE: -2.9 ± 1.6D and 6 emmetropes, 18.9 ± 0.7 yrs, SE: -0.06 ± 0.22D) were recruited. They were presented with various tasks binocularly: reading text, solving cognitive problem (arithmetic) and observing the spatial frequency gratings (6 and 12 cycles/ degree) on a computer screen placed at 50 cms for 20 seconds. Pupil and accommodative measurements were dynamically recorded using an open field autorefractor (WAM 5500) for normal and reverse contrast using two room illuminations (150 & 300 lux). Aberrations using BHVI EyeMapper were measured on natural pupils in dark illumination and retinal image quality (RIQ) calculated using VSOTF for various pupil diameters (3 – 6mm in 1mm steps).

Results:
At baseline (gazing at the blank computer screen at 50cms), accommodation and pupil diameter were not significantly different in myopes compared to emmetropes. Accommodation: 0.87± 0.53D vs 1.08 ± 0.46D at 150 lux and 0.90 ±0.60D vs 1.11 ± 0.35D at 300 lux ($p=0.2$), pupil diameter: 5.44 ± 1.08 vs 5.07±1.30 mm, 5.35 ± 1.045mm vs 4.94 ± 0.84 mm at 150 and 300 lux respectively for myopes vs emmetropes, $p=0.3$. However, pupil diameter was significantly different across illumination and contrasts, smaller pupil at 300 lux and on normal contrast ($p<0.05$).

When presented with the task, all except for gratings resulted in a further increase in accommodation (0.4 ± 0.1D) that was consistent across the duration of the task. In contrast, pupillary response (compared to baseline) was different depending on the task: constricted with reading, dilated with cognitive task and was not different for gratings ($p<0.05$, both emmetropes and myopes). Pupil diameter increased by approximately 0.5mm with the cognitive task and decreased 0.5mm with reading task across the two illuminations. RIQ decreased with larger pupil diameters (0.51± 0.20 vs 0.22 ± 0.14 for 3mm vs 6mm) with a mean decrease of 0.1 VSOTF with a 1mm increase in the pupil diameter.

Conclusion: Our results indicate that pupil and accommodative responses were not always linked, while accommodation is engaged for most near tasks, the pupillary response varies depending on the task. Notably, near based high cognitive tasks resulted in an increase in pupil diameter. A larger pupillary diameter reduces RIQ which may play a role in onset and progression of myopia.

P109: The myopia management opportunity in the United Kingdom using the latest population-based figures from the Office of National Statistics

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Title: The myopia management opportunity in the United Kingdom using the latest population-based figures from the Office of National Statistics

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Purpose: Young children with myopia will benefit the most from myopia management interventions, which function by slowing myopia progression until eye growth stabilises. Estimation of myopia prevalence for individuals under 17 years of age in the United Kingdom (UK) is of relevance to guide current and future public health provision. Coupling myopia prevalence cross-sectional data demographics with figures from the UK Office of National Statistics (ONS) offers an opportunity to provide estimates of myopia prevalence among UK children and project logistical requirements on the eye care profession to help manage these children.

Methods:
Retrospective population data from the Greater London area was analysed and the prevalence of myopia in individuals aged less than 17 years was calculated (Wong & Dahlmann-Noor, 2020). The authors reported myopia prevalence in this urban population to be 32%, which had increased from 24% in 2006. The number of UK myopic children was estimated using the 2020 data and population-based figures from ONS data, 2020 (www.ons.gov.uk). The UK population is generally congregated in urban areas (Statistica, 2022), hence these data were used to estimate the total myopia prevalence for young people under the age of 17 years.

Results:
The total number of children under 17 years in the UK was 12.7M (ONS 2020). Based on myopia prevalence estimates (Wong & Dahlmann-Noor, 2020), it can be assumed that 32% of this population are myopes which equates to 4.064M myopic children in 2020. Based on the assumption that the non-myopic children (8.636M) were assessed once per year, and myopic children (4.064M) were assessed twice per year on average (aligned to national health guidelines), approximately 16.764M eye examinations would be required annually across the UK to meet the needs of the population under 17 years. There are around 16,000 fully qualified optometrists on the General Optical Council register (Association of Optometrists, 2021). Assuming all UK optometrists work full-time in clinical practice, they would need to offer 1,048 appointments annually, or 23 appointments per week, to meet the eye care requirements of children under 17 years. Optometrists can expect to assess 11 children per week with myopia, on average, in addition to pre-myopes, emmetropes and other children with vision-correction needs.

Conclusions:
Assuming all registered optometrists embrace myopia management as part of their scope of practice (as per the World Council of Optometry Resolution: The Standard of Care For Myopia Management by Optometrists, 2021), the UK appears currently to be well placed to serve the eye care needs of the patient population under 17 years of age. The profession should be aware of potential increases in the prevalence

of myopia within this age group and be prepared to provide evidence-based advice and recommendations to help mitigate and manage childhood myopia.

P149: Visual factors associated with physical activity in schoolchildren; a cross-sectional observational study

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Purpose: Physical activity is an essential part of childhood physical and mental development. Recent research identified visual problems associated with a sedentary lifestyle in Irish children. This study explored the association between children's visual function and their engagement with physical activities outside school.

Methods: Participants were 1,626 schoolchildren (728 aged 6-7-years, 898 aged 12-13-years) in randomly selected schools in Ireland. Before data collection, parents/legal guardians of participants completed a standardised questionnaire reporting physical activity as no activity (mostly on screens), light activity (occasional walking/cycling), moderate activity (<3hrs/week engaged in sports), or regular activity (>3hrs/week engaged in sports). Measurements included logMAR monocular visual acuities (with spectacles and pinhole), in the distance (3m) and near (40cm), stereoacuity (TNO stereo-test), cover test, and cycloplegic autorefraction (1% cyclopentolate).

Results: Controlling for confounders (socioeconomic disadvantage and non-White ethnicity), linear regression analysis revealed presenting distance visual acuity, near visual acuity, and stereoacuity were significantly better amongst participants who reported regular physical activity rather than moderate, light or no activity in both 6-7-year-old and 12-13-year-old participants. Emmetropia (>-0.50D<2.00D) was associated with regular activity. Myopia (≤-0.50D) (odds ratio (OR)=3.00 (1.89-4.74)), and astigmatism (≥1D) (OR=2.15(1.52-3.05)) were associated with no activity. Participants presenting with visual impairment (VI) (better-eye vision<6/12) (OR=5.78 (2.72-12.29)), amblyopia (pinhole acuity ≤6/12 plus an amblyogenic factor) (OR=5.66 (2.33-13.76)), and participants at school without their spectacles (odds ratio=2.20 (1.33-3.63)), were significantly more likely to report no activity.

Conclusions: Children regularly engaged in physical activities, including sports, had better visual and stereoacuity and were less likely to need spectacles. Amblyopia, VI, myopia and astigmatism were associated with no physical activity, and spectacle wear compliance was associated with regular physical activity. Regular physical activity is an essential factor in children's vision, and addressing VI in children is vital to increasing participation in sports and exercise. Socioeconomically disadvantaged and non-White communities would benefit most from these measures.

P151: Eyesight and obesity in 6-7-year-old schoolchildren: a cross-sectional analysis from the Ireland Eye Study

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Title: Eyesight and obesity in 6-7-year-old schoolchildren: a cross-sectional analysis from the Ireland Eye Study

Purpose: Childhood obesity is a growing health problem, and the adverse effects of obesity on visual function in children are unknown. This population-based observational study explored the relationship between body mass index (BMI), with refractive error, ocular biometrics and visual function in Irish 6-7-year-olds.

Methods: Participants were 728 6-7-year-old (377 boys (51.8%)) children in Irish schools. The examination included logMAR visual acuity (VA) (with spectacles and pinhole), stereoacuity (TNO stereo-test), and cycloplegic autorefraction (1% cyclopentolate hydrochloride), and ocular biometry (Zeiss IOLMaster), height (cm) and weight (kg). Power vector analyses of Cartesian astigmatism (J0) and oblique astigmatism (J45) components of refractive, corneal astigmatism.

Results: BMI (weight/height^2) was positively correlated with stereoacuity (arc-secs) ($r=0.212$, $p<0.001$), logMAR VA in the distance (3m) ($r=0.102$, $p=0.006$), at near (40cm) ($r=0.110$, $p=0.005$), pinhole VA ($r=0.109$, $p=0.003$), corneal ($r=0.113$, $p=0.002$) and refractive ($r=0.118$, $p=0.001$) J0 astigmatism. Higher BMI was correlated with a deeper anterior chamber ($r=0.266$, $p=0.01$) and flatter corneal radius ($r=0.103$, $p=0.005$). Nineteen percent (139) of participants were overweight/obese. Socioeconomic disadvantage (Odds Ratio (OR)=2.18, 95%CI:1.50-3.18, $p<0.001$), and non-White ethnicity (OR=2.09, 95%CI:1.25-3.49, $p<0.001$), were associated with overweight/obesity. Controlling for confounders, overweight/obesity was associated with myopia (≤-0.50D) (OR=3.13, 95%CI:1.12-8.74, $p=0.007$), astigmatism (≥1D) (OR=2.06, 95%CI:1.14-3.71, $p=0.016$), visual impairment (VI) (VA>0.3LogMAR) (OR=3.19, 95%CI:1.49-6.82, $p=0.003$), abnormal stereoacuity (≥240 arcsecs) (OR=2.96, 95%CI:1.49-5.14, $p<0.001$). Emmetropia (SER≥-.50D≤2.00D) was associated with a healthy weight (OR=1.45, CI:1.01-2.15, $p=0.04$).

Conclusions: Higher BMI was associated with poorer visual and stereoacuity. Overweight/obese children were three times more likely to be visually impaired or myopic and twice as likely to be astigmatic. The absence of refractive error or visual problems was associated with a healthy weight. Addressing children's visual issues is essential to preventing obesity. Dedicated eye-health education programmes targeting socioeconomically disadvantaged and ethnic minority children are vital.

P159: Myopia prevalence in Portuguese schoolchildren's aged between 3 and 10 years.

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PURPOSE:
The objective of this study was to determine the myopia prevalence among Portuguese school children aged between 3 and 10 years in the north of Portugal.

METHODS:
A school-based cross-sectional study was performed in the 1st half of 2019 in all schools in the county of Paredes (a semi-urban county in the north of Portugal). Refractive error was accessed with plusoptiX S12 photoscreener (PlusoptiX GmbH Nuremberg, Germany). Myopia was defined as spherical equivalent (SE) of -≤-0.50 D. The definition of pre-myopia was considered as the SE <1.00D for children up to 6 years old, <0.75D for children aged 6 years, <0.50D for children aged 7 and 8 years and <0.25D for of 9 and 10 years. High myopia was defined for a SE value <=-6.00D. Only data for the right eye was considered for the statistical analysis.

RESULTS:

A total of 3175 children aged between 3 and 10 representing 71% of the school population in the county were assessed (50.4% are female) with a mean age (mean ± SD) of 7.8 ± 1,8 years (ranging from 3 to 10 years). The mean refractive error M (spherical equivalent) was 0.16± 0.95D (mean±SD). The overall prevalence of myopia in this study was 11.0%. The prevalence of myopia increases with age. Myopia was not found in children aged 3 years, for the 4-years-old the myopia prevalence was 1.6%, 4.0% for the 5-year-old, 3.9% for the 6-year-old, 9.4% for the 7-year-old, 13.3% for the 8-year-old, 13.7% for the 9-year-old, and 16.6% for those aged 10 years old. The difference was statistically significant (chi-square <0.001). There are no differences between gender (chi-square <0.073). The mean value also increases with age. The mean (mean±SD) values are 0,54 ±0.76D; 0.49±.63D; 0.39±0.85D; 0,40±0,66D; 0,22±0.90D; 0,07±1.01D; 0,05±1.04D; -0,024±1.04D; for children from 3 to 10 years-old, respectively. 77.9% of children can be considered pre-myopic without statistically significant differences by age or sex (X2 test p=0.360 and Fisher exact test p=0.50, respectively). Only 3 children (ages 5, 8 and 9), representing 0.1% of the sample, have high myopia.

CONCLUSIONS:
This study is the first carried out in Portugal involving a large school community in a semi-urban region. For the studied population, the results show that 11% of the population has myopia and myopia increases with age both in terms of prevalence and in dioptric value. 77.9% of the population has pre-myopia.

P157: Myopia prevalence in professional football players

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PURPOSE:
Determine myopia prevalence among professional football players
METHODS:
From 2018 to 2021, 213 professional football players were analyzed. Refractive error was assessed using retinoscopy. Myopia was defined as (spherical equivalent) M≤ -0.50D. Only the right eye was used for analyses. The athletes are grouped by region of origin (Arabs, Europeans, Africans and Latin-Americans) and based on the position occupied on the field (Goalkeeper, Defender, Midfielder and Forward).
RESULTS:
A total of 213 players were assessed (all men) with a mean age of 24.0±4.4 years. The mean refractive error M was 0.05 ± 0.63D. The overall prevalence of myopia in this study was 15.5%. The prevalence of myopia was 3.4%, 29.6%, 13.8% and 19.2% for the Arabs, Africans, European, and Latin-American players, respectively. For the position occupied on the field the prevalence for the Goalkeepers was 20.8%, 9.6% for the defenders, 15.0% for the Midfielders and 21.4% for the Forwards. A statistically significant difference was found regarding the prevalence of myopia between Arab and African athletes (Xi2 test; p=0.042). For the remaining ethnicities, no statistically significant differences were found.

CONCLUSIONS:
Arab athletes have a lower prevalence of myopia than the rest of the population. Myopia prevalence in this population is lower than published for populations of non-athletes of similar ages. It is important to carry out a more extensive study to verify if the practice of sport in an intensive and outdoor way can have a protective effect in the onset of myopia.

P117: The use of strategies to reduce the myopia progression by Portuguese optometrists

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PURPOSE:
In recent years we have witnessed the availability of several techniques to control the myopia progression. Visual health professionals are confronted in their clinical practice with an amount of information on this topic and are increasingly asked by parents about myopia and how to reduce its progression. The aim of this study was to study the knowledge of Portuguese optometrists about myopia progression control strategies. It is also intended to know which myopia progression control strategies are used in daily clinical practice.
METHODS:
During April and May 2022, a survey carried out on the google forms platform was distributed to the population of Portuguese optometrists. In the survey, it was asked if the professionals apply any strategy to control the myopia progression. If yes, what techniques did they use and what were the reasons that led them to opt for a particular technique. For those who do not use any technique, they were asked why they do not use it and if they plan to use it.
RESULTS:
The 189 validated surveys represent about 11.5% of the study population. The validated sample had 69.8% of graduates, 29.6% of masters and 0.5%of PhDs in Optometry. The age of the sample ranges from 22 to 59 years with a mean age (mean ± Standard deviation) of 38.0 ± 9.1 years. The professional experience of the participants ranges from 1 and 35 years with a mean value of 14.1 ± 7.4 years. 63.0% of the sample are female.
1.6% of the sample say they are not worried about the increasing prevalence of myopia and 55.5% say they are extremely worried. 68.0% of the respondents use strategies to control myopia, with no statistically significant differences regarding the level of academic training, age, or years of professional experience. Regarding the myopia progression control strategies, 14.3% consider that undercorrection is a valid method, single vision spectacles are considered valid by 22.8%, bifocal or progressive spectacles by 62.4%, low-addition spectacles by 65.1%, rigid gas permeable contact lenses (alignment fit) by 33.3%, soft monofocal contact lenses by 25.4% and vision therapy by 49.7%. On the other hand, 11.1% answered that orthokeratology has no effect or that it increases the progression of myopia, 21.7% say the same about atropine, 24.3% about combined treatments (eg atropine and orthokeratology), and 12.2% about the increase of outdoor activity.
Regarding the methods used to control the progression of myopia, 11.0% only use a single strategy and the rest of the sample use several. 84.6% of those who control the progression of myopia use specific myopia controlling contact lenses, 66.2% use specific myopia controlling spetacles, 10.0% use dual focus soft contact lenses, 9.2% use orthokeratology, and only 0.8% use atropine and combined treatments. On the other hand, there is a group of professionals who use techniques that are not validated or that have even been shown to be counterproductive for controlling the myopia progression. Among them, 23.8% use low-addition spectacles, 19.2% use single vision spectacles, 7.7% use undercorrection, vision therapy and monofocal soft contact lenses, 5.4% use progressive spectacles, 4.6% bifocal spectacles, 3.1% rigid gas permeable contacts (alignment fit) and 1.5% visual ergonomics recommendations. 62.3% recommend increasing outdoor activities.
Conclusions:
The results of this study allowed us to conclude that most Portuguese optometrists are aware of the myopia problem and interested in applying strategies to control the myopia progression. It seems that they have some illiteracy in relation to the effects of strategies to control the progression of myopia, ignoring the effectiveness of the different strategies. It was also found that there are professionals who apply techniques

to control myopia progression that are not supported by current scientific evidence, such as visual therapy, undercorrection and low addition spectacles.
The results demonstrate the importance of reinforcing the training of optometrists in this area.

P95: COVID-19-related school closures resulted in increased device use in myopic children in Ireland

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Purpose: To evaluate the effect of COVID-19 pandemic public health measures, particularly school closure, on behaviours in a cohort of myopic children in Ireland.

Methods: Activity data was analysed from 148 children enrolled before 12th March 2020 in the Myopia Outcome Study of Atropine in Children (MOSAIC), a 36-month randomised placebo controlled clinical trial of 0.01% and 0.05% atropine. At each visit, parents recalled daily time on devices (laptop, tablet, or kindle), mobile phones, reading and outdoors in the previous two weeks. To explore the effect of COVID-19-related school closures, subjects were grouped into those with baseline visits in Sep-Dec 2019 [Schools open at baseline and all study visits – SCHOOLS OPEN (SO) group; n=108, mean age=12.5±2.1years] and in Jan-Mar 2020 [Schools closed during 12m visit in Jan-March 2021 – SCHOOLS CLOSED (SC) group; n=40, mean age=10.8±2.5years]. Linear mixed models with age and sex as covariates and random intercepts to account for repeated measures compared baseline (pre-pandemic) to behaviour at 12- (12m; 2020/2021) and 24-month (24m; 2021/2022) visits (schools open for both groups at 24m).

Results: Compared to pre-pandemic, the SO group did not show significantly higher device use at the 12m (mean difference [MD]=+23mins, p=0.15) or 24m visits (MD=+26mins, p=0.14); however, the SC group spent significantly more time on devices at the 12m visit (MD=+180mins, p<0.001) and usage remained higher at the 24m visit (MD=+64mins, p=0.01) compared to baseline, although this was lower than the 12m visit during school closures. Phone use was significantly higher relative to baseline at 12m in the SC group (MD=+39mins, p=0.014), but not the 24m visit (MD=+10mins, p=0.60); or at either visit in the SO group (12m MD=+44mins, p=0.07; 24m MD=+44mins, p=0.09). Outdoor time was stable at 12m (SO group MD=+17mins p=0.09; SC group MD=+13mins, p=0.67), but increased at 24m in both groups (SO MD=+34mins, p=0.003; SC MD=+68mins, p=0.04). Neither group showed change in reading time.

Conclusions: In this cohort of young myopes in Ireland, device and phone use were substantially higher during school closure, and while reduced after schools reopened device use remained higher than pre-pandemic. Outdoor time increased at the 24m visits, which coincided with easing of restrictions. While essential for public health, pandemic measures may lead to lifestyle changes, which could have implications for ocular health and myopia progression.

P114: Increased myopic progression in European adolescents associated with increase of myopic risk factors due to COVID-19 pandemic: The Generation R Study.

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Abstract

Purpose

To battle the spreading of the COVID-19 virus, all over the world measures like home confinement and nation-wide lockdowns have been implemented at regular intervals. These measures have shown an increase in myopic incidence particularly in China, which applied a very strict lockdown and home confinement. The Netherlands used a so called “intelligent lockdown” which allowed children to go outside. We evaluated the association between COVID restrictions, myopia risk factors and myopia progression in a Dutch cohort of adolescents.

Methods

A total of 1101 participants (mean age 16.3 ± 3.65 yrs) of the population-based prospective birth-cohort study Generation R filled in a questionnaire about their behavior before, during, and after lockdown in the Netherlands. These participants had undergone cycloplegic refractive error measurement at 13 years of age. We evaluated time spent outdoors, time spent online (handheld or other devices), time spent on near work (education and non-educational) from March-October 2020 in myopic (spherical equivalent <-0.5D) and non-myopic children. We used a repeated measures ANOVA to compare differences between these time periods, and linear regression corrected for age, gender, and outside exposure to evaluate the association between axial elongation (mm/year) and refractive error change (Dpt/year).

Results

During and after lockdown the children spent signicantly more time online (+113 and +59min/day) on both hand held (+64 and +10 min/day) and other devices (+49 and +7 min/day), and on educational nearwork (+73 and +63min/day). Non-educational near work increased only significantly during lockdown (+176 min/day). Time spent outside did not change significantly and was ±2 hours/day. Children of non-European descent spent more time online (235min/day vs 260 min/day, P= 0.004 and on non-educational near work (452 min/day vs 559 min/day, p=0.0002). We found no significant difference in behavior between myopic and non-myopic children.

Conclusion

The Dutch lockdown for COVID increased digitized near work in adolescents but did not affect outdoor exposure. Children without myopia did not do better than those already myopic. Based on these results, we expect that the COVID pandemic will also lead to an increase in myopia prevalence and progression in European children, but to a lesser extent than in Asia.

P31: Myopic progression in anisometropic and isometropic eyes: findings from electronic health record data

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Purpose: Anisometropia commonly co-occurs with myopia, but it is unclear if myopia progression is different in anisometropic versus isometropic eyes. We investigated the association between anisometropia and myopia progression in an Irish electronic health record dataset.

Methods: Spherical equivalent (SE) was calculated from spectacle prescriptions from 40 Irish optometry practices. Inclusion criteria were aged 5-18 years (y), myopia (SE ≤-0.50 dioptres [D]) in both eyes and multiple visits. Exclusion criteria were SE <-10 D or an interocular difference in SE >5 D. Anisometropia was defined as an interocular difference in SE of >1 D and participants were categorised as: remained isometropic (isometropic at all visits), became anisometropic (isometropic at baseline, anisometropic at follow-up), remained anisometropic (anisometropic at all visits) or became isometropic (anisometropic at baseline, isometropic at follow-up). Myopia progression over time was assessed using linear mixed models with SE as the outcome, age, sex, more myopic eye at baseline and anisometropia category as fixed effect covariates and random intercept terms for subject.

Results: Of 72,175 patients aged 5-18 y, 12,038 myopic patients (41.4% male; median follow-up time=3.12 y, interquartile range: 1.86 – 4.97) met the inclusion criteria. There were 10,981 (91.2%; mean age=12.4 y), 521 (4.3%; mean age=11.1 y), 406 (3.4%; mean age=13.5 y) and 130 (1.1%; mean age=11.9 y) participants in the remained isometropic, became anisometropic, remained anisometropic and became isometropic groups, respectively. Total change in absolute interocular difference in SE was correlated with total change in SE (Pearson's r=-0.21, p<0.001). Compared to the remained isometropic group (-0.29 D/year), mean myopia progression of both eyes was similar in the remained anisometropic group (-0.30 D/year, p=0.37) and faster in the became isometropic (-0.33 D/year, p<0.001) and became anisometropic groups (-0.38 D/year, p<0.001). Compared to the contralateral eye, the more myopic eye at baseline progressed faster in the became anisometropic group (-0.41 vs -0.36 D/year, p<0.001), but slower in the became isometropic group (-0.31 vs -0.35 D/year, p<0.001).

Conclusion: Participants who progressed fastest went on to develop anisometropia, perhaps supporting dysregulated eye growth in this group. In participants who became isometropic, myopia progression appeared to be accelerated in the less myopic eye.

P105: OBJECTIVE MEASUREMENTS OF DIGITAL HABITS IN A UNIVERSITY POPULATION AND THEIR RELATIONSHIP WITH REFRACTION AND AXIAL LENGTH: A BIG DATA STUDY

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Purpose:
The exact relationship between myopia and unhealthy digital habits (excess of screen time, short face-device distance or mobile device usage under low ambient illumination) is still not precisely known. University students are especially vulnerable to unhealthy digital habits due to the large amount of near work performed under relatively low indoor illumination conditions. This was further exacerbated in the last two years due to tele-education imposed by COVID. In the present work we obtain objective digital digital habits data in a university population and investigate their potential relationship with refraction.

Methods:
A group of 82 students from the University of Murcia aged 21 ± 3 years in their first or second year of university, participated in the study. After a complete optometric examination, which included a subjective refraction and axial length measurement (IOLMaster 700, Zeiss, Germany), the subjects installed an app that measured digital habits continuously (at a rate of I Hz) using the built-in front camera (face-device distance) and light sensor (ambient illuminance). A total of 80M of data points corresponding to 13.2M seconds with at least 3600s (60') of data per subject were obtained. A statistical inference analysis was performed to reveal the relation between digital habits and spherical equivalent of their clinical refraction (SER) and axial length (AL). Number of events per day were also measured, being one event every time the subject does not see the screen of the device for at least 20".

Results:
The face-device distance for students using mobile devices was 356±66 mm with a range that oscillated between 199 and 559 mm. Intersubject mean ambient lighting was 329 ± 244 lux with range between 21 and 1280 lux. Mean number of events per day was 41 ± 34 with a range between 141 and 5.
The correlation between SER and face-device distance, illuminance, and number of events per day exhibited a positive slope while total time showed a negative slope. The slope of the linear fitting between AL and digital habits showed an opposite sign compared to the one found for SER, as expected.

Conclusions:
Objective digital habits big-data (time, distance and illumination) in a university population was collected using a combination of a mobile application (active in the background and transparent to the user) and cloud storage. The data show that subjects with more myopia on average used their mobile devices over longer periods of time, at shorter face-device distances, and with a lower number of events per day. However, in all cases the correlation was quite weak (R^2<0.02), calling for even more objective data collection over a longer period of time (several years) to be able to reveal the real effect of the digital habits on the progression of myopia.

P170: New mobile app for tele-monitoring of possible changes in spherical refraction

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Purpose:
To evaluate a new app for detecting and advising users and their eye care professionals of possible changes in spherical refraction.
Methods:
Standard clinical refraction (SCA, comprising sphere, cylinder and axis) was obtained in both eyes in a group of 122 university students of (21 ± 3 y.o.) and input into a cloud data platform (SuperVision). Subsequently, a mobile app was used by the students to subjectively obtain their sphere or sphere + cylinder using a novel method of measuring face-device distance using the built-in front camera. The app automatically configures the on-screen stimulus by loading the subject's SCA from the cloud. In most cases, the stimulus comprises blue lines, the orientation and visual acuity of which are derived from the SCA. Subjects move away from the device and indicate whether the face-device distance in diopters corresponds to their sphere + cylinder. This distance in many cases falls within a handheld distance due to the natural chromatic aberration of the human eye due to the blue stimulus. In cases where the subjects were hyperopic or highly myopic, the app required them to wear their usual correction, hence an over-correction was measured. Three repeated measurements were taken for each eye with the app. The mean refraction values found by the app are compared to the ones obtained clinically
Results:
Clinical refraction data shows a mean intrasubject value of sphere + cylinder of -2.54+-2.65 D with a range of [+6.0, -12.5] D for OD and -2.48+-2.56 D with a range of [+6.0, -11.5] D for OS. The mean value found by the app was -2.22+-2.82 D (OD) and -2.17+-2.72 D (OS). The mean intersubject SD between the three intrasubject measurements was 0.10 D (OD) and 0.11 D (OS). A very good agreement between clinical and app refraction values (confidence interval of [0.22, 0.43] D for OD and [0.16, 0.37] D for OS) was found. Linear regression shows a slope of 0.96 (OD) and 0.97 (OS) and R2= 0.97 (OD and OS). ($p<10-7$). The differences between clinical and app measurements were not statistically significative: p=2.7*10-8 (OD) and p=7.8*10-7 (OS).
Conclusions:
The initial results of a new app based on a subjective method to obtain spherical refraction (sphere or sphere + cylinder) are presented. The app shows a good precision (0.1 D) and accuracy (0.3D). Further longitudinal studies on the change of the refraction caused by myopia progression are needed to verify the real potential of the app as a tool of early detection of myopia progression.

P47: Form deprivation myopia in a 21-year-old girl after wearing an occluder lens for 4 years.

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Purpose: Most cases of form deprivation myopia (FDM) in humans have been described in very young children, often caused by ptosis of cataract. Less is known about the development of FDM in adolescents and adults. We report on a 21-year-old girl who has been wearing an occluder contact lens for the left eye for 4 years because of diplopia whose myopia increased with 4 diopters.

Methods: At the age of 14 years she was diagnosed with a medulloblastoma for which she had surgery, chemotherapy and radiotherapy. Post-operatively she developed high intracranial pressure causing a sixth nerve palsy of the left eye and a bilateral fourth nerve palsy. The sixth nerve palsy completely recovered after a drain was inserted, however the bilateral fourth nerve palsy remained. Best corrected visual acuity (VA) in the right eye (RE) was 1.0 Snellen with S-0.75; and 0.8 Snellen with S-0.5=C-0.75x15 in the left eye (LE). Media and fundus examination were unremarkable. Unfortunately, she also developed a severe Cerebellar Mutism Syndrome making a binocular orthoptic examination at the time nearly impossible. She sat alternately with one eye open. To alleviate the diplopia the family choose to use an occluder contact lens. She was tried and fitted with a black occluder lens in September 2017. The contact lens was worn all waking hours on the LE. Semi-annual check-ups were performed, however no refractive error was measured.

Results: We saw her again at our strabismus clinic 4 years after wearing the occluder contact lens. The family aimed for a more permanent solution to regain binocularity by means of strabismus surgery. Cycloplegic refraction remained stable for the RE (S-0.75=C-0.25x157), however myopia increased in the LE from S-0.5 to S-4.50=C-0.50x180. Axial length in the RE was 23.28mm and 25.10mm in the LE.

Conclusions: We found a large increase in myopia explained by the difference in AL in a 21-year-old girl. When occluding an eye for intractable diplopia in young people this should be considered or use a lens with less density but enough to minimize the diplopia. FDM can still occur in adolescents in an eye with total blackness.

P188: A bibliometric and citation network analysis on myopia control over the past 20 years.

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Purpose: The prevalence of myopia is increasing throughout the world, fuelling interest in methods to slow its progression. Analyse the relationships between the different publications and authors, as well as to identify the different areas of research on current methods of myopia control, and determine the most cited publication by citation networks.
Methods: The search for publications was carried out in the Web of Science database, using the term "myopia control" for the period between 2022 and April 2021. This period of years has been established, since orthokeratology lenses were approved by The Food and Drug Administration in 2002. The publication analysis was performed using the Citation Network Explorer, VOSviewer and CiteSpace software.
Results: 451 publications and 2904 citations were found across the network, with 2021 being the year with the highest number of publications, 107. The most cited publication was "Efficacy Comparison of 16 Interventions for Myopia Control in Children" by Huang et al., published in 2016, with a citation index of 266. The journals with the largest number of publications were as follows: Investigative Ophthalmology and Visual Science (n=56), Optometry and Vision Science (n=45) and Contact Lens Anterior Eye (n=43).
The authors with the highest publication rate and connections with other authors were Cho P (5.26%; 993), Kang P (3.54%; 666) and Sankaridurg P (3.32%; 473). Thereby, China (32.82%), USA (29.71%) and Australia (21.95%) were the countries with the most publications on myopia control. By using the clustering function, four groups covering the different research areas in this field were found: orthokeratology, atropine, peripheral hypermetropic defocus and progressive additions lens. A connection has been found between orthokeratology group and progressive additions lens group.
Conclusions: The citation network offers a quantitative and qualitative analysis of the main papers on myopia control. The research on this field is multidisciplinary, however, the main topic is being carried out is orthokeratology efficacy.

P39: CHANGES IN WAVEFRONT ERROR OF THE EYE FOR DIFFERENT ACCOMMODATION TARGETS UNDER THE APPLICATION OF PHENYLEPHRINE.

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Purpose
The wavefront error for different accommodation targets can be largely affected by accommodative miosis, thus having a larger pupil diameter may allow to better understand the changes that occur in the crystalline lens during accommodation. To ensure a large pupil diameter, pharmacological dilation with phenylephrine (PHCl) (which is not supposed to affect the accommodation) is required. The aim of this work was to investigate whether PHCl application to dilate the pupil changes the accommodative response for the same target vergences when the wavefront is computed over the same pupil size (4 mm).

Methods
Sixteen right eyes of healthy young subjects (20-33 year of age) were measured in an observational study. Measurements were made with the commercial Hartmann-Shack aberrometer irx3 (Imagine Eyes, France). Two drops of 1.0% phenylephrine (Davinefrine, DAVI, Portugal) were applied to obtain pupil dilation.
The hypothesis presented is that PHCl does not have a cycloplegic effect, i.e. it does not affect the accommodative response.
First, the wavefronts for accommodative demands from 0 to 5D, were measured three times, in 0.5D steps, without dilatation. Next, 2 drops of PHCl were instilled and the three measurements were repeated after 30 minutes. Finally, the accommodative response was calculated from both sets of wavefront measurements based the aberrometer's software. For the analysis of the results, all pupils were rescaled to a common pupil diameter of 4 mm.
Wavefront aberrations obtained in each set of measurements were expressed in a Zernike expansion up to the 6th order and averaged. Differences in the accommodative response calculated from the wavefront data, before and after phenylephrine administration, were compared with simple paired t-tests, if the sample was parametric, or Wilcoxon tests if the sample was non-parametric.

Results
The mean±SD spherical equivalent error ranged from +0.50 to -6.00D (SE), with a mean SE without PHCl of -2.46±2.06 D and a mean SE of -2.50±2.07D with PHCl. The mean±SD pupil diameter was 6.56±0.97 mm and the 7.42±0.54 mm obtained without and with PHCl, respectively. Although there were individual differences before and after the instillation of PHCl, these differences were not systematic.
It was observed that for the same Zernike coefficient, both statistical and clinical significance differ greatly depending on the accommodative demand. Specifically, for the coefficients Z (3,-1), Z (4,0), Z (5,5) and Z (6,2), as the vergence increases, they coefficients show statistically significant differences (p-value<0.05), and clinical significance increases, from a low significance (d_Cohen~0.2) at a demand of 2D to a high significance of (d_Cohen~0.6-0.8) at 4-5D vergence. Defocus (Z (2,0) and second-order spherical aberration Z (6,0), presented statistically significant differences for almost all accommodative demands, with small clinically significant differences for Z (2,0) (d_Cohen~0.2), and low-moderate for Z (6,0) (d_Cohen~0.2-0.6). The difference between the values obtained with the measurements without PHCl and with PHCl are higher for the defocus component Z (2,0).

Conclusion

At least eight of the Zernike coefficients showed one mild clinically significant difference before and after phenylephrine administration. Therefore, it can be concluded that the use of phenylephrine can produce a small effect in the accommodative response, although of very low magnitude.

Nevertheless, it is difficult to compare the results obtained in this study with other studies [1-6], because of different concentrations or doses of PHCl use with different age range.

Although some studies [6-7] that compared objective and subjective measurements of accommodation with and without phenylephrine instillation reported a variation in accommodation measured subjectively, they also report no variation when the accommodative response is measured objectively. This might be explained by the fact that objectives methods are able to separate the effects of any additional change in the shape crystalline lens from the increased depth of focus produced by smaller pupils.

P7: The Marked Increase in Myopia Among Israeli Young Adults over a Decade: Analysis of Predisposing Factors

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Purpose: To determine the trends in prevalence of myopia in Israeli young adults over close to a generation, to unravel factors associated with myopia prevalence, and to assess variations in their impact over time.

Methods: This retrospective, cross-sectional study included 104,689 consecutive conscripts 16 to 19 years of age born between 1971 and 1994, who had completed the medical profiling process at a north Israel recruitment center of the Israel Defense Forces. The prevalence of myopia over time was estimated and a polynomial regression analysis was performed. Associations of demographic and socioeconomic factors with myopia were assessed, and trends over time were analyzed using a factorial logistic regression.

Results: The prevalence of myopia increased 1.3-fold over 24 years from 20.4% among participants born between 1971 and 1982 to 26.2% among participants born between 1983 and 1994. A quite similar increase was observed among males (from 17.9% to 22.7%, respectively) and females (from 23.9% to 30.8%, respectively). The factors found to be associated with higher prevalence of myopia were as follows: more recent date of birth, female gender, more years of education, being and only child, being the eldest child, non-Israeli ethnic origin, Jewish faith, and urban residence. However, there were statistically significant trends over time in the effects of some of these factors, most notably an attenuation of the difference between members of different religions in the recent birth-years period. Most of these associations and trends were observed in both males and females separately, with some gender-specific variations. Immigrants from Ethiopia who were raised in Israel were highly more likely to demonstrate myopia than those who arrived at an older age. Furthermore, most of factors were also independent significant predictors of high myopia (of 6 diopters (D) or more) – namely: birth year, residential environment, education years, birth order, religion. Nevertheless, ethnic origin and immigration status were not significant predictors of high myopia.

Conclusions: This study demonstrated an increase in the prevalence of myopia and possible associations of urbanization- and higher education-related factors among several ethnic subpopulations and the risk for developing myopia. Future collaboration and research in other countries of diverse ethnic groups, both locals and immigrants, may provide a broader overview on predisposing factors.

P163: Spherical equivalent refractive errors percentiles in European children based on cross-sectional and real-world data

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Purpose:
Percentiles can be used to assess and compare the growth of a variable in relation to a standard range and are an excellent tool to support myopia management. The presented research has investigated the agreement of percentiles based on the spherical equivalent refractive error from a prospective, cross-sectional study and real-world data from >400 optician store.

Methods:
The prospective, longitudinal, and cross-sectional Life Child study measured refractive errors in 2000 children over a time range of up to 6 years. The optician-based database with longitudinal information about the refractive error of children aged 1-20 years for >140.000 individual was obtained from Euronet Software AG. Percentiles for the spherical equivalent refractive error were developed using Quantile regression

Results:
Below the median percentiles, Euronet percentiles showed more negative refractive values, while above the median percentiles, Euronet percentiles showed more positive refractive values. Both data sources did not find significant differences between females and males (Euronet: $p>0.09$; Life Child: $p>0.15$).

Conclusion:
Observed significant difference between both data sources can be acknowledged to the nature of the data. While the optician-based data includes prescriptions for all kind of refractive errors, children attending Life Child measurements showed a significantly smaller variation in their distribution of central refractive errors.

Acknowledgement: With kind support of the Market Research Division of Euronet Software AG

P178: Myopia & Lifestyle: Dynamic measurement of sunlight in children by a novel wearable device

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Purpose: Sunlight exposure has been found to play an important role in lifestyle of myopic children. Dynamic measurement of sunlight exposure in a child can help in understanding myopia onset and progression. The purpose of this study was to validate a device that measures the dynamic sunlight exposure on the wearer throughout the day and provide feedback by a dedicated mobile phone algorithm application.

Methods: A wearable device - LUMINO SUN DIAL(Patent Application no:202141040647) was built that can measure sunlight in terms of light intensity (LI), ultraviolet (UV) and infrared (IR). It can be synchronised to a mobile phone algorithm. Validation of the measurements was done with a standard luxmeter (Lutron, LX-101A, Taiwan). Threshold levels for indoor and outdoor were defined with the help of measurements from various lit location intensities covering both outdoors and indoors. Machine learning was incorporated to define the outdoor time.

Results: LI was found to be 136 - 5344 lux indoors and 976 – 30,112 lux in sunlight. UV index was 0-15 indoors and 2.5 - 64 in sunlight. IR index was between 0-16 for indoors and 122-3764 outdoors. The correlation between the luxmeter and device was 0.79. Machine learning reliably defined outdoor time with an accuracy of 67%.

Conclusion: This wearable device provides reliable real time data on sunlight exposure of the wearer. It can possibly help solve what factors in sunlight help in protecting from myopia progression. It may also be an effective tool for promoting outdoor time in kids with myopia and their parental and physician monitoring.

P43: Ultra-Orthodox Jewish Boys Demonstrate Less Time Outdoors and Increased Educational Demands than Religious and Secular Boys

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Purpose: In Israel, ultra-Orthodox male adolescents have higher prevalence of myopia (82.2%) than their religious (50.3%) and secular (29.7%) peers. This study aimed to assess behavioral factors that may influence myopia in these three groups of boys.

Methods: Healthy ultra-Orthodox (UO, n=36), religious (R, n=48), and secular (S, n=24) Jewish boys ages 5 to 11 years participated. Cycloplegic autorefraction and axial length measurement were measured. Myopia was defined as average cycloplegic spherical equivalent of both eyes ≤-0.50D. Time outdoors and physical activity were assessed objectively with an Actiwatch. Educational factors, time spent reading and writing, and electronic device use were assessed using a questionnaire. The duration of daylight, temperature, and rainfall were determined. Data were analyzed with $\chi 2$ and Kruskal-Wallis tests with Bonferroni post hoc comparisons.

Results: Average age was 8.4±1.7 years (range 5.1-11.5). Children wore the Actiwatch for 10.1±2.5 days. The three groups were similar for age (P=0.11), best corrected visual acuity (P=0.13), cycloplegic refraction spherical equivalent (P=0.23), and axial length (P=0.10). Myopia was present in 34.3% of the children (S: 25%, R: 33%, UO: 42%; P=0.41). Actiwatch data showed Ultra-Orthodox children spent less time outdoors then religious children (S: 1.1±0.5, R: 1.2±0.6, UO: 0.8±0.4 hours, P=0.021). All groups had similar physical activity (S: 154±23, R: 162±31, UO: 157±30, counts per 15 seconds, P=0.84). There were no significant differences between the groups for hours of daylight (P=0.46), temperature (P=0.15), or rainfall (P=0.74). According to the questionnaire, ultra-Orthodox children learned to read at a younger age (S: 6.2±0.4, R: 5.9±0.5, UO: 4.3±0.8 years, P<0.001 for both) and spent more hours per day at school (S: 6.5±1.0, R: 6.9±1.3, UO: 7.4±0.9 hours, P<0.03 for both). All groups engaged in a similar amount of near work (P=0.41) and similar writing and reading (S: 2.0±1.1, R: 2.3±1.5, UO: 2.7±2.4 hours, P=0.46). However, secular children spent more hours using hand-held electronic devices (S: 1.4±1.4, R: 0.8±1.1, UO: 0.4±0.8 hours, P<0.01 for both) and all electronic devices (S: 4.4±3.9, R: 2.8±2.8, UO: 1.1±2.4 hours, P<0.001 for both).

Conclusions: This study demonstrates that ultra-Orthodox, Religious, and Secular boys have distinct educational demands and behaviors. Ultra-Orthodox boys learn to read younger and spend more hours in school, with less time outdoors. These factors may lead to the high prevalence of myopia in ultra-Orthodox adolescents that has been previously reported

P111: Using Electronic Medical Record Data to Establish and Monitor the Distribution of Refractive Errors

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Purpose
To establish the baseline distribution of refractive errors and associated factors amongst a population that attended primary care optometry clinics.

Methods
Electronic medical record data was extracted from forty optometry clinics, representing a mix of urban and rural areas in Ireland. The analysis was confined to demographic and clinical data gathered over a sixty-month period between 2015 and 2019. Distribution rates were calculated using the absolute and relative frequencies of refractive error in the dataset, stratified for age and gender using the following definitions: high myopia ≤ -6.00 D, myopia ≤ -0.50 D, hyperopia ≥ +0.50 D, astigmatism ≥ 0.75 DC and anisometropia ≥ 1.00 D. Visual acuity data was used to explore vision impairment rates in the population. Further analysis was carried out on a gender and age-adjusted subset of the EMR data, to match the proportion of patients in each age grouping to the population distribution in the most recent (2016) Irish census.

Results
153,598 records were eligible for analysis. Refractive errors ranged from -26.00 to +18.50 D. Myopia was present in 32.7%, of which high myopia represented 2.4%, hyperopia in 40.1%, astigmatism in 38.3% and anisometropia in 13.4% of participants. The distribution of hyperopia, astigmatism and anisometropia peaked in older age groups, whilst the myopia burden was highest amongst people in their twenties. A higher proportion of females were myopic, whilst a higher proportion of males were hyperopic and astigmatic. Vision impairment (LogMAR > 0.3) was present in 2.4% of participants. In the age- and gender-adjusted distribution model, myopia was the most common refractive state, affecting 39.6% of the clinic-based population.

Conclusion
Although EMR data is not representative of the population as a whole, it is likely to provide a reasonable representation of the distribution of clinically significant (symptomatic) refractive errors. In the absence of any ongoing traditional epidemiological studies of refractive error in Ireland, this study establishes the distribution of refractive errors observed in clinical practice settings. This will serve as a baseline for future temporal trend analysis of the changing pattern of the distribution of refractive error in EMR data. This methodology could be deployed as a useful epidemiological resource in similar settings where primary eye-care coverage for the management of refractive error is well established.

P91: Smartphone viewing: effect of the visual surroundings on choroidal thickness

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Purpose: Smartphones are often viewed for long periods at near distances but within distant surroundings. The accommodation associated with viewing the phone is expected to cause myopic defocus in the more peripheral retina from the distant surround. The aim was to determine the significance of the distant surround on choroidal thickness, measured with Optical Coherence Tomography (OCT) as an indicator of the likely myopia-inducing effect of smartphone use.
Methods: 16 participants (age, mean ± SD: 22.7 ± 0.95 years; refraction, range: -0.93 to -6.19D) read webpages (Traditional Chinese characters) of their choice on a smartphone (iPhone 5s) at a 25 cm distance under two conditions: a distant (>3m) surround or a near (25 cm) surround, for 40 mins each. OCT scans of the retina/choroid were taken every 10 mins. Images were segmented using a semi-automatic algorithm to obtain subfoveal (SFCT), central (1mm, CCT), parafoveal (1 – 3 mm, paraCT), and perifoveal (3 – 6 mm, periCT) choroidal thickness.
Results: Two-way RM-ANOVA showed a significant main effect of condition ($F_{1,15} = 5.38$, $p = 0.034$) and an interaction effect of condition and time ($F_{4,50} = 2.69$, $p = 0.039$) on changes in SFCT. Viewing a smartphone at 25 cm in a distant surround caused a significant increase in SFCT relative to viewing in a near surround (mean ± SEM, difference = 8.3 ± 3.6 µm at 40 mins). Changes in thickness between the two conditions were significant at 20 ($p = 0.015$) and 30 mins ($p = 0.032$) of smartphone use. A similar effect was observed for CCT, which was significantly thicker when viewing in a distant surround compared with a near surround ($F_{1,15} = 5.38$, $p = 0.042$, difference = 7.6 ± 3.4 µm) at 20 and 30 mins ($p = 0.038$ & 0.044 respectively). No significant effects were observed on paraCT and periCT.
Conclusion: The visual surroundings in which a smartphone is used can significantly affect central choroidal thickness: viewing in distant surroundings can increase the thickness relative to viewing in near surroundings.

P57: Preliminary Modification and Adaptation of a Visual Ability Questionnaire for Children

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Purpose: With the advent of new myopia control products, it is important to have reliable and quantifiable instruments to understand how new treatments might affect children's ability to complete certain tasks based on their vision. Following patient reported outcome (PRO) guidance from the United States Food and Drug Administration (FDA, 2022), the purpose of this study was to leverage the validated Cardiff Visual Ability Questionnaire for Children (CVAQC, Khadka, 2010) to modernize the questionnaire and evaluate its suitability for optical interventions for myopia control.

Methods: Initial modifications to the CVAQC involved enabling electronic collection, modernizing terms and language, and addition of questions to address dim or low lighting conditions. Of the original 25 items, 4 were removed to simplify the questionnaire and remove reference to activities contraindicated for contact lens wear, while several were reworded. Nine subjects (ages 16-21), each with 3-8 years of recent/current experience wearing myopia control contact lenses and 11 myopic children with no experience of myopia control (ages 8-12) were recruited. Subjects reviewed the revised questionnaire independently and then discussed their visual experiences in different environments, the questions/items, and the response categories in small focus groups to assess content validity. Suggestions and edits were reviewed with subsequent focus groups. The feedback was incorporated into the questionnaire until a balance of information gathering versus collection of repetitive responses was achieved. The final questionnaire was then presented to a new focus group to ensure comprehension. All interviews were hosted by a professional facilitator.

Results: The original questionnaire assessed 7 domains (education, near vision, distance vision, getting around, social, entertainment, and sports). From the 21 items presented to subjects, opportunities for more specificity or description were observed and questions were modified, as appropriate. Other questions were removed or collated because of redundancies identified by subjects. Changes to the questionnaire were reviewed with subsequent focus groups to ensure comprehension and allow for feedback. The final questionnaire still assesses all 7 domains using a total of 18 items.

Conclusions: The current study allowed for the adaptation of an existing visual ability questionnaire to make it appropriate for children who may be using an optical intervention for myopia control. As it only represents context and content development, this questionnaire requires further prospective evaluation in a larger cohort of subjects.

This study was sponsored by CooperVision.

P141: Blur adaptation in myopes and emmetropes during selective ON and OFF pathway overstimulation

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Purpose: Exposure to blur, ambient illumination, and the relative activation of retinal ON and OFF pathways are thought to play important roles in the regulation of eye growth. This study aimed to examine how blur adaptation in myopes and emmetropes is influenced by selective overstimulation of ON and OFF pathways, under differing illumination levels.

Methods: Twenty-three healthy young adults participated in this study (mean ± SD age 24±4 years), including 11 myopes (mean spherical equivalent: -1.5±0.7 D) and 12 emmetropes (mean spherical equivalent: -0.02±0.2 D). Each participant had blur adaptation to +1.00 D myopic defocus assessed, with serial measures of distance logMAR visual acuity (VA) over 30 minutes, with either overstimulation of ON pathways (viewing a VA chart with bright letters on a dark background) or OFF pathways (dark letters on a bright background). The ON and OFF charts were matched for luminance and contrast. Each of the conditions were measured under photopic (265 lux) and mesopic (5 lux) ambient illumination, with each of the four experimental condition tested on a different day in randomised order. Linear mixed models were used to examine the changes in blurred VA over time and explore the effects of ON/OFF pathway stimulation, ambient illumination, and refractive group.

Results: The initial blurred VA was significantly better with ON stimulating viewing conditions compared to OFF stimulating viewing conditions (mean ± SEM difference; 0.11±0.02 logMAR, $P<0.001$). Considering all subjects, across both illuminations and ON/OFF pathway conditions, significant blur adaptation was observed ($P<0.001$) with a mean improvement of blurred VA by 0.06±0.01 logMAR after 30 mins of exposure to +1 D of myopic defocus. Significantly greater blur adaptation was observed in emmetropes compared to myopes ($P<0.02$), with statistically significant differences between emmetropes and myopes observed across some time points during the mesopic ON, photopic ON and mesopic OFF viewing conditions. There were no significant differences in blur adaptation between refractive groups during the photopic OFF condition at any time point (all $P>0.05$).

Conclusion: This study demonstrates more robust adaptation to blur in emmetropes compared to myopes, particularly during overstimulation of the ON retinal pathway. These findings are consistent with a potential deficit in the processing of blur signals in the ON retinal pathway associated with human myopia.

P101: Impact of Task on Digital Device Viewing Behavior in Children

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Purpose:

Habitual viewing behavior is widely believed to be an important contributing factor to the onset and progression of myopia and may be task dependent. The purpose of this study was to quantify the habitual viewing distance behavior of children performing 5 different tasks on a handheld digital device.

Methods:

The viewing behavior of 38 children (6-17 years of age, including 17 myopes with spherical equivalent between –6.00D and –0.50D) was measured while performing 5 tasks in randomized order: Playing a cell phone game, watching video in light (680lux) and dark illuminated setting (5.5lux) and reading small (8pt) and large text (16pt) of a digital book. Custom, validated software (MyopiaApp, VisionApp Solutions SL) installed on a Google Pixel 6 was used to collect real-time viewing distance and illumination data at 30 frames per second. A total of 5 minutes of data were acquired for each task. The first and last minute of viewing distance and illumination data were discarded to avoid periods of interaction with the examiner when beginning and ending the task. A gradient filter was used to remove transient viewing distance data produced by sudden shifts in viewing while performing the task. A step-down procedure was used to adjust for multiple pair-wise comparisons.

Results:

When pooled across all subjects, mean viewing distance (mm) ± SEM was similar for most tasks (video light: 296.66±13.27, video dark: 302.29±13.07, small text: 284.22±12.17, large text: 310.23±15.41, game: 288.67±14.21) with the only significant difference between tasks being that participants held the device significantly further when viewing large text than small (Δ=25.66mm; 95% CI=[-46.60,-4.72], p=0.0177). By contrast, within subject analyses indicated significant within-subject differences between tasks. Specifically, at least 82% of participants showed significant difference in viewing distance by task.

Conclusions:

Average handheld device viewing distance was similar across a variety of everyday tasks in a representative sample of myopic and emmetropic children. However, participants reading small text held the device closer than that of large text. Individual subject factors may be associated with the task-dependent differences in viewing distance behavior observed within subjects.

P143: CD-marker screening on neuronal structures in the human choroid

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Purpose: The choroid is a mediator for the transduction of visually evoked retinal signals into scleral growth response via yet unknown pathways. Signals of the cranial autonomic nervous system are additionally processed in the choroid, together with signals of intrinsic choroidal neurons. While the interaction of all these sources is not clear, it is desirable to have a tool that might allow for discrimination of the different neuronal sources in order to provide further functional aspects. Therefore, we here ask if surface markers of the CD-family are present in choroidal innervation.

Methods: Human choroids were prepared for immunohistochemistry of the pan-neuronal marker PGP9.5 and combined with CD15, CD24, CD29, CD34, CD46, CD49b, e, CD56, CD81, CD90, CD146, CD147, CD151, CD171, and CD271. Fluorescence and confocal laser-scanning microscopy was used for documentation.

Results: While CD29, CD34, CD56, CD81, CD90, CD171, and CD271 were co-localized in intrinsic choroidal neurons as detected with PGP9.5, and revealed intense immunoreactivity, a low immunoreactivity was detected with CD146, CD147, and CD151. Immunoreactivity was absent with CD15, CD46, CD49b, e. While CD24 was absent in intrinsic choroidal neurons, it was present in nerve fibres of the choroidal stroma.

Conclusion: A broad panel of CD-markers was indeed detectable in intrinsic choroidal neurons, with the exception of CD24 that is possibly associated with extrinsic choroidal nerve fibres. The here described new surface code might be helpful in upcoming functional studies of choroidal control and its involvement in the development of ametropia.

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P172: Choroidal Thickness and Tear Breakup Time are Related in Myopia Patients: Supportive Evidence for the Correlation between Myopia and Dry Eye

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Purpose: Dry eye and myopia are the emerging pandemic diseases in the world, especially in Asia. Few studies have suggested the correlation between dry eye and myopia, but no definitive study has been performed. Previously, we have reported the higher incident of myopia development in school children who had dry eye symptoms (Yotsukura et al. JAMA ophthalmology 2020). In this study, we investigated the association between dry eye disease (DED) and myopia by evaluating higher order aberrations (HOAs) and choroidal thickness (CT) among myopic children with DED symptoms. The incidence of dry eye and myopia has increased dramatically in modern society. Is it a coincidence or related to the lifestyle in modern society?

Methods: In this cross-sectional study, we recruited 72 myopic (spherical equivalent of ≤ -0.5 diopter) children with DED symptoms (age, 12.8 ± 2.7 [mean ± standard deviation] years) who presented to Keio University Hospital Myopia Clinic. They were measured for the tear film breakup time (BUT), HOAs, CT, axial length (AL) and refraction. Lifestyle questionnaires were administered, and the correlations between the BUT and HOAs were evaluated. Multiple regression analyses were performed to identify relationships among myopia and BUT/lifestyle factors, myopia and corneal/intraocular/total ocular HOAs (spherical aberration [SA], 3rd-order [S3], 4th-order [S4] and the sum of the 3rd- to 6th-order aberrations [THOA] evaluated with a natural pupillary diameter [average value, ϕ = 6.1 mm]), CT and BUT/AL.

Results: The BUT, CT, AL, and cycloplegic refraction were 5.7 ± 3.1 seconds, 285.3 ± 38.4 μm, 25.52 ± 1.14 mm, and -4.61 ± 2.38 diopters, respectively. The BUT was correlated significantly with the corneal HOAs (SA, β = -0.323, P = 0.02; S4, β = -0.497, P < 0.001; THOA, β = -0.362, P = 0.009) and intraocular HOAs (S3, β = -0.299, P = 0.04; S4, β = -0.369, P = 0.008; THOA, β = -0.368, P = 0.009) but not with total ocular HOAs. Multiple regression analyses showed that the AL was associated significantly with the BUT (β = -0.067, P = 0.004) and the intraocular S3, intraocular THOA, total ocular S3, and total ocular THOA (β = -21.8, 21.2, -41.7, and 43.6, respectively; P = 0.02, 0.048, 0.045, and 0.049, respectively) but not with the corneal HOAs. The CT was associated significantly with the BUT and AL (β = 9.15 and -7.85, respectively; P < 0.001 and = 0.01, respectively).

Conclusions: We showed that the BUT was associated significantly with the CT that is related to the AL. As the parasympathetic nervous system affects the lacrimal glands and CT, the parasympathetic nervous system might be a common upstream factor in the association between DED and myopia. We would like to propose the new pathogenesis for both diseases from the point of parasympathetic inactivation.

P11: REFRACTIVE ERROR MANAGEMENT: NEW INSIGHTS INTO INHIBITING MYOPIA PROGRESSION IN CHILDREN AND ADOLESCENTS OF CENTRAL AND SOUTHEAST EUROPE

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Purpose
The aim of the study is to determine the patterns of myopia development in children and adolescents of Central and Southeast Europe.
Methods
Retrospective data review of randomly selected patients diagnosed with primary myopia and followed-up in the pediatric ophthalmology clinics of the University Eye Department of University Hospital „Sveti Duh“ within the period 2007.- 2021. Patient's age at the first and follow-up visits, and visual acuity at near and far monocularly and binocularly were recorded. Refraction was determined subjectively and objectively by retinoscopy in cycloplegia. Patients 0-18 years (y) of age from Central and Southeast Europe origin with primary naïve myopia and ≥ 2 follow-up visits over a period of ≥ 6 months were included and stratified according to age, sex, and classification of myopia. Analysis of myopia progression was modeled using analysis of variance (ANOVA).
Results
78 female and 48 male patients (3 – 18 y) were collected. A total of 685 examinations were recorded. Mean follow-up time was 5.3 y for males and 5.6 y for female patients. Mean age and appropriate standard deviation (SD) was 12.5 with SD 4.1 y and 17.5 with SD 3.7 y for males and 11.5 with SD 3.0 y and 16.5 with SD 3.2 y for females at the first and last examination respectively. At the first examination, 10 female and 5 male patients were diagnosed with premyopia, 63 female and 40 male patients with myopia, and 5 females and 3 males with high myopia. Premyopia onset was at 13.0 with SD 5.2 y for males and 12.3 with SD 3.2 y for females, low myopia at 12.8 with SD 4.0 y and 12.0 with SD 3.0 y respectively, and high myopia at 11.6 with SD 4.9 y and 11.0 with SD 2.5 y respectively. At baseline, there was no difference between sex but at the age of 18 years, more females were myopic ($p<0.05$). Between the first and last examination, the average spherical equivalent (SE) of subjective refraction increased -1.0 with SD 0.4 D RE and -1.0 with 0.4 D LE ($p<0.05$) in female patients and -0.95 with 0.5 D RE and -0.96 with SD 0.4 D LE in males ($p=0.01$). Based on retinoscopy, the increase measured -0.1 with SD 0.1 D RE -0.1 with 0.1 D LE in females ($p=0.005$). For male patients, the average SE increase was -0.1 with 0.2 D RE and -0.1 with SD 0.1 D LE ($p=0.0087$).
Conclusion
Females developed premyopia, low, and high myopia earlier than males. We hypothesize that observed sexual dimorphism of myopia development conforms to pubertal maturation. Moreover, at the age of 18 y, more females were myopic, advocating for sex as a modulating factor in the pathophysiology of myopia development. Overall, the earliest was the onset of high myopia, while premyopia outbroke the latest. Within the 5y of follow-up, the mean SE remained stable regardless of sex, while the subjective refraction increased for 1 D. In conclusion, undercorrecting the cycloplegic error for 1 D within the first five years of myopia onset proved to be effective in inhibiting myopia progression. Further studies are needed to affirm this relationship.

P145: Influence of short-term exposure to long, middle, and short-wavelength of light on axial length in humans

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Purpose: There is growing evidence on the role of the narrowband wavelength of light exposure on altering the axial length. We investigated a) the effect of brief period of exposure to red, green, and blue light on ocular biometry in the presence and absence of lens-induced hyperopic defocus, and b) the effect of blue light exposure during morning and evening on time course change in ocular biometry in humans.

Methods: Experiment 1: 25 young adults were exposed to blue (460 nm), green (521 nm), red (623 nm), and white LED light for 1-hour each on 4 separate experimental sessions conducted on 4 different days. In each light condition, hyperopic defocus (3D) was induced for the right eye with the fellow eye experiencing no defocus. Experiment 2: 23 participants were exposed to blue light for 1-hour at two different times of the day: morning (between 9.00 to 11.00 am) and evening (5.00 to 7.00 pm). In both sessions, baseline axial length was measured under white light conditions and every 10 minutes during 1-hour of exposure to blue light. For both experiments, ocular biometry was determined using a non-contact biometer Lenstar LS 900.

Results: Experiment 1: Axial length increased significantly from baseline after red light (mean difference ± standard error in the right eye and left eye = 11.2 ± 2.0 µm and 6.4 ± 2.3 µm, $P < 0.001$ and $P < 0.01$, respectively) and green light exposure (9.2 ± 3.0 µm and 7.0 ± 2.5 µm, $P < 0.001$ and $P < 0.001$). Blue light exposure resulted in a reduction in axial length in right (−8.0 ± 3 µm, $P < 0.001$ and left eyes (−6.0 ± 3 µm, $P = 0.11$). Experiment 2: A significant reduction in axial length from baseline was noted in morning (-6.0 ± 2.7 µm, p=0.04), and evening (-10.9 ± 3.4 µm, p=0.004) blue light exposure. The rate of reduction in axial length was faster during evening than morning (slope ß, morning exposure = -0.104 versus evening exposure = -0.182, p =0.04).

Conclusion: Brief exposure to blue light inhibited the effect of lens-induced hyperopic defocus and resulted in a shortening of the axial length. Moreover, both morning and evening blue light exposure led to a significant reduction in axial length. The effect of blue light exposure in the prevention or control of myopia progression in humans as a myopia control strategy needs to be explored through randomized clinical trials.

P103: Near work or light level for myopia – which factor dominates and influences axial length?

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Purpose:
Light (inhibitory effect) and and near-work (triggering effect) under the category of environmental factors are known to be associated with myopia. It is unclear how near-work performed in outdoor natural bright light affects the transient changes in axial length. This study aimed to investigate if natural bright light can inhibit the effect of near work when performed outdoors.

Methods:
A total of 2 reading sessions were designed for all participants with location/environment type of these sessions being different. Twenty-seven young adults (18 emmetropes and 7 myopes) were tasked to 15-minute of reading a story placed at 20 cms from eye in the indoor (session-1: 70 ± 11 lux) and the outdoor environmental setting (session -2: 37394 ± 17409 lux). The reading material was "The Adventures of Sherlock Holmes", which consisted of black-on-white text printed on a paper (8 point Times New Roman English font, 3 mm of horizontal spacing between two adjacent words, contrast 90%). Both the sessions were conducted on the same day and in the morning session (before 12 PM). The primary outcome measure was the change in axial length which was recorded in each session pre- and post-near task using a non-contact optical biometer.

Results:
Axial length increased significantly from baseline for reading tasks in both indoor (mean ± SEM; 9.3 ± 2.8 µm, p=0.004) and outdoor environments (10.4 ± 2.9 µm, p=0.001). The pre- versus post near task changes in axial length between the indoor and outdoor environments were not significantly different (p=0.27). Lens thickness and vitreous chamber depth increased significantly from baseline for both the above reading tasks ($p<0.001$). No significant differences in axial length, lens thickness, and vitreous chamber depth were noted between emmetropes and myopes for both indoor and outdoor environment ($p>0.05$).

Conclusion
Irrespective of light levels/environment type (indoor or outdoor), reading tasks lead to increase in axial length. Near work seem to dominate and override the protective effect of outdoor light properties on axial length elongation and might have implications in myopia management.

P35: Contrast polarity of text presented in modified pattern electroretinogram affects retinal responses in emmetropes and myopes differently

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Purpose: Still, it is unclear which factor during nearwork makes the eye grow longer, promoting myopia. Reading black-on-white text predominantly activates retinal OFF-channels, thereby inducing choroidal thinning, which is associated with myopic onset (Aleman 2018). We performed an explorative trial to assess whether retinal responses are likewise influenced by the text's contrast polarity, and whether responses differ between emmetropic and myopic eyes. Stimulation was performed at different retinal eccentricities, with largest effects being expected perifoveally (Panorgias 2021).
Methods: Pattern electroretinograms (pERG) were recorded with a DTL electrode in 8 emmetropic and 9 myopic (SER OD -3.9±3.5D) participants (age 29±6yrs, 8 males) using a 30°-dead leaves stimulus (DLS). DLS was first overlaid by a 6-12°-ring, 12°-circle, and 6°-circle with text of changing contrast polarity (standard: black-on-white text; inverted: white-on-black text; blank: grey, no text), and lastly presented as pure DLS. Conventional pERG was also performed. For each of the 11 conditions, 128 sweeps of 188ms each were recorded, detrended, and smoothed. Groups and conditions were compared using the 95% CI of the differences between their grand-averages.
Results: N95 pERG amplitudes were reduced in myopes while responses to pure DLS were similar in the 2 groups. Modified DLS with both standard and inverted contrast led to stronger N1 responses in myopes compared to emmetropes when presented at 6-12°. Inclusion of fovea up to 12° induced weaker N2 responses in myopes than emmetropes for inverted contrast. Analyzing both groups separately revealed stronger responses at 12° to inverted than to standard and blank conditions in emmetropes. At 6-12°, emmetropes displayed stronger N1 responses to blank than to inverted and standard contrast. Contrarily, at 6°, when comparing blank to standard, they had stronger N1 for standard, but larger N2 responses for the blank condition.
Conclusions: Text contrast polarity affects electroretinograms depending on retinal eccentricity and refractive error. Compared to emmetropes, myopes had weaker retinal responses to inverted contrast for foveal and parafoveal, but not for perifoveal stimulation. To assess whether effects derive from anatomical differences or different retinal processing in myopic eyes, further studies are planned, also considering steady-state pERG, full-field ERG (ON-OFF, PhNR) or CSNB patients to isolate ON-pathway contribution.

P5: Does preventing myopia conflict with improving academic performance? Evidence from Shanghai Time Outside to Reduce Myopia (STORM) trial

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Background: Time outdoors could reduce myopia onset, but parents and students often squeeze outdoor time in pursuit of ideal academic performance. The study was to explore the relationship between outdoor time and academic performance among school-aged children.
Methods: This study was designed as a cross-sectional study. Data were derived from a school-based prospective children myopia intervention study (STORM). Outdoor time was recorded by self-developed algorithm-validated wristwatches in real-time and calculated as the cumulative average of 10 months. The academic performance was recorded and provided by the participating schools and further standardized. Other information was collected using an online standardized questionnaire. Mixed-effects model and B-Spline method were used to investigate the association between time spent on different types of daily activity, including outdoor activity and academic performance.
Results: A total of 3291 children with mean age 9.25 years were included in the final analysis. Overall, outdoor time was associated with academic performance in a non-linear manner; specifically, not exceeding 2.3 hours per day, outdoor time was positively associated with academic performance; exceeding 2.3 hours per day, this association became non-significant. Likewise, daily sleep duration and out-of-school learning time were associated with academic performance in a non-linear manner, resulting in turning points of 11.3 and 1.4 hours per day, respectively. Separate analysis showed that outdoor time and sleep duration but not out-of-school learning time were positively associated with academic performance in Chinese, mathematics and English.
Conclusion: Outdoor time, sleep duration and out-of-school learning time were associated with academic performance in a non-linear manner. Promotion of academic performance may not conflict with increasing time outdoors and myopia prevention.

P180: High myopia and Depression: The AIER-SERI High Myopia Cohort Study

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Abstract

Aim: The AIER-SERI High Myopia Cohort Study is a prospective study aiming to elucidate the natural history of high myopia and the best practice to manage high myopia. This study reports the association between high myopia and depression and relevant factors that may contribute to depression.

Methods: A total of 173 patients aged 34 to 76 years with myopia of -6.00D to -30.00D in both eyes seen at the Aier eye hospital in Changsha, China were included. All patients had undergone ophthalmic examinations, including habitual distance and near visual acuity, refractive error and axial length. Depression was evaluated by the Patient Health Questionnaire-9 (PHQ-9), which was categorized into 'no', 'mild', 'moderate' and 'severe depression'. The impact of vision impairment on daily life was assessed by the Vision Impairment questionnaire (IVI questionnaire), which comprises three parts of impact by the vision impairment: mobility and independence, reading and accessing information, and emotional wellbeing. The impact was graded as severe, moderate and mild levels. Multivariable logistic regression was conducted to determine the factors (habitual distance and near visual acuity, refractive error, axial length, the level of impact on daily life) that were associated with depression (depression was treated as binary variable for the regression analysis).

Results:

The prevalence of depression in this population was 67.2% (117/173), among which 49.1% （85/173） was mild, 17.9% （31/173） was moderate and 0.6% （1/173） was severe depression. No patients complained severe impact, but 13.8% (24/173) and 86.1% (149/173) of patients complained moderate and mild impact on their daily life. Multivariable logistic regression revealed that only the level of impact on daily life was associated with depression (p=0.02).

Conclusion: Depression was common in this group of patients with high myopia. A combined visual performance in everyday life, compared with single clinical metrics, was more sensitive to predict depression.

Keywords: High myopia, Depression, Quality of life

P41: Change in axial length during accommodation with myopia control soft contact lenses

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Purpose: While it is hypothesized that myopia control soft contact lenses (CLs) exert their treatment effects through introducing peripheral myopic defocus, the possibility that altered accommodative behaviors at near may also contribute requires further investigation. This research examined whether dual focus (CooperVision MiSight) and extended depth of focus (SEED 1dayPure EDOF) CLs alter the magnitude of axial length (AL) change during accommodation when compared to single vision distance CLs (CooperVision Proclear).
Methods: Twenty adult myopes participated in this study (mean age 23 ± 3 years, mean spherical equivalent refraction −3 ± 1 D). Measures of AL, anterior chamber depth (ACD), lens thickness (LT) and central corneal thickness (CCT) were captured using the Zeiss IOLMaster 700 while participants were wearing each of the 3 CLs, and simultaneously viewing accommodation stimuli of 0, 3 and 6D via a custom-built Badal optometer. The order of lens wear and accommodation level was randomized. CCT values were subtracted from AL values to eliminate the effect of CL thickness on the measures, and each participant's individual ocular parameters were used to estimate and correct for any error induced in AL measurements by changes in LT during accommodation. Linear mixed model analyses were performed for AL, ACD, and LT with fixed factors of accommodative stimulus and CL design.
Results: AL changed significantly with accommodation ($p \leq 0.001$), with an average axial elongation of +6 ± 13 µm at 3D ($p \leq 0.05$) and +9 ± 13 µm at 6D ($p \leq 0.001$), however there was no significant effect of CL design on these changes ($p = 0.106$). As expected, ACD and LT changed significantly between all accommodative demands (all $p \leq 0.001$), however the effect of CL design was also significant ($p \leq 0.001$), with a significantly deeper ACD ($p \leq 0.001$) when participants wore MiSight (3.90 ± 0.2 mm) compared to the Proclear (3.85 ± 0.2 mm) and SEED lenses (3.84 ± 0.2 mm), and a significantly thinner LT ($p \leq 0.001$) when participants wore MiSight (3.65 ± 0.2 mm) compared with Proclear (3.70 ± 0.2 mm) lenses. The difference in LT between MiSight and SEED CLs approached significance ($p = 0.076$).
Conclusions: While accommodation-induced axial elongation during near work was not affected significantly by either myopia CL, the ACD and LT dimensions during MiSight lens wear indicated the participants exhibited significantly reduced accommodative effort for a given demand for all accommodative stimuli tested.

P182: Estimation of the Prevalence of Myopia in New Zealand Based on Driver Licence Refractive Correction Requirement

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Purpose: The prevalence of myopia is increasing worldwide, with an estimated 50% of the world's population likely to have myopia by 2050. However, there is currently no published estimate of the prevalence of myopia in New Zealand, or whether the prevalence is increasing. This study aims to estimate the prevalence of myopia in New Zealand by using data provided by Waka Kotahi New Zealand Transport Agency (NZTA) on the number of driver licence holders that have a B condition recorded, indicating that they must wear refractive correction at all times while driving.

Methods: We performed a retrospective, secondary analysis of de-identified NZTA data on driver licence conditions for the years 2001, 2006, 2013 and 2018. The driver licence status (with or without a B condition) was provided in stratified form by gender and 5-year age groups (less than 24 to 75 years+). There were 3,672,327 drivers in New Zealand in 2018 (74.9% of the whole population). The licence condition of the 25 to 44 years age range was used to estimate myopia prevalence in New Zealand (the minimum driving age is 16 years in New Zealand). This age range was selected based on the assumptions that by 25 years, refractive error is usually stable and after 44 years, onset of presbyopia would result in an increased requirement for correction due to manifest hyperopia.

Results: The overall proportion of drivers with B condition for all ages (<24 to 75 years+) was stable from 2001 to 2018 at 27.7 ± 0.6% (mean ± SD). For the selected age range of 25-44 years, the proportion of licences with the B condition was 21.6 ± 0.5%. No significant change in this proportion was found in the 5-year age groups between 2001 and 2018. This implies a stable prevalence of myopia from 2001 to 2018. However, a significantly higher proportion of 25–44-year-old female drivers (25.2 ± 0.6%) had condition B on their drivers licence, when compared to male drivers (18.1± 0.5%; $P<0.001$).

Conclusions: Using the driver licence B condition as a proxy for the prevalence of myopia in the 25 to 44 year age group, the prevalence of myopia in New Zealand was estimated at approximately 22%, and this prevalence appears to have been stable from 2001 to 2018.

P115: A qualitative research: Myopia management policy in the Netherlands

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05-2022

ABSTRACT

Topic: Opportunities and barriers between eye care professionals and associations on collaboration regarding myopia management policy in the Netherlands.

Societal problem: Myopia is a leading cause of blindness and other ophthalmic eye conditions. Children are becoming myopic at a younger age. Because complications of myopia are largely irreversible in adulthood, the time to alter the visual prognosis of myopia lies in childhood. A lot of interventions are available in different organizations, provided by different health care professionals to reduce the eye growth of a myopic child. Examples are an ophthalmologist, orthoptist or optometrist who can work in different settings, making myopia a multi-stakeholder issue. Collaboration between different eye care professionals and organizations is of great importance in realizing myopia management policies. Currently, associations of eye care professionals and organizations develop their 'own' policies regarding myopia care for a child. At this moment, it is unclear whether parties are collaborating and what opportunities and barriers exist between eye care organizations regarding collaboration, in order to improve myopia management policy in the Netherlands.

Research Objective: The aim of this study is to contribute to a strategy of collaboration focusing on improving the current myopia management policy in the Netherlands by making an assessment of the opportunities and barriers of collaboration between eye care organizations and associations.

Research Question: What are opportunities and barriers of eyecare professionals and associations on collaboration regarding myopia management policy in the Netherlands?
Conceptual framework: Two frameworks were used to select themes to strengthen the theoretical background.

Methodology: A qualitative research methodology was used utilizing a semi-structured interview guide, based on theory and an empirical approach to fulfill the objectives of this study. Online interviews with eye care professionals (n = 13) were conducted in the period of April and May 2022 and were recorded, transcribed and coded for concepts and themes.

Results and discussion: Relationships between concepts and themes were examined and used to describe collaborative relationships in eye care settings. Four themes derived from the interviews and the conceptual framework: collaboration, communication, current myopia policy and its perspectives and moral values in the interaction of professionals.

Conclusion: Collaboration is needed to make and implement policies around myopia control. Barriers as limited time, organisation, interorganisational communication and moral values are important aspects to consider in making policy with different groups of eye care professionals. The opportunities lay in arranging annual meetings, better mutual understanding and needs, evidence based resources of myopia control, clear communication and professional role clarification. It is crucial to merge different professionals for better myopia control policies.

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P168: A Clinical Evaluation of RDx-Based Tele-Controlled Subjective Refraction

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Purpose: The purpose of this paper is to compare the reliability and acceptability of tele-controlled subjective refraction supported by RDx, a new technique that involves optical software designed for controlling phoropters remotely, to traditional subjective refraction.
Methods: We conducted a cross-sectional study on 65 participants (aged 9 to 40 years). Tele-controlled subjective refraction and traditional subjective refraction were randomly performed by an experienced optometrist. The subjects were further divided into subgroups according to age (age≤18 and age＞18) and the elapsed time taken for refraction, sphere (S), cylinder (C), spherical equivalent (SE), and the vertical and oblique cylindrical vectors (J0 and J45) were compared. We used Bland-Altman analysis to assess the agreement between both methods of refraction. Finally, a validated questionnaire distributed to each participant after the examination was applied to evaluate the patient receptibility of the tele-controlled subjective refraction.

Results: We found no statically significant differences ($P > 0.05$) between tele-controlled subjective refraction and traditional subjective refraction for all parameters in either group. The mean difference and 95% limits of agreement for SE, J0, and J45 were -0.03±0.36 D, -0.00±0.57D D, and -0.01±0.79D, respectively. Similar results were found when comparing SE, J0, and J45 among subgroups as well. We also observed the percentage of SE, J0, and J45 differences between the tele-controlled method and the traditional method of refraction that fell within ±0.50D in 99%, 89%, and 84% of all eyes, respectively. Completed questionnaires were returned by 55 participants (85%), and they showed high satisfaction and acceptance of the tele-controlled method (98%), although the tele-controlled method took more time than the traditional one ($P < 0.05$).

Conclusions: Tele-controlled subjective refraction agreed with traditional subjective refraction for all refraction components except for the cylinder axis. In addition, the broad receptibility of tele-controlled subjective refraction means practicability in clinical practice. This new technique may become a valuable supplement for areas that lack experienced optometrists.

Global trends in myopia management attitudes and strategies in clinical practice - 2022 International Myopia Institute Update

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Purpose: Surveys in 2015 and 2019 identified high eye care practitioner (ECP) concern about myopia with a reported moderately high level of activity, but the majority still prescribed single vision interventions to young myopes. This research updates these findings to examine the uptake of evidence in this field.
Methods: A self-administrated, internet-based questionnaire was distributed in local languages, through professional bodies to ECPs globally. The questions examined: awareness of increasing myopia prevalence, perceived efficacy and adoption levels of available strategies, and reasons for not adopting specific strategies.
Results: Responses from 41 countries have been received (n=508). Myopia concern was high (median 8.3/10), particularly in Chinese speakers (9.2±1.3), but overall self-rated activity was lower (6.9±1.1) Undercorrection was rated the least effective (10.1±5.1%) and combination optical/pharmaceutical therapy the most effective (63.4±20.1%). Prescribing patterns for young myopes reflected previous findings (single vision spectacles 19.1±3.8/month and soft contact lenses 8.3±4.6/month). However, a marked increase in prescribing atropine (8.9±11.0) specific myopia control spectacles (7.1±4.6) and soft contact lenses (6.3±3.9), and orthokeratology (5.1±3.0) was found. Over half (57-58%) would prescribe for a -0.50 to -1.00D child progressing 0.26-0.75D/year. The main factors preventing prescribing were cost (28.4%), treatment availability (23.2%) and inadequate information (22.3%). The type of management was mainly driven by age (77.2%) and refraction (51.7%, cyclopleged 59.1%). Refractive error and age were the main motive in beginning myopia control, whereas child/parental pressure had little impact.
Conclusion: By 2022 myopia control strategies are being adopted by ECPs, but costs and limited information are still barriers that need addressing.

Practitioners' Perception on Myopia Management Practice in China

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Purpose
To gain an in-depth understanding of myopia management patterns, the barriers and unmet needs of myopia management, and resources required to support evidence-based myopia management in China.

Methods
This is a project initiated by the Asia Optometric Congress to understand the perspectives of eye care practitioners in China on myopia management. Eighteen optometrists in China were recruited voluntarily through local professional associations. In-depth semi-structured face to face live interviews were conducted online between Jan and Mar 2022.

Interviews were up to 45 minutes and were recorded and transcribed. A framework method was used for thematic analysis of the data.

Results
Eighteen optometrists who practiced in clinical practice completed the semi-structured interview. Their clinical experience ranged from 3 to 25 years (12.4 ± 5.6 years), either in private practice or hospital.

Thematic analysis revealed five main themes: practitioner knowledge and attitudes, scope of practice, patient attitudes, public awareness and practitioner support required.

There was high interest in myopia management amongst the practitioners, however, most were concerned about the unpredictable clinical outcome, lack of public awareness and parental understanding in myopia management. Practitioners were also concerns about the limited return on investment of myopia management.

The perceived most effective myopia control treatment is myopia control spectacles or orthokeratology. Other options like traditional Chinese medicine or low-level red light therapy were also considered due to affordability. Visual hygiene and outdoor activities were recommended in addition to the myopia management treatment. Atropine was not a popular treatment due to rebound effect.

Practitioners reported that treatment cost is a major concern for patients especially in the rural areas, and lack of trust in practitioners, awareness of myopia and the complications due to myopia, and misconceptions surrounding the use of non-evidence based treatments.

The practitioners believe that professional ethics, continuing education, legislation in myopia management treatment, regulatory approval, professional development to expand the scope of practice, and public education are key to support more practitioners to practice myopia management.

Conclusions
This is the first in-depth study exploring the perspectives of practitioners in China on the barriers and solutions to support myopia management practice. The study findings will support the professional development of eye care practitioner to practice evidence-based myopia management and advance patient care and reduce the future healthcare burden due to the ocular complications associated with high myopia.

Descriptive statistical comparison of interventions for myopia control – a new analysis

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Purpose. Few comparisons of the various interventions for myopia control exist in the literature and conjecture remains as to whether myopia control efficacy can be described as an absolute or proportional effect. The aim of this study was to directly compare the 12-month myopia control efficacy of treatments investigated in randomized controlled trials reporting measurement of axial length.
Methods. The scientific literature was searched for randomized controlled trials investigating myopia control efficacy of orthokeratology, dual-focus concentric, extended depth of focus (EDOF) and multifocal myopia control soft contact lenses, low-concentration atropine (0.01 to 0.05%), bifocal and novel (DIMS, HAL and SAL) myopia control spectacle lenses. Studies were included which reported descriptive statistics (mean and standard deviation or standard error) for change in axial length in both the treatment and control groups. Standard deviations and standard errors were converted to 95% confidence intervals (CI) to enable graphical comparison of axial length outcomes of treatment effect (control minus treatment growth) and total growth of treatment and control groups.
Results. Treatment effects over 12 months (mean 0.14mm) show CI overlap for most treatments except for 0.01% atropine and CD +1.50 Add multifocal contact lenses which cross zero. Distinctly better efficacy can be seen between DIMS and HAL spectacles and the less effective EDOF contact lenses, SAL spectacles and CD +2.50 Add multifocal contact lenses. Dual-focus concentric, CD +2.50 Add multifocal and orthokeratology contact lenses overlap with DIMS, HAL, SAL and bifocal spectacles and 0.02% to 0.05% atropine. Total growth analysis reveals differences between control groups confounding direct comparison of treatment effects. Dual-focus concentric and CD multifocal control groups fall below the mean control group growth (0.35mm) while atropine control groups exceed the mean.
Conclusion. Wide CI outcomes caution against claiming superiority of any treatment, with caveats confirmed here (as previously noted by Brennan et al) that 0.01% atropine and centre-distance +1.50 Add multifocal contact lenses are less effective as their CI's cross zero. Postulation of an absolute treatment effect, however, deserves similar caution owing to the spread of CI's and dissimilarity of control groups. Accounting for control group variability may be better served through analysis of proportional myopia control efficacy.

The Future of Clinical Trials of Myopia Control

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Purpose: The field of myopia control has matured such that effective optical or pharmaceutical therapies are available to patients. This creates challenges for the conduct of randomized clinical trials in the areas of ethics, recruitment, retention, selective loss of fast progressors, non-protocol additional treatments.

1) Ethics: It is now valid to question whether placebo/non-intervention control groups are ethical
2) Recruitment: Availability of treatments is making recruitment into clinical trials more difficult
3) Retention: If masking is not possible, parents may immediately withdraw their child if randomized to no treatment. In masked trials, parents being offered the certainty of known treatments may not remain in the trial
4) Selective Loss: Withdrawal of fast progressors in the control group leading to a control group biased towards low progression
5) Non-protocol treatment: Parents may avail of other myopia treatments in addition to those within the trial

This study aims to identify the number of myopia treatment trials at risk of such issues and propose solutions.

Results: Of 36 active myopia control trials listed on ClinicalTrials.gov, 28 are conventional controlled trials (78%) which are at risk of significant compromise or failure due to these issues. There is one trial using a non-randomized, matched control group and two using sham therapies, with the remainder using atropine or orthokeratology as a control.

We propose that future trials may need to be modified to adopt one of the following designs.

A. Non-inferiority trials using an approved drug or device as the control. The choice will depend on whether a regulatory agency has approved a drug or device.
B. Virtual control group trials based on data relating to axial elongation, myopia progression, or both, accounting for subject age and race. The comparison data could be:
i. Parametric models of average progression/elongation derived from existing published data
ii. Centile-based reference charts derived from existing data
iii. Using a virtual control group of individuals from real world evidence
iv. Using a virtual control group of individuals pooled the control groups of recent trials
C. Time to treatment failure (TTF) trials using survival analysis or time to event wherein once a treated or control subject progresses or elongates by a given amount, they exit the study and receive treatment, be it the one under investigation or established. Long term progression and elongation thresholds for termination could be based on existing parametric models, centile models, observational epidemiological studies, real world evidence or meta-analyses of prior trials.
D. Short Conventional Efficacy Trials. Data from larger clinical trials suggest that the treatment benefit is greater in the first year (or six months) than in subsequent years. Adequately powered short term trials with conventional control groups could therefore establish short term efficacy without the above issues. Intermediate term efficacy may be able to be projected from existing longer trials, with definitive long-term efficacy being determined from longer non-inferiority trials with established treatments. This would be an efficient method of differentiating effective vs ineffective treatments, without requiring 2-3 trials initially.
E. Short-Term Control Data. meta-analysis shows that while Asian children progress faster than non-Asians, both groups show 15% annual reduction in axial elongation with age. Thus, a control group could be recruited but only followed for one year to establish rate of progression and elongation for the population under study.

Conclusion: The future development of new treatments in myopia control will be hampered if significant changes are not made to the design of clinical trials in this area. A coordinated response from all stakeholders will be required to make such a transition.

Management of myopia in a Danish Hospital setting

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Purpose
A Myopia Clinic has been established at the Ophthalmic Department of University Hospital of Southern Denmark to treat childhood myopia in children at risk of becoming high myopic.
We present our current treatment algorithm and the distribution of children receiving different treatment modalities.

Methods
Children aged 5 to 9 years and myopia > 2 diopters (D) cycloplegic spherical equivalent refractive error (cSEQ) or age 10 to 12 years and myopia > 4 D cSEQ without other eye diseases are referred from private ophthalmic practice to the Myopia Clinic. Treatment is indicated in children with active myopic progression and age correlated axial length with a risk of high myopia of ≥ 16% according to the growth charts by Tideman et al.[1] Treatment modalities are OKL (Dreamlite®, Procornea, LZ Eerbeek, the Netherlands) and atropine eyedrops (initial dose 0.05%).[2] Treatment modality is chosen by the family. Treatment efficacy is monitored by axial length. Acceptable axial growth is defined as < 0.15 mm in boys and < 0.12 mm in girls during 6 months.[3] Combination therapy is indicated when monotherapy is considered insufficient. Treatment is discontinued when the child is ≥ 15 years of age and the axial length is stable defined as growth <0.03 mm during 6 months.[4]

Results
A total of 149 patients were engaged with the myopia clinic the 1st of May 2022. Hereof 49 patients received atropine eyedrops (individualized dose), 34 ortho-k lenses, 3 patients received combination therapy with ortho-k and atropine, 46 patients were monitored for myopia progression, 16 patients were referred awaiting their initial examination, and one patient was diagnosed with Sticklers Syndrome and had not initiated treatment. No severe or sight-threatening adverse effects to the treatments were observed.

Conclusion
Of children in anti-myopic treatments at the Myopia Clinic at the Ophthalmic Department of University Hospital of Southern Denmark 43% are treated with OKL as mono- or combination therapy.

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The Refractive Mechanism Map: application of a biometric definition of refractive error in myopia research

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Purpose: Purely optical definitions of refractive error are appropriate for the correction of myopia, but incomplete in relation to monitoring interventions that alter ocular growth. A comprehensive biometric model of emmetropic eyes was developed and applied to classify the biometric features of myopes enrolled in on-going myopia control trials.

Methods: We analysed 11,483 European and American emmetropic eyes (+0.5 to > -0.5D), age 6 to 50 to create a gender and age-specific statistical model of emmetropic eyes that included axial length, corneal curvature, lens thickness and internal dioptric power (IDP), i.e. lens contribution from lens power and location, not lens power per se. We developed a custom algorithm based on this model, that calculates the proportion of the overall spherical equivalent refraction (SER) attributable to the axial length, cornea and lens for an eye compared to age and gender matched emmetropes. This 3-dimensional data is represented on a two-dimensional colour-coded diagram (the "Refractive Mechanism Map") that provides a means of quantifying and differentiating axial, corneal, lenticular or mixed refractive errors. We used this technique to analyse 353 myopes enrolled in myopia control trials to demonstrate the biometric variability for a given spherical equivalent refraction.

Results: Emmetropic corneal curvature showed minimal changes from 6 to 21 years of age (male 7.87mm to 7.86mm; female 7.73mm to 7.73mm). Emmetropic axial length at 6 years of age was 22.89mm in males and 22.45mm in females, increasing to 23.97mm in males at 21 and 23.46 in females. Internal dioptric power (IDP) decreased over time from 15.96D at age 6 in males to 13.20D at age 21. In females IDP decreased from 16.36 to 13.72 over this period. The gender differences (male vs female) were significant across all ages in corneal curvature (mean difference 0.137mm, 95% CI 0.139 to 0.135), axial length (mean difference 0.522mm, 95% CI 0.517 to 0.528) and IDP (mean difference -0.505D 95% CI -0.510 to -0.501), with females showing shorter axial lengths, steeper corneal radii and higher IDP. The myopic trial participants showed the expected significant correlation between ser and axial length (R2 = 0.46), but biometric analysis showed that this population showed a significant level of heterogeneity. Of the 353 right eyes, Refractive Mechanism Map calculations showed axial length was the largest contributor (i.e. true axial myopia) to the myopic refraction in 300 cases (85%), corneal power (i.e. corneal myopia) was dominant in 49 (14%) and the lens was dominant in 4 cases (1%, i.e. lenticular myopia). The proportion of axial myopes varied with SER. For SER = -1D +/- 0.5D, 70% (39/56 eyes) were classified as predominantly axial. For SER = -2D +/- 0.5D, 81% (67/83 eyes) were predominantly axial. For SER = -3D +/- 0.5D, 90% (57/63 eyes) were predominantly axial. For SER = -4D +/- 0.5D, 61/67 eyes, 91% were predominantly axial. For SER = -5D +/- 0.5D, 42/44 eyes, 95% were predominantly axial. For SER <= -6D, 22/22 eyes, 100% were predominantly axial.

Conclusions: All major biometric parameters of emmetropia are gender and age specific. While axial length is significantly correlated with ser in myopes, lower myopes include a proportion of non-axial myopes that declines with increasing myopia. Future clinical trials of treatments designed to slow axial elongation should consider biometric-based inclusion criteria to identify axial myopes and current/prior trials should consider using baseline biometric characteristics as a potential basis for subgroup analysis of efficacy.

Comparison of Superficial and Deep Retinal Layer Thickness Ratios for Diagnosing Glaucoma in Low and High Myopia

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Purpose

To evaluate the superficial/deep retinal layer thickness ratio for diagnosing glaucoma in myopic eyes.

Methods

Cross-sectional study. Subjects underwent ophthalmic examination including visual acuity, auto-refraction-keratometry, visual field testing, axial length measurement, intraocular pressure measurement with Goldmann applanation, and dilated retinal examination. Eyes were divided into low myope (LM, SE between 0 and -3D and AL < 24 mm), high myope (HM, SE < -6D or AL < 26mm), with or without glaucoma visual field loss. LM or HM eyes with glaucoma were divided into high tension glaucoma (IOP > 21 mm Hg) or normal tension glaucoma (IOP 21 mm Hg and below). Spectral domain-OCT measurements of the disc and macula were performed, and processed with automated segmentation software and MATLAB to derive sectoral and global measurements of the superficial retinal layers (ganglion cell complex and ganglion cell-inner plexiform layer complex) and deep retinal layers (inner retinal layer to retinal pigment epithelium). Magnification correction was applied based on axial length, and linear regression performed after correction for age and gender. AUCs were compared between superficial layer measurements and superficial/deep thickness ratios.

Results

110 HM subjects, 95 LM subjects, 62 HM-glaucoma subjects and 27 LM-glaucoma subjects were included in the analysis. Mean and SD of deep retina layers were similar in LM and HM, with and without glaucoma. AUCs of superficial vs superficial/deep ratios were highest in the inferotemporal sector using thickness ratios in LM-HTG (0.90), LM-NTG (0.98) and HM-NTG (0.80). AUC of GCIPL alone was highest in the inferotemporal sector for HM-HTG (0.93).

Conclusion

Superficial/deep retinal thickness ratios have good to excellent AUC for the diagnosis of glaucoma in myopia, and may be a useful adjunct for establishing an accurate diagnosis of NTG in HM eyes - a particularly challenging group of patients to manage.

Association of optic disc abnormalities with refractive error and OCT measurements in myopic children

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Purpose: Optic disc abnormalities, such as optic disc tilt (ODT), peripapillary atrophy (PPA) and large cup-to-disc ratio (CDR) are often noted in myopic children. Here, we investigate the association of these observations with refractive error and OCT measurements.
Methods: The PROM-Kids myopia cohort included children aged 7-16 years presenting to a myopic clinic in Singapore. Children were reviewed annually with cycloplegic autorefraction, axial length and fundal and optical coherence tomography (OCT) images obtained using the Topcon Triton swept-source OCT. Right-eye baseline optic disc characteristics of the first 460 children were analysed. Children were divided into 3 groups with spherical equivalent (SE) of (A) 0.00 to -3.00D, (B) -3.01 to -6.00D, and (C) -6.01 to -12.00D.
Results: There were 125 (27%), 208 (45%) and 127 (28%) children in Groups A, B and C, respectively. There were no significant differences in gender, race, intraocular pressure and CDRs between groups. As expected, SE was highly correlated with increased axial length, ODT and PPA. Increased myopia was also associated with decreased OCT-measured optic disc thickness in the superior, inferior and nasal, and increased thickness in the temporal rim. In the 190 children who had follow-up data at 2 years, subsequent faster myopia progression was associated with reductions in superior and nasal rim thickness, and increases in temporal rim thickness. Multivariate analysis suggests that superior and temporal changes may also be greater in females and in Chinese children.
Conclusion: Higher myopia was associated with reductions in OCT measured optic disc thickness in all quadrants except in the temporal rim where it was thicker. Follow-up OCT suggests that this temporal rim thickness continues to increase over time, especially in eyes with greater progression. Also of interest was a novel finding that greater change in the superior and temporal rims was noted with myopic progression in females and Chinese children within this cohort.

Comparing the orientations of fibers of the peripapillary sclera of healthy volunteers and high myopia patients with polarization-sensitive optical coherence tomography

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Purpose:
Information on the structure and direction of the scleral collagen and retinal nerves might be helpful in the diagnosis and monitoring of high myopia. In this pilot study, polarization sensitive-OCT (PS-OCT) is used to image the orientation and birefringence of collagen fiber structures in the eye of myopia patients and compared to healthy volunteers.

Methods:
A depth-multiplexed, fiber-based PS-OCT system is used to extract quantitative and local information on optic axis, birefringence, and depolarization tissue properties from the retina and peripapillary sclera. Fiber orientation en face images of RNFL, Henle's fiber layer and differently-oriented layers of sclera are created using a deep learning segmentation algorithm. The setup contains a swept-source laser centered at 1060 nm with a repetition rate of 200 kHz. Data of 24 healthy volunteers and 24 high myopia patients will be obtained.

Results:
As the orientation of the retinal nerves is known to be radially from the optic nerve head, absolute orientations of Henle's fiber layer and the sclera can be extracted. The first layer of sclera collagen fibers is oriented approximately parallel to the retinal nerves. A ring structure can be recognized around the optic nerve head, where the orientation of the collagen fibers is circular in healthy volunteers. Preliminary results show that this ring structure is asymmetrical in shape in myopia patients.

Conclusion:
PS-OCT has been used to successfully extract optic axis orientation of the retinal nerves, Henle's fiber layer and the sclera locally in 3D in vivo. The PS-OCT system will be used to detect pathological changes in fiber structures associated with disease. PS-OCT imaging of myopia can improve our understanding of retinal biomechanics and structural alterations in different disease stages.

Two-years evolution of two-dimensional peripheral refraction in children

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Purpose: A relative peripheral hyperopia has been suggested as a trigger on myopization in children. However, this is not fully validated yet, due to the lack of longitudinal results following the development process. To address the gap, our aim was to measure high-resolution two-dimensional peripheral refraction maps during two years of myopia progression in a group of children.

Methods: Peripheral refraction maps were measured using a peripheral sensor device (VPR, Voptica SL, Murcia, Spain) in a group of Chinese children (age 9-16 years) under cycloplegia. The maps cover a field from nasal 30° to temporal 30° of every 1°, and from superior 20° to inferior 16° of every 4°. After the study was closed, 214 children's data were available after one year and 152 children's data were available after two years. The participants were classified into three refraction progression groups based on their refractive change for hyperopic, emmetropic, and myopic subjects, separately. The difference of baseline peripheral defocus pattern was compared between each group by using ANOVA test. Central myopia progression as a function of peripheral defocus was investigated by simple linear regression.

Results: After the first year, a significantly different from the baseline refraction pattern was found between the various progression group in emmetropes. Baseline peripheral defocus in the central vertical field (horizontally, within ± 15°) at baseline was found to be significantly correlated with central myopic shift, especially in the superior retina [(S8°-S12°) X (N5°-T5°)]. Emmetropic subjects with more myopic defocus in the superior retina had more myopic progression (for refractive change, $r=0.32$, $p<0.001$; for axial change, $r=0.42$, $p<0.001$). In contrast, no obvious difference in baseline refraction pattern was found in the groups of hyperopes and myopes. The same tendency was confirmed after 2 years.

Conclusions: Children having the greater progression of myopia in central refraction over a two-year- period presented an initial relative myopic defocus in the superior retina. This type of relative refraction in the superior retina could be used as a predictor of central myopia. In relation, devices for keeping the superior retina emmetropic in children might be a myopia control strategy.

Relative Peripheral Refraction Topography in Unilateral Myopic Children

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Purpose
This cross-sectional clinical study aimed to compare the inter-eye relative peripheral refraction (RPR) difference in unilateral myopic children.

Methods
A total of 48unilateral myopic Chinese children aged 5-17 years old (10.96±2.08, male21 : female27) were enrolled in this study. All the subjects have not received any anisometropia treatment, such as orthokeratology or special designed defocusing spectacle lenses. Objective cycloplegic refraction and axial length measurement were performed for both eyes. Low, moderate and high anisometropia was defined as anisometropia ≤1.00D, 1.00D < anisometropia ≤2.00D D, and anisometropia > 2.00D, respectively. RPR profiles were measured by the Multispectral Refraction Topography (MRT). Group of RPR results were averaged to four circular areas (15-, 30-, 45- and 53-degree of retinal field) and four quadrants (superior, inferior, nasal and temporal retinal field). Independent T-test was used to compare the inter-eye RPR differences in four circular areas and four quadrants for the three anisometropia groups.

Results
48 unilateral myopic subjects were grouped into low (n=12), moderate (n=23) and high (n=13) anisometropia subgroups. There was no statistical significance between myopic eye and non-myopic eye for both low and moderate anisometropia group (both $p>0.05$). For the high anisometropia group, the inter-eye RPR difference within 30-, 45- and 53-degree retinal field was 0.17±0.05D ($p<0.05$), 0.40±0.10D ($p<0.05$), and 0.50±0.12D ($p<0.05$), respectively. There were also significant RPR differences at inferior and temporal quadrants for high anisometropia subjects (difference at inferior quadrant of 0.73±0.17D, $p<0.05$; difference at temporal quadrant of 0.57±0.21D, $p<0.05$).

Conclusions
Anisometropia over 2.00D could be associated with the inter-eye RPR difference beyond 15-degree retinal field. Significant different inter-eye RPR was observed at inferior and temporal retinal field, indicating the corresponding superior and nasal visual field defocus could play a key role in the anisometropic eye development.

Eye growth patterns measured with refractive error or axial length.

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Axial length increases through childhood and teenage years and this will lead to myopia when it exeeds the eye's focal points. Growth charts can be used to monitor eye growth and predict future growth and the need for treatment. However, axial length differs between myopic children and emmetropic children. We aim to studythe variability in axial length between subjects with different refractive errors and to explore the normal eye growth in children without refractive error change. We compare axial length, axial elongation and axial length corneal curvature ratio between genders and between refractive errors.
Methods
Participants of the Dutch population-based birth cohort study Generation R received ocular biometry measurements with AL and cyclopgic refractive error at ages 6 (N=), 9 (N=), 13 (N=) and 18 (N=) years of age. Myopia was defined as mean SER ≤-0.5D. Eye growth was measured by both axial elongation (mm/year) and refractive error change (D/year). Association between axial length growth and SE change was tested with lineair regression adjusted for age and gender.
Results
Average axial length(SD) / axial length growth(SD) was 22.36mm(0.75) , 23.10mm(0.84)/ 0.21mm/year ,23.50mm/0.09mm/year and 23.72mm(1.03)/0.05mm/year at 6 9 13 and 18 years respectively Average refractive error (refractive error change) was 1.46D, 0.73D(-0.20 D/year), 0.28D(-0.11D/year),-0.23D(-0.12D/year) at age 6,9,13 and 18. This was -0.34D for participants with myopia at 9 and -0.30 diopters for participants first found to be myopic at 13 years of age. The association between axial length change and refractive error change was -0.27(P<0.001) between 6 and 9, -0.33(P=0.001) between 9 and 13 and -0.06(P<0.001) between 13 and 17 years of age. Children with no refractive error change (SE +/-0.1 from previous measurement) grew on average 0.15 mm/year between 5 and 9, 0.07mm/year between age 9 and 13 and 0.03 mm/year between age 13 to 18 years.
Conclusion
Myopic children show greater progression of axial length and refractive error then non myopic children. Axial length growth is associated with refractive error change. Age of myopia incidence affects the progression rate of the axial length and refractive error.

Deep Learning System to Predict the 5-year Risk of High Myopia using Fundus Imaging in Children

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Purpose: High myopia can lead to blinding ocular complications. Identifying children at risk of developing high myopia allows for timely assessment and intervention, in order to prevent myopia progression and development of complications in adulthood.

Methods: We developed a deep learning system (DLS) based on prospective school-based cohort, using 7743 baseline fundus images of 1915 eyes; with clinical data (age, gender, race, parental myopia, baseline spherical equivalent (SE) and axial length (AL)) from 998 children, aged 6-12 years old. Three distinct algorithms: image, clinical and mixed (image + clinical) models, comprising of fundus photo, age, race, gender and SE/AL, were derived to predict the development of high myopia (defined as SE ≤ -5.00 dioptre or AL ≥ 25 mm) during teenage years (5 years later, aged 11-17). Model performance was evaluated based on area under the receiver operating curve (AUC).

Results: All models achieved robust performance, with the mixed (image + clinical) model (AUC based on SE=0.93-0.94 and based on AL=0.91-0.93) producing the best AUC, followed by the image model (AUC SE=0.92, AL=0.89) and clinical models (AUC SE=0.87-0.90, AL=0.83-0.87). The addition of 1 year SE/AL progression achieved a marginal improvement in performance for the clinical model compared to the image model, with AUC of 0.92 vs 0.95 in SE models and 0.89 vs 0.92 in AL models respectively.

Conclusion: Our DLS was able to predict the development of high myopia in school-going children by teenage years with robust performance, which has the potential to be utilized as a clinical-decision support tool to identify ‘at risk’ children for early intervention. Baseline fundus photography as a sole input parameter can potentially be translated and implemented into community or school-based programs to identify at-risk children for further assessment and intervention if required.

Novel imaging and deep learning techniques for assessing myopia

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There is an urgent need for biomarkers that predict the development of myopia in children. This is required to decide which children shall undergo treatment with atropine or other strategies to reduce the progression of pathological eye elongation. Two strategies can be followed to achieve this goal. On the one hand deep learning convolutional neural networks can be developed that use fundus photography to predict final refractive error and/or eye length in adulthood. Using this approach high area under the curve (AUC) can be achieved, but it is uncertain to which degree the results are generalizable to populations other than the ones used for training. In addition, this is a black-box approach that does not generate a clear causal relationship. Alternatively, novel imaging techniques can be employed. In our laboratory we focussed on two techniques, ultrafast ultrawide field OCT and triple input polarization sensitive OCT. The former can be used to reconstruct the 3-d shape of the eye ball using a fast and simple OCT scan with a scanning angle of 80-100 degrees. The latter can be used to study the collagen structure of the sclera in vivo. Both techniques have significant potential for future clinical care in myopia and show good performance in animal and human studies.

The development of high myopia in the guinea pig

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Purpose
High myopia has become an increasing burden worldwide with ~ 10% of the world population expected to develop high myopia by 2050, with over 70% developing associated pathologies. Animal models provide a useful method to study underlying mechanisms, so we developed a high myopia mammalian model to investigate if typical associated pathologies could be developed simply through abnormal visual input and studied the development of changes around the optic disk.

Methods
Young guinea pigs (n=27) were raised under various lighting conditions using variations of monocular form deprivation (FD) starting at 2 or 3 weeks of age and extending up to 9 weeks. Ocular measures of internal axial distances and refractive error were made prior to treatment, and at various times during myopia development. OCT of the optic disk region in some animals was compared to changes observed in cut sections from additional animals raised for 2, 3 or 8 weeks of FD (n=38).

Results
The average relative myopia between the two eyes varied depending on the raising conditions with high myopia developing in 2/3 groups (-9.8D (n=9), -7.7D (n=8), -4.3D (n=7)) after 4 weeks. Myopia was either maintained with longer deprivation periods (-9.4D (n=9) and -9.2D (n=5) after 6 weeks) or further increased (-10.7D (n=3) after 9 weeks) with individual animals developing up to -15D of relative myopia. Significant vitreous chamber elongation ($p<.01$, maximum average >200 µm) and scleral thinning ($p<.001$, maximum average -36 µm, 29% reduction) was consistently observed, with higher amounts of myopia associated with an increased contribution in lenticular expansion. The optic cup region significantly increased in both in-vivo and x-vivo studies with longer deprivation periods. Staphyloma were occasionally observed to develop on the margins of the optic disk.

Conclusions
Specific aberrant visual deprivation in guinea pig eyes can lead to extremely high myopia. Concomitant changes in the optic disk region similar to that observed in human high myopia make this a useful mammalian model to study the underlying causes of high myopia pathologies.

L opsin expression is reduced in eyes treated with diffusers and negative lenses in the chicken model

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Purpose: Previous studies have shown that wearing diffusers reduced the expression of L and M opsins in the chicken model (Gisbert at al., 2020). The purpose of this study is to find out whether the opsin expression is reduced as a result of altered spatial processing during the development of deprivation myopia, or due to light attenuation caused by the diffusers. The effect of negative defocus on opsin expression is also assessed in this study.

Methods: A group of ten chickens wore monocularly negative lenses (-7D) to induce myopia and transparent plastic foil was attached to fellow eyes to match conditions. Another group of twelve chickens wore monocularly diffusers to induce deprivation myopia and fellow eyes were covered with neutral density filters (0.3) to match the illuminance. Treatments were worn for a period of 7 days. Refraction and ocular biometry were measured at the beginning and the end of the experiment and retinal tissue was used to quantify L, M and S opsin expression using qRT-PCR.

Results: After 7 days of treatment, eyes covered by -7D lenses developed an average refraction of -0.16 ± 0.14D while their fellow eyes remained hyperopic with a refraction of 2.34 ± 0.14D. Nevertheless, diffusers had a stronger effect on myopia development since deprived eyes developed an average of -4.29 ± 0.84D. Fellow eyes showed hyperopic refractions of 2.67 ± 0.06D. Biometric results in eyes covered with negative lenses and diffusers showed that vitreous chamber depth had increased by 0.75 ± 0.03mm and 0.94 ± 0.03mm respectively compared to their baseline measurements. Interestingly, L opsin levels were significantly lower in eyes wearing negative lenses (245.08 ± 13.63; $p<0.05$) and diffusers (293.04 ± 20.9; $p<0.05$) compared to their fellow eyes (315.62 ± 29.28 and 338.88 ± 27.45 respectively). No significant differences were observed for the other types of opsins.

Conclusions: This study confirms that L opsin expression is reduced by a decrease in spatial contrast caused by diffusers rather than a decrease in illuminance levels. The fact that L opsin was also reduced in eyes treated with negative lenses could show that myopia induced by diffusers and by negative lenses share common pathways.

Post-GWAS screening of candidate genes for refractive error in mutant zebrafish models

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Purpose: In the last decade multiple association studies have been focused on dissecting the genetic factors underlying refractive error (RE). These studies resulted in the identification of almost 500 associated loci and potential candidate genes. To dissect the genetic mechanisms driving RE development, we made a prioritization of 11 candidate genes based on biological and statistical evidence (i.e., PRSS56, FBN1, TJP2, PDE11A, SHISA6, LAMA2, LRRC4C, KCNQ5, GNB3, RBFOX1, and GRIA4), and generated mutant zebrafish models. In these models, we screened for abnormalities in axial length (AL) and refractive status.

Methods: To examine whether candidate genes were expressed in human ocular tissues, published transcriptome databases were assessed. Further, RT-PCR was performed on zebrafish ocular tissue to confirm expression of genes in fish. CRISPR-cas9 was used to generate 11 mutant zebrafish lines. Ocular biometry assessment was performed in lines without large morphological abnormalities and normal breeding rates (n=8). AL was measured at 2 and 4 months (n=20 eyes per group) using Spectral Domain Optical Coherence Tomography; refractive status was measured using a custom eccentric photorefraction setup.

Results: Our database search and expression study in the zebrafish eyes confirmed that all genes were expressed throughout human and zebrafish eyes. Three of the eight studied mutant lines (lama2-/-, lrrc4c-/-, kcnq5-/-) showed a significant ($p<0.01$) increase in AL and corresponding myopic shift in refractive status ($p<0.01$). Two of the three mutants showed the largest increase in AL at 2 months (lrrc4c-/-: 140 µm, kcnq5-/-: 151 µm) which stabilized at 4 months (lama2-/-: 69 µm, lrrc4c-/-: 114 µm, kcnq5-/-: 92 µm). In contrast, and as expected, the prss56-/- mutant showed a significant reduction in AL (-157 µm, $p<0.001$) and a nanophthalmos-like phenotype at 2 and 4 months. In the other four studied lines no significant changes in AL were observed.

Conclusion: This study provides new models to study the mechanisms underlying refractive errors such as myopia. Of the eight mutants lines, 4 showed a change in refractive status. This indicates that depletion of single candidate genes selected from GWAS studies can induce myopic and hyperopic refractive errors in the zebrafish eye. Our findings support the notion that these genes may contribute to axial length determination.

Analysis of Genetic Networks Regulating Myopic Eye Growth Susceptibility in a Guinea Pig Model

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Purpose: To understand individual phenotypic variance in refractive error for identifying myopia-susceptible/causing genes and proteins by elucidating genetic difference between two strains of guinea pigs (GPs) with vastly different susceptibility to develop myopia.
Methods: Refraction and biometry measurements were assessed by retinoscopy and Sonomed A-Scan ultrasound respectively. Elm Hill albino and pigmented GPs were recruited based on post-natal day 14 refraction and grouped as either albino hyperopia (AH, 4.6±2.5D, n=9) or pigmented hyperopia (PH, 5.8±1.6D, n=9). Both groups had similar axial lengths (AH, 7.2±0.21mm; PH, 7.2±0.1mm). RNAseq (4 right eyes) and quantitative proteomic analysis (5 right eyes) were performed on the retina, choroid, and sclera tissues. QIAGEN IPA software was used to identify the pathways that differed between AH and PH in the retina, choroid and sclera based on both RNAseq data and proteomics data.
Results: Despite similar baseline P14 refraction and axial length, the AH group showed significantly different gene and protein expression as compared to the PH group. Specifically, we identified 902 differentially expressed genes (DEGs) and 364 differentially expressed proteins (DEPs) in choroid, 831 DEGs and 226 DEPs in sclera, and 129 DEGs and 107 DEPs in retina between AH and PH using a fold-change cutoff of 1.2 with an adjusted $p<0.05$. Based on the differentially expressed genes and proteins, 137 gene-based and 87 protein-based canonical pathways were identified in the choroid; 29 and 25 in the retina; and 99 and 65 in the sclera.
Conclusions: At both gene and protein levels, identified canonical pathways are similar in the choroid and sclera, and the two strains differed the least, in terms of pathways, in the retina. The common pathways identified from three tissues indicated malfunctioned systems in albino hyperopic GPs that will direct further studies.

Mice with ON-bipolar cell defect develop high myopia

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Purpose:

Myopia is a multifactorial eye disorder caused by heterogeneous genetic and environmental factors. Light exposure influences the development of myopia, with outdoor activities having a protective effect against the development and progression of this eye disorder. Complete congenital stationary night blindness (cCSNB) a group of genetically and clinically heterogeneous retinal disorders associated with high myopia in patients. Multiple mutations in cCSNB-associated genes have been found to disrupt the transmission of ON-bipolar cells (ON-BC) in the retina. As a result, cCSNB patients with high myopia lack ON-BC transmission. As ON-BCs are responsible for the retinal integration of the perception of surrounding light intensity, which is disrupted during the onset of myopia, we seek to determine whether cCSNBs models are more susceptible to develop high myopia.

Method:

To assess refractive development and induced myopia, we evaluated the levels of retinal Dopamine (DOPA) and its metabolite 3,4-Dihydroxyphenylacetic acid (DOPAC), a commonly used marker of myopia, in three cCSNB mouse models lacking Grm6, Gpr179 or Lrit3. Using an eccentric infrared photorefractometer, we measured the spontaneous refractive development of two cCSNB mouse models lacking Gpr179 or Lrit3. To assess the sensitivity cCSNB mouse lines to myopia induction, we developed a lens-induced myopia (LIM) model and measured the induced refractive error in mice lacking Gpr179 of Lrit3.

Results:

Our preliminary data revealed decreased levels of both retinal DOPA and DOPAC in all tested cCSNB mouse models. All tested groups presented the same kinetic of refractive development. Mice lacking Gpr179 displayed a higher sensitivity to LIM as shown by an increase in the mean interocular shift compared to wild-type littermates. Mice lacking Lrit3 with LIM will be measured and compared to the respective wild-type mice to document the refractive errors induced by the ON-BC defect.

Conclusion:

In summary, these results suggest that disruption of the ON-BC pathway contributes to the development of myopia and that mouse models of cCSNB represent good models to study myopia. Furthermore, our data strengthen the hypothesis of an impact of ON-BC dysfunction upon the onset and progression of myopia. These findings provide the basis for the development of pharmacological and optical therapies.

Scleral Cross-Linking in Form-Deprivation Myopic Guinea Pig Eyes leads to Glaucomatous Changes

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Purpose: To investigate the potential glaucomatous changes caused by scleral cross-linking (CXL) in a guinea pig form deprivation (FD) myopia model.
Methods: Eighty 4-week-old tricolor guinea pigs were divided into four groups: FD only, genipin CXL only; FD plus CXL; and control group. Refractive error, axial length (AL), intraocular pressure (IOP), structural and vasculature optic disc changes in optical coherence tomography (OCT) and OCT angiography (OCTA) were measured at baseline and Day 21. CXL efficacy was evaluated by scleral rigidity young' modulus values. Histological and molecular changes in the anterior chamber angle, retina and sclera were assessed.
Results: Baseline parameters were similar among groups ($P > 0.05$). FD plus CXL group at Day 21 had least increase of AL (0.14 ± 0.08 mm) and highest IOP elevation (31.5 ± 3.6 mmHg) compared with FD only (AL: 0.68 ± 0.17 mm; IOP: 22.2 ± 2.6 mmHg) and control group (AL: 0.24 ± 0.09 mm; IOP: 17.4 ± 1.8 mmHg) respectively (all $P < .001$). OCT and OCTA parameters of optic disc in FD plus CXL group at Day 21 showed glaucomatous changes and decreased blood flow signals. Sclera rigidity increased in CXL and FD plus CXL group. Advanced glycation end-products deposited extensively in retina, choroid, and sclera of FD plus CXL eyes.
Conclusions: CXL causes increased IOP and subsequent optic disc, anterior segment, and scleral changes, while inhibiting myopic progression and axial elongation in FD guinea pig eyes. Therefore, applying CXL to control myopia raises safety concerns.
Keywords: Deprivation myopia; Intraocular pressure; Optical coherence tomography; Optical coherence tomography angiography; Glaucoma; Scleral cross-linking; Genipin.

Atropine reduces axial elongation in a mouse model of syndromic myopia without altering retinal dopaminergic activity

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Purpose: Atropine, a non-selective muscarinic receptor antagonist, is often used as a treatment for common childhood myopia, but it is unclear whether it is useful to treat syndromic myopia. Here, we evaluate the effect of atropine on eye growth in mice with a Foxg1-conditional knockout of low-density lipoprotein receptor-related protein 2 (Lrp2), which causes Donnai-Barrow syndrome, characterized by excessive extremely high myopia in humans. The effect of atropine on retinal dopaminergic activity was evaluated to gain insight in its possible mechanism of action.
Methods: Male (M) and female (F) C57BL/6 mice homozygous for both FoxG1cre and Lrp2fl (KO; M n=9; F n=7) and littermates negative for FoxG1cre (Ctr; M n=7; F n=4) were housed under full-spectrum 200 lux illumination (18h day/6h night). From postnatal day (P) 30 to 56, left eyes received one droplet 1% atropine sulfate daily, while right eyes received saline. Ocular biometry was measured using SD-OCT in anesthetized mice at P28 and P56. Mice were sacrificed and retinas were isolated for high-performance liquid chromatography to measure dopamine (DA) and 3,4-Dihydroxyphenylacetic acid (DOPAC) levels, 2 (KO n=5; Ctr n=6) and 24 hours (KO n=10; Ctr n=9) after the final atropine application.
Results: At P28, KO mice had significantly larger axial length (AL) than littermate controls (mean±SEM KO M: 3265±37, Ctr M: 3166±19; KO F: 3262±48, Ctr F: 3102±30 µm; both M and F, $p<0.05$, unpaired t-tests). Atropine reduced AL growth significantly in both KO and Ctr mice (ΔAL, atropine minus saline treatment: KO M: -40±15; Ctr M: -42±10; KO F: -53±15; Ctr F: -62±3 µm, $p<0.001$ for treatment, MANOVA), which was mainly caused by a reduction of anterior chamber depth growth (KO M: -54±4; Ctr M: -42±7; KO F: -51±10; Ctr F: -47±6, $p<<0.0001$ for treatment, MANOVA). Atropine did not induce changes in DA and DOPAC levels, at 2 or 24 hours after treatment ($p>0.07$, MANOVA). Interestingly, DA levels were elevated in KO mice (saline treated, KO: 148.5±6; Ctr: 116.9±6 ng/mg tissue, $p<0.01$, unpaired t-tests) and an increased DOPAC/DA ratio (saline treated, KO: 0.37±0.04; Ctr: 0.32±0.05; $p<0.05$, unpaired t-tests).
Conclusions: Atropine reduces axial elongation in a mouse model of syndromic myopia, suggesting that this treatment could be beneficial in patients with a syndromic myopia. Atropine does not seem to modulate axial growth through downstream effects on dopaminergic activity in the retina.

A-type horizontal cell coupling is bidirectionally associated with the sign of ocular defocus

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Purpose
Myopia (short-sightedness) results from excessive ocular growth. Hyperopic defocus (negative lenses) induces a myopic growth response in animal models, however the underlying mechanisms remain elusive. Neuromodulators implicated in the myopic growth response: dopamine, retinoic acid and nitric oxide, all modulate retinal gap-junctions. As such, retinal coupling may be involved in the detection of blur and the propagation of ocular growth signals in the retina. Coupling between 'axonless' horizontal cells ('a-type', aHCs) was investigated in myopic or myopia recovery guinea pig retinae.
Method
Myopia was induced in 22 guinea pigs using a -6D lens worn over one eye for 14 days. Lenses were removed for 72 hours in 10 animals to induce myopia recovery. Coupling in aHCs was assessed in cut-loaded dark-adapted retinae from myopic and myopia recovery animals. Briefly; retinas were sustained in Ames solution (37oC, bubbled 95%O2 5%CO2) and cut with a scalpel blade coated in neurobiotin (3% wt/v in Ames media). Retinas were incubated (25 mins) to allow dye transfer, fixed (4% PFA 30 mins), reacted with streptavidin (1:100 in PBS) and imaged (confocal microscopy). Coupling was modelled using the coupling coefficient (kj) based on fits to the fluorescent decline of aHC soma perpendicular to the cut, providing an accurate novel method to account for the geometric path of dye-transfer through coupled aHCs.
Results
After 14 days of lens wear, the average difference in refractive error between the two eyes was -5.10±0.37D (lens-wearing minus contralateral untreated eye, n=22, $p<0.001$). After 72 hrs of lens-removal, animals recovered by +2.50±0.45D (difference between two eyes: -2.92±0.45, D n=10, $p<0.001$). Relative to contralateral control eyes, aHC coupling was increased in myopic retinae (0.046±0.011 vs. 0.032±0.012 cells2.s-1, $p<0.001$), and decreased in retinae undergoing recovery from myopia (0.030±0.004 vs. 0.048±0.007 cells2.s-1, $p=0.038$). Coupling of aHCs was significantly different between myopic animals and animals undergoing myopia recovery (difference between two eyes: +0.012±0.003 vs. -0.017±0.006 cells2.s-1, $p<0.0001$).
Conclusions
Coupling of aHCs is bidirectionally sensitive to the sign of optical blur that controls the direction of eye growth. Given that aHCs mediate local gain and photoreceptor negative feedback, either the detection of the sign of defocus depends on relatively early signals in the retinal network or aHC coupling is influenced by modulatory factors altered in myopia.

Shedding light on myopia by studying congenital stationary night blindness

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Purpose
Myopia is the most common eye disorder, caused by heterogeneous genetic and environmental factors. Rare inherited retinal disorders are often associated with high myopia. Genes implicated in myopia encode proteins involved in eye morphogenesis, extracellular matrix organization, visual perception, circadian rhythms, and retinal signaling. Differentially expressed genes (DEGs) identified in animal models mimicking myopia are helpful in suggesting candidate genes implicated in human myopia. Complete congenital stationary night blindness (cCSNB) in humans and animal models represents an ON-bipolar cell signal transmission defect and is also associated with high myopia. The purpose of this work was to identify the molecular cause of myopia present in cCSNB.
Methods
A whole transcriptome sequencing (RNA-seq) approach was performed using retina from three mouse lines with cCSNB, Gpr179-/-, Lrit3-/- and Grm6-/- and the expression data compared to data of age-matched wild-type littermates (n = 5). DEGs with fold changes of at least 1.2, P-values of ≤ 0.01, an expression value of at least 5 transcripts per million reads and appearing in at least two cCSNB mouse lines were investigated in detail. A meta-analysis was performed by a) comparing our data with published transcriptome data from purified retinal cells and single cell RNA-Seq data, b) pathway analyses, c) myopia databases and publications concerning their role in normal vision. Several of the DEGs were validated by RT-qPCR experiments and analyzed by western blot and immunolocalization studies.
Results
More than 50 DEGs were found in at least two cCSNB mouse lines. Expression of those was found in different retinal cell types. The difference in expression was independent of the number of nuclei present in wild-type and mutant inner retina. Pathway analysis revealed that mitogen-activated protein kinase pathways, synaptic signaling, G protein-coupled receptor ligand binding pathways, and proteins implicated in eye, endoderm and connective tissue development were affected in cCSNB. More than half of the genes were already associated with myopia.
Conclusions
Our study reveals DEGs in all retinal cell types of cCSNB models, previously associated with myopia and novel candidates. These studies combined with pathway analyses provide the basis for the development of pharmacological and optical myopia therapies.

P161: Prevalence of myopia in the Spanish pediatric population

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Purpose: Myopia is considered a major public health problem causing significant visual loss and is associated with a wide variety of eye pathologies. The prevalence of myopia is increasing worldwide for reasons still unknown. The main objective of this study is to analyze the prevalence of myopia in Spain in children between 5 and 7 years old.

Methods: The study population is children between the ages of 5 and 7. An optometric test consisting of visual acuity (VA) measurement, assessment of objective and subjective refraction, and binocular tests (cover test, the Worth test, accommodative lag, ocular motility and near point of convergence) was performed on the participants.

For the quantitative definitions of myopia, the value of the spherical equivalent (SE) was used: myopia (SE≤-0.50), low myopia (-0.50<SE>-3), moderate myopia (-3D<EE>-6D) and high myopia (SE≤-6). Data analysis is performed with the SPSS 27.0 software (SPSS Inc., Chicago, Illinois).

Results: The rate of myopia in Spain has increased in recent years (2016: 16.8%; 2017: 19-1%; 2019: 20.4%; 2020: 20.0%; 2021: 20.5%; p<0.001). However, no significant changes in the degree of myopia have been found over the years (Low: 88.8%; Moderate: 8.8%; High: 2.4%; p>0.05).

The prevalence of myopia increases with age, from 15.2% at 5 years to 21.9% at 7 years (p<0.001). Therefore, the value of the SE also becomes more negative with age (5 years: 0.12[1.7]; 6 years 0.12[1.5]; 7 years 0.00[1.7]// Spearman: rho=-0.047; p<0.001). No association was found between gender and myopia (p>0.05).

Conclusions: An increase in the prevalence of myopia in Spanish children between 2016 and 2021 has been confirmed. These results suggest the importance of starting myopia control methods at earlier ages.

P139: The Impact of Myopia on Mesopic Visual Functions

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Purpose
Eye growth is visually guided, and myopia progression can be accelerated by peripheral hyperopic retinal defocus. However, how peripheral defocus is detected by the visual system remains poorly understood. One possible means is that the visual system is sensitive to the impact of peripheral defocus on visual function. This case-control study aimed to understand how the visual system responds to peripheral blur by psychophysically measuring its impact on the contrast sensitivity function (CS). We measured CS at the central and peripheral visual field (VF) under both photopic and mesopic lighting conditions and, hypothesised that peripheral defocus will have a greater impact on contrast sensitivity detection under low light conditions.

Method
Eleven adults including six myopes (-1.00 D to -6.00 D) and five emmetropes (-0.50- to +0.50) aged between 26-36 years were recruited. All myopes had a best-corrected visual acuity of 0.00 LogMAR or better. CS was measured across different spatial frequencies (1, 2, 4, 8, and 16 cycles per degree) using a two-alternative forced-choice staircase paradigm. Stimuli were presented on a computer screen (viewing distance of 57 cm), and subjects were required to judge stimulus orientation whether tilted to the left or to right. All measurements were performed binocularly at the centre (0) and peripheral (20° in the temporal VF) under photopic (38.14 cd/m2) and mesopic (0.32 cd/m2) lightening conditions. Repeated-measures ANOVA (mixed effect model) was used to compare the CS between the gropus in the central and peripheral visual field under two lighting conditions.

Results
CS was significantly decreased in myopes at both central and peripheral VF compared to emmetropes ($p<0.01$). A negative correlation was found between the lighting conditions and CS threshold ($F(1, 88) = 5.01$, $P=0.02$). Myopes had a significant decrease in CS sensitivity at 20° under mesopic lightening conditions compared to emmetropes with mean differences of -0.61 ±0.01 ($p<0.01$). Myopia showed a significant improvement in the CS under phoptopic light; however, it was lower than that of emmetropes (mean differences 0.67±0.004 ($p<0.01$).

Conclusion
Myopes had lower CS in the peripheral VF compared to emmetropes and this was greater under mesopic light which supports our hypothesis. The findings of this study raise the possibility that peripheral defocus can be signaled to the visual system by its impact on visual function.

P44: Do Grand-Seiko autorefractors give accurate peripheral refraction measurements?

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Purpose: Grand-Seiko automated Optometers have been used for over 15 years to compare peripheral refractions in emmetropic and myopic eyes. These are convenient to use because their open field arrangement allows an unrestricted horizontal field of approximately ±35°. However, little attention has been given to whether the results with such instruments are valid. In this study, the validity of Grand-Seiko autorefractors with annular targets was investigated through simulations.
Methods: The Grand-Seiko instruments use the image size principle, for which it can be shown that refraction is given by $Rx = (\theta + \alpha)/h_1$, where θ is the angle of the ingoing radiation beam, h_1 is the height of the beam at the anterior cornea, and α is the angle of the beam emerging from the eye following reflection at the retina. Using a physical model eye, θ and h_1 were determined for the WAM-5500 variation. Into- and out-of-the eye raytracing were done for a Grand-Seiko simulation to determine α, and out-of-the eye conventional raytracing was also performed. Two eye models were used, a Navarro schematic eye and a Navarro schematic eye having a contact lens with a highly positive aspheric front surface giving an increase in sagittal power of 3.5 D at 3 mm semi-diameter.
Results: The instrument ingoing beam was determined to have $\theta = 2.88°$ and $h_1 = 2.45$ mm. Grand-Seiko refractions provided accurate estimates of peripheral refraction, when compared with conventional raytracing, for both model eyes. The results were closer to Zernike refractions (i.e., using just second-order aberration terms) than to paraxial refractions (including other even Zernike aberration terms). Spherical aberration influenced refraction by up to 0.5 D, but peripheral coma had limited influence .
Conclusion: Grand-Seiko autorefractors in current use, and having a circular annulus with an ingoing effective outer diameter at the front of the eye of about 2.4 mm, appear to give valid peripheral refractions.

P112: Evening near-work – a risk factor contributing to myopia?

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Purpose
To explore the effects of diurnal changes of ocular structures and discuss potential consequences of evening near-work.

Methods
Twenty-four ocular-healthy participants (age 17–24 yrs, 16 males, visual acuity ≤0.00 logMAR and stereo acuity of ≤120") from Southern Norway were measured in the winter and the following summer. Self-reported habitual wake times and recorded actigraphy data (over 7 days) were used to determine the participant-specific timings of 8 rounds of measurements (relative to habitual wake and sleep times) on day 8. Each round consisted of accommodation washout (15 min), saliva sampling and ocular biometry measurements (Zeiss IOLMaster 700), all under dim-light conditions. A linear mixed effects model was used to determine the presence of significant diurnal variations, and a sinusoid with a 24-hour period was fitted to the data with a non-linear mixed effects model to estimate rhythmic statistics.

Results
Melatonin concentration [pg/mL], anterior chamber depth (ACD), crystalline lens thickness (LT), vitreous chamber depth (VCD) and axial length (AL) [all in µm] underwent significant diurnal variation in winter and summer ($p<0.002$). The rhythms of Melatonin, ACD and LT were in-phase and increased in the evening with acrophases that were in antiphase with VCD and AL. The maximum depth and thickness changes in ACD and LT in the evening were +64 and +52 µm. The most parsimonious explanation is that the evening thickening of the crystalline lens primarily relates to changes of its posterior surface, which is compatible with the diurnal rhythm of VCD being in antiphase to LT.

Conclusions
During accommodation, the increase in crystalline lens thickness primarily relates to changes of its anterior surface, while the ACD becomes shallower [1]. Here, during the evening, the crystalline lens thickened while the ACD became deeper in the absence of any accommodative demand. Any evening near-work would be expected to cause additional accommodative-thickening and movement of the crystalline lens. This may disrupt the diurnal phase-relationships between intraocular structures required for coordinated eye growth. If so, this could be a risk factor contributing to myopia.

[1] Dubbelman M, Van der Heijde GL, Weeber HA. Change in shape of the aging human crystalline lens with accommodation. Vision Res. 2005 Jan;45(1):117-32.

P63: Protective Effects of Scotopic and Photopic Ambient Lighting in Lens-induced Myopia in Mice is Dependent on Cone Photoreceptor Function

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Purpose: Previously, we have shown that loss of cone photoreceptors increases susceptibility to form-deprivation myopia under typical (i.e. mesopic) laboratory conditions (Chakraborty et al., 2019). Furthermore, studies from our lab indicate that scotopic and photopic ambient lighting attenuate lens-induced myopia (LIM) development in wild-type mice (Landis et al., 2021). Here, we investigated if cone photoreceptors are necessary for the protective effects of scotopic and photopic ambient lighting in LIM.
Methods: Myopia was induced in p.28 mice with mutations in the α-subunit of cone transducin, Gnat2 (Gnat2-/-) by placing a -10 D lens over the OD eye while leaving the OS eye free as a contralateral control (n=30). Additionally, a cohort of mice without lens treatment was used as naïve controls (n=29). Mice of both groups were housed after lens placement in either scotopic (1 lux, n=20), mesopic (50 lux, n=20), or photopic (10,000 lux, n=19) ambient lighting on a 12:12 light:dark cycle. Refractive error was measured in OD and OS eyes using an automated photorefractor at baseline and after 1- and 2-weeks of lens treatment. Myopic refractive shifts were calculated by subtracting the refractive error between the OD and OS eyes.
Results: Control Gnat2-/- mice that had no lens treatment did not develop a myopic shift and there was no difference between ambient light conditions after 2 weeks (scotopic vs mesopic vs photopic, 0.08 ± 0.12 vs 0.00 ± 0.16 vs 0.70 ± 0.49 D, p=0.41, ANOVA). Compared to control mice, lens-treated Gnat2-/- mice developed a significant myopic shift ($p<0.001$, ANOVA) but there was no effect of chronic exposure to scotopic (-5.11 ± 0.34 D), mesopic (-4.32 ± 0.25 D), or photopic (-5.24 ± 0.80 D) light levels during the treatment period (2 weeks, p=0.33, ANOVA).
Conclusions: We found that the mice with dysfunctional cone transducin in cone photoreceptors were not protected against LIM in scotopic or photopic ambient lighting. These results suggest that protection against LIM in photopic conditions requires normal activation of cone photoreceptors. Surprisingly, our data suggest that in scotopic conditions, when rod photoreceptors are active, cone photoreceptors are also necessary for the protective effect of scotopic lighting. Future studies will use mice with other photoreceptor mutations, including cone-only retinas, to investigate their contribution to LIM under different ambient light conditions.

P56: Conformation of the anterior segment in human myopia

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Geometry of the in vivo anterior segment is of relevance in understanding its role in myopia and in the development of surgical procedures i.e. scleral crosslinking and transscleral drug delivery. Using MRI-generated 3D images of the human eye, regional variations in surface area (SA) and bulbosity of four anterior segment regions were investigated in association with refractive status (Rx) and axial length (AL).

A Siemens Trio 3-tesla was used to collect T2-weighted ocular MR images from adults 18-40 yrs (28.65±6.20) of British-White (n=24) and British-South-Asian (n=19) descent [MSE (D) 20 non-myopes (≥-0.50) 0.57±1.38; 43 myopes (<-0.50) -6.37±4.23]. Vector co-ordinates fitted to the MR images were designated as superior temporal (ST), superior-nasal (SN), inferior-temporal (IT) and inferior-nasal (IN) and then assessed as 2D graphical representation for the anterior section lying between 15%-40% along the axial length (equivalent to between 3.5-9mm of the anterior segment). Second order polynomials were fitted to each quadrant, these were integrated separately and subsequently rotated about the x-axis to generate SA for each corresponding quadrant. Dividing the SA by 4 provided relative SA for each quadrant. The x2 coefficient provide indices of bulbosity. Rx and AL were measured using cycloplegic autorefraction and the Zeiss IOLMaster, respectively. One- and two-way repeated measures ANCOVAs tested differences in SA and bulbosity for Rx, gender, ethnicity, and age. Pearson's correlation coefficient was used to test relationship between MRI derived metrics and biometry.

Significant differences in SA were observed between quadrants ($p<0.001$) with differences between ST:IN, IN:IT and SN:IT. An interaction effect ($p=0.012$) was seen for Rx suggesting smaller (ST and IT) and larger (SN and IN) in myopes. AL and myopic Rx showed significant negative correlation ($p<0.05$) with SA at IN, SN and IT. Bulbosity showed no regional differences nor an effect of AL or Rx. Gender, ethnicity and age had no significant effect on SA and bulbosity.

The data suggest significant regional variation in SA exists across the anterior segment that are modulated by Rx and AL. It is unclear if these structural characteristics are a precursor or consequence of myopia and may warrant investigation when developing biomechanical intervention.

P27: Recovery of pupil responses following a single drop of 0.01%, 0.02%, or 0.05% atropine sulfate solution

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Purpose
This study aims to understand how low-dose atropine (LDA) affects dynamic pupil recovery from dilation and cycloplegia, and its effects (if any) on choroidal thickness and axial length. 1% atropine sulfate drops are indicated for dilation and the treatment of amblyopia. They are used off-label in the US in concentrations ranging from 0.01% to 1.0% to slow the progression of myopia. We tested 0.01%, 0.02%, and 0.05% to determine dose-dependency of the side effects associated with LDA to inform ourselves and our patients.

Methods
We conducted a prospective crossover cohort randomized single-blind trial. 7 participants (inclusion: age 18-35, healthy) were randomly assigned to self-administer 1 drop of 0.01%, 0.02%, or 0.05% atropine in their non-dominant eye before bedtime. Dynamic pupil response to a single pulse of light, pull-away accommodative amplitude (AA), lens thickness (LT), axial length (AL), and choroidal thickness (ChT) were measured at 10 hours, 14 hours, 18 hours, and every subsequent morning until the subject returned to baseline. Dynamic pupil response was measured using an automated pupillometer (NeurOptics PLR®-3000), AA was measured with 20/25 LEA symbols, LT and AL were measured using an ocular biometer (Haag-Streit Lenstar), and ChT was measured using an OCT (Topcon Triton). Once the pupil response returned to baseline, the process was repeated for the second and third concentrations (randomized order).

Results:
18 hours following a single drop of 0.01%, 0.02%, or 0.05%:

Mean end pupil sizes after a flash of light (max constriction)
4.0mm, 4.3mm, and 5.6mm respectively (N = 7; SD = 0.28, 0.37, 0.43)
Significant difference between
0.01% and 0.05% atropine ($t = -8.341$, $df = 6$, $p < 0.001$)
0.02% and 0.05% atropine ($t = -3.099$, $df = 6$, $p = 0.027$)
No difference between
0.01% and 0.02% ($t = -1.173$, $df = 5$, $p = 0.294$).

Mean AA:
8.64D, 7.88D, and 6.96D respectively (N = 7, SD = 0.98, 0.69, 1.40)
Significant difference between
0.01% and 0.05% ($t = 4.087$, $df = 6$, $p = 0.006$)
No difference between
0.01% and 0.02% or 0.02% and 0.05% ($p > 0.05$).

LT, AL, and CT analysis to come.

Conclusion:
Increasing the concentration of LDA from 0.01% or 0.02% to 0.05% will impact the dynamic pupil and cycloplegia recovery. For those using LDA for myopia control with an indication for a higher concentration, switching to 0.05% may increase the side effects the patient experiences (sensitivity to light, reduced accommodation).

P79: Retinal nerve fibre layer thickness in myopic children with high cup-disc ratio

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Purpose: Often, in our review of myopic children, we encounter a wide range of optic disc cup-disc ratios (CDRs). When CDRs are above 0.6, there is concern that the child may have concurrent glaucoma which may have induced myopia progression.

Methods: The PROM-Kids myopia cohort included children aged 7-16 years presenting to a myopia clinic in Singapore. Children were reviewed annually with cycloplegic autorefraction, axial length and fundus and optic nerve optical coherence tomography (OCT) images obtained using the Topcon Triton swept-source OCT. Right-eye baseline optic disc characteristics of the first 460 children were analysed. Children were divided into 3 groups according to CDRs as follows: (A) 0.00-0.39, (B) 0.40-0.59, and (C) 0.60-0.80.

Results: The majority of children were in Group A (n = 248, 54%) with 179 (39%) and 33 (7%) in Groups B and C, respectively. There were no significant differences in age, intraocular pressure (IOP) and spherical equivalent (SE) between groups, although axial length was slightly smaller in Group A than Group B (25.0 ± 1.7 vs 25.3 ± 1.1 mm, p=0.004). Other significant findings include larger retina nerve fibre layer (RNFL) thickness in Group A versus Group B in the superior (137.5 ± 20.7 um vs 132.5 ± 20.9um, p=0.015) and inferior rims (135.7 ± 21.3 vs 131.4 ± 17.5 um, p=0.028). No significant difference was observed in the nasal and temporal RNFL thickness between Groups. In 190 eyes, for whom there was follow-up OCT at 2 years, there was no clinically significant change in RNFL thickness, and no significant difference in change between the 3 groups over time.

Conclusions: Myopic children with large CDRs did not show clinically important differences in IOP and RNFL measurements compared to other myopic children. Having IOP and RNFL measurements in a normal range is reassuring and lack of change in RNFL measurements over time may help exclude glaucomatous process.

P129: Myopes spend lesser time at intermediate light level than emmetropes

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Purpose
Exposure to bright outdoor light at an early age is reported to influence the development of juvenile myopia. Considering that school children spend most of their time in an indoor environment which is not as bright as outdoors, we investigated if the pattern of light exposure (illuminance level, duration, epoch) under low (≤200 lux), intermediate (201-999 lux), and high/bright light (≥1000 lux) varies between emmetropes and myopes.

Method
The light exposure profile of 127 school children (mean age±SD: 12.3±1.3 years, male=60) were recorded using a validated clip-on wearable light tracker for a continuous four days. Light exposure parameters measured as illuminance level (lux), time spent at different lux level, and epoch (defined as total number of times a child is exposed to certain lux level) were compared between emmetropes (SER: 0.00±0.50 D, N=77) and myopes (≤-0.75 D, N=50) across three different time periods: before-school (6:00-8:30), through-school (8:31-16:00) and after-school (16:01-19:00). The lux exposure level and time spent were analysed for low (20-100 and 20-200 lux), intermediate (201-500 and 501-999 lux) and high (≥1000, ≥3000, ≥5000, and ≥10000 lux) light levels, whereas, epoch was analysed for high light level.

Result
The overall median (IQR) lux exposure level was similar between emmetropes and myopes (1173[713,1656] vs 1358[844,1989] lux respectively, P=0.35). Likewise, the lux exposure level and epoch across different categories of low, intermediate and high light levels were also similar between emmetropes and myopes (P>0.05). While the time spent (min/day) in low light level (20-100 lux) was greater in myopes (232[166,275]) than emmetropes (197[158,263], P=0.27), time spent in intermediate light levels were significantly greater in emmetropes than myopes in both 201-500 (40[22,54] vs 25[17,40] respectively, P<0.01) and 501-999 lux (19[11,32] vs 15[10,23], P=0.03) categories, with no significant difference in high light level categories (P>0.48). These differences were observed in the daytime during through-school time period (201-500 lux: 24[18,41] vs 16[10,30], and 501-999 lux: 14[7,20] vs 8[6,14] min/day, P<0.01) than before- and after-school time period (P>0.1).

Conclusion
The time spent in the intermediate light levels by emmetropes is significantly greater than myopes. Given that children typically spend their time in indoor environment exhibiting intermediate level of illuminance, the role of such light level/environment in influencing the refractive status of school children needs to be explored further in relation to myopia.

P121: Application of smartphone ambient light sensors to measure daytime light intensity and their potential to quantify time spent outdoors

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Purpose: To validate and measure the light level using the smartphone ambient light sensor and to evaluate its potential to objectively measure and track time spent outdoors.
Methods: The study was conducted in 3 phases. Phase - 1: Light levels were measured using the smartphone ambient light sensor through the 'Luxmeter' Android application in 4 Android smart phones and a standard lightmeter device (LX-101A) in 15 indoor and outdoor locations; Phase - 2: Ambient light levels were measured from 40 young adults using the smartphone light sensor through the 'Luxmeter' Android application every 2 hours between 8 am to 6 pm; Phase - 3: Light levels were measured and recorded continuously using the smartphone ambient light sensor through the 'Luxmeter' Android application for one day among 20 young adults to calculate time outdoors with 1000 lux, 2000 lux and > 5000 lux. Data were entered in excel sheet and analysed using SPSS version 23. Intra class correlation coefficient (ICC) were calculated to measure reliability of the application in measuring light levels using different smart phones in different indoor & outdoor locations.
Results: Intra class correlation coefficient for light level measured using the smartphone ambient light sensor versus the standard lightmeter device for indoor and outdoor locations were 0.99 (95% CI; 0.99 – 1.00) and 0.85 (95% CI; 0.73 – 0.94) respectively for consistency and 0.99 (95% CI; 0.99 – 1.00) and 0.86 (95% CI; 0.73 – 0.94) respectively for absolute agreement.
Conclusions: The smartphone light sensor when used along with the 'Luxmeter' Android application is a reliable tool for measuring outdoor light level and could differentiate between indoor and outdoor light levels when used in different smartphones. Hence the smartphone ambient light sensor, along with the 'Luxmeter' Android application can be used to measure and track light levels and time spent outdoors.

P190: Temporal Change of Cycloplegic Refraction and Pupil Diameter by 1% Cyclopentolate in Children

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Purpose: To determine the temporal trend for 1% cyclopentolate hydrochloride eye drop among 12-year-old Chinese children.
Methods: Children aged 12 yrs were recruited and underwent comprehensive eye examination including pupil diameter, and refraction before and after instillation of 1% cyclopentolate at 20 min, 40min, 1h, 1.5h, 2h, 4h, 6h, 24h, and 48h. Repeated measures analyses of variance (RM-ANOVA) with Bonferroni adjusted pairwise comparisons were performed to evaluate the temporal trend of refractive error and pupil diameter.
Results: Totally 76 children were included with the refraction ranged from -7.25D to 2.88D. The mean pupil diameter before cycloplegia of the myopic and non-myopic eyes were 5.71 mm and 5.81 mm respectively and reached the peak mydriasis with 8.28 mm and 8.12 mm separately at 2 hour after first drop of cyclopentolate. The refractive diopter of both group increased and reached maximal cycloplegia at 2 h with 0.26 D and 0.53D for myopes and non-myopes group separately and non-myopes achieved 0.27D more cycloplegia than myopic group. Six hour after instillation, the effect of pupil dilation and ciliaris paralysis still existed and remained high.
Conclusion: The best optometry time range in children with 1% cyclopentane hydrochloride is 1-2 h after medication and it is still appropriate to complete optometry within 6 h after cycloplegia.

P102: Effect of dynamic ON/OFF stimulation with different temporal and spatial frequency on changes choroidal thickness in control and minus lens treated chickens

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Purpose:
In animals models (chicks, tree shrews, guinea pigs, marmosets, rhesus monkeys) the choroid thins during periods of experimentally-induced increased eye growth (treatment with negative lenses or diffusers and thickens during periods of reduced growth (treatment with positive lenses or recovery from induced myopia). Also in humans, the thickness of the choroid is controlled by the plane of focus of the retinal image. These changes are assumed to predict future refractive changes. Artificial visual stimuli, on the other hand, can uncouple choroidal thickness changes from changes in axial eye growth. It is therefore necessary to verify under which conditions thicker choroids can predict less myopia development.
Methods:
Seven day old chicks per group were kept in large plastic arenas (60x60x30 cm) with walls covered with 27" screens. Dynamic stimuli were presented on the screens and were also projected on the floor from above by two video projectors as described by Wang et al. (doi: 10.1167/iovs.18-26471). Checkerboard patterns with squares with repeated sawtooth-shaped temporal luminance profiles, either with a rapid ON or rapid OFF, were presented. Stimuli were applied at 3 different square sizes (68x39, 40x22, 28x16 squares/monitor) in combination with different cycle frequencies (0 Hz, 0.8 Hz, 1.2 Hz, 2.5 Hz, 6.5 Hz, 10 Hz). Chicks were either treated monocularly with a -7D lens, or both eyes were untreated. SD-OCT (HRA+OCT Spectralis) was used to measure choroidal thickness in alert animals at baseline (10 a.m.) and 3 hours after treatment (1 p.m.). A multi-factor ANOVA was used to determine the influence of treatment (both eyes control, contralateral control eye, -7D lens treated eye), square wave size, frequency and character (ON/OFF) on choroidal thickness (ChT) changes.
Results:
Minus lens treatment induced on average 12.2 µm more choroidal thinning compared to the effect of the different stimuli in the contralateral untreated eyes (delta ChT: contralateral control eye vs. -lens treated eye: -22.0 µm vs. -34.2 µm, t-test $p<0.0001$). Stimulus frequency as well as character (ON/OFF) had no significant effect in minus lens treated eyes. In contrast, the size of the fields of the checkerboard pattern had a significant main effect in the control group (delta ChT: smallest size: -22.0 ± 1.6 µm, medium size: -9.7 ± 1.8 µm, largest size: -13.8 ± 1.7 µm). The interaction between frequency and size was also significant. Changes in ChT in controls were highest at 6.5 Hz (-20.5 ± 4.7 µm) and smallest at 2.5 Hz (-8.0 ± 4.7 µm). Comparing all treatment groups, only one of the stimuli (1.2 Hz ON, medium size) caused an increase in choroidal thickness (+4.75 ± 6.5 µm) while OFF stimuli at this field size and frequency caused choroidal thinning (-11.71 ± 2.68 µm).
Conclusion:
Minus lens defocus induced the highest amount of choroidal thickening. Dynamic artificial stimuli of different frequency, size and ON/OFF characteristic influence choroidal thickness in a complex way in otherwise untreated eyes. Except for one stimulus (1.2 Hz ON medium size), all others caused choroidal thinning which was partially explained by diurnal choroidal thickness changes during the examination period. Further experiments, using longer stimulation periods, are needed to fully describe the predictive power of choroidal thickness changes on axial eye growth.

P38: Evaluation of the Predicting Myopia Onset and progression risk indicator (PreMO) to Predict Myopia Development

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The Predicting Myopia Onset and Progression Risk Indicator (PreMO) is an evidence-based framework for eyecare practitioners providing stratification and management guidance for childhood myopia. It was developed using population-based data from white children from the Northern Ireland Childhood Errors of Refraction (NICER) study and utilises a child's spherical equivalent refraction (SER), axial length (AL) and parental myopia to characterise myopia risk. This study evaluates its performance using prospective data from an independent, ethnically diverse sample of UK children.

Data from 57 Aston Eye Study participants (age 7.1±0.35 years; ethnicity 56% South Asian, 30% White, 12% Black and 2% East Asian) who were not myopic at first examination were included in the analysis. Baseline data regarding parental myopia (0, 1 or 2 myopic parents), AL (IOLMaster) and SER (cycloplegic autorefraction, Shin-Nippon) were applied to the PreMO. A total risk score for future myopia was generated for each participant (0=no risk, 1-3 low, 4-6 moderate, 7-9 high risk). Refractive status of participants 11 years after baseline (age 17.7±0.38 years) was determined as either myopic (mean SER ≤-0.50D) or non-myopic (SER>-0.50D). Receiver Operator Characteristic (ROC) curve analysis was used to evaluate the performance of the PreMO in identifying future myopia. Cut-off values were estimated using the highest Youden's J Index. Data were also used to evaluate sensitivity, specificity and area under the curve (AUC) of the PreMO when applied in the absence of AL (risk scores 0 to 6) or using previously identified, singular predictors for future myopia at 6-7 years; SER <+0.75DS and AL ≥23.07mm (75th centile of NICER growth chart).

A risk score ≥4 was highly sensitive (0.97) and specific (0.96) in predicting future myopia within 11 years in UK children of all ethnicities (AUC 0.996). When compared to application of the full PreMO framework, removal of AL data and/or use of singular predictors for myopia development demonstrated similar sensitivity but lower specificity for prediction of future myopia. Sensitivity, specificity and AUC were 1.0, 0.83 and 0.980 respectively for the PreMO without AL, 0.97, 0.83 and 0.902 for SER alone and 1.0, 0.52 and 0.758 for AL alone.

A PreMO risk score ≥4 is strongly indicative of future myopia and is applicable to UK children across ethnicities. The PreMO framework can be used in clinical practice to optimise detection of future myopia.

P194: Eye colour does not modify the effect of low-concentration atropine eye drops on pupil size and accommodative lag

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Purpose: Few studies on low-concentration atropine eye drops for myopia control exist in non-Asian populations. Anti-muscarinic agents bind to melanin; thus, can affect light and dark iris colours differently. We aimed to evaluate the effects of 0.01 and 0.05% atropine eye drops on accommodative lag and pupil size among myopic adults with dark brown and light blue eye colours.
Methods: Healthy participants aged 18-25 years were enrolled in the Treatment Optimisation of Atropine Study (TOAST) and randomly assigned to using one drop of either 0.01% or 0.05% atropine into each eye nightly over 14 days, followed by a 14-day washout period. At baseline and days 1, 3, 7, 14, 21 and 28, accommodative lag was monocularly evaluated at 1m, 33 and 20cm using an open-field autorefractor, while wearing habitual correction. Pupil size was measured using Espion V6 software while participants were exposed to uniform white light of luminance -0.5, 0, 0.5, 1.0, 1.5 log cd/m2 (Ganzfeld ColorDome, Diagnosys). Data were analysed with linear mixed models, including visit and treatment assignment as fixed-effect covariates and random intercept terms to account for within-person correlation. An interaction term between eye colour and visit tested if the effect of atropine treatment differed between blue and brown eye groups.
Results: Thirteen blue-eyed (6 in 0.05% atropine group; 7 females) and 14 brown-eyed (9 in 0.05% atropine group; 9 females) participants were enrolled. Compared to baseline, accommodative lag in dioptres was significantly increased at days 3, 7 and 14 at 33cm (mean difference [MD]=+0.17 p=0.007, MD=0.22 p<0.001, MD=+0.19 p=0.002, respectively) and 20cm (MD=+0.2 p=0.004, MD=+0.47 p<0.001, MD=0.41 p<0.001, respectively), but, at 1m, did not change between visits (all p>0.05). Similarly, pupil size at all backgrounds was significantly increased during days 1, 3, 7 and 14, compared to baseline (+1.97, +1.79, +2.03, +1.8 mm, respectively, all p<0.001). There was no significant interaction between eye colour and visit for accommodative lag at 1m (p=0.52), 33cm (p=0.07) or 20 cm (p=0.80) or for pupil size (adjusted for luminance condition, p=0.51). Mean lags combined at 0.01% atropine were significantly lower than 0.05% at days 3, 7 and 14 (-0.526D, p=0.002; -0.602D, p<0.001; -0.333D, p=0.047). Pupil size was significantly different between step and visit date versus atropine concentration (p=0.009 and p<0.001, respectively).
Conclusions: We did not find evidence that the effect of atropine treatment on accommodative lag or pupil size was different between blue and brown eyes. This suggests that near blur or light sensitivity may not be worse in individuals with light colour eyes; however, caution is warranted due to the small sample size of this study.

P85: Comparison of subjective and objective pupil size measurement methods in a pediatric population

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Purpose: Low-concentration atropine is used widely to slow myopia progression in children, and there is currently no standard for measuring pupil size among clinicians. The goal of this study is to examine the agreement and correlation of two different methods of measuring pupil size in a pediatric population. The secondary outcome is to observe whether pupil size changes as a function of time.

Methods: 8 pediatric subjects (range: 8-10 years old) from a single site were followed prospectively for 3 years as part of a larger multi-centered double-blinded randomized clinical trial evaluating the safety and efficacy of low-concentration atropine. Pupil size was measured at 6, 12, 18, 24, and 36 month visits manually using a ruler in bright illumination, and objectively using a Neuroptics pupillometer. Agreement and correlation between the two methods were calculated using one sample statistics and Bland-Altman method. A mixed model analysis was used to determine change in pupil size as a function of time.

Results: Our findings indicate that manually measured pupil sizes were 1.36mm larger than when measured using the pupillometer (CI: 1.16-1.56mm, $p<0.001$). The correlation between the two methods is poor, though significant with $r=0.7$ ($p<0.001$). There was no significant change in pupil size as a function of time (pupillometer, $p=0.77$; manual, $p=0.3$).

Conclusions: There is poor agreement between the ruler and pupillometer measured pupil sizes with manual measures consistently over-estimating pupil sizes compared to pupillometry. Clinicians who are following patients on atropine treatment for myopia management long-term should pick one method to measure pupil size and stay with it.

P81: Age and Gender based percentiles for axial length and axial length to corneal curvature ratio for Indian children between the ages of 5 to 12 years

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Purpose: To generate age-specific percentile curves for ocular biometry components: axial length (AL), and AL/Corneal curvature (AL/CR) ratio stratified by gender for Indian children
Methods: Children of grades 1, 4, and 6 (aged 5-12) enrolled in the Sankara Nethralaya Tamil Nadu Essilor Myopia (STEM) study who had both refraction and ocular biometry measurements were included for the generation of percentile curves. Non-cycloplegic open-field autorefraction (Grand Seiko WAM 5500, Ajinomoto trading inc, Tokyo, Japan) and non-contact ocular biometry (IOL Master Version 5.4, Carl Zeiss-Meditec, Germany) were performed. Logistic Quantile regression was used to generate the gender-specific percentile curves for three grades for AL and the AL/CR ratio
Results: A total of 4514 children in grades 1, 4, and 6 with mean ages of 6, 9 and 11 (age range 5 to 12 years) were included for the analysis. Boys represented 54% (n=2442) of the sample. Only the right eye biometric components were included for the generation of percentile curves as there was a strong correlation (Pearson correlation r=0.86) between refraction estimates for the two eyes. The mean spherical equivalent refraction in the right eye was -0.01 (0.86) D and the prevalence of myopia in the sample was 11.7% (95% CI 10.8—12.7%). The AL cut-offs showed a significant increasing trend with increasing grades for both sexes ($p<0.001$) across all the percentiles. Overall, median AL increased by 0.68 mm from ages 6 to 11 in boys (22.67 mm to 23.35 mm), while for girls the change was 0.61mm (22.18 mm to 22.79 mm). Similarly, the AL/CR ratio increased with grades for both sexes across all percentiles ($p<0.001$). At grade 6 the AL/CR ratio for the 50th percentile was 3.00 and 2.98 for boys and girls respectively. The prevalence of myopia above the median percentile at this grade was similar between sexes [25.9% (95% CI 22.0—30.3%) for boys; 26.1% (95% CI 21.5—31.3%) for girls]. For cut-offs above the 90th percentile (3.02 and 3.01 for boys and girls), the prevalence of myopia exceeded 50% for both sexes [51.7% (95% CI 38.6—64.4%) and 53.8% (95% CI 39.6—67.5) respectively] at grade 1. The prevalence of myopia increased by grade 6 to 88.0% (95% CI 75.2—94.5) for boys and 79.0% (95% CI 67.8—87.1%) for girls for the cut-offs above the 90th percentile (3.12 for boys and 3.09 for girls respectively).
Conclusion: The AL growth percentiles of Indian children were similar to European children at 6 years of age but were considerably shorter than European children by 9 years of age. The percentile curves of Indian children were shorter than reported for Chinese children across all ages for both boys and girls. This work provides ocular biometric normative data for young Indian children that can be used as a reference to screen and monitor myopia development in this ethnic population.

P54: Myopia therapy – keep it simple: Physiological axial length growth as the treatment goal

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Purpose
With the introduction of specially designed spectacle lenses with the aim to inhibit myopia progression in children, the portfolio of myopia therapy has been expanded by an easy-to-use and non-invasive option that can be performed by ophthalmologists and optometrists as well. Currently, however, there is no consensus on the specific goal of myopia therapies, what criteria should be used to monitor the therapeutic success and when an adjuvant therapy should be administered.

Methods
A literature review on parameters of myopia development and progression, that are collected during myopia therapy, was performed and published epidemiologic studies on refractive development and axial length growth were reviewed.

Results
To assess myopia progression, the consideration of axial length change is preferable over refractive change; high axial length is determinant of the risk of myopia-associated eye diseases in adulthood. The primary goal of myopia therapy in children should be the reduction axial length growth. Epidemiologically collected growth curves show that even eyes with an axial length associated with emmetropia in adulthood, experience the highest growth rates during childhood. Consequently, physiologically required axial length growth is always underlying the excessive axial length growth of myopic (pediatric) eyes.
From data in the literature and own data, curves have now been developed which describe the so-called "physiological" axial length growth as a function of age. This should be defined as a therapy goal for myopia therapies.
For the implementation of these curves in clinical practice a tool was developed, which classifies the currently observed axial length growth in relation to the modeled physiological growth in an age-specific manner. Thus, information about the efficiency of the current therapy can be obtained.

Conclusions
The developed tool opens the possibility to classify the currently observed axial length growth on the basis of modeled data and thus to get an idea about the therapy efficiency. The use of this tool is conceivable for ophthalmologists as well as for optometrists, since the introduction of new biometers enables everybody to monitor the growth of the axial length.

P133: Effect of a 1-hour break outdoors on cumulative daily light exposure in primary schools in Auckland, New Zealand

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Purpose: Enhancing the brightness of the school environment has regained traction as a tool to reduce childhood myopia incidence. We investigated the relative distribution of light within classrooms in a sample of Auckland schools and compared cumulative daily light exposure that would be experienced by including a 1-hour break outdoors compared to indoors.

Methods: An array of 21 light meters sampled illuminance every minute over two days in a variety of positions and directions within a classroom, in 5 Auckland schools. Additional meters were placed outdoors, and under shade outdoors. The meters (HOBO Pendant®) were fitted with infrared filters to better match their response profile to that of the human eye. Cumulative illuminance indoors versus outdoors was compared over a typical school break hour, as well as over the 6-hour school day. Indoors, the effects of location, compass direction, and direction relative to the main windows were investigated. All readings were taken within the same 6-week period in winter. One-way ANOVAs determined the group variance within and between each classroom.

Results: There was a strong positive correlation between the indoor and outdoor illuminance at each time point ($r(1805)=.521$, $p<.001$). Cumulative comparisons showed that a 1-hour break outdoors at midday typically increased the total daily light exposure by 7 to 11 times. In the shade, cumulative light exposure over the midday hour was between ⅓ and ¾ of that over the full 6-hour day indoors.
There were no statistically significant differences in mean illuminance with respect to location within each classroom ($F(4,73)=0.62$, $p=.651$) or compass direction across all classrooms ($F(3,73)=1.07$, $p=0.368$). The direction facing the main windows was significantly brighter than the other directions ($F(3,73)=16.76$, $p<.001$). A significant positive correlation was found between relative window area and mean illuminance of the classrooms ($r(4)=.991$, $p=.009$).

Conclusions: Our results suggest that a child's position within a classroom would not significantly affect their light exposure, but that spending 1 hour outdoors could increase cumulative light exposure over the school day by more than 7-fold. Therefore, encouraging outdoor time during school breaks would seem to be a simple, safe, and equitable strategy aimed at inhibiting myopia development in children.

P40: Parental socioeconomic status, high complexity schools and myopia

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Title: Parental socioeconomic status, high complexity schools and myopia

Purpose: Current evidence indicates the existence of a direct association between socioeconomic status measured with the educational level and the prevalence of myopia in the adult population. However, to our knowledge, there are no studies that assess whether this association also occurs in children.
We conducted a cross-sectional study to investigate whether there is an association between the presence of myopia in 8-year-old children from southern Europe and parental educational level as well as employment status.

Methods: Child participants aged 8 years old were recruited from 16 schools located in the city of Terrassa, Barcelona, Spain (n=813). Ten out of the 16 schools were classified by the local government as high complexity (low socioeconomic status) schools.
During the 2021-22 school year, a complete visual screening was performed to all child participants, which included the measurement of habitual visual acuity, and refractive error assessed objectively using non-cycloplegic refraction, while fogging the contralateral eye using positive lenses. The Spherical Equivalent (SE) refractive error was classified into 3 groups: emmetropic ($-0.50 \leq SE \leq +1.50D$), hyperopic ($SE > +1.50D$) and myopic ($-0.50 < SE$). Following this, parental questionnaires were used to gather socioeconomic information such as parental education level and employment status.
Children for whom clinical or socioeconomic data was incomplete or not available were excluded from further analysis. Given that SE was not normally distributed, non-parametric Kruskall Wallis, Mann Whitney and Chi-square tests were used for statistical purposes. These statistical tests allowed to evaluate the association between SE and parental educational level and employment status as well as differences in the SE distribution between high complexity schools and regular schools.
Results: Data from 63 children were excluded due to incomplete datasets, and therefore the final study included a sample of 750 children aged 8 years (46.5% males and 53.5% females). Chi-square tests revealed a significant association between children attending high complexity schools and SE ($p=0.014$). In contrast no associations were found between SE and parental socioeconomic status defined by parental employment status and parental educational level. Myopia was also found to be more prevalent than hyperopia in the population sample (11% vs 4%).

Conclusions: The study findings support the view that there is not a direct relationship between SE in children and parental socioeconomic status. However, the same study indicates that myopic refractive errors are more frequently found in children who attend regular schools compared to high complexity schools. This finding is in line with the results previously found in the adult population, which indicate an increased prevalence of myopia for higher educational level. Future studies to further understand refractive error development in both school settings and the possible long-term impact of socioeconomic status in myopia development are warranted.

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P21: The efficacy and safety of topical 0.02% atropine for controlling near work induced transient myopia

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Purpose: To investigate the efficacy and safety of topical 0.02% atropine for controlling near work induced transient myopia (NITM).
Methods: This was a cohort study. The participants were randomly treated with topical 0.02% atropine eye drops (study group), and topical 0.02% atropine sulfate eye drops solvent eye drops (control group). Both systematic and ocular parameters were evaluated at baseline and on day 30 during treatment. In addition, ocular discomfort and adverse effects were recorded.
Results: Finally, 131 eligible participants were enrolled, including 67 participants in the control group and 64 participants in the study group. No significant difference in the magnitude of initial NITM was found between the 2 groups at baseline. On 30 day, the initial NITM in study group was -0.1±0.12D, which was significantly smaller than that at baseline ($p<0.001$). On 30 days, the difference of initial NITM in study group compared with baseline was 0.3±0.16D, which was significantly larger than that in control group (0.2±0.18, $p=0.0005$). In study group, 54 (84.4%) eyes showed effective, and the efficient of study group was significantly higher than that of control group ($p<0.001$). On 30 days, the PD in study group was 6.5±0.61 mm, which was significantly larger than that in baseline ($p<0.001$), and that in control group ($p<0.001$). In study group, there were one participant with eye pain, one participant with photodysphoria, and one participant with influenza. All symptoms were healed by themselves.
Conclusions: It was effective to treat NITM using topical 0.02% atropine eye drop. The pupil dilation induced by topical 0.02% atropine was acceptable, without any serious complications.

P73: Does the ratio between refractive error and the length of the eye depends on the annual progression?

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Purpose
The link between the axial length (AxL) of the eye and its refractive error is very distinct, especially in adults where a change of 3D of the spherical equivalent ametropic error (SE) is caused by a change in 1mm of the length of the eye (Ratio: 3:1). Such a correlation is reduced in the developing eye and the ratio of the spherical equivalent refractive error and the length of the eye and is around 2:1. The purpose of the study is to investigate if this ratio is depending on the annual progression of refractive errors using data from a European cohort of children with longitudinal data.
Methods
The prospective, longitudinal, and cross-sectional Life Child study measured refractive errors using wavefront aberrometry (ZEISS i.profiler plus, ZEISS) and axial length using partial coherence interferometry (Lenstar 900, Haag Streit) in 2000 children aged 3-18 years over a time range of up to 6 years. Annual progression was calculated in children with minimum two visits and children were categorized according to their annual progression of their spherical equivalent refractive error. The AxL/SE ratio was calculated for the difference between the first and second visit. Analysis was run for the following bins of progression: group 1: 0 to -0.25D SE (n= 450 children); group 2: -0.25 to -0.5D (n=129); group 3: -0.5D to -0.75D (n=29).
Results
Children with a progression in the range of 0 to -0.25 showed a ratio of 2.43:1, while the ratio was significantly higher in children with higher amounts of myopic progression (group 2: 3.3:1; group 3: 3.37:1). Kruskal Wallis statistics revealed significant differences between group 1 vs. group 2 ($p < 0.001$) as well as for the comparison of group 1 vs. 3 ($p < 0.001$). Also, the average spherical equivalent refractive error was more negative in group 2 (-0.28D) and group 3 (-0.26D) when compared to group 1 (0.12D).

Discussion
When the eyes grow, the ratio of the progression between the spherical equivalent refractive error and the length of the eye seems to depend on the annual progression. Further research is needed to investigate such behavior also in randomized clinical trials and different intervention groups.

P50: Prediction of cycloplegic refractive errors in Norwegian children and adolescents

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Purpose: Non-cycloplegic assessment of refractive errors is prone to underestimate the degree of hyperopia. Here, we assessed different models for predicting cycloplegic refractive error from non-cycloplegic autorefraction and ocular biometry in children and adolescents.
Methods: The study included 595 eyes from 301 participants (7–19 yrs). Refractive errors and ocular biometry were measured with Huvitz HRK-8000A and Zeiss IOLMaster 700, before and after administration of cyclopentolate 1%. The participants were randomly assigned to a modelling group (395 eyes) and a validation group (200 eyes). Prediction models for cycloplegic spherical equivalent refractive error (SER) were developed by multiple regression analyses based on non-cycloplegic SER and ocular biometry in the modelling group. Model M1 predicted cycloplegic SER based on non-cycloplegic SER, axial length (AL), anterior chamber depth, lens thickness, mean corneal refractive power, corneal astigmatism, sex, and age. Model M2 predicted cycloplegic SER based on non-cycloplegic SER and the ratio of AL to mean corneal radius (AL/CR). Each prediction model was then validated by its application in the validation group.
Results: In the validation group, measured cycloplegic SER correlated significantly with predicted SER (M1: R^2=0.87, M2: R^2=0.88, p<0.001). The difference between non-cycloplegic and cycloplegic measured SER was less than ±0.25D in 21.5% of the participants, whereas the difference between predicted and measured cycloplegic SER by both M1 and M2 was less than ±0.25D in 46% of the participants. The distributions of predicted versus measured cycloplegic SER were overlapping, but all were significantly different from non-cycloplegic measured SER (p<0.001). The pairwise differences between predicted and measured cycloplegic SER were significantly different (mean ±SD; M1: 0.07 ±0.49D, p=0.05; M2: 0.07 ±0.45D, p=0.04). The sensitivity/specificity to detect hyperopia (SER≥+0.50D) were 40%/98% (by non-cycloplegic SER alone), 84%/74% (M1), and 88%/74% (M2).
Conclusions: The results show that the combination of non-cycloplegic SER and ocular biometry doubles the sensitivity to detect hyperopia compared with non-cycloplegic SER alone (84% and 88% versus 40%). Still, in more than half of the participants, the difference between predicted and measured cycloplegic SER was larger than ±0.25D. This underlines the necessity of using cycloplegia in assessment of refractive errors in children and adolescents.

P71: Ginkgo biloba Extracts Altered Choroidal Blood Perfusion in Mice

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Purpose: It has been reported that Ginkgo biloba extracts (GBEs) increase early growth response 1 (Egr-1) activity in luciferase assay, and oral administration of GBEs suppresses a myopia shift of refraction and axial elongation in a murine model of lens-induced myopia. This study was aimed to investigate the mechanism of GBEs to inhibit the progression of myopia, a mouse model was used to evaluate the change of choroidal blood perfusion after oral GBEs administration and the expression of Egr-1, and endothelial nitric oxide synthase (eNOS) in the choroid.

Method: 3-week-old male C57B6/ J mice were randomly divided into two groups: mice fed with normal chow (control group) and mice fed with 0.0667% GBEs (GBEs group) (n = 10 in each group). Choroidal blood perfusion was measured with OCTA (OCT-S1, Canon, Tokyo, Japan) before and 3 weeks after feeding. In addition, choroid samples were collected and the mRNA expression of Egr-1 and eNOS, as a vascular-related factor of the choroid was observed by real-time PCR.

Result: In the control group, choroidal blood perfusion was measured to increase by 8.24 ± 14.79 %Area (mean ± standard deviation) compared with pre-administration, while in the GBEs group, choroidal blood perfusion increased by 22.56 ± 14.38 %Area. The GBEs group showed a significantly greater change in choroidal blood perfusion compared with the control group after 3 weeks of administration (P = 0.025). Real-time PCR revealed significant increase of Egr-1 (P = 0.040) and eNOS expression (P = 0.029) in the choroid after 3 weeks of GBEs administration.

Conclusion: GBEs may inhibit the progression of myopia by increasing choroidal blood perfusion and Egr-1 and eNOS expression in the choroid.

P67: Alpha-1 blockers suppress lens-induced myopia in mice by maintenance of choroidal thickness

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Purpose: The choroid thinning occurs with myopia progression, and the decrease in choroidal blood flow is considered as one of the causes of myopia. An alpha-1 blocker binds to alpha-1 adrenergic receptors in vascular smooth muscle and causes vasodilation. Preventive effects of alpha-1 blocker on myopia progression are expected by the maintenance of the choroidal blood flow. In this study, we examined the therapeutic effects of alpha-1 blockers in a lens-induced myopia mouse model.

Methods: C57BL/6J mice were induced myopia at 3-week-old by a method established in our research group (Jiang X et al. Sci Rep. 2018). For 3 weeks, mice were equipped with lenses in both eyes, a left for 0 D lens as internal control and a right for -30 D lens as myopia induction. During this period, we administered 0.01% of bunazosin hydrochloride, prazosin hydrochloride, or urapidil hydrochloride by eye instillation once a day in both eyes and PBS as control. Ocular components including refraction errors, axial length, and choroidal thickness before and after myopia induction were measured by an infrared photorefractor and an SD-OCT.

Results: In the eye with -30 D lens of control group, significant changes in a myopic shift of refraction ($p < 0.01$) and axial elongation ($p < 0.05$) compared to 0 D lens were observed. In contrast, bunazosin or prazosin groups showed no significant difference between both eyes suggesting myopia progression was suppressed by bunazosin treatment. In the urapidil group, myopic shift was slightly suppressed while axial elongation was not. Furthermore, the changes in the choroid thickness of the eye with a -30 D lens were maintained with bunazosin (0.47 μm±0.89) or prazosin (0.33 μm±0.75). In contrast, a significant choroidal thinning was observed in control (-0.49 μm±0.68, $p<0.05$ compared to 0 D lens) and urapidil (-0.46 μm±0.50).

Conclusion: The eye instillation of bunazosin and prazosin but not urapidil showed preventive effects on myopia progression by suppressing axial elongation and choroidal thinning.

P52: Agreement of Sub-foveal Choroidal Thickness Measured by ARGOS with Swept-Source Optical Coherence Tomography in Pediatric Indian Myopes.

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Purpose: Sub-foveal choroidal thickness (SFChT) is one of the key characteristic changes in myopic children. To the best of our knowledge, there is no automated inbuilt method to measure the SFChT from the existing retinal imaging devices. This study aims to describe a new method to measure the Choroidal thickness using an optical biometer and to evaluate the agreement between the new method and the standard clinical method.

Methods: Forty-seven (71 eyes) consecutive pediatric myopic subjects who visited the myopia management clinic, and who underwent both ocular biometry (SS-OCB; ARGOS; Movu, Aichi, Japan) and swept-source optical coherence tomography (SS-OCT; Atlantis DRI OCT-1 system, Topcon Medical Systems, Paramus, NJ, USA) were enrolled into the study. A system-generated single A-scan image was used for quantifying the SFChT by manually placing the cursors on the retinal peak and choroidal peak. Two experienced masked observers measured SFChT using the ImageJ application (National Institutes of Health, USA). An intraclass correlation coefficient (ICC) and Bland-Altman's plot were used to evaluate the agreement between the methods

Results: The mean ± SD age, spherical equivalent, and axial length (AL) of the study subjects were 9.69 ± 1.91 years, -3.49 ± 1.55 D, and 24.62 ± 1.00 mm respectively. The mean ± SD SFChT by SS-OCB and SS-OCT were 245.01 ± 60.50 µm, and 250.65 ± 58.17 µm respectively, (mean difference, 5.64 ± 31.41 µm). The ICC showed a good (κ=0.87, CI: 0.80 – 0.92) agreement between the methods. Similarly, the Bland-Altman plot showed a good agreement (The mean difference between the two methods was 5.64 µm) with a wide limit of agreement (LOA: 65.25 & -53.96 µm).

Conclusion: SFChT measures from optical biometer exhibit a strong correlation and good agreement with SS-OCT in young pediatric myopic subjects. In the absence of optical coherence tomography, a biometer can be used as a substitute for SFChT measurements for clinical purposes.

P61: The retinal response to different signs and magnitudes of optical defocus

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Purpose: In animals, eye growth is locally driven in response to visual stimuli by pathways that originate in the retina, ultimately changing the rate of scleral growth. However, there is still much we need to understand about how the retina uses these visual signals to guide eye growth. For example, how does the retina, at a biochemical level, differentiate different signs and magnitudes of defocus, thus leading to different growth outcomes? This is likely to have significant ramifications for how optical myopia control interventions are designed and prescribed. To address this question, this study investigated the molecular response of the retina to different signs and power of defocus by measuring the expression of the gene early growth response 1 (EGR1), a key retinal biomarker of ocular growth.

Methods: To investigate how the biochemical response of the retina changes with increasing the magnitude of retinal defocus, chicks were fitted with different powers of lenses for a period of 1 hour, a timepoint which is known to show robust molecular changes. Specifically, chicks were fitted with either negative (-1D, -2D, -5D, -10D, or -15D) or positive (+1D, +2D, +5D, +10D, or +15D) lenses, with EGR1 mRNA levels (n=10 per condition) measured by semi-quantitative real-time PCR (sqRT-PCR). Data are presented as mean fold change ± standard error and were analysed via a univariate analysis of variance (ANOVA).

Results: Increasing the magnitude of either hyperopic or myopic retinal defocus did not induce a linear change in EGR1 levels. Instead, the expression of EGR1 was best fit by a parabolic model, with the strongest response observed following ±5D lens-wear (ANOVA($F(7,73) = 2.83$, $p < 0.05$) and ANOVA($F(7,73) = 4.21$, $p < 0.05$)).

Conclusions: This work suggests that increasing the magnitude of optical defocus does not produce a linear increase in the retinal response, and hence may not produce a linear physiological change. Instead, it appears that the retina is most sensitive to specific magnitudes of defocus, showing a parabolic response. Therefore, optical growth suppression may only show optimal results at specific defocus levels that fit this parabolic response.

P30: Eye size and shape in 10-year old children in relation to refractive error: a magnetic resonance imaging study

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Purpose: To determine the association between eye shape and volume measured with MRI and ocular biometry and refractive error (RE) in school children.
Methods: 3,757 10-year-old children from a population-based birth-cohort study underwent ocular biometry (IOL-master 500) and T2-weighted MRI scanning (height, width and volume). Cycloplegic RE was determined by automated refraction. Eyes were segmented with MRI using automated algorithm combining atlas registration with voxel classification. Associations between ocular biometry, anthropometry, MRI measurements, and RE were tested using Pearson correlation. Shape was calculated as height2/AL2 -1 and width2/AL2-1; shape >0.005 was considered oblate; shape <0.005 as prolate; and else as spherical. Differences between RE groups were tested using ANOVA.
Results: Mean volume of the posterior segment was 6.35(±0.68) cm3. Myopic eyes (SE≤-0.5D) had 0.47 cm3 (P <0.001) and 0.97 cm3 (P <0.001) larger posterior segment volume than emmetropic and hyperopic eyes (SE≥+2.0D) respectively. Mean horizontal shape was 0.056(SD 0.066). Myopic eyes were on average oblate, but 45% was prolate, whereas 87.5% of hyperopic eyes were oblate. The correlation between MRI-derived posterior segment length (r -0.51; P <0.001) and RE was stronger than the association between height (r -0.30; P <0.001) or width of the eye (r -0.10, P <0.001) and RE.
Conclusion: In this study, eye shape at 10 years was predominantly oblate, even in eyes with myopia. Of all ocular biometry measured on MRI, posterior segment length was most prominently associated with RE. Whether eye shape is an independent predictor for development of myopia should be investigated in longitudinal studies.

P192: Short-term effect of topical cyclopentolate and tropicamide eye drops on subfoveal choroidal thickness in myopic children

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Purpose: Changes in choroidal thickness (CT) have been linked to myopia onset and progression and treatments for myopia progression have been noted to alter CT. However, to date, there has not been a consensus on the procedural approach (pre- or post-dilation) in measuring CT in myopic children. This study was to investigate the effect of cyclopentolate and tropicamide eye drops on subfoveal CT in myopic children enrolled in myopia treatment trials.

Methods: Data from 188 myopic children aged 7-19 years enrolled in two separate randomised placebo-controlled trials of low-dose atropine (0.01% or 0.02%) eye drops were used. Participants in the two trials received either 1% cyclopentolate hydrochloride [n=139] or 1% tropicamide [n=49] eye drops in both eyes five minutes apart after topical anaesthesia. Subfoveal CT measurements were obtained just prior to instilling eye drops and 30 minutes after the second drop using swept source optical coherence tomography (DRI OCT Triton Plus, Topcon). Presented data are mean±SD and paired t-test was used to compare mean change in choroidal thickness. Bland-Altman test was used to explore limits of agreement (LOA) between pre- and post-dilation CT measurements.

Results: Mean subfoveal CT decreased after instillation of both cyclopentolate (234.2±68.8 to 229.2±69.1µm, P<.001) and tropicamide (224.7±61.1 to 223.1±61.4µm: P=.09). A higher proportion of individuals demonstrated a decrease (74.6% and 61.2%) versus an increase (18.8% and 36.7%) in CT post dilation for cyclopentolate and tropicamide, respectively. 95% LOA ranged from -18.7 to 8.8µm, coefficient of repeatability (CR), 16.8µm for cyclopentolate; and -14.2 to 11.0µm, CR of 12.8µm for tropicamide. Intraclass correlation coefficient for pre- and post-dilation measurements were 0.992 (95% CI; 0.974 to 0.997; P<.001) and 0.994 (95% CI: 0.99 to 0.997; P<.001) for cyclopentolate and tropicamide groups, respectively.

Conclusions: The current study showed that there was a mean decrease in CT after both eye drops. Interestingly, the LOA and CR in our study were larger than normal test-retest LOA (-10.2 to +12.4µm) and CR (8.6µm) previously reported in a study of myopic children, suggesting the eye drops could account for some of the variation in the pre- to post-dilation measurements. Post-dilation values are likely to be thinner than pre-dilation, particularly with cyclopentolate, but the difference is not systematic, hence a consistent approach is recommended.

P96: Omega 3 polyunsaturated fatty acids showed suppression of choroidal thinning and subsequent myopia inhibition by lipidomic analysis in murine experimental models

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Purpose:
Omega 3 (n-3) polyunsaturated fatty acid (PUFA) has been reported to have a wide variety of effects such as cardiovascular and anti-inflammatory. Myopia suppressive effect is not an exception. This study is aimed to investigate lipid metabolites associated with myopia suppression with lipidomic analysis.
Method:
A lens induced myopia (LIM) model was created using C57B6/J 3-week-old mice by applying -30 diopters (D) lenses on one eye to induce myopia, and 0 D lenses on the other as a control. Chows containing various rates of n-3 and n-6 were given to the wild-type LIM mice. Chows containing little n-3 were given to transgenic LIM mice (fat-1tg), which can produce n-3 PUFA endogenously, to confirm the effect of n-3 on myopia suppression. Refraction, axial length, and choroidal thickness were examined at the beginning of the experiment and the end of the myopic induction using an infrared photorefractor. Using enucleated eyes, untargeted lipidomic analysis was performed to identify the lipids which contribute to myopia suppression using quadruple time-of-flight/MS, and subsequently, targeted lipidomic analysis was performed to detect the lipid metabolites using a triple quadruple linear ion trap mass spectrometer. Derived metabolites were given to LIM mice models to confirm the results of lipdomic analyses.
Results:
Either in the group of the larger ratio of n-3 than n-6 PUFAs or in the group of fat-1tg mice, myopic refractive change, axial elongation, and choroidal thinning were suppressed. Untargeted lipidomic analysis revealed eicosapentaenoic acid (EPA) was responsible for such suppressions. Target lipidomic analysis demonstrated that some of EPA-derived metabolites were shown to significantly increase in myopia-suppressed eyes compared to myopia-induced eyes. Myopia was suppressed in the EPA-supplemented mice, with suppression of the thinning of the choroidal thickness (-4.99±3.41 μm vs. 6.45±2.35 μm, $p<0.05$), suppression of the myopic changes in refraction (control vs. EPA-supplemented: -11.83±3.73 D vs. +7.08±1.70 D, $p<0.001$), and suppression of axial elongation (0.33±0.01 mm vs. 0.27±0.02 mm, $p<0.01$).
Conclusions:
This study suggests that EPA-derived metabolites are correlated with suppression of choroidal thinning and myopia.

P58: Two-dimensional peripheral refraction features in adults

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Purpose: The shape of the eyeball evolves with the changes of refractive error. The study was to establish a database of the two-dimensional peripheral refraction profiles in adults and to explore the defocus features with various central refractive error.

Methods: A total of 479 adult subjects, aged from 17 to 50 years with an average of 24.87± 5.33 years, participated into the study. Their central refractive error (CSER) ranged from +4.14 D to -10.64 D with an average of -4.69±2.86 D, and were divided into different groups based on the CSER. Peripheral refraction in right eye was measured by a custom-made view Hartman-Shack scanning wavefront sensor (VPR, Voptica SL, Spain). Two-dimensional (2D) data were collected in the horizontal meridian from temporal 30° to nasal 30°and in the vertical meridian from 20° superior to 16° inferior every 4°, covering a visual field of 60°×36°, with a scanning resolution of 1°. The area scanned was divided into 9 regions to investigate the synchronization of refraction between peripheral regions and the center. In addition, the central retina with 16° eccentricity was separated into up and down halves divided by the horizontal line through the fovea. Each half was further divided by the diagonal lines. The defocus asymmetry index (DAI) was introduced to quantify the symmetricity of defocus across the retina. The DAI of axisymmetricity and centrosymmetricity was calculated as the mean of the absolute difference in the refraction between the symmetrical points, using the horizontal line through the fovea and the fovea per se as the reference, respectively.

Results: In general, the peripheral refraction demonstrated relatively myopic in hyperopes and relatively hyperopic in myopes. The heterogenous pattern of peripheral refraction became more prominent with increased CSER. With the increase of central myopia, the superior-nasal and superior-temporal regions significantly lagged behind, followed by the temporal and nasal regions. In contrast, central-superior or central-inferior regions synchronized relatively well with the center. In terms of the symmetry assessment, both the axisymmetric and centrosymmetric DAI was found to increase with the myopic shift of the CSER.

Conclusion: Significant asymmetrical pattern of peripheral refraction was found in adults with various central refractive error. These features would offer an important reference for the designs of optical devices for vision correction and modulation.

P83: Novel Utilization of Anterior SS-OCT for the Evaluation of Lens-to-Cornea Relationship in OrthoK Treatment

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Purpose:
When fitting overnight OrthoK lenses, traditional dynamic observation utilizing sodium fluorescein (NaFl) can be confounded by irritative tearing and may not be entirely representative of a lens fit. Moreover, despite the reported advantages of various edge profile designs on the onset of myopia correction and the initial comfort, to our knowledge, the direct relationship between OrthoK lenses and cornea has not been fully investigated with any imaging technology. In this explorative study, we aimed to study the OrthoK lens-to-cornea fitting relationship using images acquired with anterior SS-OCT and compare them to images captured using traditional NaFl observation.

Methods:
Two OrthoK designs with different peripheral systems (tangent vs. curved) were fitted on the same eyes (n=4) of two subjects. The lens-to-cornea relationship was imaged with both SS-OCT and NaFl videography once the fitting was deemed ideal. Lenses with less-than-ideal landing parameters of each design were also imaged to compare to the ideal fitting. Three clinician reviewers blinded from the design allocation were asked to identify the designs and grade the lens-to-cornea relationship of lenses in varying parameters.

Results:
A total of 46 images of 23 lenses on four eyes were reviewed and analyzed. All reviewers were able to correctly identify the tangential versus curved landing design but not with NaFl image analysis. The width of the clearance underneath the return zone (reverse curve) of the lenses and the area of applanation of the landing zone or the alignment curve of the lenses on the mid-peripheral cornea can be easily annotated on the OCT images. Additionally, the edge profile of the lenses and their interactions with the peripheral cornea is clearly shown on the SS-OCT images.

Conclusions:
High-resolution anterior SS-OCT images of OrthoK lens over cornea increase sensitivity and specificity of identifying lens-specific design compared to NaFl analysis, which was independent of the fitting experience of the reviewers. These preliminary findings demonstrated the capability of SS-OCT as an excellent supplementary tool for observing the lens-cornea fitting relationship and guide design improvements to achieve better initial comfort, long-term safety, and efficacy of OrthoK treatment.

P125: Influence of education systems on children's visual behaviours as an environmental risk factor for myopia: a quantitative analysis with LIDAR-sensor tracking in classrooms

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Purpose: A pilot study on Hong Kong children in a local and an international school found that, despite a much higher prevalence of parental myopia and high myopia, the myopia prevalence among the international school students is lower than that in the local school, suggesting that environmental factors related to the educational system have a protective effect on myopia development. We quantify this hypothesis by rigorous comparison of the working distance and dynamic visual behaviours in a sub-cohort of these two school systems, using head-mounted distance sensors in the children's classroom setting.

Methods: Children (8-10 years) were recruited from a local (n=28) and an international school (n=27) for high-frequency (10 samples/second) working distance logging in their school day. To track the visual behaviors during 90 minutes of typical lessons in their classroom, each child wore a head-mounted LIDAR as part of a wearable technology ensemble consisting of eye-tracking glasses, and light and distance sensors. Visual behavior was expressed as dioptric viewing distance (1/working distance). To quantify the dynamic nature of the visual behaviour, we calculate the autocorrelation, i.e., the correlation of a dioptric distance with a delayed copy of itself, as a function of delay.

Results: Local schoolchildren on average exhibited a significantly higher dioptric viewing distance (i.e., shorter working distance) in class than international schoolchildren (2.55±0.45 m^(-1) vs. 1.82±0.23 m^(-1); two-sample t-test, P <0.001). In the local school, emmetropic children showed a slightly larger dioptric distance than myopic children (2.81±0.53 m^(-1) vs. 2.39±0.32 m^(-1), two-sample t-test P=0.017). No statistically significant difference was found between emmetropic and myopic children in the international school (1.87±0.22 m^(-1) vs. 1.75±0.24 m^(-1); two-sample t-tests, P=0.182). Interestingly, the dioptric distances of local schoolchildren changed significantly slower than those of international schoolchildren (0.33±0.10 s^(-1) vs. 0.66±0.24 s^(-1) ; Kolmogorov–Smirnov statistic (KSs) = 0.77, P=<0.0001). Conversely, no statistical difference was found in the dioptric distance dynamics between emmetropic and myopic children in the same school using the two-sampled KS test (local school KSs = 0.4, P = 0.19 and international school KSs = 0.26, P = 0.68).

Conclusions: Although the association between education and myopia has been well established, only a few studies have compared the risk factors for myopia with children from the same geographical location, but different education systems. Our quantitative analysis based on LIDAR data revealed sizable differences in the static and dynamic visual behaviours of Hong Kong children attending two schools that employ contrasting pedagogical approaches, but not between emmetropic and myopic children within the same school. These results indicate that the education system plays a predominant role in determining children's visual behaviour and thus can be an environmental risk factor for myopia development.

P34: Evaluating the parameters in OCT characteristics of the macula in adolescent with unilateral anisometropic amblyopia

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Purpose: To compare the differences of parameters in the macular area between adolescents with anisometropia amblyopia and the normal population by optical coherence tomography (OCT).

Methods: Thirty-nine children with anisometropia amblyopia who were admitted to Changsha Aier Eye Hospital from August 2020 to May 2021 were recruited for this study. As controls, nine hundred and eighteen healthy children were recruited from the Aier Children and Adolescents Refractive Development Cohort study. Retinal thickness, retinal nerve fiber layer (RNFL) thickness and choroid thickness were measured by OCT (DRI OCT Triton, Japan, Topcon). Then the relationships between age, refractive error, axial length, and the main parameters were analyzed by a Spearman's correlation, generalized estimation equation (GEE) and multiple linear regression analysis.

Results: Bilateral differences between the eyes of amblyopes were found when variables such as age, diopter, and axial length were taken into account. The EDTRS for the foveal region, the amblyopia eyes showed increased retina thickness in the central area (A1)(+5.08μm; P=0.043) and the inner inferior quadrant (A4) (+9.62μm; P=0.019), and increased RNFL thickness in the central area (A1) (+7.42μm; P=0.035), the inner temporal quadrant(A3) (+3.62μm; P=0.043), the inner nasal quadrant (A5) (+6.20μm; P=0.003), the outer superior quadrant (A6)(+3.90μm; P=0.02), the outer inferior quadrant (A8)(+4.79μm; P=0.046), and the outer nasal quadrant (A9)(+6.37μm; P=0.008) when compared with the non-amblyopic eyes. There was no difference in choroid thickness between the amblyopia and non-amblyopic eyes. Differences between amblyopia eyes and normal eye is predictable. The amblyopic eyes showed increased retina thickness in the central area (A1)(+31.39μm; P<0.001), and a reduction in the inner temporal quadrant(A3)(-8.15μm; P<0.001) and the inner inferior quadrant (A4) (-9.42μm; P=0.001) when compared with subjects with normal vision. For RNFL thickness, the amblyopic eyes showed an increase in the central area (A1) (+13.50μm; P<0.001), the inner superior quadrant (A2) (+7.04μm; P<0.001) and the inner nasal quadrant (A5) (+5.91μm; P<0.001) when compared to normal eyes. The non-amblyopic eyes of amblyopic patients also differ from normal eyes. For retina thickness, the non-amblyopic eyes showed an increase in the central area (A1) (+25.65μm; P<0.001) and the outer inferior quadrant (A8) (+10.87μm; P=0.001) , and a reduction in the inner temporal quadrant(A3) (-8.05μm; P<0.001), the inner nasal quadrant (A5) (-6.51μm; P=0.004) and the outer superior quadrant (A6) (-5.11μm; P<0.001) when compared to normal eyes. For RNFL thickness, the non-amblyopic eyes showed an increase in the central area (A1) (+6.41μm; P<0.001) and the inner superior quadrant (A2) (+2.45μm; P<0.001), and a reduction in the inner temporal quadrant(A3) (-1.88μm; P<0.001), the inner inferior quadrant (A4) (-7.64μm; P<0.001), the outer temporal quadrant (A7) (-0.99μm; P<0.001) and the outer inferior quadrant (A8)(-4.23μm; P<0.001) when compared to normal eyes.

Conclusion: There exists some difference in structure of macula between amblyopic eyes and non-amblyopic eyes in adolescent with unilateral anisometropic amblyopia. Differences were also found in the macula structure in both eyes of unilateral anisometropic amblyopes compared with subjects with normal vision.

Keywords: amblyopia; anisometropia; optical coherence tomography; macula; nerve fiber layer; choroid.

P131: The assessment of iris colour in a myopia risk factor study among Estonian schoolchildren

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Purpose

Exposure to sunlight is a well-established protective factor against myopia as bright light inhibits eye growth through retinal signalling. While the majority of light is transmitted to the retina through the pupil, approximately 10% reaches the retina through the iris and sclera. As a more pigmented iris transmits less light than a less pigmented iris, we hypothesised that darker iris colour could be a risk factor for myopia. In this paper, we assessed the effect of iris colour on myopia in three age groups of Estonian schoolchildren.

Methods

The study population included 187 students from grades 1, 5 and 9 (aged between 7-8, 11-12 and 15-16, respectively), recruited as part of a larger project aimed at assessing the risk factors of myopia in Estonia. Myopia was defined as cycloplegic spherical equivalent refractive error (SER) ≤–0.50 dioptres (D). Iris colour was assessed separately by two examiners using Seddon´s five-grade iris colour classification system. . Participants were divided in two groups by iris colour: light (Seddon scale I-II) and dark (Seddon scale III-V). The right eye of each participant was used in this analysis. Parental myopia was assessed with a questionnaire. A logistic regression model was fitted with myopia as outcome; and iris colour, gender, parental myopia and grade as covariates.

Results

There were 42 myopes and 146 non-myopes in the study cohort, 57 from grade 1 (51% boys), 65 from grade 5 (46% boys), and 65 from grade 9 (40% boys). From the 187 eyes, 133 were classified as having light irises and 54 as dark irises. There were 98 participants who reported at least one of their parents being myopic, the remaining 89 had no parental history of myopia. Children with parental history of myopia had higher odds for myopia (OR 3.5, 95% CI 1.6–7.8). Students from grade 5 and 9 were more likely to have myopia than students from grade 1 (OR 9.2, 95% CI 2.5–33.7 for grade 5; OR 9.4, 95% CI 2.5–35.2 for grade 9). Gender did not affect the likelihood of having myopia. Finally, we found that having a darker iris did not affect the odds for myopia (OR 1.16, 95% CI 0.52–2.59).

Conclusions

Our current results confirm that parental myopia is an important risk factor for myopia among Estonian schoolchildren. In this population, we did not find an association between iris colour and myopia.

P92: Effects of High Frequency ON, OFF and Square Wave Stimuli on Choroidal Thickness and Retinal Dopamine Metabolism in Chickens

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Purpose It has been demonstrated that short-term (3h) stimulation of the retinal ON-pathway induced an increase in choroidal thickness (ChT) and retinal dopamine metabolism, compared to OFF stimuli. However, these initial changes in choroidal thickness did not predict the amount of negative lens-induced myopia (LIM) after 7 days: chickens reared under ON and OFF stimulation developed a similar amount of myopia and even more myopia than chicks reared under room light. To test whether the underlying repetition frequency of 1 Hz itself was myopigenic (as found before by others) we also tested higher frequency ON and OFF stimuli (10 Hz). In addition, a square wave temporal luminance profile was generated to investigate whether the presentation of a dynamic pattern itself increases the sensitivity of the retina to defocus.
Methods Chicks were treated monocularly with a -7 D lens and randomly assigned to one of seven groups: room light, 1.2 Hz ON, 1.2 Hz OFF, 1.2 Hz square-wave, 10 Hz ON, 10 Hz OFF, or 10 Hz square-wave group (n = 7 in each group). Illuminance was approximately 400 lux. The checkerboard patterns (square side length of each randomly phase-shifted field: 1.5 cm) with sawtooth-shaped temporal profiles (ON or OFF stimuli), or square-wave profile were presented on computer screens. Chicks were exposed from 9 a.m. to 6 p.m. for 7 days. Refraction (RE) was measured every two days. Vitreous chamber depth (VCD) was measured before and after the treatment and choroidal thickness (ChT) every day. Concentration of dopamine and its metabolites DOPAC and HVA were determined after the treatment using HPLC measurements.
Results There were no differences in ΔRE and ΔVCD among groups at the end of treatment, neither among the contralateral control eyes nor among the lens treated eyes. However, there were differences in the time course of refractive development: Between day 2 and day 4, all OFF stimuli (1.2 Hz, 10 Hz and 1.2 Hz square-wave) induced a significantly higher myopic shift in the treated eyes compared to treated eyes in room light. In the later part of the treatment period (day 4 - day 7), ΔRE in 10 Hz OFF group stopped progressing compared to the room light group, although not statistically significantly (0.29 ± 0.37 D vs. -0.84 ± 0.26 D, p = 0.07). The ChT in the LIM 10 Hz OFF group decreased significantly less than under room light (day 7, ΔChT day 7 – baseline: -12.20 ± 15.82 µm vs. -74.57 ± 20.01 µm, 2-way ANOVA, Dunnett's post hoc-test, p = 0.04). Looking into the daily ΔChT changes (day n – baseline), we found that the 10 Hz OFF stimulus thickened ChT in both lens wearing eyes and the fellow eyes, at day 5, 6, and 7, which might explain why myopia development stopped progressing at this time. Besides, the 10 Hz ON stimulus increased ChT during the last 2 days of treatment in the fellow eyes. Furthermore, 10 Hz OFF stimulus boosted the amount of vitreal HVA in both eyes, but not 1.2 Hz OFF stimulus. Also ON and square-wave stimuli (1.2 and 10 Hz) increased the concentration of vitreal HVA in treated and fellow eyes, except for the 10 Hz ON stimulus, which only affected the fellow eyes.
Conclusions Although there was no significant effect of different stimuli (1.2 and 10 HZ, ON/OFF/square wave) on refractive development and vitreous chamber depth, the time course of refractive changes and choroidal thickness changes was different. Especially the high frequency OFF stimulus induced a different time course in refractive development, with an accelerated myopic shift starting in the middle of the treatment period. This was followed by a recovering phase in the later period, with increasing choroidal thickness and increasing vitreal HVA concentration, which may indicate increased retinal dopamine metabolism. The mechanism underlying stimuli of different frequencies and the especially temporal characteristics of changes need further exploration but a central conclusion is that long-term treatment may induce adaptation effects, perhaps causing different ocular growth responses.

P106: Post Lens-Induced-Myopia Emmetropization: Binocular Compensation in Progression and Recovery of Myopia

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Post Lens-Induced-Myopia Emmetropization: Binocular Compensation in Progression and Recovery of Myopia

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Purpose: Apart from genetic factors, most recent myopia studies have focused on a localized mechanism, in which myopia-inducing visual signals triggers ocular molecular and cellular reactions, leads to tissue remodeling and eventually eyeball elongation. In this research, we sought to elicit the interaction and compensation between the two eyes throughout myopia progression and recovery, which could hardly be explained by mere local mechanism.
Methods: Monocular minus 30 diopter (D) lenses was attached to 3 weeks old mice (n=10) with the other side untreated. All lenses were took off after three weeks of myopia induction. Both eyes were aligned to recover for 1 week in the same environment. Refraction statuses, axial length (AL) and choroidal thickness were measured before myopia induction, 1 week, 3weeks of lenses wearing and after 1 week of recovery, respectively, which serves as indicators to evaluate the progression of myopia.
Results: Refractive status of -30D group showed significant myopia shift (-8.19 ± 3.46 D) after 3weeks of lens wearing and emmetropic shift was shown after 1 week of recovery (7.94 ± 3.46 D). In untreated group, the refractive status was mild hyperopic (11.83 ± 4.21 D) after 1 week of lens wearing and switched to slightly myopic after lens removal (-0.87 ± 1.81 D). Different trends were observed in the changes in choroidal thickness between -30D wearing group and untreated group after 1 week of lens wearing (-30D vs untreated : -1.46 ± 0.48 μm vs 0.28 ± 0.31 μm). After lens removal, choroid significantly thinned in untreated group while thickened in -30D group (-30D vs untreated : 1.15 ± 0.38 μm vs -0.78 ± 0.41 μm). AL of -30D lenses wearing group showed significant growth compared to untreated group after 3 weeks of lens wearing (-30D vs Untreated:3.310 ± 0.02 mm vs 3.258 ± 0.05mm, $P<0.01$). As -30D group AL ceased to grow after lens took off, AL of untreated group showed relatively increase in recovery, the binocular axial length gradually converged (-30D vs untreated : 3.298 ± 0.02 mm vs 3.303 ± 0.038 mm).
Conclusions: In untreated eyes, compensation, including thickening and thinning of the choroid, changing of axial length and refractive statuses were elicited by contralateral visual cues solely. This suggests the existence of binocular interaction and integration of visual-signal-oriented feedback modulation in ocular development, which possibly happened in a higher center like the central nerve system.

P104: Atropine-induced choroidal thickening in the chicken: interactions with light and dopamine

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Purpose. Atropine, a muscarinic antagonist, is a potent drug to inhibit myopia development in both animal models and children. It causes rapid but transient thickening of the choroid which is associated with the inhibition of myopia development. We have studied the potential roles of dopamine, released from the retina, in the choroidal response in the animal model of the chicken.
Methods. Choroidal thickness changes were tracked by optical coherence tomography (OCT) after intravitreal injection of either atropine (250µg), atropine combined with a dopamine antagonist, spiperone (500 µMol), or spiperone alone. To stimulate dopamine release, other chicks were exposed to flicker light of 1, 10 or 400 Hz (duty cycle 0.2) and choroidal thickness was tracked. In all experiments, dopamine and DOPAC were measured in vitreous, retina, and choroid by high- performance liquid chromatography with electrochemical detection (HLPC-ED). The distribution of the rate-limiting enzyme of dopamine synthesis, tyrosine hydroxylase (TH), neuronal nitric oxide synthase (nNOS), vascular endothelial growth factor (VEGF) and alpha2A adrenoreceptors (alpha2A- ADR) was studied in the choroid by immunofluorescence.
Results. The choroid thickenend heavily in atropine-injected eyes (mean choroidal thickness 4h after injection 270.7+12.8µm), less so in atropine + spiperone-injected eyes (mean choroidal thickness 4h after injection 243.5+25.8µm) and became thinner over the day in spiperone alone-, vehicle- or non-injected eyes. Flickering light at 20 lux, both 1 and 10 Hz, increased choroidal thickness (mean choroidal thickness 2h after flicker start 1Hz 196.9+20.2µm, 10Hz 195.7+26.5µm) , compared to 400 Hz (mean choroidal thickness 2h after flicker start 160.5+11.7µm), and stimulated retinal dopamine release (dopamine content 2h after flicker start 1 Hz 10.5+4.7, 10 Hz 9.6+2.7ng/mg protein, versus 400Hz 1.82+0.9ng/mg protein). Correlation analysis showed that, the higher retinal dopamine levels or release, the thicker became the choroid. TH-, nNOS-, VEGF- and alpha2A ADR- positive nerve fibres were localized in the choroid around lacunae and in the walls of blood vessels with colocalization of TH and nNOS, and TH and VEGF.
Conclusion. Retinal DOPAC and dopamine levels were positively correlated with choroidal thickness. TH-positive nerve fibres in the choroid were closely associated with peptides known to play a role in myopia development. Findings are in line with the hypothesis that dopamine is related to retinal signals controlling choroidal thickness.

P90: ON and OFF inner retinal signaling is modulated in a mouse model of lens-induced myopia

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Purpose: Visual pathways that signal luminance increments (ON pathway) and decrements (OFF pathway) are suggested to differentially influence myopia progression. However, ON and OFF retinal signals have not been directly studied electrophysiologically in myopic eyes. Here, we investigated how ON and OFF retinal signals are modulated in lens-induced myopia (LIM), testing the hypothesis that myopia disrupts ON/OFF retinal balance.

Methods: Myopia in C57BL/6J mice (males, p.28) was generated unilaterally by fixing a -10D lens over the OD eye leaving the OS eye as a contralateral control (LIM, n=29) while a subset of mice were not treated with lenses (Ctrl, n=9). Refractive errors (RE) were measured in animals before lens placement and weekly for at least two weeks. After lens treatment, retinas were collected and prepared for single-cell recordings. Full-field, 500 msec duration flash stimuli (white OLED, max luminance: ~2,400 cd/m2) were presented to inner retinal neurons identified via fluorescent labeling. ON and OFF light-evoked excitatory and inhibitory response strength was quantified.

Results: LIM mice developed a myopic shift (ΔRE OD - OS) after 2 weeks (-2.7±0.2 D, $p<0.001$, ANOVA) whereas Ctrl mice did not. Interestingly, myopia had opposite effects on dark-adapted ON and OFF inhibition: ON inhibition decreased ~28% and OFF inhibition increased ~42% in myopic (ON n=23, OFF n=20 cells) compared to non-myopic eyes (Ctrl + LIM OS eyes, ON n=14, OFF n=12 cells; effect of lens treatment $p=0.03$; Mixed-effects model). When the same cells were stimulated in light-adapted conditions with responses normalized to their max dark-adapted response, the average ON+OFF inhibitory signal was reduced ~25% more in myopic (n=29 cells) than non-myopic eyes (n=17; $p=0.03$; KS test). Finally, while the ON+OFF excitatory response was on average weaker in myopic (n=14 cells) than non-myopic eyes (n=12 cells), it was not significant ($p=0.76$, KS test).

Conclusions: Our results provide direct electrophysiological evidence suggesting modulation of retinal signaling in myopia. On average, LIM led to weaker ON-driven inhibition and stronger OFF-driven inhibition in dark-adapted retinas, weaker ON and OFF inhibition after light adaptation, and no significant change in excitation. Therefore, our preliminary findings suggest myopia affects retinal ON/OFF and excitatory/inhibitory balance supporting further investigation of myopia-induced changes in cell-type specific retinal pathways.

P69: Wavelength exposures that facilitate recovery of lens-induced myopia in the guinea pig

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Purpose: The specific light conditions that may facilitate slowing myopia progression in children is of much interest. However, there is conflicting evidence as to which wavelengths may prove useful. Animal studies have generally raised animals continuously under various wavelengths or coupled simultaneously with myopia inducing paradigms. To improve the relevance to potential human therapies, we used an interrupted recovery paradigm superimposed on a myopiagenic background. Specifically, animals were raised with lens-induced myopia but regularly exposed to short daily lens-free periods under various wavelength conditions to determine stimuli efficacy for limiting myopia development and ocular growth.

Methods: Eight groups of guinea pigs (n=74) were raised with a negative spectacle lens on one eye for 2 weeks from 9-23 days of age under specific baseline wavelength conditions from 7am to 7pm. A myopia control group remained in their baseline wavelength condition with their spectacle lenses worn continuously. All other animals had their lenses removed for two 1 hr periods/day while exposed to various different wavelength conditions. These were: Complete darkness and various wavelength conditions matched in luminance. Wavelengths were in the visible range, and concentrated on stimulating the blue cones, ipRGCs, rods, or green cones in the guinea pig retina.

Results: Control animals developed -8.2±0.7D of relative myopia and 81±17µm of ocular elongation. Repeated exposure to dark periods without the lens completely eliminated axial elongation but only partially reduced the relative myopia (-5.8±1.4D) and did not affect the choroid. Conditions which included wavelengths that stimulated ipRGCs induced maximum shrinkage in relative vitreous depth (-91±22µm) but also reduced crystalline lens growth in both eyes and failed to stop myopia induced lenticular expansion resulting in -5.4±1.1D of relative myopia. The best conditions that eliminated myopic refractive errors were cool white (-2.9±0.8D) or restriction to short wavelengths that stimulated the blue cones (-1.6D±0.2D). Choroidal expansion was a significant feature in all light recovery conditions regardless of efficacy.

Conclusions: In a dichromatic mammal, stimulation of blue cones was effective at reducing myopic refractive errors, while darkness and ipRGC stimulation eliminated or reversed relative posterior eye elongation respectively but were less effective at reducing myopia due to concurrent optical changes.

P137: Axial Length Progression in Asian Children

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Purpose: There is a lack of normative data on axial length progression against which to assess and monitor progression of both myopic and non-myopic eyes. We aimed to determine the influence of refractive error, age, parental myopia and gender on AL progression in Asian children and develop normative data.
Methods: A retrospective analysis of data from 6 longitudinal studies from China. Data comprised of 2791 participants (5582 eyes) aged 6 to 16 years with refractive error ranging from +6 to -6D wearing no correction or single vision specs. Each study contributed 1,2 or 3 annualised progression data resulting in a dataset of 9024 participant eyes, of which 24.5% were myopes (defined as cycloplegic spherical equivalent refractive error (SE) ≤-0.50D at the start of an annual period). Longitudinally collected data included AL, SE, and corneal curvature. Eyes showing shortening (1.9%) were assumed 0mm progression for modelling purposes. Annual AL progression ranging from 0 to 2.43mm was log transformed to develop an exponential model. Factors included age, SE, gender and parental myopia. Main effects and interactions were tested for significance. Model based estimates and its prediction intervals were determined and plotted. Level of significance set at 5%.
Results: Correlation of AL and SE progression indicates considerable inter participant variability (R^2=0.5). Annual AL progression decreased significantly with increasing age and SE but was significantly higher in myopes than non-myopes. AL progression in myopes was influenced more by age and to a lesser extent by SE, whereas AL progression in non-myopes was influenced by both age and SE. Females and children with parental myopia had higher progression. As an example, estimated AL progression for an 8- and 12-year-old myopic (-1D) male with no myopic parents was 0.42mm and 0.22mm respectively, whereas for an 8- and 12-year-old myopic (-1D) female with 2 myopic parents it was 0.48mm and 0.27mm respectively. Similarly, for an 8- and 12-year-old hyperopic (+1D) male with no myopic parent it was 0.26mm and 0.14mm respectively, whereas for an 8- and 12-year-old hyperopic (+1D) female with 2 myopic parents it was 0.31mm and 0.18mm respectively. Overall, the 95% Predictive intervals for annual progression were wide and ranged from ±0.24 to ±0.36mm.
Conclusions: In the Asian population, annual AL progression is greater in myopes than non-myopes and is dependent on age, RE, gender and parental myopia. Influence of age and refractive error on axial length progression is different in myopes versus non-myopes. Protocols that consider AL progression to evaluate myopia progression need to consider the influence of these factors.

P98: Evaluating the duration-dependent impact of high-intensity light and optical refocus on the development of lens-induced hyperopia in chickens

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Purpose: To evaluate the duration-dependent and synergetic impact of high-intensity light (HL) and optical refocus (RF) on a chicken model of lens-induced hyperopia (LIH).
Methods: One-day-old chicks (Golden comet/white leghorn, n=130) were assigned to 10 groups of 13 chicks each. Chicks were reared under 12/12h light-dark cycle (150 lux) for 8 days in a temperature-controlled enclosure. Hyperopia was induced randomly in one eye of chicks in all the groups starting from day 1 post-hatching (D1) until D8 using +10D lenses and custom-built lens holders. The fellow eyes acted as uncovered control. While one group served as control without any interventions, the other nine groups were exposed to continuous 2 hours (h), 4h or 6h per day of either HL (15,000 lux, 4000K LED); RF (removal of +10D lens); or both (HL+RF). On D1, D4 and D8, ocular axial length (AL), refractive error and choroidal thickness (CT) were measured using ultrasonography, infra-red refractometry and optical coherence tomography, respectively. Outcome measures are expressed as inter-ocular difference (IOD = experimental - control eye) ± SEM. A two-way ANOVA was used to compare outcome measures between groups and intervention durations.
Results: By D8, reduced axial elongation (-0.42±0.03 mm), increased hyperopic refraction (+3.48±0.32 D) and choroidal thickening (+85.8±35.2 µm) were observed in the control LIH group (all, $P<0.001$). Outcome measures of LIH were not significantly affected by exposure to 2h of HL, RF or HL+RF. HL was associated with duration-dependent, increase in hyperopic refraction, while only 6h of HL significantly decreased axial elongation ($P=0.02$). RF caused a duration-dependent increase in AL, and decrease in hyperopia. The impacts of both 2h and 4h of HL+RF and RF on AL and refraction were not significantly different. Conversely, 6h of HL significantly reduced the impact of RF on AL (HL+RF vs RF, $P<0.05$). Independently of the duration of the intervention, HL increased CT compared to RF ($P=0.007$) and HL+RF ($P=0.03$).
Conclusion: Daily exposures to HL promotes axial shortening and hyperopia in a duration-dependent manner in eyes developing LIH. Conversely, RF promotes emmetropization and reduces the development of LIH. Simultaneous exposure to 6h, but not 2h or 4h, of HL can attenuate the drive of RF potentially through change in CT.

P59: Daily intermittent exposure to high levels of light prevents form-deprivation myopia in a monkey model

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Purpose: Continuous long-duration exposures to high light levels “bright light” can be protective against myopia. Here we evaluated the impact of shorter, intermittent, bright light exposures on ocular growth and refractive error development in a monkey model of form-deprivation myopia (FDM).

Methods: Twelve infant macaques (21±4 days old) were housed for 154 days under a 12/12h light-dark cycle using standard fluorescent light (SL, 140 lux, 4000K). FDM was induced monocularly using a custom-built 3D-printed helmet fitted with a plano lens and occlusion foil (~20/300) over the form deprived (FD) eye. The fellow (control) eye was covered with a plano lens. Macaques were assigned into 2 groups. Animals in group 1 (n=6, 3 Rhesus, 3 Cynomolgus) were raised under SL. Animals in group 2 (n=6, 5 Rhesus, 1 Cynomolgus) were exposed to 4h/day of intermittent bright light (IBL, 11,066 lux, 4000K) delivered for 1h every 2h of SL during the light period. Axial length (AL), vitreous chamber depth (VCD), refractive error, and choroidal thickness (CT) were assessed fortnightly using ultrasonography and optical coherence tomography. Results are expressed as average interocular difference (IOD= FD - control eye) ±SD. Outcome measures were compared between eyes on day 154 (D154) using a paired t-test and between groups using a Mann-Whitney U-test on areas under the outcome measures’ curves throughout form-deprivation (D0 to D154). The animals’ rest-activity cycles were assessed continuously using collar-worn actiwatches.

Results: By the end of form-deprivation (D154), FD eyes exposed to SL showed increases in AL (IOD= +0.25±0.16 mm; P=0.01), myopic refraction (IOD= -3.88±0.82 D; P<0.001) and VCD (IOD= +0.13±0.09 mm; P=0.01), in addition to reduced CT (IOD= -14.33±8.04 µm; P=0.007), compared to control eyes. FD eyes exposed to IBL showed no changes in AL (IOD= -0.09±0.13 mm), refraction (IOD= +0.5±0.76D), VCD (IOD= -0.12±0.14 mm) and CT (IOD= +1.0±4.98 µm), compared to control eyes (all P>0.05). Throughout form-deprivation, compared to SL, IBL reduced/abolished the impact of form deprivation on AL, refraction, CT, and VCD in FD eyes (all P<0.01). The animals’ rest-activity profiles, and diurnal and nocturnal activity amplitudes were not different between groups.

Conclusion: Exposure to 4h/day of IBL (~11,000 lux) can prevent FDM in infant Rhesus and Cynomolgus macaques. Moreover, IBL does not alter the animals’ rest-activity profiles compared to standard background light.

P118: The effect of topical 1% atropine on the diurnal rhythms of the human eye.

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Purpose: Changes in the phase relationships between the diurnal rhythms of ocular parameters have been tied to altered ocular growth [1]. While atropine is commonly used as a myopia control therapy, its mechanism of action is poorly understood. We conducted a paired-eye study to investigate the effects of 1% atropine on ocular diurnal rhythms.

Methods: Twenty-two ocular healthy participants (age 19–25 yrs, 19 females, visual acuity ≤ 0.00 logMAR and TNO stereo vision ≤ 120'') were included in the study (cycloplegic SER -4.13–1.90 D). Habitual sleep times (HST) recorded over a 7-day period using actigraphy in combination with self-reported habitual wake times (HWT) were used to determine participant-specific timings of 8 sets of measurements on day 8. Baseline data from both eyes were collected on day 7, 4 h after waking (HWT+4). Each set included accommodation washout, intraocular pressure (IOP, iCare, iCare Finland Oy), ocular biometry (Zeiss IOLMaster 700), and retinal and choroidal imaging (Heidelberg Spectralis OCT2 EDI). On day 8 at HWT+2, atropine (Atropine Minims 1%, Bausch Health) was instilled in the dominant eye, keeping the non-dominant eye as control. The thicknesses of the central 1 mm of the retina (RT) and choroid (CT) were extracted from semi-automatic segmentation of the OCT images. For both eyes, sinusoids with periods of 24 h were fitted to the data, and a non-linear mixed-effects model (NLME) was used to estimate rhythm characteristics (MESOR, amplitude, acrophase) for each parameter.

Results: There were no baseline differences between the two eyes. Pre- versus post-atropine comparisons (day 7 HWT+4 vs. day 8 HWT+4) revealed the following effects in treated eyes: lower IOP, deeper anterior chamber (ACD), thinner crystalline lens (LT), shallower vitreous chamber (VCD) and shorter axial length (AL) (all $p \leq 0.005$). Both eyes showed significant diurnal variations in all ocular parameters ($p<0.05$), albeit with significant atropine-induced interocular differences. Relative to the control eye, atropine-treated eyes had deeper ACD, thinner LT, and shallower VCD (MESORS: NLME model, $p<0.038$ for all), and thicker CT ($p=0.56$). Atropine-treated eyes also had larger AL and RT amplitudes ($p<0.05$), smaller VCD ($p<0.05$) and CT ($p=0.2$) amplitudes, with significant phase advancement for ACD and VCD ($p<0.001$ for both).

Conclusions: Various ocular dimensions exhibit characteristic diurnal rhythms that were found to persist for 24 h after instillation of 1% atropine, although amplitudes and phases were altered. Further work is needed to understand the implications of these changes for the myopia control effects of atropine when used chronically.

[1] Nickla DL. The phase relationships between the diurnal rhythms in axial length and choroidal thickness and the association with ocular growth rate in chicks. J Comp Physiol A Neuroethol Sens Neural Behav Physiol. 2006 Apr;192(4):399-407.

P75: The difference between cycloplegic and non-cycloplegic autorefraction in myopes and non-myopes

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Purpose
Cycloplegic autorefraction is the gold standard for determining the presence of refractive errors. The effect of cycloplegia is affected by the accommodative power of the eye, and several lines of evidence suggest a reduced accommodative response in myopic individuals. In this study, we investigated the effect of cycloplegia on autorefraction measurements in myopes and non-myopes in three age groups of children.

Methods
244 schoolchildren from grades 1, 5 and 9 (aged 7-8, 11-12 and 15-16, respectively) who were recruited as part of a larger myopia study, were included in this analysis. Cycloplegia was induced by applying two rounds of 1% cyclopentolate with a 5-minute interval and cycloplegic refraction was measured no earlier than 40 minutes after the instillation of the first eye drops. Nidek HandyRef autorefractor was used to measure the non-cycloplegic and cycloplegic refraction. Measurements of the right eye of each participant were used in this analysis. Myopia was defined as a cycloplegic spherical equivalent refractive error (SER) ≤–0.50 dioptres (D).

Results
The study cohort included 70 participants from grade 1 (52% boys), 83 from grade 5 (45% boys), and 91 from grade 9 (51% boys). There was a total of 60 myopes and 186 non-myopes in the study cohort. Cycloplegic autorefraction measurements were significantly more hyperopic than non-cycloplegic measurements in non-myopes as well as myopes (average difference between cycloplegic and non-cycloplegic SER 1.08 D for non-myopes and 0.33 D for myopes, $p < 0.001$ for both, paired samples Wilcoxon tests). Cycloplegia affected the autorefraction measurements to a different extent in myopes and non-myopes. The effect of cycloplegia on SER was significantly larger in non-myopes compared to myopes (main effect of myopia status $p < 0.001$, two-way ANOVA). At the same time, the effect of cycloplegia on SER was not significantly different between children from different grades (main effect of grade $p > 0.05$, two-way ANOVA).

Conclusions
Here we demonstrate a difference between cycloplegic and non-cycloplegic refraction in school-aged children and show a difference between myopes and non-myopes. These results support previously published findings of a reduced accommodative response in myopes. The findings also highlight the importance of using cycloplegic refraction in studies investigating refractive errors as well as for prescribing glasses to children.

P87: Comparing the Myopia Master with the IOLMaster700 and Huvitz autorefractor

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Purpose: Accurate and precise ocular biometry measurements are crucial for studying the progression of myopia. The purpose of this study was to compare axial length (AL) and corneal radius (CR) measured with the OCULUS Myopia Master and Zeiss IOLMaster 700 in young adults. In addition, the Myopia Master was compared with the Huvitz autorefractor (AR, HRK 8000-A) for measurement of spherical equivalent refraction (SER).

Methods: The study included 74 participants (16 males), with a mean age of 22.8±3.7y (range: 19–41y). Axial length, corneal radius and cycloplegic objective SER, were obtained with the Myopia Master, IOLMaster 700 (AL and CR) and Huvitz AR (SER). Paired t-tests and Bland-Altman analyses were used to assess the agreement in ocular biometry between the Myopia Master and IOLMaster 700, and in SER between the Myopia Master and Huvitz AR. The 95% limits of agreement (LoA) were expressed as the mean difference ± 1.96 standard deviation (SD) of the difference.

Results: Only right eyes were included in the analyses, of which 26 were myopic (SER ≤ -0.50 D), 19 emmetropic and 29 hyperopic (SER ≥ 0.50 D). The Myopia Master and IOLMaster 700 showed excellent agreement in AL measurements (95% LoA: -0.118–0.101 mm) with no significant differences between the pairs of AL measurements (mean difference ± SD: -0.004 ± 0.05 mm, $t(73) = -0.57$, $p=0.55$). CR measured with the Myopia Master was significantly flatter than with the IOLMaster (0.036 ± 0.03 mm, $t(72) = 10.4$, $P<0.001$), with 95% LoA from -0.022 to 0.094 mm. Compared with Huvitz AR, the Myopia Master measured a significantly more negative SER (-0.20 ± 0.26 D, $t(73) = -6.47$, $p<0.001$), with 95% LoA from -0.71 to 0.32 D.

Conclusion: The Myopia Master and IOLMaster showed high agreement in AL measurements in young adults, but statistically significant differences were observed in mean CR. There were also differences in cycloplegic SER between the Myopia Master and Huvitz AR.

P46: Clinical validation of two biometers for myopia follow-up in paediatric population: MYAH & AL-Scan

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Purpose:
In recent years, there is an increased interest in optical biometry in paediatric population, associated to myopia development follow up. The biometers have classically been validated in adult population, but not in the population of interest for myopia development. The purpose of this observational cross-sectional study has been the clinical validation of the MYAH (Topcon) and Al-Scan (Nidek) biometers in paediatric population.

Methods:
The repeatability, reproducibility and accuracy of the MYAH and AL-Scan biometers was studied. For the repeatability, three consecutive measurements were performed in each patient by the same operator. The patient was separated from the chinrest after each measurement and immediately measured again. For the reproducibility, two measurements were performed to each patient by two different observers with a 5-minute interval between measurements. The patient was separated from the instrument after each measurement. For the accuracy, each patient was measured once with each instrument.

Results:
A total of 183 patients, with a mean of 8.52±0.34 years, +0.40±0.74 D of sphere and -0.57±0.47 D of astigmatism participated in the study. For the repeatability the within subject standard deviation was 0.01 mm for both instruments and no statistically significant differences were found when applying the repeated measures ANOVA ($p = 0.162$ for MYAH and $p = 0.774$ for AL-Scan). The pairwise differences highlighted 95% confidence intervals (CI) of ±0.04mm and ±0.03mm when considering the first measurement for MYAH and AL-Scan respectively and of ±0.01mm for both instruments when not considering it. For the reproducibility the within subject standard deviation was 0.01 mm and the repeated measures ANOVA showed statistically significant differences for the AL-Scan ($p = 0.002$) but not for the MYAH ($p = 0.643$). Regarding the agreement among both instruments, the 95% confidence interval ranged from -0.04 to 0.04 mm, and the differences were statistically significant ($p = 0.021$).

Conclusions:
Considering that, the normal axial length growth is estimated in 0.1mm/year in emmetropes and double or triple in myopic children, the repeatability, reproducibility and agreement of both biometers seems optimal for the follow up of myopia. The results suggest that there can be a learning effect in the measurement procedure (wrong fixation, movement, etc.), as the first measure differs from the other two. Thus is should be considered to discard it for clinical purposes, in order to improve the biometers reliability.

P17: Clinical efficacy of 2 drops of 0.01% atropine compared to 1 drop of 0.02% atropine solution

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Purpose
Atropine sulfate solution in the United States is used off-label at low concentrations to slow the progression of myopia, however, compounding pharmacies may not offer 0.02% concentration. The aim of this study is to determine if patients with progressive myopia who need a higher concentration (0.02%) would be able to use 2 drops of 0.01% instead.

Methods
This was a prospective crossover cohort randomized trial. 9 participants randomly received 1 drop of 0.02% atropine or 2 drops of 0.01% atropine in one eye. Dynamic pupil response to a single pulse of light and accommodative amplitude (AA) were measured 1 hour, 2 hours, 4 hours, 8 hours, and 24 hours after instilling the drop(s). Dynamic pupil response was measured using an automated pupillometer (NeurOptics, Irvine, CA). AA was measured using the pull-away method using 20/25 LEA symbols. After the subject returned to baseline values, they received the other dosing regimen in the same eye. Dynamic pupil response and AA were measured again at the same time intervals.

Results:
The mean maximum change in dynamic pupil diameter was 2.44 mm (±0.39 mm) in response to 1 drop of 0.02% atropine (1 drop group) and 2.57 mm (±0.27 mm) in response to 2 drops of 0.01% atropine (2 drop group). The mean time at which the mean maximum change occurred was at 3.11 hrs (±0.35 hrs) in the 1 drop group and at 3.55 hrs (±0.29 hrs) for the 2 drop group . The mean maximum change in AA was -2.41D (±0.58D) in the 1 drop group and -3.20D (±0.62D) in the 2 drop group. The mean time at which subjects experienced the maximum change in AA was at 2.77 hrs (± 0.76 hrs) after instillation of atropine in the 1 drop group and 4.33 hrs (± 0.78 hrs) after instillation of atropine in the 2 drop group.

Conclusion:
There was no statistically significant difference in dynamic pupil response or AA between the 1 drop and 2 drop groups at any measured time point ($p>0.05$). Noninferiority testing further revealed that 1 drop of 0.02% and 2 drops of 0.01% atropine were bioequivalent in the eye. This study suggests that patients who are prescribed 1 drop of 0.02% atropine for myopia control may be able to use 2 drops of 0.01% atropine instead.

Conflict of Interest:
None

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P77: Macular and Peripapillary Choroidal Vascularity Index in Children with Different Refractive Status

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Purpose: To report variations of choroidal vascularity index (CVI) in Chinese children with different refractive status using swept-source optical coherence tomography (SS-OCT).
Methods: A total of 5864 children aged 6-9 years participated in the study, including 396 myopes, 1909 emmetropes and 3559 hyperopes. They underwent comprehensive ocular examinations at school, including cycloplegic autorefraction, axial length (AL) and SS-OCT measurements. Choroidal thickness (ChT) was carried out by the built-in software. CVI was calculated using an automated algorithm previously validated by our research team. The Early Treatment of Diabetic Retinopathy Study (ETDRS) grid centered on both the fovea and optic disc was applied to separate ChT and CVI into different sectors. CVI in the macular and peripapillary regions were compared among children with different refractive status. The topographic variation and influencing factors related to the CVI were analyzed.
Results: The mean spherical equivalent (SE) and AL of the participants was 1.01±1.00 diopter (D) and 22.87±0.76 mm. The mean total ChT and CVI were 275.88±53.34 μm and 34.91±3.83 in the macular region, and 191.96±46.28 μm and 32.35±4.21 in the peripapillary region. CVI in macular and peripapillary regions was significantly lowest for myopes, followed by emmetropes and hyperopes in all sectors (all $P < 0.001$). CVI showed a significant variation among different sectors ($P < 0.001$). CVI in the macular region decreased horizontally from the nasal quadrant to the temporal quadrant, and vertically from the superior quadrant to the inferior quadrant, while the center fovea had the lowest CVI in the horizontal direction. In the peripapillary region, the CVI was highest in nasal sector and lowest in inferior sector. Multiple regression showed that SE, AL, intraocular pressure (IOP), ChT, age and girls were significantly related to CVI in macular region (all $P < 0.05$), while the above variables except for AL ($P=0.475$) were significantly related to CVI in peripapillary region.
Conclusions: The distribution of CVI in the posterior pole is not uniform in children. CVI decreases from hyperopia to emmetropia and from emmetropia to myopia. The reduction in CVI is associated with the decrease in SE, AL elongation and choroidal thinning, suggesting that choroidal vasculature may be involved in the thinning of ChT during myopia onset and shift.

P127: Modelling non-myopic eye growth as a reference for myopia development

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Purpose: To understand myopization, it is essential to understand how the eye develops under normal circumstances (i.e., in absence of myopization). Although there are many reports in the literature on how ocular biometry evolves with age, these data are often fragmented into separate parameters or limited to a certain age range. This work presents a meta-analysis of the ocular growth of normal eyes in the period before birth until 18 years of age.

Methods: A literature search was performed in 5 databases (PubMed, Scopus, Web of Science, Google Scholar, Microsoft Academic and Crossref) using a series of keywords such as "[Parameter] & [age group]" was used, with [Parameter] the ocular parameter under study and [age group] an indication of age (i.e., "children", "baby", "infants", "new-born" or "preschoolers"). This search provided 34,409 references that were imported into EndNote for duplicate removal, followed by screening based on title and later based on abstract and manuscript text, ultimately leaving 290 references with usable, non-myopic data. Where possible, the available parameters were used to calculate additional parameters, such as the axial length/ corneal radius ratio, Bennett crystalline lens power, whole eye power and axial power.

Results: The literature analysis provided 500 average values for 17 parameters, calculated over a combined total of 685,741 individual measured or calculated values. Each parameter was plotted as a function of the logarithm of the gestational age and fitted with a sum of two exponentials. This function provided a good fit for near all biometric parameters, with r^2 values ranging between 0.643 for corneal thickness and 0.993 for axial length. The only exceptions were lens thickness, which could only be fitted by a 3rd order polynomial series ($r^2 = 0.803$), and refractive error, which required a sum of 4 exponentials ($r^2 = 0.582$).
In the cases that were well fitted with a sum of two exponentials, the first exponential often reached its asymptote (95% value) before the age of 6 months, and at 18 months at the latest, suggesting that this corresponds with the intra-uterine 'scaled' growth. Meanwhile, the second exponential reached its asymptote at a later age, ranging between 4 years of age for the anterior corneal radius of curvature and well past adulthood for most lenticular dimensions. This second exponential may represent the coordinated, homeostatic phase of the eye growth.

Conclusions: The proposed model may form an interesting reference tool to better study myopic growth processes.

P93: Influence of lifestyles on the refractive state

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Purpose: Uncorrected refractive errors are the leading cause of visual impairment globally. Its etiology is multifactorial, resulting from the interaction of environmental and genetic risk factors. The objective of the study is to analyze the influence of time in near vision/use of digital devices and time outdoors on the evolution of the refractive state.

Methods: The study population is children aged between 5-7 years. The tests performed are the measurement of distance visual acuity with its usual correction, determination of subjective refraction without cycloplegia, accommodative and binocular tests. Likewise, a questionnaire about their lifestyle was filled out. The cut-off point to define the refractive state is established according to the value of the spherical equivalent (SE): hyperopia (SE≥+0.50), myopia (SE≤-0.50) or emmetropia (-0.50<SE> +0.50). Data analysis is performed with the SPSS 27.0 software (SPSS Inc., Chicago, Illinois).

Results: A significant association was found between refractive status and time in near vision ($p<0.001$). Within this time interval, it has also been found that the time of use of the digital devices influences the refractive state ($p<0.001$). The spherical equivalent becomes more negative as time in near vision increases (0-2 h/day: 0.12(1.7); 2-3h/day: 0.00(1.7); >3h/day: 0.25(1.8)) and greater use of digital devices (<25%: 0.25 (1.7); 25%-50%: 0.12(1.7); >50%: 0.00(1.6). On the other hand, it has been found that the longer the time outdoors, the spherical equivalent becomes more positive (0-1.6h/day: 0.25(1.9); 1.6-2.7h/day: 0.00(1.7); >2.7h/day: 0.25(1.5); $p<0.001$).

Conclusions: Lifestyles suggest that they can be a risk factor in the development of myopia. The excessive use of electronic devices and lower exposure to the outdoors causes a higher risk for children aged between 5- and 7-years developing myopia.

P23: Optic disc tilt and change in myopic children in the Atropine in the Treatment Of Myopia (ATOM2) study

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PURPOSE:
To study how factors such as age, spherical equivalent (SE), axial length (AL) and concentration of atropine eyedrops influence the optic disc tilt and change over time.

METHODS:
Fundus photos (taken at baseline and at 2 years) of 344 myopic children (aged 6-12.9 years old) from the Atropine in the Treatment of Myopia (ATOM2) study were evaluated and their myopic disc tilts were graded into none (grade 0), mild (grade 1), moderate (grade 2) and severe (grade 3) based on Myopia Cohorts Grading Scales. Clinical parameters such as age, SE, AL and atropine eyedrop concentration were correlated with changes in myopic disc tilt.

RESULTS:
310 (90%) of children were Chinese and 178 (52%) were males. At baseline, 55 children (16%) had no tilt, while 174 (51%) children were noted to have grade 1 tilt, and 89 (26%) and 26 (6%) already had grades 2 and 3 tilt, respectively. Not unexpectedly, children with greater tilt were older, and also had greater SE and AL. Mean baseline SE was -4.40D, -4.63D, -4.96D and -5.74D, and mean baseline AL was 24.90mm, 25.16mm, 25.36mm and 25.44mm in children with no tilt, grade 1, 2 and 3 tilt, respectively. Over a 2 year period, disc tilt remained stable in 267 (78%) children. However, 64 (18%) and 13 (4%) showed change of more than 1 and 2 grades of tilt, respectively. Multivariate analysis suggests that increased disc tilt was associated with younger age, lower baseline SE and greater change in SE or AL, after controlling for race, gender, and atropine concentration.

CONCLUSIONS:
Many myopic children already had a mild amount of disc tilt at baseline. Progressive tilt could be identified over 2 years mainly in younger children and in those with highly progressive myopia.

P135: Younger Myopia Onset with Tutorial Classes or Full Day School Schedule

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Younger Myopia Onset with Tutorial Classes or Full Day School Schedule

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Purpose: The academic performance in number of daily hours of schooling could have an effect on myopia development. The aim of this study was to investigate the effect of tutorial classes and schooling schedule in childhood on age of myopia onset in young adults. In an environment with low prevalence of myopia, taking tutorial classes and going to school eight hours a day were associated with earlier age of myopia onset compared to no tutorial classes or only four daily hours of schooling.

Methods

Study population

Refractive data, from 8 dispensing opticians or refractive ophthalmologists' offices in Argentina, were collected in subjects aged 18 years or above during the winter months of year 2021. Refractive data were first prescriptions or correction renewals, including broken glasses. Data collection was performed in several locations, including Salta, Marcos Juarez, Leones, San Pedro, Lobos, Rosario, Buenos Aires and Mendoza. The study was conducted in accordance with the tenets of the Declaration of Helsinki and the study protocol was submitted to the ethics committee of the Argentinian Council of Ophthalmology. Verbal consent was obtained from all subjects after the nature of the study was explained. Data were completely anonymised and in full compliance with data protection laws.

Refractive error and age of myopia onset

Assessment of refractive error was performed by multiple eye care providers, either qualified opticians who sold spectacles based on ophthalmologists' prescriptions or ophthalmologists who prescribed the spectacles in their office. Data were obtained when the consecutive subjects came asking for new prescriptions at the respective locations. The spherical equivalent (SE) was calculated using the standard formula (SE = sphere + ½*cylinder). Myopia was defined by an SE of the prescribed glasses of -0.75D or worse. SE for both eyes and age of myopia onset was registered by the opticians or ophthalmologists using a questionnaire form. Patients with blindness of one eye or other ocular pathologies, such as keratoconus, cataracts, or glaucoma, were excluded from the study. Subjects with astigmatism of -2.00 dioptres (D) or worse were also excluded.

Questionnaire for risks factors

Argentina has an obligatory education system, which consists of 6 years of primary school beginning at ages 6-7 years, and 6 years of secondary school (from age 12-13 years on). Schooling schedule includes 4 hours per day either attending school either in the morning or in the afternoon in the public education sector. On the other hand, most private schools have a full day of schooling scheduling consisting of 8 hours per day. A

questionnaire in Spanish was administered onsite (via an online googledocs form) by the opticians or ophthalmologists to the consecutive myopic subjects. The questionnaire obtained demographic data, including age, gender, age of first spectacle prescription (defined as age of onset of myopia), and environmental risks factors such as number of years of education, schooling schedule (half day or full day schedule, both in primary and secondary school), tutorial classes (yes, no), time spent on near work (hours per day using computers or performing other near vision tasks), time outdoors (hours per day) and time of day spent on studying and outdoors, in childhood.

Statistical analysis

Prescriptions of myopic glasses with refractive error up to - 6D SE were eligible for analysis as high myopic subjects are probably mainly genetic cases with early onset in this country with low prevalence of myopia in the population. SE of right and left eyes was highly correlated ($r=0.81$, $p<.001$) so the analysis was performed with the SE of right eyes only. Using multiple linear regression models, we examined the childhood factors (tutorial classes, years of education, time of day attending school, hours per day reading and outdoor time) associated with age of myopia onset and adult SE. The results are reported with adjustment for confounders by including the following variables as covariates in the model: age and gender. The results of the regression models are reported as □ and p values. In all the analyses, statistical significance was defined as a p value <0.05. All statistical analyses were carried out with SPSS (IBM, United States, version 26).

Results

A total of 274 myopic adults with myopia between - 0.75 and - 6.00 D were eligible for this study. The mean age of the subjects was 36.9±14.5 years (range 18-83) and 168 (61.3%) were females. Their mean SE was -2.95±1.45 D and the mean age of onset was 14.2±5.4 years. There were no significant differences in mean SE or age of onset between genders. The mean years of education for these subjects was 15.2±3.2 years. The mean hours (h) of reading per day was 2.6±1.3 h and the mean time spent outdoors per day was 2.7±1.5 h in childhood. There were no significant differences in mean time spent reading or outdoors between genders in childhood. Tutorial classes after school in childhood were taken by 24.8%. Most spent their time outdoors in the afternoon (83.6% of cases) in childhood. The majority spent time studying in the afternoon (46.4%) and at night (44.5%; only 9.1% studied in the morning) in childhood. Nearly 60% of the subjects attended school 4 hours in the morning and 20% in the afternoon, both in primary and secondary schools, while only about 20% had full day schedule of 8 hours.

There were no significant differences in time spent reading for children who went to school either morning, afternoon, or full day. However, adults who spent the full day at school in childhood had less time outdoors than their peers in primary or secondary schooling ($p<.001$). Adults attending tutorial classes in childhood also tended to spend less time outdoors than their peers (2.37±1.49 h versus 2.79±1.49; $p=.059$).

The total years of education of the subjects was greater in those attending full schedule schooling ($p<.001$). Adults who went to school 4 hours a day (morning or afternoon) in childhood had approximately 15 years of study/education and the ones that had full day scheduling school had 17 years of education ($p's<.001$) in either primary or secondary school, but there were no significant differences in numbers of years of education by tutorial classes.

Children who went to school only 4 h per day spent more time outdoors compared to those with full schedule ($p<.001$). There were no significant differences in mean adult SE according to time of day attending school or tutorial classes, but the mean age of myopia onset was more than two years before for adults who took tutorial classes or went to school full day schedule compared with those who went to school only 4 hours per day (Table 1).

Children with later age of onset spent less time reading (ANOVA $p<.001$).

There were no significant differences in mean SE or age of myopia onset by time-of-day subjects studied (morning, afternoon or at night) or time-of-day outdoors (morning or the afternoon). The multiple linear regression analysis for age of onset and SE in adulthood as linear variables is shown in Table 2. Adults that

attended after-school tutorial classes (p=.005) or a full day school scheduling (p=.035) or that spent more time reading (p=.010) in childhood had younger age of myopia onset. Age of myopia onset was the only risk factor associated with adult SE (p<.001).

Table 1. Tutorial classes and school scheduling and the association with age of myopia onset and SE (n=274).

	n	Age of onset (years)	P	n	SE (D)	p
Tutorial classes						
No	198	14.66±5.23	0,008	206	-2.96±1.44	0,92
Yes	68	12.65±5.60		68	-2.93±1.50	
School scheduling in primary School						
Half-day (4 hours)	211	14.66±5.41	0,002	218	-3.02±1.48	0,13
Whole day (8 hours)	55	12.16±4.82		56	-2.69±1.29	
School scheduling in secondary school						
Half-day (4 hours)	206	14.45±5.23	0,081	213	-3.03±1.49	0,1
Whole day (8 hours)	60	13.10±5.81		61	-2.68±1.28	

Table 2. Multiple linear regression analysis for age of myopia onset (n=274).

	b	p
Age (years)	-0,03	0,28
Gender	-0,32	0,65
School scheduling in primary school	-1,07	0,035
School scheduling in secondary school	-0,09	0,85
Years of study	0,13	0,24
Tutorial Classes	-2,23	0,005
Hours per day reading	-0,7	0,01
Hours per day outdoors	0,21	0,39
Studying at night or afternoon	-0,38	0,48

Conclusion.

In conclusion, we found an independent association of educational system and myopia onset. Adults with myopia that attended tutorial classes and/or full day schooling schedule or performed more near work in childhood had younger age of myopia onset. Near work and education intensity play an important role in myopia development. Strategies to curb an early myopia onset are important to prevent the progression to high myopia.

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P42: Novel Artificial Intelligence (AI) Choroidal Segmentation of Optical Coherence Tomography (OCT)Scans in Eyes with Pathologic Myopia

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Purpose: To evaluate the performance of a novel AI algorithm for precise segmentation of the choroidal thickness in Optical Coherence Tomography (OCT) macular scans in eyes with pathologic myopia.

Methods: 91 pathological myopia eyes were acquired using a commercial swept-source OCT (SS-OCT)system, (PLEX Elite 9000, Carl Zeiss Meditec Inc., Dublin, CA, USA) at a 1050 nm wavelength, scanning speed of 100,000 A-scans/sec and 3 mm × 3 mm scanning protocol, centred at the macula. Manual segmentation of the retina and choroid on OCT images were used as the ground truth. We implemented a novel multi-task deep convolutional neural network architecture, Spatial Aggregated Networks (SA-Net), that reconstructs and segments a target B-scan with the incorporation of spatial context from neighbouring B-scans. Intersection over Union (IoU) of the volumetric segmentation, Dice coefficient and Structural Similarity Index Measure (SSIM) were used to assess performance.

Results:
A total of 91 eyes with pathologic myopia were analysed with spherical equivalent of -7.00 ± 3.96 and axial length of 27.54 ± 1.30. Subjects were aged 51.07 ±13.02 with 64 (70.32%) females. 94.51% were Chinese, 4.40% were Malay and the remaining were Others. SA-Net was able to replicate segmentation of the anatomical layers of the retina and choroid on OCT images that was comparable to that of the manually segmented ground truths, with an IoU of 0.87 ± 0.09, Dice coefficient of 0.93 ± 0.05 and SSIM of 0.60 ± 0.18.

Conclusions:
Our study demonstrated that the novel SA-Net approach showed a high accuracy in segmentation and delineation of choroid from volumetric OCT cube scans in eyes with pathologic myopia. The results are promising for the automated detection of the choroid and could be beneficial in further studies pertaining to the choroid in eyes with pathologic myopia.

P196: Fluctuating axial length measurements in an 11-year old myopic boy treated with high-dose atropine

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Purpose: Atropine dosage is mainly guided by the growth in axial length (AL). We report on a case who presented with an unusual monocular fluctuation of the AL measurements on multiple visits to the out-patient clinic.
Methods: A healthy 11-year-old with progressive high myopia who has been compliant with high-dose atropine treatment for 6 years, presented with a sudden AL elongation of the left eye (LE). Right eye (RE) was stable. Refractive error was obtained in atropine with the Topcon-KR8900 autorefractor. AL was measured with the Carl Zeiss IOL Master 700. A full ophthalmic examination was performed, including Visual Acuity (VA) measurement, biometry, Optical Coherence Tomography (OCT) and electrophysiology (VEP/ERG) was performed.
Results: The measured refractive error was RE: S-10.50=C-2.25x10 and LE: S-11.75=C-1.25x160 with a known suboptimal-VA of 0.6 Snellen. Spherical equivalent of the RE and LE remained unchanged in 6 months. AL of RE progressed with 0.05mm, to 27.45mm; the LE with 0.23mm, to 27.75mm in 6 months. Three additional AL measurements of the LE were performed each within 5 minutes: 27.30mm, 27.54mm and 27.75mm. During the measurements, the fixation was stable. After 6 months, a fluctuating AL in the LE was found again: 27.29mm, 27.32mm and 27.56mm. No lens abnormalities or media opacities were present. OCT ruled out signs of a staphyloma, or retinal- or choroidal thickness abnormalities. We performed whole exome sequencing to evaluate ocular disease genes, but did not identify a genetic cause. VEP/ERG were within normal limits.
Conclusion: After careful evaluation, we could not clarify the fluctuation in AL measurements in only the LE. Possible explanation could be that in higher AL measurements a greater variability is present and needs to be taken in account when undertaking myopia management on AL. Although, in case of a monocular AL elongation in high myopic patients, a full ophthalmologic workup is indicated.

P65: The role of epigenetic changes in translating environmental cues into ocular growth changes

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Purpose: Animal models have indicated that eye growth is driven locally by signals emanating from the retina in response to external visual cues. But how are environmental cues, such as visual defocus, translated into changes in gene expression which ultimately alter the rate of ocular growth? Recent evidence has suggested that this may occur through epigenetic changes in DNA methylation, with localised analyses observing differential methylation in several genes implicated in myopia development. Therefore, to expand on the role of DNA methylation in eye growth, this study examined how the whole retinal methylome is affected during the development of experimental myopia.

Methods: Retinal tissue was collected from chicks (n=3 per group) following 4, 24, and 72 hours of form-deprivation (FDM; growth induction). DNA was extracted from treated (FDM) and contralateral control eyes, and prepared for sequencing using the Illumina TruSeq DNA methylation kit. Bisulfite converted libraries were sequenced via Illumina HiSeq X sequencing, and differential methylation was defined as a significant ($p<0.05$), greater than 10% change in overall methylation for: individual CpGs or CpG regions both within and outside of CpG clusters or CpG islands.

Results: Form-deprivation induced significant changes in the methylome at all timepoints tested. These were found in CpG regions and at individual CpGs, both within and outside of CpG clusters and islands. The greatest number of differential changes in methylation were observed at a CpG cluster level, with 347, 393, and 284 regions found to be differentially methylated at each of the three respective timepoints (4, 24, and 72 hours). While differentially methylated regions were found throughout the genome, these changes were most commonly seen in introns. Some of these differentially methylated regions were associated with genes that have previously been implicated in myopia (e.g., PAX6), while others have not been previously observed in transcriptome or proteome analyses (e.g., FOXP1 and MEIS1).

Conclusions: The findings of this study support a potential role for DNA methylation as the mechanism by which external visual cues are translated into the molecular signals that may ultimately govern ocular growth.

P123: Metric to Predict Future Myopia in Young Children

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Purpose:
There is lack of consensus on which parameters are most useful in the prediction of a child's future myopia. We use the baseline data from the PICNIC (Preventing myopia: Investigating Contributing factors to Nearsightedness In Children) longitudinal study to investigate structural, functional and heritable metrics that may predict future myopia in young children with functional emmetropia.

Methods:
N=97 children with ages 6 to 9 years, uncorrected visual acuity (VA) 0.1 LogMAR (20/25 equivalent) or better, refractive error (spherical equivalent, SE) 0.00D to +2.25D, no more than 0.75D of astigmatism or anisometropia, and no significant ocular history were enrolled in the PICNIC study between July 2020 and September 2021. Refractive error was determined by cycloplegic (2gtt 1% cyclopentolate) open-field autorefraction, and optical biometry data were obtained following cycloplegia to determine the axial length (AXL), corneal radius (CR), anterior chamber depth (ACD) and lens thickness (LT). Children were classified as having High Risk (HR) or Low Risk (LR) for myopia based on parental myopia and current SE and also based on refractive centiles curves calculated from age and SE (Loughman & Flitcroft). Other metrics included AXL and AXL/CR at baseline. Univariate general linear models were used to evaluate differences between the two groups after correcting for age. Linear regression models were used to elicit the ocular parameters that affect refractive error.

Results:
Enrolled children were 7.60±0.96 years of age at baseline. Based on our initial criteria of SE and parental myopia, N=46 children were classified as HR (SE=+0.62±0.44 D, AXL=22.80±0.64 mm) and N=51 as LR (SE=+1.26±0.44D, AXL=22.77±0.77 mm). Based on centiles calculations, N=49 children were classified as HR (Centile average 68.86%) and N=48 as LR (Centile average 34.97%). The two classifications gave significantly different results ($\chi_{21,97}$= 41.10, $p<<0.01$, different for 17 or the 97 children), but were correlated (R=0.65, $p<<0.01$). Univariate general linear models (ANCOVA) with age as covariate show a significant effect for AXL between the original HR/LR groups ($F_{1,94}=4.98$, $p<0.01$), with longer AXL in the HR group (HR: 22.87±0.09mm, LR: 22.71±0.09mm), as well as longer ACD ($F_{1,94}=3.99$, $p=0.01$) and thinner LT ($F_{1,94}=4.20$, $p=0.02$). A multiple linear regression model showed that ACD, AXL, CR and age significantly predicted SE (R=0.61, $F_{4,95}=13.68$, $p<<0.01$). The two main parameters are AXL and CR; for any 1.07mm increase in AXL the child's hyperopia is reduced by 1D, and for any 0.10mm increase in corneal curvature the child's hyperopia is decreased by 1D. The ratio AXL/CR also significantly predicted SE (R=0.45, $F_{1,91}=22.97$, $p<<0.01$), as did AXL alone (R=0.25, $F_{1,96}=6.21$, $p=0.01$), but to a lesser extent.

Conclusions:
Although SE and AXL are correlated, the classification of pre-myopic children into high and low risk groups is significantly different when using each parameter. Even though AXL/CR may be the most predictive metric of SE at this time point, we will be able to determine which parameter provides a more accurate prediction for myopia development at the conclusion of the longitudinal study.

P48: Circulating immune cell alterations in patients with myopic retinopathy

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Purpose: Inflammation is known to be involved in the development of myopia. However, the role of inflammation in myopic retinopathy remains elusive. We conducted a retrospective case-control study to see the link between circulating immune cell alteration and myopic retinopathy.
Methods: Blood test results and demographic information of 392 myopic patients who underwent lens replacement surgery or sought medical assistance due to myopic retinopathy and 129 healthy emmetropia who had their routine health checkup in Changsha Aier Eye Hospital from May 2017 to April 2022 were collected. Blood test parameters included white blood cells count (WBC), the counts of neutrophils, lymphocytes, monocytes, eosinophils, basophils, platelets, platelet-to-lymphocyte ratio (PLR), lymphocyte-to-monocyte ratio (LMR) and neutrophil-to-lymphocyte ratio (NLR). Ocular information included diagnosis of eye diseases, myopic diopter, axial length, duration of myopia and demographic information. Myopic eyes were further divided into six subgroups: simple high myopia (SHM, n = 96), peripheral retinal degeneration (PRD, n = 60), rhegmatogenous retinal detachment (RRD, n = 86), posterior staphyloma (PS, n = 58), myopic maculopathy (MM, n = 37), myopic choroidal neovascularization (mCNV, n = 55). The difference in blood test parameters between emmetropia and different groups of myopic patients was analyzed.
Results: Compared with emmetropia, the percentages of neutrophils and basophils and NLR were significantly higher in myopic patients, whereas the percentages of lymphocytes and monocytes, lymphocyte and eosinophil counts were significantly lower in myopic patients. After adjusting for age, gender, BMI, allergic and other systemic disease (e.g., diabetes, hypertension) the difference in the percentage of neutrophils (higher in myopia) and monocyte (lower in myopic) remains. Interestingly, the platelet count were significantly lower in myopic patients after the adjustments. Further analysis of different subgroups of myopia showed that basophil counts were significantly higher in SHM, PRD and mCNV but not PS, RRD and MM. Patients with mCNV also had significantly higher levels of WBC and neutrophils compared to controls. The NLR was positively correlated with axial length, but negatively correlated with the myopic diopter.
Conclusions: Increased neutrophils and basophils and decreased lymphocytes are related to pathological myopia, particular in patients with mCNV, suggesting an altered innate and adaptive immunity in these patients.

P25: The Safety of 0.05% Atropine in Retarding the Progression of Myopia in Chinese Children

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Purpose: The purpose of this study is to investigate the safety of 0.05% atropine in retarding the progression of myopia in Chinese children.

Methods: Fifty-six children with myopia were asked to use one drop of 0.05% atropine eye in each eye once-nightly for two weeks. Pupil diameter, visual acuity, accommodation, and choroid thickness were evaluated at baseline and two weeks into treatment. In addition, ocular discomfort and adverse effects were recorded.

Results: Fifty-six children completed the study, and twelve subjects (21.43%) had adverse reactions within one week. These symptoms disappeared with longer medication time, and the visual function questionnaire showed no effects on these patients' vision quality. For those who completed the study, after two weeks of eye drop administration, near and distant BCVA didn't change significantly, photopic pupil diameter increased by 1.4±1.0mm, mescopic pupil diameter increased by 0.9±0.7 mm, and accommodation amplitude reduced by 3.3±4.2D. The choroidal thickness increased by 11μm in 6mm diameters of macular region. For ocular surface evaluation, tear secretion and R-scan were both increased after two weeks of medication.

Conclusion: We found a once-nightly dose of 0.05% atropine eye drops to be safe and well tolerated in retarding the progression of myopia in the Chinese children in our sample.

Distribution of axial length in Australians of different age groups, ethnicities and refractive errors

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Purpose: Although increased axial length (AL) is associated with myopia, there is little information on the population distribution of AL. We profiled the distribution of AL in Australians aged 5–89 years with different refractive errors.

Methods: We retrospectively analyzed spherical equivalent (SE) and AL data of 5146 participants from 6 Australian studies. Participants underwent an eye examination including ocular biometry and cycloplegic autorefraction. Based on the SE, participants were classified into hyperopes (SE > +0.50 D; n=1522), emmetropes (SE +0.50 D to >-0.50 D; n=2172) and myopes (SE ≤-0.50 D, n=1453). A non-linear piecewise regression model adjusted for age, sex, and ethnicity (European, European/Polynesian, East Asian, South Asian and Other/mixed) was used to analyze the association between age and AL. The regression slopes were obtained for 759 participants below 18 years and 4387 participants 18 years or older. These results were compared with longitudinal data from the Raine study where the AL was measured at the ages 20 years (baseline) and 28 years of age.

Results: The median SE and AL were +1.00 D (IQR= +0.75 D to +1.38 D) and 23.12 mm (IQR= 22.63 mm to 23.64 mm) in hyperopes; +0.13 D (IQR= -0.13 D to 0.38 D), and 23.38 mm (IQR= 22.84 mm to 23.90 mm) in emmetropes; and -1.25 D (IQR= -2.50 D to -0.75 D) and 23.90 mm (IQR=23.25 mm to 24.76 mm) in myopes. After adjustments, females had shorter AL by 0.53 mm (95% CI: 0.58 to 0.49) compared to males (p<0.001), and East Asians and participants of other/mixed ancestries had longer AL by 0.51 mm (95% CI: 0.27 to 0.76; P<0.001) and 0.37 mm (95% CI: 0.17 to 0.60; p<0.001) compared to Europeans. A piecewise regression showed that until 18 years of age, the AL was longer by 0.013 mm in hyperopes (p=0.091), 0.046 mm in emmetropes (p<0.001), and 0.114 mm in myopes (p<0.001) per 1-year increase in age. After 18 years, the AL was longer by 0.004 mm in hyperopes (p=0.005), 0.005 mm in emmetropes (p<0.001), and 0.012 mm in myopes (p<0.001) per 1-year increase in age. The longitudinal data from the Raine study revealed that only myopes showed a significant change in the SE and AL by -0.16 D (P<0.001) and 0.041 mm (p=0.03) per year when compared to emmetropes and hyperopes.

Conclusions: This cross sectional population data suggests there is minimal increase in AL in non-myopic eyes over the age of 18 years. Myopic eyes appear to have longer eyes that increase more rapidly in childhood and slightly in early adulthood. Further studies of longitudinal changes in AL through to adulthood are required if we are to use this data in guiding myopia interventions.

Retinal photon dosing in eyes with different axial lengths

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This paper explains on a theoretical level how the retinal lux level can be very different in the eyes of two children in the same illumination environment and with identical pupil diameters but with different axial lengths, something that has not been understood up to now.
This paper considers mathematically how pupil size and axial length affect the levels of illumination of photoreceptors in the developing eye. It explores how absolute and relative lux levels and their effect on choroidal temperature inside the eye might have an input in the process of emmetropisation. Very little in any thought is given to the considerable heat load on the macula and retina during normal viewing in natural outdoor daylight and how the choroidal blood flow is responsible to removing this heat.
The paper theorises a mechanism about atropine's effect on the pupil diameter which might explain some of its efficacy in slowing myopia in children. Taking account of these considerations might allow some progress in the quest to eliminate environmental myopia by expanding our thinking about happens in an overgrown eye and possible give some direction to the next area for myopia research.

Estimating the risk for long-term myopia progression using a training-free method

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Purpose: Nowadays ophthalmologists have effective therapies at their disposal to control myopia progression in children. For cost-effectiveness, these therapies should preferably be applied only to those at risk at developing progressive myopia. To this end, we present a simple, training-free method to identify such children, both in the near and long term.

Methods: The analysis retrospectively uses the longitudinal refraction data of 1997 right eyes of Chinese school children aged between 7 – 12 years that were measured in the Anyang Childhood Eye Study. The proposed method, named MyoMatch, starts from a child's cycloplegic refractive error at age 7 years, gender, and number of myopic parents. Next the algorithm searches the Anyang database for matching eyes with the same gender, age, number of myopic parents, and a refractive error within ±0.5D from that of the inputted eye. Finally, the median and percentile values of the refractive error measurements of the matching eyes are determined, which serves as a forecast of the refractive error for a period of up to 5 years. When the child comes back for next year's follow-up, the same procedure is repeated, this time matching the refractive errors of both the first and second visits, and so on for subsequent visits. Unlike machine learning, MYOPEDS does not require training. Hence, the same database can be used to validate the method, provided the eye being forecasted is excluded.

Results: Sequentially selecting a single eye from the Anyang database and estimating the future refractive error by matching all other eyes shows a match with the real measured values within ±0.5D for 83.8% of cases for the next visit and for 37.7% over a 5-year period. MyoMatch's forecast of developing myopia (defined as ≤ –0.5D) was 92% accurate for the next visit and 80% accurate over a 5-year period. The positive predictive value (PPV) was 94% for the next visit and 80% over a 5-year period. For the negative predictive value (NPV) these values were 91% and 79%, respectively.

Conclusions: MyoMatch can provide an accurate estimate of the expected change in refractive error over a 1-year period and a reasonable estimate over a 5-year period. These results are comparable or somewhat better than earlier attempts in the literature, while requiring only minimal clinical information. One limitation is that the method may be highly specific to East Asia and may require an update for other regions of the world.

Young children with fast axial length growth also progress faster during teenage years

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Purpose: Axial length growth is an important parameter in myopia development. Fast progressive children with myopia have an accelerated eye growth. It is unknown if the fast progressors before the age of 10 are also fast progressors during teenage years. The aim of this study is to examine the correlation between eye growth at different ages and to test how children with accelerated eye growth progress subsequently.
Methods : Children from the population-based birth cohort study Generation R underwent ocular biometry measurements with AL at ages 6 (N = 6321), 9 (N = 5430), 13 (N= 4851) and 18 (N=759) years of age, with measurements of objective cycloplegic refractive error at 9, 13 and 17 years. Myopia was defined as mean SER of ≤-0.5D in both eyes. Correlation between growth at the different intervals was calculated using Pearson correlation.
Results : Axial length was measured at 6.2 (0.5), 9.8 (0.3), 13.6 (0.4) and 18.4 (0.5) years (SD) old and was on average 22.36 (0.75) mm, 23.10 (0.84) mm, 23.50 (0.95) mm and 23.72 (1.03) mm respectively. Axial length eye growth (mm/year) was 0.21 (0.09) between 6 and 9, 0.11 (0.07) between 9 and 13 years and 0.05 (0.04) between 13 and 17 years of age. Myopic children at 13 grew on average 0.29 (0.10) , 0.20 (0.08) and 0.08 (0.05) mm/year between 6-9, 9-13, and 13-17 years of age respectively. Correlation between growth between 6-9 and 9-13 years was 0.49 ($P < 0.001$) and between 9 and 13 and 13-17 years was 0.52 ($P < 0.001$). The 456 (11.9%) with a myopic growth (≥0.29 mm/year) between 6-9 year grew twice a fast between 9-13 years (0.09 vs 0.19 mm/year $P <0.001$) and 13-17 years (0.04 vs 0.10 mm/year $P <0.001$).
Conclusions: Children with faster axial length growth at a young age also progressed faster after the age of 10 years. This is important for myopia management as growth rate will continue to be high when myopia control is stopped too soon in progressive myopes.

Association between chronotype and refractive error

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Purpose
Increasing evidence suggests that circadian rhythms modulate the development of refractive errors. This retrospective observational cross-sectional study aimed to uncover the associations between circadian rhythms and refractive error by analysing the chronotype or morning-evening preference of people with myopia and hyperopia.

Methods
69,836 participants of the Estonian Biobank who had completed the Munich Chronotype Questionnaire (MCTQ) before the age of 70 were included in the analysis (66% female, aged between 17-69, median age 44 years). Chronotype was defined as the mid-point of sleep on non-working days adjusted for sleep deficit on workdays (MSFsc). Diagnoses of myopia and hyperopia were retrieved from electronic health records (ICD-10 codes H52.1 and H52.0, respectively). A logistic regression model was fitted with the outcome as myopia or hyperopia; and MSFsc, age, gender, education level, and time people reported spending in daylight as covariates.

Results
12,533 participants with myopia and 6,804 with hyperopia were identified in the study population. The median MSFsc of participants diagnosed with myopia was 3.8 (interquartile range, IQR 3.2–4.5), of those with hyperopia 3.3 (IQR 2.6–3.9) and those without a refractive error 3.6 (IQR 3.0–4.3). After adjusting for age, gender, education level, and time people reported spending in daylight, participants with a later chronotype (higher MSFsc value) were more likely to have myopia (OR = 1.09, 95% CI 1.06–1.11, p = 1.2E-16). Intriguingly, early chronotype was associated with hyperopia as there was a negative association between MSFsc and hyperopia (OR = 0.96, 95% CI 0.94–0.99, p = 0.006). In addition, higher level of education was positively associated with myopia (OR = 1.27, 95% CI 1.22–1.33, p = 1.4E-31) and negatively with hyperopia (OR = 0.65, 95% CI 0.61–0.68, p = 3.3E-51). Furthermore, participants who reported spending more time in daylight (hours per week) were more likely to have hyperopia (OR = 1.68, 95% CI 1.48–1.90, p = 6.9E-16) while time spent in daylight was negatively associated with myopia (OR = 0.84, 95% CI 0.75–0.95, p = 0.003).

Conclusions
We demonstrate that late chronotype is associated with myopia and early chronotype with hyperopia. With access to the genomic information of the Estonian Biobank participants, further genomic analyses will reveal the potential molecular basis for the interaction and address the causality of this relationship.

Myopia and screentime in 6-7-year-old schoolchildren: a cross-sectional analysis from the Ireland Eye Study

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Purpose
Explore the relationship between time spent on screens, refractive status and ocular biometric and anthropometric factors in 6-7-year-old schoolchildren in Ireland.

Methods
Participants were 728 6-7-year-old (377 boys (51.8%)) children in Irish schools. The examination included cycloplegic autorefraction (1% cyclopentolate hydrochloride), ocular biometry (Zeiss IOLMaster), height (cm) and weight (kg). Power vector analyses of Cartesian astigmatism (J0) and oblique astigmatism (J45) components of refractive, corneal astigmatism. Parents/guardians reported their child's screentime as: <1hr/day, 1-2hrs/day, 2-4hrs/day, >4hrs/day.

Results
One in five (19.75) 6-7-year-olds reported > 4hrs/day on screens. Socioeconomic disadvantage was associated with >4hrs/day on screens (Odds ratio (OR)=8.89 (3.20-24.69, p<0.001). Controlling for socioeconomic status, myopia (≤0.50D) was associated with >4hrs/day (OR=5.58 (1.52-20.58), p=0.01), and 2-4hrs/day (OR=10.67 (2.80-40.59, p=0.007) than <1hr/day on screens. Mean (standard error) spherical equivalent was higher in participants <1hr/day (1.47(0.05)D) compared to >4hrs/day (1.29 (0.38)D, p=0.03) on screens. Astigmatism was lower in those <1hr/day (0.53 (0.03)D, than >4hrs/day (0.97 (0.14)D, p=0.002) on screens. There was no difference in axial length (AL) with screentime. Mean corneal radius (CR) was longer in participants <1hr/day (7.73(0.02) mm), than > 4hrs/day on screens (7.67 (0.02)mm), p=0.02). Participants > 4hrs/day had a higher AL/CR (2.91 (0.07)) than participants <1hrs/day on screens (mean 2.87 (0.09) p=0.004). There was no difference in corneal or refractive J45 or corneal J0 astigmatism with screentime. Refractive J0 was higher in participants >4 hrs/day (0.63 (0.17)D), compared to those <1hr/day (0.32 (0.04)D p=0.03) on screens. Height was not associated with screentime. Participants >4hrs/day were heavier (27.8 (1.69)) kg than participants <1 hr/day (25.0 (0.24), p=0.001) on screens. BMI (weight/height²) was higher in participants >4hrs/day (17.93 (0.73) kg/m²) compared to <1hr/day on screens 16.11 (0.10) kg/m², p<0.001) on screens.

Conclusion
Increased time spent on screens was associated with increased odds of myopia, more myopic refraction, higher degrees of with-the-rule astigmatism, and increased weight and BMI in 6-7-year-old Irish schoolchildren. Dedicated eye-health education programmes promoting decreased screentime in children (further supporting disadvantaged children) are vital.

Accommodative facility and response time before and after near task of varying durations in young adults

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Purpose: To explore/investigate the changes in near accommodative facility and response time in young adults following near tasks of varying durations

Methods: 50 subjects (37 females, 13 males) aged 20.63 ± 1.33 years were included in this experimental study. All subjects underwent preliminary examination to rule out binocular vision anomalies and ocular pathologies. Subjects were made to sit in dark room prior to pre task measurement. Monocular near accommodative facility was measured using ±2.00 DS flipper at 40 cm using N6 target before and after two reading conditions. Condition 1: Reading from a laptop for 30 minutes while viewing through -2.00 D lens at working distance of 25 cm. Condition 2: Reading from a laptop for 1 hour while viewing through -2.00 D lens at working distance of 25 cm. The order of testing was randomized. Both pre and post task measurements were video recorded in a smart phone and the number of cycles per minute, positive and negative response times was calculated from the video recording. Data were analyzed using SPSS Version 14.0

Results: Out of the 50 subjects, 32 were emmetropes and 18 were ametropes. The mean spherical equivalent for right eye was -0.63 ± 0.98 D and -0.60 ± 1.01 D for left eye. The mean pre task accommodative facility was 6.79 ± 3.52 cycles per minute and post task accommodative facility was 6.25 ± 3.65 cycles per minute (p = 0.096) for 30 minutes task and 5.76 ± 3.89 cycles per minute (p = 0.011) for 1 hour task. The mean pre task positive response time was 2.87 ± 1.55 seconds and post task positive response time for 30 minutes and 1 hour task was 2.86 ± 1.67 seconds (p = 0.884) and 2.98 ± 2.33 seconds (p = 0.421) respectively. The mean pre task negative response time was 8.77 ± 8.83 seconds and post task negative response time for 30 minutes and 1 hour task was 11.83 ± 14.28 seconds (p = 0.159) and 14.72 ± 17.32 seconds (p = 0.026) respectively.

Conclusion: Monocular near accommodative facility was significantly reduced and negative response time was delayed following 1 hour computer work.

A high-frequency, point-of-care ultrasound device to quantify myopia-induced microstructural changes in the anterior sclera

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Purpose
There currently exists no method to quantitatively assess myopia development and severity in vivo. Numerous studies have demonstrated how myopia affects the microstructural properties of the posterior sclera and more recent investigations provide some evidence that anterior sclera is also affected. We propose a point-of-care (POC) device utilizing a high-frequency ultrasonic transducer and quantitative ultrasound (QUS) methods to quantitatively evaluate the anterior sclera in vivo non-invasively.

Methods
The proposed POC device must satisfy several requirements for effective clinical use: the measurement portion is handheld and user interface is simple, safety and health-data security requirements by relevant governing bodies are satisfied, and measurement data have sufficiently high signal-to-noise ratio (SNR) and consistency for processing with our QUS algorithms. To satisfy the first requirement, an 80MHz transducer is housed in a custom, 3D printed pen-like holder to allow a user to easily acquire measurements of the anterior sclera. A foot switch initiates measurements and a custom PC interface allows easy saving of anonymized US echo data. Per the second requirement, pressure field measurements were performed using a 40μm needle hydrophone to ensure ultrasound intensities and mechanical index were within the United States FDA limits for ophthalmic ultrasound. Preliminary measurements were then performed using the POC device to acquire data on calibration phantoms with known acoustic and scatterer properties to ensure measurement data have sufficient SNR and consistency.

Results
All requirements have been met in the POC device. Measurements of the US pressure field indicate the US pressure field complies with ophthalmic FDA guidelines. IRB approval has been granted at Singapore Eye Research Institute, the location where patient data will be acquired. Preliminary measurements on calibration phantoms suggest the echo SNR and consistency are suitable for QUS processing.

Conclusion
A fully functional POC system has been created for evaluating the microstructure of the anterior sclera with high-frequency QUS. With IRB approval granted, clinical measurements will begin in late 2022. Results of the study that can now be performed will help clarify how myopia may alter the microstructural properties of the anterior sclera in vivo. If effective, this inexpensive, portable, and easy-to-use POC system could become an integral part of routine eye exams.

Retinal On-Off pathway activity in myopes and non-myopes

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Purpose: Previous reports show that visual stimuli which selectively overstimulate Off-pathways produce a short-term reduction in choroidal thickness. Reduced choroidal thickness has been implicated in the development of myopia. However, the direct involvement of the retinal On-Off pathways in myopia remains unclear. The aim of this study was to compare the activity of retinal On-Off pathways measured with photopic On-Off electroretinograms (ERGs) between myopes and non-myopes.
Methods: Twenty healthy subjects comprising 11 myopic (age, mean ± SD: 24.0 ± 1.9 years; spherical equivalent refraction (SER), range: -0.50 to -4.50D) and 9 non-myopic adults (age, mean ± SD: 22.7 ± 1.3 years; SER, range: +1.00 to -0.25D) underwent light-adapted On-Off ERG testing on a RETIScan system (Roland Consult, Germany). Amplitudes and peak times of the On-response (a-wave and b-wave) and Off-response (d-wave) in the right eye were compared between myopes and non-myopes using Welch's t-tests. Pearson's correlation analysis was used to evaluate the association between SER and On-Off responses.
Results: Both the a-wave and b-wave peak times were significantly shorter in myopes compared with non-myopes (mean ± SEM, a-wave: 16.8 ± 0.32 vs 18.2 ± 0.30 ms, $p = 0.0048$; b-wave: 30.4 ± 0.37 vs 32.1 ± 0.65 ms, $p = 0.035$). Pearson's analysis revealed a significant positive correlation between SER and b-wave peak times ($r = 0.45$, $p = 0.048$). However, the peak time of the d-wave (Off-response) was not different between myopes and non-myopes (220.6 ± 0.31 vs 220.1 ± 0.26 ms, $p = 0.234$). In the amplitude domain, no differences were found between myopes and non-myopes in either the On or Off-response magnitudes (all $p > 0.05$).
Conclusion: It has previously been suggested that overstimulation of retinal Off-pathways is likely linked to myopia development. However, our results found no change in ERG Off-response peak times or amplitudes with myopia. On the contrary, in our study, myopic subjects had faster On-pathway activity than non-myopic subjects, with On-response speed increasing with the magnitude of myopia. This suggests an imbalance of retinal On-Off activity with a neural bias toward On-pathway response in myopia. A relatively enhanced On-pathway response could be a consequence of structural alterations of retinal neural elements in myopia or perhaps a compensatory response to Off-pathway overstimulation that is purportedly implicated in myopia development.

Association between Peripheral Refraction and Corresponding Electro-Retinal Signals

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Purpose: This study aimed to investigate the association between peripheral refraction and corresponding multifocal electroretinogram (mfERG) responses from central to peripheral retina in young adult non-myopes and myopes.

Methods: Central and peripheral refraction using an open-field autorefractor (NVision-K-5001, Shin-Nippon) and mfERG responses using an electrophysiology-stimulator (MonPackONE, Metrovision) were recorded for the right eyes of 20 non-myopes (-0.50 to +1.00 D) and 24 myopes (-0.50 to -6.00 D), aged 18-36 years. The mean absolute N1, P1, and N2 mfERG amplitudes were compared against the corresponding absolute spherical equivalent refraction (SER) measurements at the best-matched eccentricities along the principal meridians: fovea (0°), horizontal (±5°, ±10°, and ±25°) and vertical meridians (±10° and ±15°) using a two-way ANOVA.

Results: The mean ± standard error for foveal SER in non-myopes and myopes were +0.25 ± 0.09 D and -2.88 ± 0.36 D, respectively. In non-myopes, the mean absolute peripheral refraction was -0.73 ± 0.11 D at nasal 25° and -0.36 ± 0.10 D at temporal 25°. In myopes, the mean absolute peripheral refraction was -3.22 ± 0.37 D at nasal 25° and -2.49 ± 0.30 D at temporal 25°. There were statistically significant differences in the mean absolute SER between non-myopes and myopes at all eccentricities across both meridians ($p<0.01$). The mfERG N1, P1, and N2 amplitudes at the retinal periphery were significantly smaller compared to the fovea ($p<0.01$) and were also significantly different between the two refractive groups ($p<0.05$). In myopes, the difference in the absolute mfERG amplitudes between the extreme temporal (25°) and nasal (25°) eccentricities (temporal – nasal) for N1, P1, and N2 amplitudes were -73 ± 10 nV, 102 ± 4 nV, and -94 ± 8 nV, respectively (overall $p<0.01$). When the central and extreme peripheral retina experienced the same magnitude of absolute refraction (data pooled for both refractive groups), the absolute mfERG amplitudes at the peripheral retina were significantly smaller compared to the central retina across both meridians ($p<0.01$). Furthermore, the reduction in mfERG amplitudes in the peripheral retina were similar for varying degrees of absolute peripheral refraction at each meridian ($p>0.05$).

Conclusions: These results show that the mfERG electro-retinal signals may not be associated with corresponding peripheral refraction from central to peripheral retina in young adult eyes.

Efficacy versus vision: breaking the nexus

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Purpose
There is no robust evidence that any myopia control treatment achieves greater than 0.44mm (about 1.0D) efficacy. Striving for greater efficacy in myopia control soft contact lenses inevitably comes at a cost to vision quality. We have found a way to disrupt this inter-relationship.

Methods
Extensive empirical testing was conducted on a purpose-built optical table. Key features of the apparatus included: optical biometric measurement of short-term change in axial length of the eye (in response to choroidal thickness change), used as a biomarker for myopia protection; use of a spatial light modulator to introduce optical stimuli to the eye, enabling diverse designs to be tested without the need to manufacture prototype contact lenses; pupil tracking to maintain the position of design relatives to the eye; visual acuity, contrast sensitivity and halo measurement. This unique program of investigation, along with optical modelling, enabled sophisticated concept development and optimization of myopia control lens design.

Results
In dual-focus designs, a dose-response effect was evident between short-term reduction in axial length and 'add' power. Increasing add power only reduced VA up to about +2.0 to +3.0 D; beyond these powers, it was degraded marginally as a result of simple contrast reduction. Haloes were found to be a major source of visual artefact with increasing add power. In real-life scenes, these are observed as ghosting or shadowing. Use of non-coaxial plus power in the treatment zone substantially reduced this artefact while unexpectedly retaining myopia control properties. Lens designs applying this principle comprised a conic section of a torus as the optics of the myopia control treatment zone, overcoming the previous limitation of the efficacy-vision relationship. The removal of the need to bring light passing through the treatment zone to a point focus frees the optical designer to produce a lens with either enhanced efficacy but similar vision quality as classical concentric-annulus dual-focus designs, or with similar efficacy but reduced vision impact as such designs. A 6-month masked, randomized, controlled clinical trial confirmed this discovery.

Conclusion
A soft contact lens with enhanced efficacy but similar vision quality to a classic dual-focus design was developed and granted breakthrough device designation by the US FDA.

Myopia control efficacy of spectacle lenses with highly aspherical lenslets: 3-year results

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Purpose: Spectacle lenses with aspherical lenslets control myopia progression over two years (Bao et al., 2022), but their long-term efficacy remains to be evaluated. This study assesses myopia control efficacy over one year in children wearing consecutively spectacle lenses with highly aspherical lenslets (HAL) for the third year and for children switching to HAL after wearing spectacle lenses with slightly aspherical lenslets (SAL) or single vision lenses (SVL) for two years.

Methods: At the end of the 2-year MyCAL clinical trial in which myopic children wore either HAL, SAL or SVL, participants were equipped with HAL and followed for a third year. At the beginning of the third year, children were aged 10 to 15 years. 52 children from the former HAL group, 51 from the former SAL group (SAL-HAL) and 47 from the former SVL group (SVL-HAL) were followed for one more year with 6-monthly visits. Primary outcomes were cycloplegic spherical equivalent refraction (SER) and axial length (AL). For comparison purposes, a new SVL (nSVL, n=56) group was recruited and matched with the original SVL group based on age, gender, SER, and AL at the end of the second year.

Result: Of 191 participants who completed the third-year visit, 51 were analysed in the HAL group, 50 in the SAL-HAL group, 42 in the SVL-HAL group, and 48 in the nSVL group. SER and AL changes (±SEM) were comparable (all P>0.05) in the HAL (-0.38D±0.05D; 0.17±0.02mm), SAL-HAL (-0.36±0.06D; 0.18±0.02mm) and SVL-HAL (-0.33±0.06D; 0.14±0.02mm) groups while the nSVL group progressed by -0.56±0.05D and 0.28±0.05mm, respectively. Changes in SER and AL in the three original groups in the third year were significantly less than in the nSVL group (mean differences, HAL vs nSVL: -0.18±0.08D, P=0.02, 0.11±0.02mm, P<0.001; SAL-HAL vs nSVL: -0.20±0.08D, P=0.01; 0.10±0.02mm, P<0.001; SVL-HAL vs nSVL: -0.23±0.08D, P=0.006; 0.14±0.02mm, P<0.001). In the SVL-HAL and SAL-HAL groups, changes in SER and AL during the third year were lower compared with the second year (mean differences, SVL-HAL: -0.33±0.07D, 0.20±0.02mm, all P<0.001; SAL-HAL:-0.18±0.06D, 0.08±0.02mm; all P<0.02).

Conclusions: HAL remains effective in slowing myopia progression and axial elongation in the third year of the clinical trial. Myopia control efficacy of HAL is demonstrated in older children who have been wearing either SVL or SAL in the two previous years.

Effect of optical myopia-control interventions on peripheral vision

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Purpose: Animal studies suggest that the peripheral retina has an important role in the regulation of eye growth. Different optical interventions for myopia control aim to manipulate the peripheral image in order to slow the progression of myopia, but it is not yet known what the peripheral effect of these interventions is compared to each other. This study investigates the similarities and dissimilarities of different optical interventions in their effect on peripheral vision with the aim to better understand their treatment properties.
Methods: Peripheral (20° nasal visual field) low-contrast (10%) resolution acuity of 2 myopes was evaluated by a two-alternative forced-choice paradigm with four optical myopia control interventions: a) spectacles with horizontal progressive addition (Perifocal from ArtOptica), b) spectacles with highly aspherical lenslets (Stellest from Essilor), c) spectacles with defocus incorporated multiple segments (MiyoSmart from Hoya), and d) multifocal soft contact lenses (MiSight from Cooper Vision). The peripheral acuity thresholds were compared with those of normal monofocal spectacles (control). All measurements were repeated three times and the average thresholds in logMAR as well as the differences from the control were calculated (intervention threshold minus control threshold).
Results: The differences in thresholds from the control case for subject 1 were a) 0.005 logMAR for Perifocal, b) -0.004 logMAR for Stellest, c) 0.019 logMAR for MiyoSmart and d) 0.232 logMAR for Misight. For subject 2 the differences in thresholds were a) 0.038 logMAR for Perifocal, b) 0.076 logMAR for Stellest, c) 0.085 logMAR for MiyoSmart and d) 0.117 for MiSight.
Conclusion: In both subjects, the MiSight intervention reduced peripheral vision more, followed by MiyoSmart. Thus, we can conclude that although all four interventions have been reported to have similar myopia control efficacy, there is a large difference in how much they reduce the retinal contrast. Furthermore, there is substantial variation on individual level. Knowledge of the contrast reduction caused by the intervention in the individual eye may provide cues on how to optimize the treatment effect. It should also be balanced against safety, since large contrast reductions in the periphery hamper daily tasks involving peripheral vision such as detection, orientation, and locomotion.

Slowing of myopia and eye growth reversal with wear of spectacles comprising highly aspherical lenslets

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Purpose: Utilising a randomized, double-masked, and cross-over trial involving wear of spectacle lenses with highly aspherical lenslets (HAL) versus single vision spectacles (SV), we previously found that HAL slows myopia. In this analysis, we report the percent of eyes that demonstrated a) responsiveness to HAL, i.e. a slower eye growth than the control single vision (SV) spectacles, and b) reversal of eye growth with either of the lens types.
Methods: 119 Vietnamese children, aged 7 to 13 years with baseline (BL) refractive error ranging from -0.75 to -4.75D, cylinder ≤ 1.50D were assigned to 2 groups to wear either HAL or SV, and after 6 months (Stage 1) crossed over to wear the other lens type for another 6 months (Stage 2). At the end of Stage 2, all children (n=105) wore HAL for a further 6 months. Cycloplegic auto refraction was performed at BL and then every 6 months and axial length (AL) measurements collected at BL and 3 monthly thereafter. For the current analysis, myopia progression (6 monthly change in AL and spherical equivalent refractive error (SE)) was determined. Thereafter, for each participant eye, AL and SE change during Stage 1 was compared to Stage 2 and where change was less with HAL than SV, the eye was categorised as a responder, and eyes with a reduction of AL of ≥ 0.05mm (growth reversal) were determined. Univariate analysis followed by multiple logistic regression was conducted to determine factors if any influencing growth reversal. Level of significance was set at 5%.
Results: Myopia progressed slower with HAL than SV during both Stages 1 and 2 (AL change Stage 1: 0.07mm vs 0.14mm, p=0.004; Stage 2: 0.04mm vs 0.17mm, p<0.001; SE change Stage 1: -0.21D vs -0.27D, p=0.317, Stage 2: -0.05D vs -0.32D, p<0.001). In eyes that crossed over from SV (Stage 1) to HAL (Stage 2), 80.0% and 71.4% of eyes (AL and SE respectively) had slower progression to HAL wear. Similarly, with cross-over from HAL to SV, 77.7% and 60.4% of eyes (AL and SE respectively) responded to HAL wear. A greater proportion of HAL than SV eyes exhibited growth reversal (13.4% vs 1.7% (Stage 1) and 15.0% vs 1.0% (Stage 2), p <0.001). Factors associated with growth reversal were older age and shorter axial length at BL and longer lens wearing time (p<0.05).
Conclusions: A majority of eyes slowed in progression in response to HAL wear. Interestingly, growth reversal was observed in a proportion of HAL wearers. Whilst there were factors associated with growth reversal, the interrelationship between these factors and the mechanism underlying growth reversal remains to be explored.

Montreal experience part 2 : Corneal topographical changes induced by four orthokeratology lenses and their relationship with axial elongation.

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Purpose

To investigate the relationship between topographical changes induced by various orthokeratology lens designs and axial elongation.

Methods
This is a retrospective analysis using the data from the Montreal Experience study. Data were extracted from the file of each patient who consulted between January 2017 and December 2018 and were kept under the same myopia management strategy. The patients fitted with orthokeratology lenses (OK) were selected (N=140). Among participants, 4 different OK lens designs were prescribed (L1 Optic zone of 6.0 mm ; L2 Optic zone 5.6 mm; L3 Optic zone 5.5 mm, L4 Optic zone 5.0 mm) For each participant, corneal topographical analysis were done using the tangential differential maps as described by Marcotte-Collard earlier. The differential map between baseline and 3 months follow-up was analyzed, which means determining the treatment zone diameter (TZD) and the high mid-peripheral convex power (HCP) generated under the reservoir. Topo maps were compared based on the OK lens design worn. Finally, the area of the TZD/HCP was put in proportion with the pupillary area and the correlation between this ratio and the progression of the axial length at 1 year was established.

Results

The horizontal TZD was the larger for L1 (3.7 ± 0.45 mm), which was considered statistically different than L4 (3.2 ± 0.58 mm), L2 (3.00 ± 0.64 mm) and L3 (2.97 ± 0.58 mm). There was no significant differences between the 3 other lenses.
The amount of positive mid-peripheral power induced by the orthokeratology lens after 3 months of wear was analyzed. The mean values of the amount of positive mid-peripheral power measured in the four quadrants were compared according to the four lens designs used (L1: 9.4 ± 3.3 D, L2: 9.1 ± 3.6 D, L3: 9.3 ± 4.2 D, L4: 9.1 ± 3.4 D) There were no significant differences between the four OK designs.
The HCP zone area vs the pupil represents 38.5 ± 22.1 % for L1, 56.6 ± 17.3 % for L2, 56.3 ± 17.3 % for L3 and 55.8 ±16.0 % for L4. There is a significant negative correlation with axial elongation after 1 year. (r = -0.48)

Conclusion
Four different OK lens designs generate the same convex power value but differ in the central treatment area induced on the cornea. The larger zones are associated with faster progression of axial length over 1 year. This suggests that the treatment zone size impacting the proportion of convex power (defocus) that enters the pupil is a key factor to consider for myopia control. This would tend to confirm that there is an inverse dose-response relationship between the distance zone diameter and axial length progression. These results reinforce the importance of topographic analysis, and not simply the description of designs, in the studies and research performed in orthokeratology.

Fast progressors are successfully treated with MiSight® 1 day myopia control contact lenses

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Purpose:
Although standard control vs. treatment cohort data pooling used in rigorous clinical trials of myopia control treatments (e.g., Chamberlain 2019) provides a convenient assessment of overall efficacy (52%), it fails to reveal if the treatment is more or less effective for certain sub-classes of subjects. By collecting 3 years of eye growth data before initiating 3-years' of treatment, which allows to identify the growth rate prior to and during treatment, and therefore address the impact of MiSight 1 day treatment on the faster and slower progressing eyes.
Methods:
The original control cohort from the 3-year clinical trial of MiSight 1 day (Chamberlain 2019) were switched to MiSight 1 day lenses for a second 3-year period (Chamberlain 2022). Average age at the start of the trial was 10.1 ± 1.4 and 92 eyes from 46 subjects followed for six years are included in this analysis. At each annual visit, cyclopleged refractive errors (Grand Seiko WAM-550) and axial lengths (AL; optical biometer Zeiss IOL Master) were recorded. Sub classes of patients were stratified by quartiles (Q) according to the pre-treatment growth rates observed in the first 3-years of the study. Observed growths during treatment were compared with published data on growth of untreated myopic eyes (Jones 2005, Shamp 2022).
Results:
AL growth rates of individual eyes during treatment correlated with their rates observed prior to treatment (e.g. AL growth observed over three years of treatment = 0.29 x AL growth observed over three years prior to treatment, R=0.22, consistent across the full progression range). A bivariate analysis of growth across these sequential 3-year periods revealed that 90% of eyes can be described by a common model in which eye growth slowed to 22% of its earlier pre-treatment rates, whereas if left untreated the expected growth would likely only have slowed due to age to approximately 73%-83% of the earlier growth rate. Nine eyes (10%) grew at the same pre-treatment rate during treatment, a sub-group can be identified as "non-responders". Tracking each quartile of the 90% of responding eyes revealed a consistent trend in which growth rates were year-by-year greatest for the fastest progressing eyes (identified by accumulated 3-years of pre-treatment growth). The faster growing eyes prior to treatment generally remained the fastest growing eyes during treatment, consistent with the proportional treatment effect revealed by the bivariate analysis. Eyes that progressed more slowly prior to treatment (Q1) effectively stopped progressing once treatment was initiated. Pre-treatment axial length (AL) growth rates of responders exhibited a large range, with upper quartile (Q4) rates being 0.33, 0.26 and 0.22 mm faster than Q1 for years 1, 2, and 3, respectively. Along with reduced mean growth and progression and consistent with the proportional treatment model, variability in growth rates also decreased during treatment with Q4 growth being 0.05, 0.03 and 0.03 mm greater than Q1 for years 4, 5, and 6, respectively.
Conclusions:
MiSight 1 day dual focus contact lenses provided the greatest slowing of eye growth and myopia progression for the fastest progressing eyes, suggesting that those eyes at greatest risk of high myopia will obtain the greatest benefit from treatment.

Biometric changes associated with active stimulation of the peripheral retina with myopically defocused images in humans

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Purpose
Several studies show that application of peripheral myopic defocus with a clear central aperture suppresses the rate of increase of axial length. Additionally, light therapy has also been shown to inhibit increase in axial length and increase choroidal thickness in human subjects. Therefore, we surmised that projection of a bright (1,600 nits) myopically defocused image on the peripheral retina would combine these two effects and lead to a greater efficacy of myopia inhibition. We have conducted a number of studies on young adults as well as teens using several image propagation platforms, both to monitor transient effects on the axial length and choroidal thickness immediately following stimulation, as well as long term ocular changes. The picture that emerges out of these preliminary studies is that myopically defocused images projected on the peripheral retina can cause both transient changes in axial length and choroidal thickness as well as long term changes in spherical refraction equivalent (SRE) even when the daily duration of application of the stimulus is relatively short (1-2 hours/day).

Methods
We investigated the physiological effects on axial length and foveal refraction generated by an image projection system set up on an optical bench ("the bench top system") as well as a prototype spectacle lens type device after 1.5 hour of daily stimulation on healthy teens and adults during the same part of the day (7:00 AM to 12 noon) in order to minimize diurnal variations. When seated at the bench top apparatus, the subject's central 15° of field was clear and unimpeded. Thus, each subject could view a central target (the television screen) in the distance, while being exposed to the surrounding myopic defocus stimuli (as described above) in the periphery. Each subject was fully corrected with custom made spectacles. The ambient light levels were maintained at moderate photopic (naturalistic) levels during the testing period. The subjects were seated comfortably and instructed to watch television using a color monitor display approximately 4 meters away and was approximately 1 meter diagonal. The subjects kept their physical movements to a minimum during the defocus sessions.
Target images were created and projected on the pupil of the subject's test eye at 7.5° – 17.5° eccentricity by means of a series of micro-lenses, beam splitters and mirror assemblies. Micro-LEDS of color temperature in the range 5,000-6,000K were used to simulate the effect of sunlight. Masks were used to generate images of a set of 8 Maltese Crosses of reverse polarity with spatial frequency distribution peaked at 0.3 cycles/deg. The stimuli were defocused +4.0D over the best refractive correction worn by each subject, and were projected on the peripheral retina, covering approximately 30% of the retinal surface within the annulus of 7.5° to 17.5°, leaving the central 15° foveal zone unaffected, the aim being to provide a proof of concept for the use of any device which may project defocus into the peripheral retina, resulting in a lasting ocular physiologic change. Daily stimulation (5 days per week) on the bench top system was performed at the clinic on seven subjects (5 females) in age range of 21-32 years (25.1+/-4.0), for a period of 4 months (n = 7), while the prototype devices were dispensed to 11 teens (mean age 13.7 years) for a period of 6 months. Male female ratio was 5(M)/6(F), and 8 /11 were of Asian ethnicity. Both studies were monocular, with the left eye serving as control in the study with the bench top device, while the more myopic eye was chosen as the test eye in the study with the engineering prototype, the other eye serving as control. In case of equal refraction in both eyes, the test eye was chosen at random. The WAM-550 (Grand Seiko, Hiroshima, Japan) was used to obtain the cycloplegic refractive endpoints after full pupil dilation was achieved with 1% cyclopentolate topical ophthalmic solution. Transient studies were also performed on each device, using one hour stimulation in each case. They were always carried

out in the morning, from 7:00 AM to noon, in order to minimize inter-subject variability of axial length and choroidal thickness due to diurnal changes. Axial length measurements (Haag-Streit Lenstar APS900) and radial sub-foveal choroidal scans (Heidelberg Spectralis SD-OCT with EDI) were obtained just prior to and just after each defocus session on both test and contralateral eyes, serving as controls. A group of 12 young adults (9 males, 3 females, 7/12 Asian) were tested in the transient mode on the bench top apparatus at three levels of brightness of the stimuli. Axial length and subfoveal choroidal thickness were measured as above. Subjects for the transient study on the engineering prototype were drawn from the same subject population as the long-term study on the same device, selecting 11 teens with a mean age of 15.75 years, and a male/female ratio of 5:6.

Results

Long Term studies

For the 4 month stimulation study on the bench top set up, using all (7) subjects in a linear model, the estimated treatment effect improves by 0.068D (95% CI: 0.011 to 0.125; p = .011) per month of treatment. That is, with each month of treatment, the test eye becomes 0.068D less myopic as compared to the control eye. Using the estimated slope, the predicted treatment effect after 12 months would be 0.816D with 95% confidence that the true effect falls within the interval of 0.132D to 1.5D. The estimated treatment effect improves by 6.051 microns (95% CI: 1.500 to 10.604 microns; p = .006) per month of treatment. That is, with each month of treatment, the test eye becomes 6.051 microns shorter as compared to the control eye. Using the estimated slope, the predicted treatment effect after 12 months would be 72.606 microns with 95% confidence that the true effect falls within the interval of 18.0 to 127.25 microns. The 6 month study on the engineering prototype is currently in progress, with 8 subjects having completed the 6 month stimulation protocol at this time..

Transient studies

Change in axial length recorded on the control eye measured just prior to and just after stimulation was +7.1 +/-3.0 microns, while the test eye recorded a mean decrease due to stimulation, being -5.0 +/-5.0 microns, with a p value of 0.03. The average relative effect for the test eye compared to the control eye was approximately 8.0 microns decrease for axial length and approximately 6.0 micron increase for the central choroidal thickness. The mean change in central choroidal thickness measurements performed at 0.50 mm (subfoveal), 1.00 mm (parafoveal), and 1.50 mm (perifoveal) of retinal eccentricity were each significantly different in the test eye versus the control eye ($p<0.05$) for all comparisons made before and after the defocus sessions. Transient changes in axial length and ChT were also found to be strongly correlated with the brightness of the stimuli.

Conclusions

These initial results clearly lay the basis of future studies of the physiological effect of myopically defocused virtual images projected on the peripheral retina and efficacy of devices built to provide this type of therapy to inhibit myopia progression. A review of our studies to date in this area will be presented.

Changes in relative peripheral refraction in children who wore Defocus Incorporated Multiple Segments (DIMS) lenses

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Purpose: To investigate changes in relative peripheral refraction (RPR) associated with myopia progression in myopic children who wore DIMS lenses over 3 years and children who wore single vision (SV) lenses in the first 2 years then switched to DIMS lenses in the third year and.
Methods: In the first 2 years, children were allocated randomly to wear either the DIMS lens or SV spectacle lens. In the third year, the children who were in the DIMS group continued to wear the DIMS lenses (DIMS group), and those who were in the SV group were switched to wear the DIMS lenses (Control-to-DIMS group). Central and peripheral refraction, axial length after cycloplegia were monitored every 6 months over 3 years.
Results: Over 3 years, DIMS group (n=65) continually showed good myopia control effects. Children in the Control-to-DIMS group (n=55) showed significantly myopia control effects after wearing DIMS lenses in the third year compared to wearing SV lenses in the first 2 years. DIMS group maintained a relatively constant and symmetrical profile of RPR, without significant changes over 3 years. In the first 2 years, children who wore SV lenses showed asymmetrical changes in RPR, with a statistically significant increase in hyperopic RPR at 20N (mean difference: 0.88±1.06 D, $p<0.0001$) and 30N (mean difference: 1.07±1.09, $p<0.0001$). In the third year, children in the Control-to-DIMS group showed a reduction in hyperopic RPR. Compared to the RPR changes of the first 2 years, a significant reduction in hyperopic RPR at 20N (mean difference: -1.14±1.93, $p<0.0001$) and 30N (mean difference: -1.07±1.17, $p<0.0001$) was observed in the third year. The changes in PRP of the Control-to-DIMS group in the third year were symmetrical, without a significant difference between the nasal retina and temporal retina ($p>0.05$).
Conclusions: Symmetrical changes in RPR were found in children who wore DIMS over 3 years and children switching from SV to DIMS lenses. Myopia control using myopic defocus in the mid-periphery influenced the RPR changes and slowed central myopia progression by altering the overall retinal shape.

Choroid Changes with the Initiation of Sphere and Multifocal Contact Lenses in the Bifocal Lenses In Nearsighted Kids (BLINK) Study

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Purpose

The BLINK Study was a 3-year clinical trial that evaluated center-distance multifocal contact lenses (MFCLs) for myopia control and found reduced myopia progression and eye growth with +2.50 add MFCLs compared to both +1.50 MFCLs and single vision contact lenses (SVCLs). This analysis explores the effect of 2 weeks of contact lens wear on the choroid.

Methods

Spectral-domain optical coherence tomography (SD-OCT) star scans (30° B-scans; 6 meridians; right eye) of myopic children in the BLINK Study were acquired using enhanced depth imaging (EDI) prior to study contact lens wear, and again using follow-up mode 14 ± 7 days after wearing their assigned contact lenses (SVCLs, +1.50 or +2.50 add MFCLs). B-scans were cropped by 100 pixels per side to eliminate most optic nerve and edge artifacts, resulting in 26° scans. The retinal pigmented epithelium/choroid boundary and choroid/sclera boundary were segmented using validated semi-automated routines utilizing graph theory and dynamic programming. Mean subfoveal choroidal thickness and mean choroidal area of the 6 B-scans were calculated from the segmented images, and changes after 2 weeks of lens wear were analyzed using ANOVAs with Tukey's post-hoc testing, when appropriate.

Results

There were 267 children with OCT data available at both visits. The mean ± SD age and right eye spherical equivalent refractive error (SER) were 10.3 ± 1.2 years and -2.43 ± 1.02 D, respectively. Mean baseline subfoveal choroidal thickness (303 ± 58 µm) and choroidal area (2.25 ± 0.40 mm²) did not differ among groups (both $p \geq 0.70$). After 2 weeks of contact lens wear, changes in subfoveal thickness ($p < 0.02$) and choroidal area ($p < 0.004$) differed between groups. The mean (± SD) 2-week change in subfoveal thickness in the SVCL, +1.50, and +2.50 MFCL groups were -4 ± 19 µm, -1 ± 23 µm, and +5 ± 18 µm, respectively. Subfoveal choroidal thickness in the +2.50 MFCL group increased by (mean ± SE) 9 ± 3 µm versus the SV group ($p = 0.009$). Choroidal area in the +2.50 MFCL group increased by 0.07 ± 0.02 mm² versus SVCL wearers and by 0.05 ± 0.02 mm² versus +1.50 MFCL wearers (both $p \leq 0.039$). There were no differences between SVCL and +1.50 MFCL wearers in thickness or area (both $p > 0.74$).

Conclusions

On average, MFCLs increased choroidal thickness in a dose-dependent manner, but there was high within-group variability. Further work is needed to determine whether short-term choroidal changes are associated with slowed progression.

High Myopia – the patient's view

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Background: The myopia boom is leading to an increasing number of patients with (high) myopia and parents of children with progressive myopia. Patient management options and information provided by eye care providers can be very confusing to them. In the Netherlands, highly myopic patients and parents have united themselves in a patient organization which is formally recognized by the Eye Association Netherlands since 2021. This organization expresses a strong willingness to work together with specialists and researches to improve prevention measures, diagnoses and treatment.

Purpose: To provide the patient's view on experience of the eye healthcare process and the information received from professionals.

Methods: Patients from the high myopia patient organization were asked about own experience and view on optimal eye care by an online questionnaire.

Results: The parents experience the increasing number of options for myopia control as a promising development, but information comes to them through multiple channels, is not unequivocal, and sometimes comes too late. This creates uncertainty and agitation. The highly myopic patients often have comorbidity with complications like glaucoma, retinal detachment, cataract and macular degeneration, which are treated by multiple subspecialists. For both the patients and the specialists it can be a challenge to determine the best treatments and their order to optimize outcome and prevent additional complications.

Conclusion and impact: Patients urge professionals to unite in a multi-disciplinary team of eye care providers for both myopia control in children as well as for patient management in highly myopic adults. They also strongly advise to team up with patients to make the best personalized decisions. This will improve quality of myopia prevention and treatment, and provide insight in gaps of knowledge which need further research.

Design and baseline characteristics of a randomized clinical trial to investigate the effect of natural classrooms on myopia development among children in China

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Aim: Spatial frequency spectra of the man-made environment has been proposed as one driver of the human myopia epidemic in the recent industrial society. This clinical trial was conducted to assess whether the mimic of the indoor spatial properties as natural outdoor environment could prevent the development of myopia in children.

Methods: This is a 2-year, two-arm, cluster-randomized controlled trial. Classes in Grade 4 in a school in Lijiang city, China, were randomly assigned into either natural classroom group or traditional classroom group. The natural classrooms were installed custom-made wallpaper with forest and sky scene with comparable spatial frequency spectra as natural outdoor environment, while the traditional classroom group remained a white wall setting. The cycloplegic spherical equivalent refractive error (SER) of the right eye for each student was adopted for analysis. The primary outcome was the accumulative myopia incidence, while the secondary outcome was the change of SER during the 2-year period. Questionnaires were filled out in the natural classroom group to assess the psychological impact of this intervention.

Results: Ten classes, comprising 520 students, were included in the trial and half of classrooms had custom-made wallpaper installed. There was no difference in the mean SER for the intervention and the control group (0.49 ± 1.19 D vs 0.42 ± 1.37 D, P = 0.50). No differences were found in the categories of refractive error between the two groups (Myopia: Emmetropia: Hyperopia, 16.3% vs 49.4% vs 34.2% in the intervention group, 18.3% vs 49.0% vs 32.7% in the control group; P =0.83). Overall, the natural classroom was appealing to both teachers and students. Compared to the traditional classroom, 8 (88.9%) teachers and 230 (87.5%) students felt the natural classroom enjoyable, 2 (22.2%) teachers and 198 (75.3%) students reported higher concentration, and 7 (77.8%) teachers and 40 (15.2%) students reported no change. Four (44.4%) teachers and 200 (76.0%) students reported higher learning efficiency in the natural classroom, and 5 (55.6%) teachers and 48 (18.3%) students reported no change.

Conclusion: Natural classroom was favoured by both the teachers and students, and unlikely to exert negative influence in the teaching activity. Given its feasibility, the strategy might provide a potential approach to arrest myopia development in school.

Simulation of the Progression Trajectories of Myopia from Childhood to Older life in China

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Purpose: Myopia is a growing public health challenge. Earlier myopia onset in childhood could result in more high myopia in adulthood and then progress into pathological myopia or even blindness in older life. This study was to estimate the progression trajectories of myopia among the current population of children aged 6-12 years old in China, and furtherly to evaluate the trend of progression under different intervention scenarios.

Methods: Multistate Markov Model was applied to simulate the progression of myopia. From the life course perspective, the progression trajectories of myopia can be divided into six states including health, low myopia, high myopia, pathological myopia, blindness, and death (see Figure 1). These six states were progressive and irreversible, which satisfied the characteristics of the Markov Chain. The transition probabilities from each state to the next one can be approximated by the incidence rate of each disease. Transition probabilities multiplied a coefficient (0~1) to simulate the intervention effects. Parameters for the simulation model were retracted from the 7th National Census and published papers (see Table 1). The life course started from current children aged 6-12 years old to their life expectancy of 75 years old.

Results: The current prevalence of myopia among children aged 6-12 years old was 32.9%. Without any effective interventions, the estimated prevalence of pathological myopia would take off at their age of around 50 for current children and then increase to 16.2% (95%CI: 11.0%~21.4%) at their age of 75 years old, and the estimated prevalence of blindness could arrive at 7.9% (95%CI: 5.3%~10.1%). If the effects of current intervention measurements could achieve 50% relative reduction at each stage, the progression to pathologic myopia and blindness would reduce to 6.5% (95%CI: 4.4%~8.8%) and 3.1% (95%CI: 2.1%~4.1%).

Conclusion: Pathologic myopia and blindness will be the next public health challenge current children getting old. It's urgent to prevent myopia onset or slow down myopia progression among current children to reduce the future burden of pathological myopia and blindness.

An interim analysis of a telehealth tool to self-assess refractive error and visual acuity in a progressive myopia population

Claessens J

Purpose: Remote eye-testing is a promising avenue to achieve universal access to eye care, particularly relevant for the mounting healthcare demand of myopia management. We hypothesise that an in-home exam, performed independent & unsupervised by patients, is an effective tool in the detection and follow-up of progressive myopia. The aim of this study is to evaluate the efficacy of a platform for self-assessing visual acuity and refractive error in myopic children.

Methods: In this ongoing prospective study, consecutive myopic children (age >6 years) without visual acuity influencing comorbidities are requested to perform the remote web-based refraction examination at home (the index test), together with their parents, shortly after their conventional VA and refractive assessment during the clinic visit (the reference test).
Results: Between January 27 and July 1, 2022, 53 patients (mean age was 13±3) have been included in the study. The mean refractive error (Spherical Equivalent) is -4.80 dioptres (D), ranging from -12.50 to -1.00 D. Only 6 participants (11%) did not respond to the web-based exam invitation. All of the participants who started the web-based tool (n=47), were able to fully complete the remote refraction assessment.

Conclusions: Preliminary results indicate that myopic children and their parents are willing and able to perform these remote tests. These are the first results of the platform in a pediatric population. The outcomes of this project serve as a stepping stone to the development of a full remote myopia management solution.

The Impact of the First Peak of the COVID-19 Pandemic on Myopia treatment practice patterns among ophthalmologists - an IPOSC global perspective

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Purpose: To map how ophthalmologists controlled myopia progression globally during the COVID-19 pandemic and trends among pediatric ophthalmologists before and during this epidemic.
Methods: Responses were collected using an online survey from January to June of 2020. The questionnaire included 21 questions including characteristics of participants and choice of pharmacological or optical therapies to control myopia progression.
Results: Of 3207 respondents, 2269 (70.7%) completed the entire survey and were consequently included. The participating ophthalmologists resided in 94 countries. Most were pediatric ophthalmologists (64.6%) or ophthalmologists from other subspecialties (32.2%). Most were affiliated with a university hospital (62.5%) followed by those from other types of hospitals (37.5%). Combined pharmacological and optical treatments were the most popular modalities of treatment. In America and Australia – New Zealand, optical treatment was utilized only as part of combination therapy. Pharmacological treatment in general (86.1% vs 86.4% p=0.889), effective pharmacological treatment (81.6% vs 81.4%, p=0.901) and optical treatment in general (81.4% vs 83.6%, p=0.249) were equally used by both pediatric and other ophthalmologists. In contrast, effective optical treatment was more commonly used by other ophthalmologists (66.3% vs 72.5%, p=0.007)
A comparison between this survey with a pre-Covid-19 survey, we have conducted, revealed a change in the geographical distribution of respondents with less participation from North America (143, 31.7%, to 186, 12.9%), but an increase in response from Europe (53, 11.8%, 287, 19.9%) and the Far East (107, 23.7%, to 610, 42.3%). In addition, less respondents were affiliated with a university hospital (188, 41.7% to 401, 27.8%) (P<0.001). The prevalence of pediatric ophthalmologists using a general or effective pharmacological treatments increased in all locations. A decline in optical treatment was recorded in all regions. however, effective optical treatment usage increased everywhere.
Conclusions: This global study revealed an increase in evidenced-based effective approaches of combined pharmacological and optical treatments during the Covid-19 pandemic. It showed more involvement of non-university affiliated ophthalmologists. Future studies may explore changes in practice patterns among optometrists and the impact of novel optical measures on optical treatment preferences by ophthalmologists.

Pathologic myopia in highly myopic patients with high axial anisomyopia

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Purpose: There are highly myopic adults with high axial anisometropia without amblyopia. The structural characteristics, prevalence of pathologic myopia (PM), and risk factors for PM in the shorter eye in these patients have not been described. Using a clinic-based cross-sectional study, we aimed to characterize the shorter eye in patients with high axial anisometropia and evaluate if PM in the longer eye was associated with increased risk of PM in the shorter eye of highly myopic anisometropes.

Methods: Patients with high myopia (HM) defined by a manifest spherical equivalent of ≤-6.0 diopters or axial length (AL) of ≥26.5mm were recruited from the high myope clinic of Singapore National Eye Centre from January 2017 to December 2020. Patients with high axial anisometropia, defined as an AL difference of ≥2.5mm, were included in this study. Ocular biometry, fundus photography, and swept-source optical coherence tomography were performed. Structural characteristics and presence of PM in either eye, including myopic macular degeneration (MMD), myopic traction maculopathy (MTM), posterior staphyloma (PS), dome shaped macula (DSM), and myopic choroidal neovascularization (mCNV), were described. Stepwise multivariate regression was performed to find associations between PM in the longer eye and pathology in the shorter eye, after controlling for confounding variables such as age and AL of the shorter eye.

Results: 184 patients met the inclusion criteria (age 65.8±13.5 years [mean ± SD]). Mean AL was 30.6±2.0 mm in the longer eye and 26.2±2.3 mm in the shorter eye (p<0.001). 97 (52.7%) shorter eyes had AL <26.5mm. A structural explanation for anisometropia was apparent in 49 (26.6%) eyes: 33 had staphyloma with non-foveal apex and 16 had DSM. The prevalence of MMD, macula-involving PS, MTM, and mCNV in the shorter eye was 52.2%, 36.5%, 13.0%, and 8.2%, respectively. Macular hole in the longer eye was associated with increased risk of MTM in the shorter eye (odds ratio [OR]=4.88 (95% confidence interval [CI] 1.42-16.85, p=0.01). mCNV in the longer eye was associated with mCNV in the shorter eye (OR=3.57 [CI 1.18-10.79], p=0.02). Macular PS in the longer eye was associated with macular PS in the shorter eye (OR=4.03 [1.89-8.62], p<0.001). DSM in the longer eye was associated with DSM in the shorter eye (OR=13.48 [3.45-52.67], p<0.001).

Conclusions: The shorter eyes in patients with HM with high axial anisometropia may have AL confounded by DSM or staphylomata with non-foveal apex. In addition, even when controlled for AL, complications of PM in the longer eye predict similar complications of PM in the shorter eye, which may support the hypothesis that PM eyes are different from HM eyes. Patients with high axial anisometropia with PM in the longer eye should be monitored carefully for complications of PM in the shorter eye.

Differing Macula Deformation Comparing Healthy, High Myopia, High Myopia with Glaucoma, and Pathologic Myopia

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Purpose: To assess the macula deformation following IOP elevation in healthy, highly myopic eyes, highly myopic eyes with glaucoma and pathologic myopia.

Methods: We recruited 328 subjects, which comprised of 32 emmetropic controls, 50 high myopia (HM: >26 mm in axial length), 108 HM with glaucoma (HMG) and 138 pathologic myopia subjects (PM= HM + staphyloma and/or myopic macular degeneration). For each subject, we imaged the macula using Spectral-domain optical coherence tomography (OCT) under the baseline condition and under acute intraocular pressure (IOP) elevation (to ~40mmHg) achieved through ophthalmodynamometry. For each macula scan, we manually aligned the scans (baseline and IOP elevation) using 4 vascular landmarks in the macula tissue. We then automatically segmented the sclera and the choroid tissues using a deep-learning algorithm and extracted the point clouds of the sclera-choroid interface. We calculated the macula curvatures by fitting a second-degree polynomial to the sclera-choroid points cloud along the nasal-temporal direction. Curvatures were calculated at regular intervals (every 100 microns). We calculated differences in curvatures between baseline and elevated IOP scans at each corresponding location and reported the mean curvature difference in each subject.

Results: IOP elevation resulted in a high macula curvature change in the PM (10.5±10.2 micron-1) and HMG (5.2±5.1 micron-1) eyes as compared to HM (3.1±2.7 micron-1) eyes (both $p<0.05$). Interestingly, HM eyes had the same curvature change as emmetropic eyes (4.2±4.3 micron-1).

Conclusion: We found that the macula of HMG and PM eyes were more sensitive to IOP elevation as compared to HM eyes and emmetropic eyes. These preliminary results indicate that macula curvature changes may serve as a biomarker for HM eyes at risk of developing other pathologies (e.g. glaucoma and staphyloma).

Risk Factors for Bilateral Macular Neovascularization in High Myopia.

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Purpose: Intravitreal anti-vascular endothelial growth factor (VEGF) improves the visual prognosis in myopic macular neovascularization (MNV) at short term, but visual acuity (VA), recurrence rate, and second eye involvement at long-term remain unclear. We performed a longitudinal clinical study with real-world data to learn about the long-term outcomes of anti-VEGF in a large European cohort.
Methods: Up to 12 years of longitudinal data from a tertiary hospital in the Netherlands (2008 – 2018) were analyzed. Patients with high myopia (spherical equivalent (SE) ≤-6D), an active CNV lesion and European descent were included. Fellow eyes with a history of myopic MNV or macular atrophy were excluded.
Results: A total of 88 patients (mean age 57±14 years, mean SE -14 ± 4D) were included. In 24 patients, the fellow eye developed a myopic MNV during follow-up. Cumulative incidence of bilateral MNV was 8% at 2 years, 21% at 5 years and 38% at 10 years. Patients aged under 40 years at the first diagnosis, have an increased risk for the development of MNV in the fellow eye (HR 3.3, p = 0.01). Both, the presence of MMD or lacquer cracks in the fellow eye at baseline, were not significantly associated with the risk of MNV in the fellow eye.
Conclusion: More than one third of the high myopic patients with myopic MNV develop a MNV in the fellow eye at 10 years. Especially young patients are at risk for bilateral myopic MNV.

Intravitreal Panitumumab for Prevention of Myopic Axial Elongation in Highly Myopic Adult Eyes with Myopic Macular Degeneration: Clinical Phase-1 Study

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Purpose: Recent histomorphometric and clinical studies suggested that axial myopic elongation occurs through an enlargement of Bruch´s membrane (BM) in the retroequatorial and equatorial region, leading to retinal thinning and reduced density of retinal pigment epithelium (RPE) and photoreceptors in that region, and to a thinning of choroid and sclera at the posterior pole. Thickness of the retina and choriocapillaris and RPE-density in the macular region and BM thickness in any region remain independent of axial length. The axial elongation-associated optic disc-fovea distance elongation is due to parapapillary gamma zone, while macular BM length is independent of axial length. The equatorial-to-retroequatorial BM enlargement may be caused by an epidermal growth factor (EGF)-associated RPE activity. Experimental studies in guinea pigs and monkeys showed a reduction in axial elongation by intravitreally applied blockers of EGF family members and the EGF receptor, and an increase in axial elongation by intravitreally applied EGF family members. In a clinical study, the intraocular EGF amount correlated with longer axial length. It led to the hypothesis, that ocular axial elongation is associated with EGF, and that further axial elongation may be prevented by an EGF blockade. We therefore examined here the safety of intravitreally applied panitumumab, an EGF receptor blocker which has been in clinical systemic use in oncology for two decades.
Methods: The phase-1 study included highly myopic adult patients with myopic macular degeneration. The eyes received one to two intravitreal injections of 0.6 mg (60 µL) or 1.2 mg (120 µL) panitumumab.
Results: The study included 5 patients (age 56 to 69 years, axial length: 29.10mm-30.86mm). Examined at day 1, 7, and 28 and at 2 and 3 months after the injections, the injected eyes did not show any intraocular inflammation or morphologic or functional changes, assessed by retinal electroretinography, perimetry, optical coherence tomography, tonometry and visual acuity measurement.
Conclusions: The preliminary observations of these five patients are in agreement with a notion of an intraocular tolerability of panitumumab repeatedly injected in doses of 0.6mg and 1.2mg.

P80: Enhanced electrophysiological response of the inner layers within the macular area with an extended depth-of-focus contact lenses for myopia control in young myopic subjects

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Purpose: Despite the efficacy of contact lenses (CLs) in myopia control reported in several studies, it is unclear how the retina activity is changed by these devices to eventually initiate the cascade of events that conduct to their therapeutic effect. A controlled, non-dispensing, random, cross-over study was conducted to test the hypothesis that the electrophysiological activity of the inner retinal layers is altered when using extended a depth-of-focus (EDOF) CL, demonstrating myopia control efficacy.

Methods: Fifteen myopic young adults (27.1±5.8 years, 12 women) with spherical equivalent of -3.16±1.48 D were fitted with a single-vision CL (SVCL) and an EDOF of the same material - Filcon 5B (60) - in one eye. The global-flash multifocal electroretinogram (gf-mfERG) was recorded after 20 minutes of wear, for each lens, fitted in random order, with the Reti-port/scan-21 (Roland consult, Germany). The multifocal 61 hexagons scaled with eccentricity stimuli was presented on a 19-inch LCD monitor at 33cm from the eye. The stimulus array followed an m-sequence with four frames: a multifocal flash frame (~83 cd/m2), a dark frame (~3cd/m2), a global-flash frame (~166 cd/m2) and a dark frame. The peak-time (in milliseconds, ms) and the amplitude (in nano-volts, nV) of the direct and implicit components (DC and IC, respectively) of gf-mfERG were analyzed for five concentric areas (Ring 1 – 0º to 4.8º; Ring 2 -4.8º to 15.0º; Ring 3- 15.0º to 21.6º; Ring 4- 21.6º to 40.6º; Ring 5- 40.6º to 54.10º) and quadrants (Q1 – inferior-nasal; Q2 – superior-nasal; Q3 – superior-temporal; Q4 – inferior-temporal). Non-parametric comparisons between SVCL and EDOF were performed.

Results: The peak times of SVCL and EDOF did not differ between both conditions. Generally, the DC amplitude with EDOF was lower than SVCL, except at Ring 3 and Q2. The difference of 82.21±79.46 nV was statistically significant at Ring 2 ($p = 0.002$). The IC amplitude was significantly lower with EDOF in SUM (37.84±61.77, $p = 0.023$), Ring 5 (52.71±81.27, $p = 0.036$), Q2 (58.32±73.79, $p = 0.009$) and Q4 (67.54±107.40, $p = 0.031$). The IC amplitude of Ring 1 (macula) was significantly higher in 160.91±220.27 nV with the EDOF compared to the SVCL ($p = 0.015$) and this increased activity was present in 13 out of the 15 eyes under evaluation.

Conclusions: There seems to be a tendency of decreased retinal electrical activity (lower DC and IC amplitudes) with the EDOF CL in the parafoveal and mid-peripheral areas of the retina. However, in the macular area these lenses enhanced the electrical activity of the innermost retinal layers. The physiological changes observed might be involved in the signaling mechanism for ocular growth regulation observed with optical devices.

P16: Over-minusing in myopic and highly myopic children – habitual spectacles versus cycloplegic autorefraction

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PURPOSE
Current clinical advice advocates for the full correction of myopia to reduce progression, however refractive accuracy may be influenced by assessment methods. The purpose of this study is to establish the degree of under- or over-correction of myopic refraction in young myopes.

METHOD
Data from 306 subjects (612 eyes), aged between 6 – 16 years (11.5 +/- 2.3 years), enrolled in myopia management trials at the Centre for Eye Research Ireland were collated and analysed. Subjects date of birth, habitual refraction, cycloplegic autorefraction and axial length measurements were recorded. The difference in spherical equivalent (SE) between the subjects habitual spectacles and cycloplegic autorefraction for each eye was calculated and categorised at baseline (pre-randomisation) visit only. SE differences between >-0.24DS - < 0.24DS were the reference group and categorised as 'fully corrected', SE differences between -0.25DS - 0.49DS were classed as 'mild over-correction', between -0.50DS to -0.99DS were 'moderate over-correction' and SE differences ≤ -1.00DS were 'high over-correction'. SE differences > 0.25DS were categorised as 'under-correction'.

RESULTS
Mean habitual and cycloplegic SE was RE: -3.55 ± 1.9DS, LE:-3.52 ± 1.82DS and RE:-3.18 ± 1.75DS, LE: -3.16 ± 1.65DS respectively; a statistically significant myopic over-correction ($p<0.001$). Overall 57% of children were over-corrected (range: -0.25DS to -2.69DS), with 27% fully corrected and 16% under-corrected (range: +0.25DS to +1.50DS). In high myopes (SE ≤ -6.00DS; n=60), the proportion of children over-corrected was significantly higher (88%; $p<0.001$), a mean difference of -0.82 ± 0.24 DS, with 5% fully-corrected and 7% under-corrected. Controlling for age and eye, mixed linear regression analysis revealed subjects in the moderate and high over-correction groups were significantly more myopic (-0.38DS and -0.86DS; $p<0.001$) when compared to those fully-corrected, with subjects in the moderate over-correction group being older ($p<0.01$), after adjusting for SE.

CONCLUSION
Long-term effects of under or over-minus therapy on myopia progression is relatively unknown. However, over-correction presents more frequently and at greater magnitude with increasing myopia. The pattern of over-correction, which likely reflects the absence of cycloplegic refraction in routine practice, is likely understated herein, as habitual spectacles were invariably older than the cycloplegic autorefraction conducted at baseline.

P148: Peripheral image quality in three types of myopia control spectacles

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Purpose
Due to the increasing prevalence of myopia in the world, myopia control spectacles have been introduced in recent years. These spectacles typically have a central clear zone that corrects the foveal refractive error, and an off-axis treatment zone. The aim of this study was to investigate how these new spectacles affect peripheral image quality.

Methods
Three healthy adult subjects (one emmetrope, two myopes) were fitted with three pairs of myopia control spectacles: MiyoSmart from Hoya, with Defocus Incorporated Multiple Segments (D.I.M.S.); Stellest from Essilor, with Highly Aspherical Lenslet Targets (H.A.L.T.); and Perifocal from ArtOptica, with horizontal progressive addition. The control case was single vision spectacles for the myopes and no spectacles for the emmetrope. Central corrections were the same for the test spectacles and the control case. Foveal and peripheral (30° nasal visual field) wavefront errors and through-focus double-pass point spread functions (PSF) were measured for the right eye for all subjects with the different spectacles. Each measurement was repeated three times. The fixation target was a back-illuminated Maltese cross (2° visual angle), situated 3.25 m away from the eye. The same fixation target was used for both the wavefront and the PSF measurements.

Results
No consistent shift in relative peripheral refraction (RPR) was seen for Stellest and MiyoSmart. However, there was a broadening in the peripheral double-pass PSFs for all subjects, causing an overall reduction in the modulation transfer function (MTF) as calculated from the double-pass PSF. At the same time, broadening was not observed when reconstructing the PSFs and MTFs from the wavefront measurements.
On the other hand, there was a significant myopic shift in RPR for Perifocal (linear mixed effects model, $p < 0.01$), but their effect on the peripheral PSF and MTF was not consistent across subjects. This to be expected, as each subjects' baseline RPR affects if the add power results in better or worse image quality.

Conclusion
Stellest and MiyoSmart induced a general broadening of the peripheral double-pass PSF without a clear shift in refraction, whereas Perifocal induced a myopic shift that for some subjects also resulted in a broadened PSF. This broadening in turn leads to a reduction in retinal contrast, which might affect the progression of myopia.

P152: Impact of soft contact lens design on ease of handling and comfort in myopic children

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Purpose: Johnson and Johnson Vision developed a soft contact lens design with a smaller diameter and steeper base curve, intended to improve insertion in smaller palpebral apertures present in pediatric populations. This study assessed ease of handling and comfort of two senofilcon A based designs in myopic children using the Pediatric Comfort and Handling Questionnaire (PCHQ), a new qualitatively valid patient-reported outcomes (PRO) questionnaire, compared to a marketed myopia control lens.
Methods: The study was a multi-site, bilateral, dispensing, randomized, single-masked, 3x3 crossover study with a run-in period. Myopic children from 7 and 17 years old were recruited. All eligible subjects were fitted with a daily disposable soft contact lens with conventional optics (etafilcon A) for a 1-week run-in period. After the run-in, the subjects were fitted with an omafilcon A dual focus design (DF) and 2 mechanically equivalent senofilcon A designs, one a soft contact lens with RingBoost Technology (RB) and another with prototype optics (PO). The order of lens wear was randomized and each design was worn for 2-weeks. PCHQ items were completed via computer or tablet following each lens fitting and at the 2-week follow-up, with separate forms reflecting the appropriate instructions and recall period.
Results: 63 subjects completed all study visits per-protocol. The 7-12 and 13–17 year age groups included 33 (mean 10.6 ± 1.00 years) and 30 (mean 14.7 ± 1.32 years) subjects, respectively. Rank-order trends for comfort and handling by lens design were consistent across age groups. The greatest proportional differences in “good” responses (two best) were in contact lens insertion, comfort, and compensating behavior constructs. The RB and PO designs had a similar proportion of good responses (PGR) across these constructs. The PGR at follow-up with RB and PO exceeded those with DF by at least 15% in five of the six insertion-related items and on several items from the comfort and compensating behavior constructs. The PGR with DF was never higher than RB or PO on any item in the lens insertion, comfort, or compensating behavior constructs.
Conclusions: The senofilcon A based lenses with the smaller diameter and steeper base curve tended to have a higher proportion of good responses than the dual focus lens on items related to lens insertion and comfort, but a larger, powered study would provide a more definitive conclusion.

P185: Clinical Assessment of Characteristics in Young Myopes with Atypical Ocular Findings

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Purpose
Atypical ocular findings associated with myopia progression are viewed as common, yet underrecognized, in the pediatric population. This study is to assess ocular characteristics of young myopic children specifically referred for myopia management.

Methods
De-identified data were analyzed for all patients presenting to two myopia management treatment centers from Aug 2016-Sept 2019. Records were retrieved for 342 children completing at least 1 annual visit. Data presented are Mean [SE] with P <0.05 set for statistical significance.

Results
At initial examination, 188 of the 342 children (55%) had one atypical ocular manifestation, 20% had 2 or more, and 7% had 3 or more similar findings (see figure). These atypical ocular findings included myopic macular degeneration, retinal holes, retinal detachments, epiretinal membrane, tessellation of the vessels, peripapillary atrophy, retinal thinning, window defects, peripheral retinal traction, and optic nerve crescent.

Characteristics of the 188 children with an atypical finding were: Age 11.04 [0.19], range 5.27 to 18.0 years; 54% female; 29% Asian/22% Caucasian; CSER -4.45D [0.20]; AL 24.94mm [0.10]; age became myopic 7.33 [0.15]; 66% both parents myopic, 26% 1 parent myopic, 8% neither parent myopic.

Characteristics of the 154 children without an atypical finding were: Age 10.26 [0.21], range 4.35 to 17.4 years; 53% female; 10.5% Asian/28.5% Caucasian; CSER - 3.60D [0.18]; AL 24.67mm [0.10]; age became myopic 7.65 [0.19]; 62% both parents myopic, 16% 1 parent myopic, 22% neither parent myopic.

Age is a major risk factor for the progression of myopia, and it was different between the 2 groups (unpaired 2-sided t-test, P = 0.01). However, the differences observed were unremarkable given there was less than one year of difference. Since the stretching of the eye with increased axial length (AL) is considered to be a major risk factor, it was subject to further investigation. The difference in axial lengths at baseline was statistically significantly different (unpaired 2-sided t-test, P <0.0002). In children with one atypical ocular finding, 21% of them had an axial length of >26 mm; for those without any ocular finding, 9% had an axial length of >26mm, which was statistically significantly different (Fischer's exact test, P = 0.011).

Conclusion
Children in our study referred for myopia management showed at least one atypical ocular manifestations, older in Asian ethnicity, and with a higher CSER and greater AL than children without similar characteristics. While it may not represent the entire pediatric population, at-risk children presented with these clinical characteristics may be more likely to exhibit clinically significant AL values. Practitioners should be vigilant of the long-term ramifications for young children exhibiting these atypical ocular findings associated with myopia, even at the initial visit of examination.

P158: The use of rigid gas permeable contact lenses in low-vision children with high myopic

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Purpose: To observe the safety and visual improvement over the course of RGP contact lens wear on children with unilateral or bilateral low-vision children with high myopic.
Methods: A retrospective analysis case series study. Clinical records of 28 infants low-vision children with high myopic who were fitted with RGP contact lenses were reviewed.
Results: The mean baseline BCVA was logMAR 0.87 ± 0.28,
which improved to a VA of 0.33 ± 0.38 at the time of review ($p < 0.05$). Baseline myopia also increased from −5.18 ± 1.93DS to −10.41 ± 2.96DS ($p < 0.05$). The final visual acuity at the time of this review was correlated with the initial refractive error ($p < 0.05$) as well as the initial BCVA ($p < 0.05$). There was also a strong correlation between initial refractive error and initial BCVA ($p < 0.05$).
Conclusion: RGP contact lens were safe and effective treatment option in low-vision children with high myopic.

P28: Identification of key genes and pathways involved in myopic choroidal angiogenesis and drug discovery based on biomedical data analysis

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Purpose: Choroidal angiogenesis is one of the pivotal pathogenic factors of high myopia, especially pathological myopia with choroidal neovascularization. This study aims to identify genes and pathways of choroidal angiogenesis in myopia and to discovery potential therapeutic drugs using bioinformatics models.

Methods: Use the pubmed2ensembl database for text mining to detect genes related to choroid, angiogenesis, and myopia. g: Profiler is used to analyze the biological process of gene ontology and the KEGG pathway. Protein interaction network analysis is performed through strings and visualized in Cytoscape. Use the DGIdb drug-gene interaction database to find candidate drugs for the treatment of myopia.

Results: Through text mining, we identified 38 genes related to choroid, angiogenesis, and myopia. Gene enrichment analysis includes 14 GO terms and 14 related KEGG pathways. A protein-protein interaction (PPI) network with 23 nodes and 56 edges was constructed through MCODE to discover two key clusters. Then select cluster I of 9 genes (CTGF, IL1B, F8, CRP, SEPINR1, TGFB2, TGFB1, NOS3 and IL10) as key genes for gene-drug interaction analysis. The 9 central genes of cluster I can be targeted by 47 drugs.

Conclusions: According to the construction of PPI network, CTGF, IL1B, F8, CRP, SERPINE1, TGFB2, TGFB1, NOS3 and IL10 are potential key targets of choroidal angiogenesis in myopia, corresponding to 37 potential therapeutic drugs, which provide a basis for further research in the future and more possibilities.

P68: Soft contact lens parameter optimization for pediatric use in myopia control

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Purpose: To optimize fit and handling of soft contact lenses for myopia control in pediatric patients.

Method: Initially, 300 myopic children aged 8 to 15 years were studied. Ocular biometric characteristics including width of Horizontal Eyelid Fissure (HEF), Palpebral Aperture (PA) and Horizontal Visible Iris Diameter (HVID) were assessed though frontal eye imaging and analyzed with an automated image processing software (iMetrics®). Corneal topography was assessed with Medmont E300. Lens design parameters such as diameter, base curve, and shape factor were evaluated in a series of clinical studies. Performance (centration and movement) of the preferred mechanical design was evaluated with various optical designs in 6 clinical trials involving 530 pediatric subjects of multiple races.

Results: In primary gaze, mean (SD) HEF, PA and HVID were 23.5 (1.49), 9.3 (1.09), and 11.7 (0.44) mm, respectively. Compared to Chinese and Caucasian adults,[1] HEF and PA of Chinese children were at least 1 mm smaller while HVID was similar. Corneal Sim Ks and shape factors were: 44.2 (1.44), 0.17 (0.146) and 43.0 (1.34), 0.38 (0.122) at steep and flat meridians, respectively. These findings led to soft contact lens designs with reduced diameters (ranging from 13.6 to 14.0 mm) and base curves (BC) ranging between 7.9 and 8.5 mm with a shape factor of 0.26. An aspheric design with 13.8 mm diameter and 7.9 mm BC were found to provide optimal centration and movement with minimal observations of corneal limbal exposure compared to other designs. Unacceptable lens fit, due to either limbal exposure and/or excessive, unacceptable lens movement, was only observed in 4 subjects (0.75%) wearing an early lens prototype. In a trial of a soft contact lens with Ringboost® optical design (n=199, age 7 to 12 years), no instances of unacceptable lens fit were observed. Centered fit and optimal movement were reported in 94.7% and 88.2% of eyes, respectively, during initial fitting. Study lenses were successfully dispensed in 96% of subjects after one training session for contact lens insertion and removal. Among 191 subjects completing 1-month of wear, 93% and 95% agreed it was easy to insert and remove lenses, respectively.

Conclusion: Soft contact lenses designed specifically for pediatric use have demonstrated excellent fit and handling.

[1] Hickson-Curran S et al. Optom Vis Sci. 2014;91:1396.

P193: Whole Exome Sequencing Combining Association Analysis Identified Novel Loci for High Myopia in the Han Chinese Population

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Purpose: High myopia (HM) is genetically heterogeneous, and plenty of genes have been discovered to be associated with HM. However, few studies with large sample size of Chinese population have been reported. In this study, we aimed to expand the HM gene spectrum in the Han Chinese population.

Methods: We conducted a family-based whole exome sequencing (WES) in 24 HM families for variants screening, as well as a population-based association analysis in another independent cohort (case=527, control=2207, 1:4) for validation. We also performed a multi-dimensional strategy to assess the reliability and priority of the candidate genes.

Results: At stage I, a total of 2120 protein deleterious variants were identified by WES. At stage II, a number of 59 variants in 54 different genes demonstrated nominal significance in association with HM ($p<0.05$). Among these variants, the missense variation of rs6756629 in ABCG5 (c.C148T p.R50C) was still significantly associated with HM after the Bonferroni correction (p=6.90*10-17). In the ranking of the other candidate genes, two known myopia-related genes (ZDHHC11 and RP1L1) showed higher priority, as well as several genes which may have potential susceptibility to HM (UGT1A3, HES and UBD).

Conclusions: We identified ABCG5 as a novel candidate gene for HM in the Han Chinese population. However, further validation with larger sample size among different ethnic populations as well as functional experimental verification are still needed.

P18: A short tandem repeat polymorphism exome-wide association study for high myopia

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Purpose:
A substantial proportion of the heritability of high myopia (HM) remains unexplained. Short tandem repeats (STRs) are a relatively understudied class of polymorphism. STRs can influence the expression or stability of nearby genes. We aimed to investigate if STRs located in gene exons on chromosomes 1-22 and chromosome X confer susceptibility to high myopia in a UK sample.

Methods:
UK Biobank participants with whole-exome sequencing (WES) data and autorefraction information available were selected as cases or controls if their refractive error averaged between the two eyes was ≤ -6.00 D or ≥+2.00 D, respectively. There were 2002 cases with high myopia (HM) and 6806 controls with hyperopia. The mean age of the sample was 60.3 (SD 7.2) years and 56.1% were female. STRs were genotyped from WES CRAM files with HipSTR. Association of case-control status and STR length (average of 2 alleles) was tested by logistic regression, adjusting for sex, age, and principal components. Weighted Bonferroni correction was used to account for multiple testing.

Results:
In general, genotyping accuracy was lower for STRs than for single-nucleotide polymorphisms (SNPs). By studying STRs on chromosome X in males, we observed the genotyping error rate was related to the STR motif length. In the HM case-control association study, we identified two STRs on chromosome 2 and 14 respectively that were strongly associated with HM case-control status. The lead STR on chromosome 2 lies within the ALPP gene, which is 100kb from PRSS56. The lead STR on chromosome 14 lies within the RBM8B pseudogene, which is 100kb from SIX6. Conditional analyses revealed the two lead STRs were in linkage disequilibrium with previously identified myopia-associated SNPs.

Conclusions:
This exome-wide association study revealed an association between HM case-control status and specific STR polymorphisms located near to PRSS56 and SIX6. The results confirm the association with SNPs identified in previous studies. Further studies will be required to find out if the STRs influence refractive development directly or if they tag the causal variants in these regions.

P134: Measuring treatment adherence and lens wear duration in children using mobile phone text messaging in a myopia control trial

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Purpose: Previous studies have identified the impact of multifocal soft contact lens wear duration on myopia control outcomes, however lens wear duration is largely measured using verbal questions which are subject to recall bias. This prospective study aimed to evaluate the feasibility of tracking treatment adherence and daily lens wear duration in children treated with multifocal soft contact lenses to control myopia progression using mobile text messaging, and to compare outcomes to verbal questions conducted at in person study visits.

Methods: Lens wear duration was measured during an ongoing clinical trial investigating multifocal soft contact lenses for the treatment of progressive myopia in children aged 6-12 years over a 1-year treatment period. Text message surveys were sent daily for the first seven consecutive days of each 30-day period of the study duration, allowing for sampling of 84 out of 365 days while enrolled in the trial. The survey questions requested information on whether lenses were worn the previous day, followed by lens insertion and removal times. Lens wear duration was then calculated for each day, averaged over a seven-day period to represent each month's lens wear. Each monthly value was then compared to lens wear durations obtained at the corresponding follow-up visit (1, 3, 6 and 12-month) via verbal questions. Average lens wear time was pooled from all study visits and agreement assessed using paired t-tests and Bland-Altman plots.

Results: 13 participants (mean age 11.0±1.2 years) have been dispensed lenses and returned for follow-up visits to date (study ongoing). Data was compared for n=20 visits. Response rate for text-messaging surveys was 70.1±29.9%. Average duration of daily lens wear was lower when reported through text messaging compared to verbal questions (8.6±3.9 vs 11.3±1.6 respectively, mean difference 2.6±2.9 hours, p=0.008). Upper and lower limits of agreement of the mean difference were 10.3 and -5.1, respectively.

Conclusion: Participants report on average 30% higher daily lens wear duration through verbal questions compared text-message surveys. Mobile phone text-messaging may provide a valuable adjunct to measure lens wear time in future myopia control clinical trials involving contact lens use.

P82: The impact of Dual Focus contact lenses in the global-flash multifocal ERG response in young myopic subjects

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Purpose: The knowledge of optical devices used, such as contact lenses used to control myopia progression, is still unclear as to their impact on signal processing in the retina. A controlled, non-dispensing, random, cross-over study was conducted to test the hypothesis that the electrophysiological activity of the inner retinal layers is altered when using Dual Focus contact lenses (Misight 1 Day contact lens), demonstrating myopia control efficacy.
Methods: Fourteen myopic young adults (23.71 ± 5.41 years, 12 women) with spherical equivalent of -2,16 ± 1,41D were fitted with a baseline without refraction (baseline) and a Misight 1 Day contact lens in one eye. The global-flash multifocal electroretinogram (gf-mfERG) was recorded after 20 minutes of wear, for each lens, fitted in random order, with the Reti-port/scan-21 (Roland consult, Germany). The multifocal 61 hexagons scaled with eccentricity stimuli was presented on a 19-inch LCD monitor at 33cm from the eye. The stimulus array followed an m-sequence with four frames: a multifocal flash frame (~83 cd/m2), a dark frame (~3cd/m2), a global-flash frame (~166 cd/m2) and a dark frame. The peak-time (in milliseconds, ms) and the amplitude (in nano-volts, nV) of the direct and implicit components (DC and IC, respectively) of gf-mfERG were analyzed for five concentric areas (Ring 1 – 0º to 4.8º; Ring 2 -4.8º to 15.0º; Ring 3- 15.0º to 21.6º; Ring 4- 21.6º to 40.6º; Ring 5- 40.6º to 54.10º) and quadrants (Q1 – inferior-nasal; Q2 – superior-nasal; Q3 – superior-temporal; Q4 – inferior-temporal). Non-parametric comparisons between SVCL and dual focus CL were performed.
Results: The electrophysiological response of the retina, using the Dual Focus CL, showed greater implicit time and amplitude of the P1 component, in the superior temporal retina and in Ring 5, these being statistically significant. The implicit time of the P2 component increased in the temporal retina and in the retinal area delimited by Ring 3, 4 and 5 ($p < 0.05$). The implicit time of the direct component increased significantly in the temporal retina. On the contrary, the implicit time of the induced component was minimally altered, however, it decreased on average by 1.71m in the area delimited by Ring 2 ($p=0.041$). Dual focus CL induces an increase in CD amplitude across the entire retinal area.
Conclusions: The increase in time implicit in the temporal retina suggests changes in the electrical response to the retina with the use of LC. The Dual focus CL appears to induce more changes in the response in the most peripheral retina particularly in the temporal and superior region.

P130: Image Quality Assessment of Myopia Control Ophthalmic Lenses

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Purpose: The global prevalence of myopia is increasing, and both pharmaceutical and optical treatments aimed at slowing progression are being developed with several successful options already available. Novel spectacle lenses with central clear zones and peripheral plus powered (non-coaxial) lenslets are one such option. However, the optics of these lenses remain somewhat ill-defined and difficult to compare. The purpose of the current study is to evaluate and compare the on- and off-axis imaging quality of two commercially available myopia control spectacles.

Methods: Two myopia control spectacles (Hoya MiYOSMART and Essilor Stellest) and a single vision (SV) reference spectacle lens were tested. The point spread function (PSF) at 0 through 30 degrees nasally and temporally in 10-degree steps was acquired. All measurements were performed with a 4f optical imaging system using a 636.8 nm laser diode, a 5 mm pupil placed at 17 mm behind the spectacles (simulating the distance from the spectacle to the pupil plane of the human eye). The PSFs were recorded using a CMOS sensor with 1.55 mm pitch and 12-bit digital output from which the MTF was computed. The area under the MTF curve (AUC) for the myopia control spectacles were divided by the on-axis AUC of the SV spectacle to describe the relative image quality of the lenses on- and off-axis.

Results: At the 0 degrees eccentricity, the (mean±SD) AUC ratios were 0.89±0.01 and 0.76±0.01 for the Stellest and DIMS lenses, respectively. At 10, 20, and 30 degrees the AUC ratios of the SV lens decreased to 0.96±0.01, 0.93±0.01, and 0.91±0.01, respectively, due to off-axis aberrations (e.g. astigmatism, coma). Both myopia control spectacle lenses demonstrated a further decrease in AUC ratio. The AUC ratios at 10, 20, and 30 degrees were (0.81±0.04, 0.67±0.01, and 0.6±0.03 and 0.72±0.02, 0.51±0.02, and 0.51±0.01) for Stellest and MiYOSMART, respectively. However, after 20 degrees, the MiYOSMART spectacle AUC ratio describes a stable trend, while the Stellest AUC ratio continues decreasing.

Conclusions: The off-axis optics of myopia control spectacle lenses decrease the AUC ratio relative to SV lenses. Lenslet geometry and spacing contribute to the optical quality provided by the lenses.

P140: The impact of a myopia control spectacle lenses with highly aspherical lenslets on visual acuity with peripheral gaze and peripheral visual acuity

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Purpose: The impact of myopia control spectacle lenses with peripheral lenslets on foveal visual acuity (VA) with central gaze, i.e., perpendicular to the lens, has been evaluated (Li et al., 2021; Gao et al., 2021). To study the conditions where eyes are turned to look obliquely through the peripheral zones containing the lenslets, we tested VA with peripheral gaze. Furthermore, the impact of peripheral lenslets on peripheral visual acuity was also measured.
Methods: Distance VA was measured using Freiburg Visual Acuity and Contrast Test (FrACT) at a distance of 3 m and room luminance of 10 lux. For each test, two spectacle lens designs were evaluated in random order: a spectacle lens with concentric rings of highly aspherical lenslets (HAL), and a standard single vision lens (SVL) as control. The optical center of the lens was aligned with the pupil center while looking straight ahead. A head and chin rest was used to maintain head stability. A target screen showing FrACT was placed at about 22 degrees of visual angle on the nasal side. For the foveal VA with peripheral gaze test, subjects were instructed to turn their eyes to look at the target screen. For the peripheral VA test, subjects were asked to fixate at a fixation cross placed straight ahead while attending to the target screen. An eye-tracker was employed to ensure correct fixation. Ten, for VA with peripheral gaze, and 18, for peripheral VA, adult subjects participated in the study. They are myopes or emmetropes wearing habitual visual corrections, with ages ranging from 27 to 52, and spherical equivalent refraction ranging from -8.50 D to +0.50 D. All tests were done monocularly on the right eye.
Results: VA with peripheral gaze through the SVL and the HAL is 0.06 ± 0.15 LogMAR and 0.13 ± 0.12 LogMAR, respectively. Compared to the SVL, the HAL reduces VA with peripheral gaze by 0.07 ± 0.08 LogMAR. The difference between the two lenses is not significant ($p = 0.27$, Paired Sample t-Test). Peripheral VA is 1.10 ± 0.09 LogMAR for the SVL, and 1.09 ± 0.07 LogMAR for the HAL. Peripheral VA through the SVL and the HAL is not significantly different ($p = 0.63$, Paired Sample t-Test).
Conclusions: The impact of HAL on VA with peripheral gaze is comparable to central gaze. Peripheral VA is not affected by the HAL compared to the SVL.
Reference:
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P124: Eye movements and accommodative microfluctuations in daily disposable myopia management contact lenses

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Purpose

Increasing interest in myopia management has led to the development of several licenced soft contact lenses to limit progressive myopia. These lenses have different optical designs, such as extended depth of focus (EDOF) and dual focus (DF) peripheral optics. In this prospective, double-masked, cross-over study, we investigated whether these different lens designs had any impact on accommodative microfluctuations and eye movements during reading tasks.

Methods

23 Participants (aged 18 – 29 years old) with normal binocular vision and accommodation were recruited to take part. Each participant was fitted with three lenses using manufacturer fitting guides, in a randomised order within a single visit; an EDOF lens design (Etafilcon A; NaturalVue), a DF design (Omafilcon A; MiSight), and a single vision (SV) contact lens (Omafilcon B; Proclear) as a control. Accommodative microfluctuations were measured for a near target at 25cm over the course of at least 90 seconds in each lens, using a Shin-Nippon SRW-5000 autorefractor that is adapted to continuously record accommodation at a sampling rate of 22Hz. Eye movement data was collected with the Thomson Clinical Eye Tracker which incorporates a Tobii Eye bar (Thomson Vision Solutions). Frequency of eye movements analysed include fixations per row, fixations per minute, mean regressions per row, total number of regressions, and total rightward saccades. Accommodation data was analysed using power spectrum analysis in Python and SciPy. Differences in mean reading eye movement values between the lenses were compared using a two-way Friedman test, with subsequent pairwise comparisons and Bonferroni correction. All statistical analyses were performed in SPSS.

Results

The average mean spherical error for participants was -2.65D ±1.42DS, with an average age of 23.4 ±3.5 years old. No significant difference in accommodative microfluctuations was found between the three lens designs (P=0.06). Significant differences were found for fixations per row (P=0.03), fixations per minute (P=0.008), mean regressions per row (P=0.002), and total number of regressions (P=0.002), but not for total rightward saccades (P=0.10) between the three lenses. Post-hoc analysis of the data indicated that the EDOF lens design results were significantly different from the DF and SV lenses, with more frequent regressive saccades (such as mean values for total number of regressions of 37.7, 36.9, and 48.3 for the SV, DF, and EDOF designs, respectively).

Conclusion

Regressive eye movements appear to significantly increase when wearing EDOF lens designs for reading, which may impact reading speed and visual comfort during lens wear. Further studies in children, and after a longer period of adaptation are recommended to assess the potential impact of this finding on reading activities, such as those performed in school.

P191: What is the relationship between IQ, education and myopia? A Mendelian randomization study.

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Purpose:

The aim of this study was to determine the independent causal associations between IQ and education on myopia using a type of statistical inference based on genetics called Mendelian randomization (MR).

Methods:

Two-sample univariable and multivariable MR analyses were performed using 162 single nucleotide polymorphisms (SNPs) associated with education and 189 SNPs associated with IQ. Instrument strength was determined using the F-Statistic and the Q-Statistic measured heterogeneity.

Results:

More time in education was causally associated with higher IQ scores (beta=1.08; standard error (SE)=0.36; p<0.001) and higher IQ was causally associated with more time in education (beta=0.51; SE=0.02; p<0.001). Furthermore, education (beta= -0.79; SE=0.16; p<0.001) and IQ (beta= -0.78; SE=0.10; p<0.001) were both strongly associated with negative refractive error (myopia) in univariate MR analyses. The instruments for IQ and education were strong (F>10) with a high degree of heterogeneity (Q-statistic>160).

In multivariable MR analyses, there was no significant association between education and refractive error (beta=0.22; SE=0.39; p=0.58) when controlling for IQ but IQ was causally associated with negative refractive error when controlling for education (beta= -1.0213; SE= 0.31; p=0.001). However, both IQ and education were weak instruments (F<2) and there were high levels of heterogeneity (Q-statistic>380) due to the overlap in SNPs between exposures and outcome.

Conclusions:

The independent causal effects of education and IQ on myopia could not be determined using current methods in MR due to weak instrument bias and high levels of heterogeneity. Further epidemiological studies are required.

P120: Effect of Overnight Orthokeratology Lenses on Tear Film Stability in Children

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Purpose: To assess the tear film surface quality after orthokeratology using an automated Medmont E300 corneal topographer.
Methods: Children who wore orthokeratology lenses for more than one year were selected in this retrospective study. Tear film disruption (TFD) and central tear film disruption (cTFD) were measured with Medmont E300 corneal topographer at initial and each follow-up visit after fitting with orthokeratology lenses, providing a nominal value from 0 (perfect) to 1 (poor). Tear film surface quality before and after ortho-k treatment was compared.
Results: 145 children using orthokeratology lenses were observed. TFD and cTFD significantly increased at 1-day follow up (TFD, $t=-17.3$, $P<0.001$; cTFD, $t=-10.4$, $P<0.001$). This change remained consistent through to 12-months visit (TFD, $F=51.1$, $P<0.001$; cTFD, $F=28.0$, $P<0.001$). A sub-group of n=11 children were discontinued for 1-month before being refit with OrthoK lenses of a different design. Similarly, there was a significant increase in TFD compared to pre-orthoK scans (0.172±0.161), but this returned to baseline levels after ceasing lens wear (0.084±0.059). A sub-group of monocular OrthoK wearers (n=23) found that TFD and cTFD values increased in eyes with monocular lens-wearing but remained stable in the lateral eyes.
Conclusions: Objective measurements of tear-film quality are reduced in children after fitting with orthokeratology lenses, but return to baseline after 1-month of lens cessation. It is of importance to ensure tear film surface quality is continuously monitored throughout use of orthoK lenses.

P72: Predictors of Toric Compared to Spherical Contact Lens Prescription in Optometric Practice

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Purpose:
Limited research exists relating to prescribing patterns of toric compared to spherical contact lenses (CLs) in Ireland. This study investigated determinants of toric compared to spherical CL prescription, in patients attending Irish optometry practices.

Methods:
Anonymised electronic medical record data (total patients = 199422) was analysed from 9842 CL patients (median age = 35 years, IQR = 24 – 46 years) attending 28737 visits (multiple visits per patient included if applicable) in 36 optometry practices across Ireland between 1990 and 2022. Multivariable logistic regression fit with a generalised estimating equation approach to account for within-subject correlation, was used to identify variables associated with prescription of toric compared to spherical CLs (outcome variable). Spherical component of refractive error, cyl, age, optometry practice and year attended, were included as exposure variables.

Results:
Spherical CLs (power [median, IQR] = -3.50DS, -2.00DS to -5.00DS) were prescribed to 53.3% of CL patients (prescription (rx) [median, IQR]: sphere = -3.25DS, -1.75DS to -5.00DS; cyl = -0.75DC, -0.75DC to -1.00DC, age [median, IQR: 37 years, 25 – 48 years) and toric CLs (power [median, IQR]: sphere = -2.25DS [-0.50DS to -4.25DS]; cyl = -1.25 DC [-0.75DC to -1.75DC]) to 46.7% of CL patients (rx [median, IQR]: sphere = -2.25DS, -0.50DS to -4.50DS; cyl = -1.50 DC, -1.00DC to -2.25DC, age [median, IQR]: 34 years, 24 – 44 years). Younger patients (odds ratio [OR] per 5-year increase = 1.05, $P < 0.0001$) with a less myopic spherical refractive error (OR per 1D increase = 1.03, $P < 0.0001$) and higher astigmatism (OR per 1D increase in absolute cyl power = 2.09, $P < 0.0001$) were more likely to have been prescribed toric compared to spherical CLs. Prescription year (OR per 5-year increase = 1.40, $P < 0.0001$) and optometry practice (OR range = 0.22 – 3.07, $P < 0.0001$) were also significant predictors for toric CL prescription.

Conclusions:
Refractive status, age, optometry practice and prescription year significantly affect patient likelihood of being prescribed toric compared to spherical CLs in Ireland. A 1DC increase in astigmatism was associated with doubling in the odds of toric CL prescription, but ≥ 25% of patients with spherical CLs had astigmatism ≥ -1.00DC. Prescription of toric compared to spherical CLs has also increased over time.

P76: Axial length changes with defocus spectacles for myopia control

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Purpose.

Recent randomized clinical trials have shown that peripheral hyperopic defocus spectacles or contact lenses have 50-60% effectiveness in arresting myopia progression in schoolchildren.1-3 There is more interest in myopia control spectacles since children aged 6-12 seldom use contact lenses and they are the ones prone do develop high myopia because of their early onset.4-6 The present study tested axial length changes with Lenstar under the use of a simple peripheral plus add spectacle design that can be carved in any conventional or digital optical laboratory. We also tested eye and head movements, tolerance, and visual fields under the use of this spectacle design.

Methods.

Subjects for this study were current users of monofocal glasses or contact lenses, aged 15-25 years, with myopic spherical equivalent in the range of -1.00 to -5.00 diopters in both eyes and astigmatism less than -1.00 diopters in both eyes. They gave verbal consent to participate in the study using a pair of special myopia control spectacles that were provided free of charge for an experiment that lasted approximately two hours. The study was conducted in accordance with the tenets of the Declaration of Helsinki. The Ethics Committee of the Argentinian Council of Ophthalmology approved this study. Verbal consent was obtained from all subjects after the nature of the study was explained. The ophthalmological exam included subjective refraction, intraocular pressure measurement, biomicroscopy of the anterior segment and fundus observation after pupil dilation. All myopic subjects had normal ocular exams except for their myopia.
The volunteers chose a frame for the special spectacles and then the optical pupil centering was digitally measured taking a photograph of the subject's face with those frames in place, with an especially designed centering device (IPD, Novar, Buenos Aires, Argentina). Fifteen days later, once the spectacles were ready, the experiments were conducted at 9 o'clock in the morning. Subjects were advised to rest and sleep for about 8 hours the night before and to have a light breakfast that could consist of tea or coffee with something light to eat in the day of the experiment. The subject were also advised to wear their habitual monofocal spectacles. During the whole procedure, subjects did not drink or eat anything else, except for a sip of water, and were sat down or walked briefly in the room where the experiment was performed. The experimental room had the usual artificial illumination which was maintained constant through the experiment.
This experiment consisted in reading an online book with black letters on white background on a desktop computer. The text letters were in Times New Roman and subtended a visual angle of 1 degree, being read at 40 cm distance (20/200 near visual acuity). In the first step of the experiment, the subjects were instructed to read for 20 minutes with their monofocal lenses to adapt to the illumination of the room. Then, without any interval, 10 measurements of the axial length of the right eye were made with the Lenstar deleting the deviated ones as the machine points them. These measurements were averaged up to three decimals.
Next, the subject continued reading the book on the computer for 40 minutes with his same usual monofocal glasses. After this, during a short pause, a new measurement of the axial length of the right eye was made with the Lenstar (10 measurements again, same procedure). In the second step of the experiment, the subjects were instructed to read for 40 minutes with the special defocus spectacles provided for the research study and a third axial length measurement was performed. After approximately two hours of work, the experimental procedure ended and the subjects carried

home the special spectacles to try them for tolerance for 4 weeks after which a short questionnaire about its use was administered.
The statistical analysis was performed with SPSS 25 software. The means for baseline, first and second period in each subject's right eyes were recorded and the differences up to 1 micron between pre- and post-spectacle use were calculated. Paired Student t test were performed to find differences between pre- and post- defocus spectacle use as the data followed Gaussian normal distributions with Kolmogorov-Smirnov test. As the distributions of axial length were normal and had similar variances, paired t Student tests were performed comparing axial length means for baseline, usual spectacles and defocus spectacles. A p value < 0.05 was considered significant for these differences.

Results.

For the present study, 17 subjects of both genders were studied with the same protocol by three different ophthalmologists. Their mean age was 22.3+/-5.5 years and 13 were women. Their mean spherical equivalent of the right eye was -2.31+/-1.06 diopters. The mean axial length for baseline (after 20 mins adaptation), after usual spectacles (40 mins more) and after special defocus spectacles (40 mins more) are given in Table 1. There was a significant difference of +8.1 microns increased axial length from baseline when reading with the usual prescription. When subjects read in the same situation with the defocus spectacle the axial length significantly returned to baseline measurement shortening by -10.6 microns (Table 2).

Table 1. Lenstar Axial Lengths at Baseline, Monofocal and Defocus Lenses.

	20 mins.	60 mins.	100 mins.
Mean Axial Length (mm)	24.317	24.325	24.314
Standart Deviation (mm)	0.637	0.641	0.641

Table 2. Effect of Monofocal and Defocus Spectacles on Axial Length

	Monofocal	Defocus
Mean change in Axial Length (microns)	+8.1	-10.6
Paired Student t test	p<0.05	p<0.01

After 1 month, the tolerance was tested in a new interview in 7 subjects up to now in this ongoing study. The subjects referred some problems with the use of the defocus spectacles. They were uncomfortable for walking in the streets. The volunteers could use them easily to work or read at the computer at usual desktop working distance but had some trouble when reading downwards at a book or cellphone in their hands, as they had to tilt downwards their chin and head. However, they also realized that they had to move their head from side to side to read comfortably at the computer. They were happy with the idea of using some device for myopia control.

Visual fields were tested in one subject with monofocal and defocus spectacles. This visual field testing showed normal visual macular fields in the central 20º diameter. In addition, it also showed a 5% reduction in sensibility around this central macular area up to 60º diameter. This volunteer was also filmed while reading on the computer to show his head movements just from his back to maintain anonymity.

Discussion.

This paper presents evidence of axial length changes after 40 minutes of reading with special defocus spectacles with peripheral plus add +3.50 diopters. These changes have been shown with similar methods in human subjects under hyperopic and myopic defocus, 7 under super-diluted atropine drops, 8 while reading with letters in positive or negative contrast 9 and with especial spectacles or contact lenses for myopia control. 10 It is generally believed that these changes in axial length are indirect evidence of corresponding changes in choroidal thickness, and choroidal thickening, as has probably been evidenced in this study with defocus spectacles, is in the line of a possible effect on myopia control with these spectacles.

The fact that this special design can be used relatively well for reading but not well tolerated for walking, suggests that a clinical trial of tolerance and effectiveness on myopia control would be of relevance. As today it is unacceptable to leave a control group under the natural history of myopia without any treatment, these special spectacles should be tested in a non-inferiority trial against superdiluted atropine or already tested spectacle designs. Myopic defocus signals in the retina (animal experiments) have been shown to be more robust than hyperopic defocus signals, and the presentation or myopic defocus in the afternoon is more effective than in the morning (also animal experiments). Thus, the possible trial could test this new design applied to children on a part-time daily basis for only 3-4 hours in the evening at home after school and before going to bed. During the rest of the day, children should use their usual monofocal prescription for school and outdoor activities.

We have also observed that in the design of these glasses with peripheral defocus, the centering in the frames must be optimized, as tolerance and adaptation to these spectacles depend on correct centering according to our experience. The effectiveness of different designs and clinical regimens for applying spectacles with peripheral defocus treatments is still under study. Research in this area is promising for finding an easy and affordable treatment for myopia control.

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P62: Changes in higher order aberrations during use of orthokeratology lenses

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Purpose
During overnight ortho-k lens usage corneal shape is altered. We aim to evaluate changes in total corneal higher order aberrations (HOA) during treatment with orthokeratology lenses.

Methods
An 18-month 1:1 randomized, controlled trial on 60 myopic children aged 6 to 12 years with the intervention being orthokeratology lenses (OKL) and the control-group receiving single-vision spectacles. Total corneal root mean square (RMS) HOA were measured with scheimpflug topography (Pentacam, Oculus, Wetzlar, Germany) at baseline, day 3, day 7, 1-, 3-, 6-, 9-, 12-, 15-, and 18-month follow-up for the intervention group. Data from right and left eyes were included in the analysis. Four consecutive measures per eye were obtained at baseline, 6-, 12-, and 18-month follow-up. For the remaining follow-up visits, two or three measurements were obtained. Only measurements with the status OK and Error 0 were included in the analysis. The measurements for each eye were averaged for examination. Statistically data were handled with a mixed model using Stata software (version 16.1; StataCorp, College Station, TX, USA). For subjects dropping out of the study, data were included in the analysis until dropout occurred. A p-value < 0.05 was considered statistically significant.

Results
A total of thirty patients were included in the analysis. We found a significant increase in RMS HOA from 0.35 µm at baseline to 0.97 µm at day 3 ($P < 0.001$, 95% confidence interval (95% CI) 0.53 to 0.72, mixed model) and a significant decrease from day 3 to day 7 of 0.13 µm ($P < 0.02$, 95% CI –0.24 to –0.03). Hereafter there were no significant changes in RMS HOA ($P \geq 0.26$).

Conclusion
OKL use increases HOA in children. The changes are stable seven days after treatment initiation.

P22: Translation of mRNA to Protein Levels in Progression of Myopia Versus Hyperopia in a Spontaneous Myopia Guinea-Pig Model

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Purpose: To identify myopia-susceptible gene and protein levels in the regulation of spontaneous myopia in an albino guinea pig (GPs) model. Translation of mRNA to protein levels will provide valuable insight into the molecular basis of myopia progression and help identify signalling pathways that are involved in eye growth and myopia development.
Methods: Refraction and biometry measurements were assessed by a Nidek autorefractor and Sonomed A-Scan ultrasound respectively. Elm Hill albino GPs were divided into two groups, based on post-natal day 14 refraction, as either albino myopia (AM, n=10) or albino hyperopia (AH, n=10). Four tissues from each group were analyzed by RNA sequencing and the rest analysed by quantitative Tandem-Mass-Tag-based proteomics analysis. QIAGEN IPA software was used to identify the canonical pathways in the retina, choroid and sclera from both RNAseq and proteomics data.
Results: AM and AH groups differed in terms of refraction (-5.0±1.5D vs. +3.6±2.4D, $p<0.001$) and axial length (7.4±0.2mm vs. 7.2±0.1mm, $p<0.001$). Around 17,000 of gene IDs for GPs were identified from Ensembl, however only 150 genes in the sclera showed significantly different expression between AM and AH ($p<0.05$). Proteomics analysis revealed >8,000 protein names for GPs (identified from UniiProt). AM and AH groups had significantly different levels of 274 retinal proteins, 106 choroidal proteins and 125 scleral proteins ($p<0.05$). The canonical pathways identified at the gene level were far fewer than at the protein levels among all three tissue types.
Conclusions: The identification of differentially-expressed mRNA to proteins levels can increase the confidence for biological discovery in the spontaneously myopic eye, which can elucidate the molecular basis of individual susceptibility to myopia development and progression. These findings have the possibility to lead to the development of potential therapeutic strategies to tackle this preventable blinding disorder.

P136: Comparing Different Types of Spectacle Lenses designed to Myopia Control: Acceptance, Efficacy and Visual Performance.

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Purpose: Recently arrived to market new spectacle lenses designed to prevent myopia progression. The aim of this work was to analyze of most recent clinical trials evaluating different spectacle lenses at level of myopia retention efficacy and also visual performance, accommodation facility and binocular function in children.

Methods: A search was performed using PubmedCentral and including all randomized clinical trials (RCT) that were found in search by "spectacle lenses to myopia control". Results were filtered and only the results from the last 10 years were included. Results including bifocals, orthokeratology, atropine or progressive addition lenses (PALS) reports were excluded.

Results: Total of 4 types of lenses designed to prevent myopia progression were identified: Peripheral Defocus Management (PDM) commercialized by CarlZeiss as MyoVision, Defocus Incorporated Multiple Segments (DIMS) commercialized by Hoya as MiYOSMART, Highly Aspheric Lenslets (HAL) commercialized by ESSILOR® as Stellest and Perifocal (PF) commercialized by INDO as SuperKid Miofocal (Iberia) or FRAMETEC Perifocal (Germany). At this time, duration of studies varies between 1 (HAL) and 5 years (Perifocal). The efficacy in myopia retention determined by refractive error was 15%, 52%, 63% and 60% respectively using PMD, DIMS, HAL and PF. Not verified significant differences in distance and near VA high contrast between DIMS, HAL and PF comparing Single Vision (SV). Binocular function and accommodation not significantly varied with DIMS and HAL comparing with SV.

Conclusions: Most recent and efficient spectacle lenses designed to avoid myopia progression reveals positive tolerance and acceptance by children and demonstrated lower impact on both visual acuity and contrast sensitivity. Although the levels of scientific evidence are limited, there are notable contributions to preventing the progression of myopia with ophthalmic lenses designed for this purpose.

P74: Efficacy of Multifocal Gas Permeable Lenses on Progressive Myopia and Axial Length Elongation: A Retrospective Review

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Purpose: Converging evidence from clinical studies have shown myopic inhibiting effects from optical treatments that induce myopic defocus and higher order aberrations (HOAs), such as overnight orthokeratology (OrthoK) and multifocal soft contact lenses (MFSCL). Multifocal gas permeable contact lenses (MFGPCL) offer better visual correction to myopic patients with high refractive error and astigmatism, while creating similar optical profiles to that of MFSCL. This retrospective review study aimed to investigate the anti-myopia efficacy of MFGPCL in clinical settings.

Methods: Thirty six eyes of eighteen patients (11 female) who were empirically fitted with MFGPCL at the UC Berkeley Myopia Control Clinic, (age 10.27 ± 3.73, min 2.9, max 16 years) and with a follow-up duration of no less than 12m were included in this study.

Results: The patients' baseline myopia was -7.98±2.67D, with -2.74±1.51D of astigmatism. The average duration of MFGPCL wear was 3.97 ± 1.52 years, with minimum 1.31 years and maximum 6.4 years of wear. All patients adapted quickly to the comfort and visual correction of MFGPCL since initial dispense of the lenses and there were no serious adverse effects reported. The average spherical equivalent (SE) progressed by -0.48 ± 0.60D in the first year of MFGPCL wear, -0.43 ± 0.56D in the second year, and -0.54 ± 0.62D in the third year. The axial length (AL) elongation in the first year of MFGPCL wear was 0.40 ± 0.26mm, 0.25 ±0.21mm in the second year, and 0.19±0.19mm in the third year. A subgroup of eight eyes of four patients < 7 years old (5.14 ± 1.81 years) had SE progressed by -0.55 ± 0.85D in the first year and -0.80 ±0.51D in the second year. The AL elongated by 0.64±0.20mm and 0.50 ±0.20mm in the first and second year of MFGPCL wear respectively.

Conclusion: MFGPCL offered great visual correction, easy adaptation, and long-term tolerability to patients with high, progressive myopia combined with high astigmatism, who were not ideal candidates for MFSCL. Despite faster AL elongation seen in this cohort likely attributable to younger age hence more significant physiological axial growth, the change of myopia was comparable to what had been reported.

P8: The efficacy of defocus incorporated multiple segments (DIMS) spectacle lenses in arresting juveniles' myopia progression: a retrospective real-world study

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Aim: DIMS has been shown a powerful capacity of slowing down myopia progression in Chinese juveniles previously by a randomized controlled trial. The purpose of the study was to evaluate the performance of DIMS in real-world settings.

Method: Records of DIMS and single vision (SV) lenses prescribed between July 1 2018 and November 30 2020 were collected retrospectively from 9 subsidiary hospitals of Aier Eye Hospital Group in China. The records of subjects who had applied other interventions for myopia control purpose or had no follow-up visit between July 2 2018 and November 30 2021 were excluded for analysis. Spherical equivalent refractive error (SER) of the right eye was adopted to assess the myopia progression. The strategy of propensity score matching (PSM) was applied to match the confounding baseline characteristics between the DIMS and the SV group.

Results: A total of 3639 subjects with DISM lenses and 6838 subjects with SV lenses were included in the study. The age of the subjects included was between 6 ~ 16 with an average of 11.02 ± 2.53 years, and the SER was between 0.00 ~ -10.00 D with an average of -2.78 ± 1.74 D. After the PSM treatment with 1:1 ratio, 2240 pairs of 1-year follow-up subdataset and 735 pairs of 2-year follow-up subdataset were obtained to compare the of myopia progress between the DIMS and SV groups. Significantly slower progression achieved by DIMS compared with SV was observed from both the 1-year subdataset (DIMS: -0.50±0.43, SV: -0.77±0.58 D, P <0.001) and 2-year subdataset (DIMS: -0.88±0.43, SV: -1.23±0.58 D, P <0.001). In the 1-year subdataset, 40% and 19% had myopia progression of less than 0.25D for DIMS and SV group, respectively, while 20% and 39% had myopia progression of greater than 0.75D for DIMS and SV group (χ^2=303.31, P<0.001). In the 2-year subdataset, 33% and 20% had myopia progression of less than 0.50D for DIMS and SV group, respectively, while 12% and 29% had myopia progression of greater than 1.50D for DIMS and SV group (χ^2=76.49, P<0.001).

Conclusion: Aligned with the previously RCT, this study confirmed but demonstrated a weaker effectiveness of DIMS over SV in the real-world settings.

P66: A 2-Year Multi-Site Observational Trial of Hoya MiYOSMART myopia control spectacle lenses in UK children: Baseline data and tolerability

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Purpose: MiYOSMART 'myopia control' spectacles lenses have been shown to be well tolerated and effective in reducing myopia progression in Chinese children (8-13 years) compared to peers wearing single vision (SV) spectacle lenses. The present 2-year observational trial investigates tolerability and efficacy of MiYOSMART in UK children. Baseline cohort characteristics and initial tolerability are presented.
Methods: Children aged 5-15 years with cycloplegic spherical equivalent refraction (SER) of -0.50 to -8.50D, anisometropia≤1.50D and astigmatism≤2.50D were recruited. All children were prescribed MiYOSMART spectacle lenses with peripheral myopic defocus. SER (cycloplegic autorefraction) and axial length (AL, IOLMaster) were measured at baseline. Distance and near logMAR visual acuity (DVA, NVA), stereoacuity (Randot stereogram) and accommodative response (modified Nott technique, 4D target) were measured through the MiYOSMART spectacle lenses at commencement of wear and compared to outcomes through habitual SV lenses. Tolerability was evaluated using an online symptom questionnaire within one week of wear.
Results: 127 children (mean age 10.4±2.4years; 43% male; ethnicity 64% White, 20% Indian Asian, 6% Chinese, 10% Other) were recruited. Mean baseline SER and AL were -3.15±1.65D and 24.65±0.95mm, respectively. Mean DVA, NVA, stereoacuity and accommodative lag through MiYOSMART spectacles were -0.00±0.07 logMAR, -0.03±0.07 logMAR, 42±17 secs and 0.47±0.38D, respectively. These measures did not differ statistically or clinically to measures achieved while the child wore habitual SV lenses (all p≥0.29). 94 participants responded to the tolerability questionnaire within one week of wear; 57% reported no adverse symptoms, 22% reported difficulties/slowness in refocusing, 11% reported unstable distance vision and 10% noted eyestrain.
Conclusions: This 2-year observational trial will explore efficacy and tolerability of MiYOSMART spectacle lenses in a UK cohort with a wide range of ages and myopia. Efficacy will be compared with existing control groups. On receipt of MiYOSMART spectacle lenses, visual performance was comparable to that achieved with SV spectacle lenses. Most children had no adverse symptoms within the first week of wear, however some children reported initial difficulties with refocusing, unstable distance vision and eyestrain. Data collection is ongoing at 6-monthly intervals.

P156: Multifocal Contact Lenses for the Treatment of Progressive Adult Myopia

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Purpose: School-age myopia has been thought to stabilize in the mid-teenage to young adulthood years yet there is still a certain subset of adults that continue to progress. Currently, there are limited studies on the efficacy of myopia management treatments on progressive adult myopia. A retrospective clinical case series analysis was conducted to learn about the efficacy of multifocal contact lenses to treat adult myopia progression.

Methods: A retrospective analysis of all adult patients fit into multifocal contact lenses for the purposes of myopia management from 04/01/2016 to 04/01/2022 at UC Berkeley's Herbert Wertheim's School of Optometry Myopia Control Clinic was performed. 10 adult patients (ages 18-30 years, mean 23 ± 4.57) fit the inclusion criteria. All patients included in the analysis had at least 0.25 D of myopic progression or more in their habitual correction within the year prior to starting myopia management and were followed for a minimum of 12 months after being fit into multifocal contact lenses. The primary outcome measure was change in spherical equivalent refraction. Each eye was analyzed individually, and a linear regression analysis was performed to determine rate of myopic progression pre and post myopia management.

Results: Myopic progression in the year prior to being fit into multifocal contact lenses ranged from -0.25 D to -2.38 D, with an average progression of 0.73 ± 0.14 [mean ± 1SE] D. After one year of multifocal contact lens wear, rates ranged from -0.25 D to -1.75 D, with an average progression of -0.44 ± 0.13 D. While this trend was found to be statistically insignificant (p=0.07), approximately 90% of eyes showed reduction of annualized myopic progression, with 60% of eyes showing a decrease of 50% or greater. Of the 50% or greater group, 66.67% of eyes showed complete halting of myopic progression and 16.67% demonstrating myopic regression.

Conclusions: Multifocal contact lenses can be an effective myopia treatment strategy to manage myopic progression in adults.

P122: Effects of defocus incorporated multiple segments (DIMS) spectacle lens design on reading behaviour of Caucasian children.

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PURPOSE:
To assess the effects of a defocus incorporated multiple segments spectacle lens design (DIMS) on reading behavior through eye movement recordings in Caucasian children.

METHODS:
Twenty Caucasian children aged 7 to 12 years with a corrected monocular distance high contrast visual acuity ≤0,00logMar, spherical refractive error between -0,50D and -5,00D and refractive astigmatism <0,75D were selected. The Clinical Eye Tracker system (Thomson Software Solutions Ltd.) with a sampling frequency of 60Hz and an accuracy of 0,5° was used to record the reading behaviour. For the study were used different targets, validated to evaluate the speed and correctness of reading in children (prove MT Cornoldi), presented on a computer monitor (E27705H, AOC) at a viewing distance of 50 cm. Reading rate (number of words read per unit time), Fixations (the total number of "eye stops" or pause of the eyes during reading) and Regressions (fixations that are directed from "right to left" or regressive movements) were measured in two separate days, during wear of single vision (SV) and DIMS spectacle lenses always using the same frame. The power of both lenses was determined on subjective refraction (maximum amount of spherical plus power for best visual acuity). The results obtained with the different spectacle lenses tested were analyzed using the Student's t-test and a $p<0.05$ was considered statistically significant.

RESULTS:
The DIMS design compared with SV induced a significant increase (t-test $p<0,01$) of number of words read in a minute, respectively 198±63w/m vs 165±43w/m (mean±SD) and a significant reduction (t-test $p<0,05$) of number of fixations in a minute (respectively 15,22±4,58 fix/m vs 16,91±3,79 fix/m). No significant differences (t-test $p=0,33$) were found for the number of regressions (respectively 4,62±1,77reg/raw vs 5±1,21reg/raw).

CONCLUSIONS:
The data obtained in this pilot study suggests that the spectacle lenses with DIMS design may improve the children's reading behavior, increasing the reading speed, and reducing number of fixations in a minute.

P12: Prescribing Patterns of Contact Lenses for Myopia Control among Irish Optometrists

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Purpose:

Orthokeratology and soft peripheral defocus contact lenses have both been found to be effective methods of limiting axial length elongation in myopic children. It is however unclear how frequently these contact lenses are prescribed to myopic children.

Methods:

Anonymized electronic medical record (EMR) data was sourced from 33 optometry practices in Ireland. From this data it was determined how many practices were prescribing contact lenses for myopia control and how frequently these lenses were prescribed over the period 2017 – 2022. The data was analysed to determine how many children aged 5 – 18 were found to be myopic (≤ -0.50 D). Of those children found to be myopic, the number that were prescribed any type of contact lens and the number prescribed myopia control contact lenses (MCCL) were determined. Any patterns in prescribing of MCCL were assessed using multiple logistic regression.

Results:

In total 12,484 children met the inclusion criteria with 23% of these children demonstrating myopia progression of at least -0.25 D/year. Of these 2,263 were found to have been prescribed some form of contact lens with 137 having been prescribed a MCCL. Of all 33 practices, 10 were found to prescribe MCCL with these 10 practices having prescribed contact lenses of any type to 1,028 children in total over the time period. The overwhelming majority of MCCL prescribed were soft peripheral defocus contact lenses (≈99%). In those practices fitting MCCL, there has been a significant increase in the proportion of new fittings with only 3% of contact lens wearing myopic children fit with a MCCL in 2017 which has increased to 28% in 2021. The mean age at which MCCL were first prescribed was 12.3 ± 2.35 years with the mean spherical equivalent refractive error (SERE) at which they are first prescribed -3.47 ± 1.85 D. The mean age at which MCCL were first prescribed did not vary significantly from 2017 to 2021 (12.25 ± 1.75 years vs 11.91 ± 2.54, p = 0.584) nor did the mean SERE at which MCCL were first prescribed (-3.97 ± 3.07 D to -3.33 ± 1.71 D, p = 0.642). The most predictive factors for being prescribed MCCL were practice attended (OR range: 0 – 26.7, 95% CI: 11.13, 63.82), year of exam (OR: 1.9, 95% CI: 1.7, 2.2), younger age (OR: 1.4, 95% CI: 1.37, 1.45) and worse myopia (OR: 1.17, 95% CI: 1.09, 1.25). In general, children prescribed MCCL were faster progressors than non-MCCL contact lens wearing children (mean progression: -0.59 ± -0.53 D/year vs -0.24 ± -0.16 D/year) however 63% of non-MCCL contact lens wearing children still demonstrated myopic progression of at least -0.25 D/year.

Conclusions:

The proportion of Irish contact lens wearing myopic children that are fit with myopia control contact lenses has been increasing over the past 5 years, however this varies significantly between practices. There is a significant proportion of children that are suitable for myopia control contact lenses that are not being prescribed this option. When children are fit with myopia control contact lenses in Ireland, they are older and more myopic than is considered ideal.

P88: A randomized controlled trial for the effect of violet light transmitting eyeglasses on myopia progression in children

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Purpose:
Outdoor activity has been reported to be an important factor to prevent progression of myopia. Violet light (VL), of which wavelength is from 360 to 400 nanometers encompassed in the sunlight, was brought up as a candidate for an element contributing to myopia suppression, and therefore, VL-transmitting eyeglasses could be useful for children with potential of myopia progression. A double blinded randomized clinical trial was performed to investigate the efficacy of VL-transmitting eyeglasses.

Method:
Children from 6 to 12 years old of age living in one city in Japan were enrolled in this study. Inclusion criteria were those whose cycloplegic refraction was between -1.50 D and -4.50 D, those who had one or two parents with myopia, and those who had no ocular diseases other than ametropia. The effects of VL-transmitting eyeglasses and placebo on myopia suppression were followed up for two years. Ophthalmic checkups, oral or written interviews, and measurements of refraction and axial length under mydriasis were periodically performed at the initial visit, i.e., the baseline, and, 1, 6, 12, 18, and 24 months later.

Results:
Although the mean change of refraction and axial length between the VL-transmitting eyeglasses group and the placebo group was not significantly different in Full Analysis Set, the change in axial length in the VL-transmitting eyeglasses group was significantly smaller than that in the placebo glasses group under condition that the time for near-work was less than 180 minutes and that the subjects had never used eyeglasses. (95%CI: -0.351, -0.060, p=0.006) The rate of suppression of axial elongation for 2 years by the VL-transmitting eyeglasses was 21.4%. No adverse effect was observed during the trial.

Conclusions:
Axial elongation was suppressed in the VL-transmitting eyeglasses group when near-work time was less than 180 minutes and in the subjects without previous eyeglasses use.

P70: Case Report: The Effects of a Decentered Treatment Zone with Orthokeratology Lenses in Relation to Axial Length Elongation

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Purpose:
More studies have shown that axial length stabilization can be achieved using orthokeratology when the treatment zone of the cornea is well-centered on the patient's pupil, however there are some studies that indicate a decentered treatment zone from the pupil may also provide axial length stabilization.

A retrospective, observational case study was performed to show the effects of how a decentered treatment zone of an orthokeratology patient can result in a stabilized axial length in their myopia progression.

Methods:
A 14 year old Middle Eastern female presented to the Midwestern University Eye Institute for an orthokeratology refit on March 4th, 2021 as a way to manage her myopic progression over the last 7 years started at her previous practice. At her initial visit, the patient was washed-out over 7 weeks from her previous orthokeratology lenses to restart her fit because her vision, treatment zone decentration, and refraction were sub-optimal. She had numerous follow-up visits until the lenses were acceptable to finalize. Various tests including vision, topography, contact lens assessment, over-refraction, refraction, and axial length were measured during the visits in order to finalize the patient's contact lenses.

Results:
In 2014, the patient's clinical data prior to starting orthokeratology included her refraction OD: -3.50-0.50x120; OS -3.75-0.25x090 and her keratometry readings OD 45.00/46.00D @086; OS 45.00/45.25D @086.

In 2021, her initial OCULUS Pentacam tangential topography map displayed that the treatment zone was decentered about 3mm temporally from the center of the pupil in each eye. This decentration may have contributed to her sub-optimal vision when she arrived to our clinic.

After the patient was washed-out 7 weeks after her initial appointment, her refraction was OD: -4.75-2.50x015; OS: -6.50-1.50x165 with her vision being 20/20 in each eye with that correction. Her keratometry readings were OD: 44.25/45.75D @090; OS: 43.75/45.00D @099 and her axial length measured using the IOL master was OD: 24.63mm; OS: 25.40mm. The patient was finalized acceptable orthokeratology lenses that provided 20/20 vision with some decentration of the treatment zone in each eye.

In March 28th, 2022, the patient's vision uncorrected was OD: 20/25; OS: 20/25 and OU: 20/20. Her refraction was OD: 0.00-0.75x029; OS: 0.00-2.00x180 while her keratometry readings were OD: 42.25/44.00D @111; OS: 42.75/43.75D @061. The patient's axial length measurement a year later with the IOL Master was OD: 24.67mm and OS: 25.38mm. The OCULUS Pentacam tangential topography map showed that the treatment zone was decentered about 3mm temporally OD and about 1.5mm temporally OS from the center of the pupil with her new orthokeratology lenses.

As shown, there was no clinically significant increase in axial length over a 12 month period as see with this patient with decentered treatment zones of her orthokeratology lenses for each eye.

Conclusion:
Decentered corneal treatment zones with orthokeratology lenses resulted in no clinically significant increase in axial length after 12 month period for this myopia control case.

P183: Characterization of the Shorter Eye in Highly Myopic Patients with high Axial Anisometropia

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Purpose:
High axial anisometropia is often assumed to result from unilateral visual deprivation in childhood, but the structural characteristics and risk of pathologic myopia complications in the shorter eye have not been investigated. We aimed to characterize the shorter eye in patients with high axial anisometropia using swept source optical coherence tomography (SSOCT).

Methods
This was a clinic based observational study in which patients with high myopia defined by a manifest spherical equivalent (SE) of ≤ -6.0 dioptres (D) or axial length (AL) of ≥26.5mm, were recruited from the High Myopia clinic of the Singapore National Eye Centre from January 2017 to December 2017. Patients with high axial anisometropia, defined as an axial length difference of ≥2.5mm, were included in this study. All patients underwent ocular biometry with the IOLmaster, fundus photography and SSOCT. Structural characteristics and complications of pathologic myopia in the shorter eye, including posterior staphylomata, dome shaped macula, myopic maculopathy (MMD), myopic traction maculopathy (MTM), and myopic choroidal neovascularization (mCNV) were described.

Results
Of 350 patients who attended the high myopia clinic, 51 patients (14.6%) had high axial anisometropia. The mean age was 64.1±2.10 years and 86.3% were female. Mean AL was 26.2±2.1mm in the shorter eye and 30.7±2.1mm in the fellow eye ($p<0.001$). 28 (54.9%) shorter eyes had AL < 26.5mm. Anterior chamber depth was not significantly different between eyes (short eye vs longer eye, 3.9±0.8mm vs 3.9±0.9mm, $p=0.97$). Visual acuity was significantly worse in the longer eye (logMAR best corrected visual acuity 0.99±0.60 vs 0.39±0.40, $p<0.001$). Posterior staphyloma was observed in the shorter eye of 18 (35.3%) patients. A structural explanation for anisometropia was apparent in 11(21.6%) eyes: 7 (13.7%) had staphylomata with non-foveal apex and 4 (7.8%) had dome shaped macula. The prevalence of MMD, mCNV and MTM was 56.9%, 10% and 6% respectively, in the shorter eye. In contrast, the prevalence of these complications in the longer eye were 98%, 34% and 44.9% respectively.

Conclusions
The shorter eyes in patients with high axial anisometropia could be attributed to the dome shaped macula or staphylomata with non-foveal apex, and therefore are also at risk of the complications of pathologic myopia.

P126: Corneal topographic and peripheral refractive changes with Dual Focus contact lenses in young myopic subjects

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Purpose: Several studies, already carried out, have demonstrated the effectiveness of multifocal or dual focus contact lenses in controlling the progression of myopia. A controlled, non-dispensing, random, cross-over study was conducted to test changes in peripheral refraction by the use of a contact lens to control the progression of myopia when using Dual Focus contact lenses (Misight 1 Day contact lens).

Methods: Fourteen myopic young adults (23.71 ± 5.41 years, 12 women) with spherical equivalent of -2.16 ± 1.41D were fitted with a baseline without refraction (baseline) and a Misight 1 Day contact lens in one eye. Axial and off-axis refraction were measured with an open-field autorefractometer before and after stabilized treatments. Off-axis measurements were obtained for the horizontal (35° nasal and temporal retina) and vertical (15° superior and inferior retina) meridians, and for two oblique directions (45–225° and 135–315°) up to 20° of eccentricity. The refractive profile was addressed as relative peripheral refractive error (RPRE). Anterior segment parameters were analysed with a Medmont E300 corneal topographer. Non-parametric comparisons between baseline and Misight 1 Day were performed.

Results: Peripheral refractions become significantly more myopic when myopia is corrected with LC Misight 1 Day. The change in peripheral refraction induced at 30º Temporal is -0.66D. The greatest induction of peripheral myopization was observed in the 25º Nasal (-0.74D) and 15º Temporal (-0.73D). Regarding the values of corneal topographies, for the radius of curvature of the flattest meridian the increase was greater than 2.4 in relation to the most curved meridian, this difference being 1.59±1.05 (p=0.001). Eccentricity decreases with placement of LC Misight 1 Day. SAI and SRI values are higher for LC Misight 1 Day with statistical significance (p=0.002) and (p=0.001), respectively.

Conclusions: Our results suggest that the use of LC induces a greater degree of myopic defocus in the temporal retina when compared to the nasal retina. The Misight 1 Day contact lens alters the refractive power of the anterior surface of the cornea. Corneal power decreased in the central zone and increased in four distinct zones, but never greater than the initial topography.

P84: Can we estimate variations in axial length in the control of myopia progression?

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Purpose: The aim of this study was to study whether mathematical formulations for estimating axial length based on refraction and keratometry can be applied to control myopia progression with contact lenses.

Methods: A retrospective study was performed on myopic patients using Dual Focus contact lenses (Misight 1 Day contact lens). The formulas were tested in 2 groups: One group (G1) of 110 myopes treated for one year (10.57±1.49 years [8 to 13 years], 53% female) and another group (G2) of 58 myopes treated for two years (9.78±1.70 years [6 to 14 years], 48% female). The analysis of the results was done taking into account the data obtained from refraction (Rx), axial length (AL), keratometry (Kx) and the age of the subjects at the baseline of the study and at the end of the treatments. Two mathematical formulas (F1 and F2) based on refraction and keratometry were used to calculate the AL.

Results: Data at baseline in G1 were M=-2.09±1.09 D, K=7.65±0.24 mm and 24.04±0.79 mm and in G2 of M=-2.35±1.13 D, K=7.77±0.28 mm and 24.33±0.85 mm. The use of formulas F1 and F2 did not show statistically significant differences in the calculation of AL in G1 and G2. However, the same result was not found when the differences between baseline and the end of treatment (one year in G1 or two years in G2) were analyzed. In G1 the changes that occurred after one year in AL were Real= 0.18±0.14mm, F1=0.12±0.24mm and F2=0.09±0.23mm (p=0.006 ANOVA, with Bonferroni test Real_F1 and F1_F2 non-significant). In G2, the differences after 2 years were Real= 0.52±0.28mm F1=0.34±0.26mm and F2=0.29±0.25mm (p<0.001 ANOVA, with Bonferroni test F1_F2 non-significant).

Conclusions: Our results suggest that although mathematical formulations are useful for estimating the value of axial length, they should be used with caution when estimating the AL progression in subjects using optical devices for controlling myopia progression. The two formulas underestimate AL values compared to the real values.

P26: Familial exudative vitreoretinopathy and high myopia

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Purpose: Myopia is the most common eye disease worldwide. Its incidence rate has been rising in the past decades, especially in East Asia. It is predicted that by 2050, nearly half of the world's population will become myopic, including 10% of patients with high myopia.High myopia can lead to vision threatening complications such as early cataract, glaucoma, retinal detachment, choroidal neovascularization, myopic macular degeneration and macular hemorrhage. Epidemiological investigation found that genetic factors have a significant impact on the occurrence and development of high myopia, and familial exudative vitreoretinopathy (FEVR) is a common blinding genetic eye disease, which is often accompanied by high myopia, resulting in retinal detachment and low vision. The purpose of this study was to explore the relationship between familial exudative vitreoretinopathy and high myopia.
Methods: A retrospective study was conducted on the probands diagnosed with FEVR from January 2020 to January 2021. The recorded case data and family history of the probands and their family members were reviewed, and the probands with familial exudative vitreoretinopathy with high myopia were screened. The slit lamp examination, naked eye vision, computer optometry, best corrected vision, eye axis length, color fundus photography, frequency domain optical coherence tomography and fluorescein fundus angiography were collected. The peripheral venous blood of patients and their families was extracted, and the whole genome DNA was extracted. The probands were screened for pathogenic gene mutations by using the whole exon sequencing technology. The suspicious gene mutations found were checked in HGMD to see if they were reported pathogenic mutations. If it is a new mutation that has not been reported, the pathogenicity of the new mutation should be evaluated according to the "Criteria and Guidelines for Interpretation of Sequence Mutations" published by the American Society of Medical Genetics and Genomics (ACMG) 2015.

Applied Bioinformation Analysis Software:Polyphen-2 (http://genetics.bwh.harvard.edu/pph2/)、

MutationTaster (http:// mutationtaster.org/)、SIFT(

http://sift.jcvi.Org/www/SIFT_chr_coords_submit.html)、PMut (http://
Mmb2.pcb.ub.es:8080/PMut/) and GERP++(http://wannovar.wglab.org/) Predict whether the mutation of candidate pathogenic genes will have a meaningful impact on the structure and function of the encoded protein, and preliminarily speculate the pathogenicity of the mutated genome sequence. If these softwares predict that the mutation of the candidate gene will cause functional damage, it will be presumed that this gene is the pathogenic gene causing the disease of this family. Sanger sequencing method was used to verify whether candidate pathogenic genes were co-isolated with clinical phenotype in all family members. Search the related literature of FEVR, analyze the relationship between high myopia and FEVR, study the expression of pathogenic genes related to FEVR in retina, explore the possible pathogenesis of high myopia, and further study the relationship between genotype and phenotype.
Results:A total of 8 probands of FEVR with high myopia were collected, and their refractive state was ≦-6.00DS. Fluorescein fundus angiography showed obvious peripheral retinal angiopathy. Among them, six probands were found to have disease-causing gene mutations, including LRP5 gene mutation c.G1123A(p.A375T), FZD4 gene mutation c.313A>G(p.M105V), CHM gene mutation c.T284C(p.I95T) and TSPAN12 gene mutation c.14_15insAAGA(p.D5fs) ,c.452A>T(p.N151I),c.543C>G(p.C181W).Looking back at the past history of 8 probands, 7 probands were diagnosed as "high myopia" before the age of 10. Among them, 3 cases found that the anisometropia of both eyes was equal to or greater than 2.5D days, and 2 cases had retinal detachment in one eye in adulthood. In fundus fluorescein angiography, it was found that the proband with LRP5 and FZD4 gene mutations had more severe peripheral retinal vascular disease than the proband with CHM and TSPAN12 gene mutations, and the probability of low vision damage

and retinal detachment was higher. Reviewing the related literature, it is reported that FEVR is one of the common blinding hereditary eye diseases, and its inheritance modes are diverse, including autosomal dominant inheritance, autosomal recessive inheritance, X chromosome linked recessive inheritance and other scattered inheritance modes. There is a high degree of genetic heterogeneity, and there is no fixed correspondence between genotype and phenotype. Most FEVR patients have been ill in infants and young children, and often have no history of premature delivery and oxygen inhalation. They are mainly found when seeing a doctor with high myopia and strabismus. Some patients don't show any eye symptoms at rest, only occasionally find that peripheral retinal vessels are not perfused during fundus fluorescein angiography, and there are new blood vessels in peripheral avascular areas and retinal junctions after vascularization. When total retinal detachment occurs, it can cause severe visual impairment or even blindness. It is difficult to check the peripheral fundus especially in mild condition or childhood, and it is easy to be missed and misdiagnosed, which often leads to serious complications. Therefore, early screening is of great significance to the treatment of this disease. Fluorescein retinal angiography and genetic screening are the main diagnostic methods of this disease.

Conclusion: Familial exudative vitreoretinopathy is prone to high myopia, which may be accompanied by anisometropia, especially in childhood. Further fundus examination with fluorescein retinal angiography and genetic screening for all children with high myopia are helpful to the early diagnosis and screening of familial exudative vitreoretinopathy and reduce the incidence of blindness.

P10: Systematic analysis of visual cues used by the retina to detect the sign of defocus during emmetropization

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Purpose: Until today, it is not understood how the retina detects the sign of defocus to fine-tune axial eye growth during development. Moreover, there is evidence that also accommodation does not simply minimize blur but rather responds to the vergence of light rays, using a yet unknown mechanism. To answer these questions, we are studying possible visual cues in young human subjects by presenting movies with tightly controlled visual features to induce transient changes in axial length as a measure of retinal output.
Methods: A group of 20 young adult emmetropic participants is involved in the study (age range 18 to 35 years old). Three main projects are in progress: (1) The role of longitudinal chromatic aberration (LCA) is studied by using achromatizing lenses which remove LCA, and RGB channels in the movies are spatially filtered to simulate real and inverted LCA. (2) To find out whether the retina can detect changes in ray vergence, perceived brightness changes are psychophysically recorded while a tunable lens is flipped in front of the eye between 0 and +3D, in rapid alternation with calculated defocus of the same magnitude in the visual target (after correction for changes in image magnification). (3) Further determining which peripheral retinal areas are required for emmetropization in the the foveal region, we use our custom-developed eye tracker to follow the position of the fovea in the movie and cover the fixated area by an isoluminant grey "patch" that obscures continuously the relevant foveal input.
Results: Experimental results will show (1) whether the emmetropic human retina is able to respond to simulated and inverted chromatic defocus to control eye growth to achieve the best focus for the M and L cone focal planes while blue remains myopically defocussed, (2) whether participants perceive changes in brightness when optical positive defocus is imposed, showing that the retina can respond to changes in vergence of light rays, (3) whether selective stimulation of the peripheral retina can significantly change axial length in the fovea, as has previously been found in monkeys.
Conclusions: After completion of these experiments, we believe that we will have a better understanding of the retinal tricks to detect the sign of defocus and process of emmetropization in young human subjects.

P20: The role of the PADHA10 gene in high myopia pathogenesis – further investigation

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Purpose: High myopia (HM) is caused by the interplay between environmental, genetic, and likely epigenetic factors. Here, in the experimental study, we investigated the role of PCDHA10 gene and its methylation in HM pathogenesis, and its potential as a noninvasive indicator of HM, detectable in blood samples.

Methods: Based on previously performed genome-wide methylation analysis of blood DNA of 18 Polish children with HM (refractive error of -6.0 D to −15.0 D, and axial length of 26.22 - 27.85 mm) and 18 matched controls, we retrieved CG dinucleotides with lower methylation levels in HM cases. The genomic region overlapping the exon 1 of PCDHA10 as well as selected sequence variants in the remaining regions of the PCDHA10 gene were Sanger sequenced in the studied children and members of a Polish family affected with HM.

Results: We currently suggested the decreased methylation of dinucleotide cg27494055 in the PCDHA gene cluster, as a probable indicator of HM in children (abstract at the conference of ESHG 2022, no. EP03.007). The cg27494055 is located within transcription start site-1500 region of PCDHA10 and intronic regions of PCDHA1–9 that are mapped at myopia locus MYP25 (5q31). Here, we present SNV in the cg27494055 CG dinucleotide that might influence the methylation signal. Its occurrence creates a potential binding site for YY1 transcription factor and causes demethylation of this site that might influence the expression. Also, we show that the SNV rs246073 in PCDHA cluster, previously associated with refractive error in Europeans (PMID:32231278), was more common in our control group, and did not fully segregated with HM in the studied Polish family. Furthermore, the nonsense variant rs200661444 (c.2017C>T, p.(Q673X)) in exon 1 of PCDHA10, detected in our previous exome sequencing (PMID:33711669), and predicted as disease causing, showed violation of Mendelian inheritance, and we found that one parent and two children are hemizygous for the exon 1.

Conclusions: The role of the PCDHA10 gene methylation is still inconclusive, but sequence variants in this gene might be involved in the HM pathogenesis. As the methylation results were obtained from blood samples, the next step would be a verification using the samples of ocular tissue.

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P24: Myopia-26, a female-limited early-onset high myopia, occurring in a Hungarian family

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Purpose
Myopia-26 (Myp-26), for the most part reported to be a female-limited form of early-onset high myopia (eoHM), is an ARR3-associated rare monogenic disorder, which has not gone through detailed phenotypic characterization previously. Our aim with this clinical genetic observational case series was to elucidate the exact genetic background; describe the whole clinical landscape; and based on the results to provide potential pathomechanisms for refractive error development in a five-generational Hungarian family displaying female-limited eoHM.

Methods
For genetic analysis whole exome sequencing and Sanger sequencing were performed. For phenotypic characterization comprehensive ophthalmological and electrophysiological testing were carried out.

Results
Whole exome sequencing of 2 individuals identified a novel nonsense mutation (c.214C>T, p.Arg72*) in the ARR3 gene, which was then confirmed by Sanger sequencing in all 18 investigated individuals. This pathogenic variant fully segregated with the Myp-26 disease in all available family members. Ophthalmological examinations did not reveal any signs of cone dystrophy as opposed to animal models. Electrophysiology and color vision tests similarly did not evidence a general cone system alteration, rather a central macular dysfunction affecting both the inner and outer (postreceptoral and receptoral) retinal structures in all patients with ARR3 mutation. Based on these results the cone- and the ganglion cell hypotheses are provided for refractive error development in this family.

Conclusions
This is the first description along with a detailed phenotypic characterization of a Caucasian family displaying Myopia-26. Two hypotheses are also presented that
could potentially explain the pathomechanism of ARR3-associated Myp-26 disease.

P132: Comparing children, teenagers, and young adults' subjective responses to myopia control contact lenses

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Purpose:
Myopia control (MC) efficacy in children is linked with compliance with wear time and quality of vision. There is little research on MC in teenagers and young adults and how their experience differs to children.
Methods:
Data were retrospectively reviewed from two double-masked, bilateral wear, crossover contact lens clinical trials in participants with myopia between -0.75D to -3.50D and less than 1.00DC. In both trials, study participants wore two MC contact lenses (stepped centre plus, one with a relative peripheral plus (RPP) of +1.50D and the other of +2.50D) and a single vision (SV) control. Each design was worn for one week. Participants were aged 18-35 years (young adults) in one trial and 9-17 years in the other (divided into two subgroups, children 9-13 years and teenagers 14-17 years). Data collected included Visual Acuity (VA), wearing time (hours) and subjective gradings of comfort, distance vision clarity, near vision clarity and overall vision (1-10 scale). Generalized estimating equations with subject random intercepts and identity link functions were used in analysis.
Results:
A total of 31 participant data were reviewed (10 children, 11 teenagers and 10 adults) with 61% female and no difference in gender balance between age groups. There was no difference between age groups for VA at dispensing with test ($p=0.55$) and control ($p=0.12$) lenses. After one week, all age groups could discriminate between lens types for subjective vision quality with the SV lenses having the best ratings and the lens with the RPP of +2.50 having the lowest (all $p<0.02$ for subjective ratings of distance, near and overall vision). There was no difference between age groups for subjective ratings of comfort, distance and near vision for test and control lenses. Children rated overall vision quality higher than teenagers and adults for both test and control lenses (test lenses: 8.1±1.7, 7.7±2.2, 6.5±1.9, respectively, and control lenses 9.8±0.8, 9.4±1.0, 8.9±0.9, respectively; $p<0.05$) but the difference in ratings between test and control lenses was not different for all age groups ($p>0.50$). Daily wear time was lower for children than teenagers and adults for all lens types including SV (all $p<0.02$). There was a higher wearing time for SV lenses compared to MC lenses for all age groups ($p=0.01$).
Conclusion:
Children, teenagers, and adults could discriminate subjectively between lens types for vision quality with ratings worsening with increasing RPP for all age groups. The subjective experiences appear no different between age groups relative to SV control lenses. Wear time varied between age groups and reduced with increasing RRP for all age groups.

P144: Comparison of Toric Orthokeratology and Soft Toric Multifocal Contact Lenses in Managing the Astigmatic Myope

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Purpose: When compared to individuals with no or low levels of astigmatism, there are fewer myopia management options for patients with moderate to high astigmatism. Current contact lens options include toric orthokeratology (TOK) and soft toric multifocals (STM). To date, no study has directly compared these treatments. This study aims to quantify visual performance and potential efficacy with TOK and STM contact lenses in the same cohort of myopic patients with moderate to high astigmatism.

Methods: Thirty adults, age 18-39 years, with myopia (plano to -5.00 D) and refractive astigmatism (-1.25 to -3.50 D) in both eyes (corneal plane) were recruited to complete this five-visit crossover study. Subjects were fitted with both TOK and STM lenses and wore them in random order for 10 ± 2 days each. There was a 14 ± 2-day washout between lens types. Visual performance and acceptance were measured with logMAR visual acuity and patient-reported outcome surveys. Cycloplegic peripheral refraction (Grand-Seiko WAM-5500) and wavefront aberrometry (iTrace) were measured to determine the lens' potential impact for myopia management. Friedman, Wilcoxon Signed Rank, and Chi-square tests were performed as appropriate, with Bonferroni adjustments for multiple comparisons.

Results: All visual performance measures (high-contrast, low-contrast, glare visual acuity) were reduced with TOK compared to STM (approximately 1.5 lines, all $p < 0.01$). The subset of participants ($n = 17$) who achieved acceptable vision (20/40 or better) with both lens types preferred TOK over STM for vision and overall (both $p < 0.01$). TOK resulted in more myopic defocus than STM at all locations (range -0.59 to -2.94 D, all $p < 0.05$) except at 20 degrees nasal and temporal in the left eye. Average (± SD) higher-order root mean square wavefront error (5 mm pupil) was significantly increased with TOK (0.64 ± 0.22 µm) versus STM (0.48 ± 0.11 µm, $p = 0.026$). TOK induced more primary spherical aberration (0.41 ± 0.16 µm versus 0.22 ± 0.14 µm) and coma root mean square (0.43 ± 0.19 µm versus 0.32 ± 0.13 µm) compared to STM (both $p < 0.05$).

Conclusions: Adult myopic astigmats with acceptable vision in both lens types preferred TOK. TOK induced greater peripheral myopic defocus and primary spherical aberration than STM, which may indicate improved efficacy for myopia management. Future work should assess these toric correction types longitudinally in children.

P64: Effect of Defocus Incorporated Multiple Segments (DIMS) lens on choroidal thickness in myopic children: 3 years result

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Purpose: To investigate the 3-year changes in subfoveal choroidal thickness of children involved in the previous clinical trial of Defocus Incorporated Multiple Segments (DIMS) lens.

Methods: Chinese myopic children who have completed the previous 2-year randomized clinical trial of DIMS lens (ClinicalTrials.gov: NCT02206217) were included. Those wearing DIMS lenses continued the lens wear while the children who wore single vision (SV) spectacle lenses as control switched to DIMS lens wear (Control-to-DIMS) in the third year. Myopia progression was monitored in terms of cycloplegic spherical equivalent refraction (SER) and axial length (AL), and choroidal thickness was measured every 6 months. Three horizontal and three vertical line scans across the macula were acquired by Heidelberg spectral domain OCT with enhanced depth imaging in both eyes. Choroids were auto-segmented from the OCT images by a custom-made algorithm via deep learning. Subfoveal choroidal thickness (ChT) of the right eyes were extracted and changes relative to the baseline or relative to the ChT at 24 months (M) were calculated and compared between groups. Changes were presented as mean ± SD.

Results: There were 65 and 55 children in DIMS and Control-to-DIMS group, respectively. Changes in SER and AL in DIMS group were -0.52 ± 0.69D and 0.31± 0.26mm, respectively over 3 years. Children wore DIMS lenses for 3 years in DIMS group demonstrated a significant thickening of choroid at 12M, 24M and 36M compared to the baseline (repeated measure ANOVA, $p < 0.0001$). Mean changes in ChT relative to baseline at 12M, 24M and 36M were 14.21 ± 23.74 µm, 15.94 ± 25.88 µm and 17.68 ± 30.66 µm, respectively. These changes were not statistically significant over time.
In Control-to-DIMS group, ChT significantly decreased in the first two years with SV lens wear compared to the baseline. However, a significant choroidal thickening at 36M compared to those at 24M was found after switching to DIMS in the third year (mean change: 10.80 ± 22.62 µm, paired t-test, $p=0.001$). The magnitude of the thickening was comparable to those observed at the first 12 months in DIMS groups (mean change: 14.21± 15.93 µm, unpaired t-test, $p > 0.05$).

Conclusion:
A significant thickening of the choroid was sustained in the schoolchildren with DIMS lens wear over 3 years. This finding indicated that the sustained myopic control effect by DIMS lens in the third year might be maintained via the choroidal thickening. An increase in choroid was also shown in the children started DIMS lens wear in the third year.

P150: Evaluation of a Mobile Fitting Application for Orthokeratology Contact Lenses

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Purpose
Close agreement between contact lens parameters determined by diagnostic fitting and empirical fitting tools can aid eye care professionals (ECPs) in fitting orthokeratology contact lenses in myopic and astigmatic patients. The aim of this retrospective data analysis was to compare diagnostically fit lens parameters to those recommended by the Paragon CRT® mobile application.

Methods
Subjects six to thirty-five years of age fitted with Paragon CRT® contact lenses at eight clinical sites with refraction sphere ranging from -0.50 to -6.00 DS with maximum cylinder of -1.75 DC were included. Subsequent Paragon CRT® and Paragon CRT® Dual Axis (Paflufocon D, CooperVision Specialty EyeCare) lens parameters were determined diagnostically, and lenses were dispensed. Subjects returned for appropriate lens fitting and ocular health follow up visits until lens parameters were optimized for visual correction and finalized for long-term overnight wear. Retrospective to lens fitting, refraction data, keratometry values, and corneal size was entered into the Paragon CRT® mobile app to determine the recommended Paragon CRT® lens parameters (Diameter, Base Curve, Return Zone Depth, and Landing Zone Angle). The app recommendation for the lens parameters were compared (mean deviation [MD] and standard deviation [SD]) within 1 step parameter changes to the eyes which achieved ideal, long-term diagnostically fit orthokeratology lenses.

Results
Parameters of Paragon CRT® lenses diagnostically fit to 357 eyes (138 myopic, 219 myopic astigmatic) from 186 patients were compared to the parameter recommendations of the Paragon CRT® mobile application. Lens diameter, Return Zone Depth, and Landing Zone Angle were all significantly correlated. The final optimized lens diameter was within ±0.50mm of the Paragon CRT® mobile application recommendation in 95% of eyes (MD 0.28mm, ±0.65 SD). 96% of Return Zone Depth (MD 11µm, ±17 SD) and 91% of Landing Zone Angle (MD 0.55º, ±0.74 SD) outputs from the app suggested the same parameter finalized by ECP diagnostic fitting. Base Curve comparison resulted in a mean deviation of 0.10mm (±0.13 SD).

Conclusion
The Paragon CRT® lens parameters recommended by the Paragon CRT® mobile application were in close agreement with diagnostically determined lens parameters. Given this high level of agreement, the Paragon CRT® mobile application can be confidently used as a clinical tool to aid in orthokeratology fitting success, saving valuable chair time.

P78: Significance of double-sided mirror training in the prevention and control of myopia in patients with moderate myopia with exophoric deviation and adjustment lag

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Objective: To compare and observe the effect and significance of myopia prevention and control in adolescent patients with moderate myopia with exophoria and delayed diagnmentosis and adjust after double-sided flip mirror training.

Methods: Retrospective analysis: 200 patients aged 9 to 11 who could exercise outdoors for 1-2 hours in the daytime every day , with myopia between -3.00D and -5.00D and accompanied by exophoria, were divided into two groups with whether to conduct double-sided mirror training, there were 100 patients in each group. All patients in each group were given ordinary monocletic glasses within one year, and all patients were diagnosed with adjustment lag. According to the doctor's advice, the first group of patients myopia（-3.85±0.68）D，BCC（1.00±0.63）D，exophoria（-3.2±1.23）△，insisted on wearing glasses every day. In the first month, they insisted on double-sided mirror training for 3 minutes for the right eye, 3 minutes for the left eye and 3 minutes for both eyes, a total of 9 minutes.After two months, they still insisted on double-sided mirror training every day. From the fourth month to the sixth month, they could keep double-sided mirror training every other day. In the last six months, they kept double-sided mirror training twice a week, with an interval of 2 to 3 days. The second group of patients，myopia （-3.60±0.59）D，BCC（0.42±0.25）D，exophoria（-2.94±1.08）△，did not train according to the doctor's advice and only insisted on wearing glasses every day. Patients in both groups could keep regular review according to doctor's advice.

Results: one year later, in the first group of 100 patients, myopia increases on average is（-0.40±0.29）D,BCC（-0.05±0.21）D,9 patients' myopia increased by more than -1.00d, 12 patients' myopia increased by -0.75d, 64 patients' myopia increased by -0.50 to -0.25d, and 15 patients' myopia did not increase. Among the 100 patients in the second group, myopia increases on average is （-0.79±0.28）D，BCC（0.45±0.24）D,42 patients' myopia increased by more than -1.00d, 35 patients' myopia increased by -0.75d, 21 patients' myopia increased by -0.50d to -0.25d, and 2 patients' myopia did not increase. The results of the two groups had statistical significance in myopia prevention ($P < 0.05$).

Conclusion: in the adolescent patients with moderate myopia with exophoria and diagnosed as regulating lag, double-sided mirror training of visual function has a better effect of myopia prevention and control.

P86: 3% Diquafosol Ophthalmic Solution Alter Ocular Surface parameter in Children Wearing Orthkeratology Lens

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• Purpose: This study investigate the efficacy of 3% diquafosol ophthalmic solution (DQS) on ocular surface in children wearing overnight orthokeratology (OrthoK).

• Methods: Nineteen participants (38 eyes) who wore OrthoK lenses every night and 27 (54 eyes) OrthoK lenses candidate (controls) were enrolled in this prospective observational study. All participants received 3% DQS four times per day for 1 month. Noninvasive keratograph tear film break-up time (NIKBUT,first and average), noninvasive tear meniscus height (NIKTMH), conjunctival hyperemia [redness score (RS)], blink pattern analysis, dry eye questionnaire(DEQ-5) were evaluated at baseline and 1 month after intervention.

• Results: Forty-six children completed the study. NIKTMH increased from 0.20±0.06 mm to 0.22±0.05 mm (t=3.88,p=0.00), NIKBUT-F and NIKBUT-A prolonged from 7.79±5.84 s to 10.50±6.27 s, from 10.00±6.22 s to 13.28±6.20 s (all $p < 0.05$) respectively, RS decreased from 0.65±0.29 to 0.53±0.28 (t=4.27,p=0.00) and DEQ-5 scores reduced from 9.18±3.86 to 8.04±3.06 (t=-2.83,p=0.00) ,while PBR didn't change significantly. The OrthoK group and controls had similar signifificant improvement in NIKBUT after intervention ($p < 0.05$). However, OrthoK group demonstrated higher improvement in NIKTMH and dry eye symptoms ($p < 0.05$). Within controls group, RS was improved significantly($p < 0.05$) but not in NIKTMH and DEQ-5.

•Conclusion: Short-term use of 3% diquafosol ophthalmic solution clinically reduced dry eye symptoms and also improve ocular surface parameter in children wearing overnight orthokeratology.

P6: AI-Assisted Prescription Determination for Orthokeratology Lens Fitting:From Algorithm to Clinical Practice

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Purpose: Orthokeratology (OK) is widely used for myopia control, but there is a large gap between demand and supply of experienced practitioners. The objective of the study was to explore the potential of artificial intelligence (AI) to assist prescription determination for OK lenses.
Method: The study involved two stages: 1) development of a machine-learning-based decision-making algorithm using historical data; 2) evaluation of the proposed approach's performance in a real-world trial.A total of 11,502 records collected from 7 clinical environments covering almost all major brands of OK lenses were randomly divided in a three-way data split. For each of the three OK lens parameters, cross-validation was used to identify the most accurate algorithm, followed by an evaluation based on an independent test dataset. An online AI-assisted system was then implemented and further assessed in a real-world trial involving four junior and three senior clinicians.
Results: In stage I, accuracy (ACC) was the primary metric used to evaluate the candidate algorithms' predictive performance. In stage II, the primary outcomes used to assess the AI-assisted system's efficiency and efficacy was the number of trials taken to specify a final prescription and 1-month unaided visual acuity, respectively. The Support Vector Machine Regressor (SVMR) algorithm performed best in predicting targeted reduction amplitude (ACC=0.80) and lens diameter (ACC=0.82). The Gradient Boosting Regressor (GBR) algorithm achieved the best performance for the prescription alignment curve (ACC=0.83). With the assistance of the AI system, the number of trials needed to arrive at the final prescription was significantly reduced for six of the seven participating clinicians (all $P < 0.01$). This reduction was more significant among junior clinicians than among consultants (0.76 ± 0.60 vs 0.32 ± 0.60, $P < 0.001$). Junior clinicians also achieved clinical outcomes comparable to their seniors, as 93.96% (140/149) and 94.44% (119/126), respectively, of the eyes fitted achieved unaided visual acuity no worse than 0.8 ($P = 0.864$).
Conclusions: Combining AI algorithm development and real-world validation, the findings confirm that AI can assist prescription of OK lenses by improving efficiency and reducing discrepancies in clinical outcomes among clinicians with differing levels of experience. The embedment of AI in practice should ultimately help to lessen the medical burden and improve service quality for myopia boom emerging across the world.

P14: Effect of myopia control contact lenses on choroidal thickness

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Research purpose: Research exploring the visual regulation of eye growth has identified the human choroid's ability to rapidly alter its thickness in response to visual blur. With current optical myopia interventions adopting deliberate peripheral myopic defocus, this research examined relative changes in subfoveal choroidal thickness (SFCT) following a day's wear of two commercially available, CE-marked soft contact lenses marketed for myopia control.
Methods: Fifteen young myopic adults (mean age23.1±4.6years, MSE-2.52±1.40D) participated in a masked, randomised study. Choroidal images were obtained with Enhanced Depth Imaging Optical Coherence Tomography following 8 hours of unilateral wear of two daily multifocal contact lenses (MiSight®[Coopervision] and NaturalVue®[Visioneering Technologies]) and a single vision daily contact lens (Proclear®[CooperVision]). Time of day for imaging was kept constant. Subfoveal choroidal boundaries were manually segmented, by a masked observer, using ImageJ software, and 5SFCT measurements were averaged per lens design. This study was 80% powered to detect an 8.5µm change in choroidal thickness.
Results: The resultant mean SFCT was thickest with MiSight® (362.8±43.3µm), followed by NaturalVue® (358.9±47.8µm) and thinnest with Proclear® (334.9±51.9µm). One-way repeated-measures ANOVA confirmed these differences not to be statistically significant (all $p>0.05$).
Conclusions: Considering the variable relative plus power with multifocal designs, a greater choroidal thickness would be expected relative to single vision lens wear. However, these results suggest NaturalVue or MiSight contact lenses didn't produce any detectable change in choroidal thickness at a subfoveal level, at least in young adults. Further research is warranted to explore the wider choroidal profile following exposure to such defocusing lenses.

P160: A novel use of multifocal scleral lenses used in combination with low-concentration atropine in a highly myopic child

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Purpose: To highlight a clinical case utilizing multifocal scleral contact lenses (MFSCLs) in combination with low-concentration atropine as a treatment option for myopia control in a highly myopic pediatric patient with non-compliance in multifocal corneal gas permeable contact lenses (MFGPs).
Methods: The patient was fit into distance-center MFSCLs. Clinical data was collected including age, sex, best-corrected visual acuity, refraction, biometry, topography, contact lens parameters, binocular vision findings, and ocular health findings.
Results: The 10-year-old female's spherical equivalent refraction was -12.75 diopters (D) in the right eye and -16.00 D in the left eye with a visual acuity of 20/30 in each eye with spectacles due to mild amblyopia. To limit myopic progression, she was prescribed atropine 0.05% QHS OU and concurrently fit into MFGPs as she was outside the range of parameters offered by multifocal soft contact lenses. The patient had poor compliance with MFGPs due to inadequate comfort and discontinued wear. Given the patient's high refractive error and continued axial length progression, distance-center MFSCLs were recommended as a form of combination treatment. The patient was successfully fit and reported improved comfort, improved visual acuity, and willingness to wear these lenses more consistently. Ocular health revealed bilateral tilted optic nerve and posterior staphyloma, consistent with high myopia.
Conclusions: Contact lenses can significantly benefit patients with high myopia due to reduced minification effects, freedom from heavy spectacle lenses, and elimination of prism or peripheral distortion from decentration. MFSCLs may be a viable treatment option in the myopia control setting as a means to provide peripheral myopic defocus on the retina. Multifocal optics in soft contact lenses have been proven to be efficacious in slowing myopia progression, but there is limited research exploring comparable multifocal optics in gas permeable lenses. Similarly, there are limited studies regarding combination therapies. However, given the patient's limited contact lens options available in her prescription, she was prescribed a combination of low-concentration atropine and distance-center MFSCLs to give her the best opportunity at limiting myopic progression. Further studies must be done to determine the short and long-term efficacy of combination therapy and multifocal optics in gas-permeable contact lenses.

P142: Investigation of association between myopia risk loci and human cone-driven retinal electrical responses to flicker stimuli

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Purpose

Over 450 genomic regions have been identified conferring susceptibility to refractive error through genome-wide association studies. Light-signalling by the retina is believed to be important in driving eye growth. We recently found an association between a specific locus near the GJD2 gene and retinal cone-driven flash responses. In the present study, we explored associations between a group of known myopia-associated variants and electroretinogram (ERG) responses to light-adapted flicker stimuli recorded in healthy adults.

Methods

Over 1600 twins from the TwinsUK cohort underwent ERG recordings as part of wider studies. One subset (group 1) included 786 genotyped subjects who underwent non-mydriatic ERG recording (RETeval system, LKC technologies, Gaithersburg, MD) with skin electrodes to flicker stimuli designed to deliver retinal illuminance equivalent to the international standard. Another subset (group 2) included 185 participants who underwent conventional standard mydriatic 30 Hz ERG recording (Colordome, Diagnosys UK, Cambridge, UK) with conductive fibre electrodes following 10 min light adaptation to the standard light-adapting background. Flicker ERG peak times were normalised before analyses. Associations between 334 known myopia risk loci and ERG peak times were tested using linear mixed models with adjustment of age, sex and familiar relatedness in the two groups. Summary statistics from the two groups were pooled for a fixed-effect inverse variance meta-analysis.

Results

The two groups were of comparable age and both predominantly female. The same polymorphic variant, rs13268738 within CNGB3, was identified among the most significant associations observed in both subsets. This locus ranked 4th in group 1 ($p=0.0148$) and 2nd in group 2 ($p=0.0053$), remaining statistically significant ($p=0.0005$) in meta-analysis. The flicker ERG responses of those with two risk alleles at the locus showed an earlier peak time than those without risk alleles in both groups.

Conclusions

CNGB3 encodes one subunit of the cyclic nucleotide-gated (CNG) channel, which is expressed in cone photoreceptor outer segments and mediates their electrical response to light. Rare pathogenic variants in this gene cause achromatopsia. The observed association of this myopia risk variant with flicker ERG peak time in two groups of participants and the meta-analysis findings provide further evidence that changes in cone-driven signalling contribute to myopia development.

P138: One-year results of Orthokeratology for High Myopia (OHM) study

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Purpose: To compare the myopia control efficacy of partial reduction (PR) and full reduction (FR) orthokeratology (ortho-k) lenses in highly myopic children over one year.

Method: Children with myopia of -5.00 D or more and aged 7 to <14 years were randomly assigned to PR and FR ortho-k groups. Children in the PR group were corrected using 4-zone five-curve ortho-k lenses targeting a -4.00 D correction, and children in the FR group were fitted with 4-zone six-curve ortho-k lenses, targeting full-correction. Residual refraction was corrected with single vision spectacles for both groups if necessary. Participants attended routine aftercare visits following one night, one week, two weeks, and one month of lens wear, and every three months thereafter. Axial length (AL) was measured every six months following cycloplegia using the IOLMaster. The eye with higher baseline myopia or longer baseline AL (if the degree of myopia was the same in both eyes) was selected for data analysis and presentation.

P181: The characteristics of the optic disc in young high myopia people

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Purpose This study aimed to investigate the characteristics of the optic disc in adolescents and young adults with high myopia via applying optical coherence tomography angiography (OCTA).
Methods A total of 115 patients aged 12 to 30 years old were enrolled in this cross-sectional study. The patients were divided into two groups based on age: 55 in the adolescent group, 60 in the young adult group. Peripapillary retinal nerve fiber layer (pRNFL) and radial peripapillary capillary vessel density (RPC VD) around the optic disc were obtained on the images of optic disc angio scan. Parapapillary atrophy (PPA) and ovality index (OI) from scanning laser ophthalmoscopy images, and the degree of optic disc tilt from the optic nerve head (ONH) OCT B-scans were analyzed by Image J and Matlab software.
Results The PPA area of the young adult group increased and the OI decreased compared with adolescents, while the two groups had no difference in the degree of optic disc tilt. There was no significant difference in the average pRNFL between the two groups, while in contrast RPC VD existed in the young adult group ($p = 0.029$). Age was positively correlated with PPA area ($r = 0.198$, $p = 0.034$), and RPC VD ($r = 0.201$, $p = 0.031$), but there was no correlation between age and the degree of optic disc tilt or OI.
Conclusions In young high myopia patients, the effect of age on characteristics alteration of the optic disc should also be considered.

Results: 31 subjects (18 PR and 13 FR), median [range] age of 12.0 [8.6, 14.0] years and myopia of -6.00 [-9.75, -5.25] D, completed the one-year visit. No significant differences were found in baseline characteristics and demographics between the two groups. After one year, the change in myopia from baseline was greater in FR subjects (PR: 4.50 [2.50, 5.50] D; FR: 5.25 [2.50, 6.75] D; p=0.02), and residual myopia was less in the FR subjects (PR: -1.63 [-5.75, 0.00] D; FR: -0.50 [-4.25, 0.75] D; p=0.08). No significant difference was observed in axial elongation (PR: 0.02±0.17; FR: 0.02±0.14mm; p=0.95). Multiple linear regression analysis showed that axial elongation was significantly correlated with the change in myopia (standardized beta = -0.58, p =0.004) but not with sex, age, group, baseline myopia or baseline AL (p>0.14).

Conclusions: Both PR and FR ortho-k lenses retarded myopia progression effectively in highly myopic children. As anticipated, the FR lenses produced a greater reduction in myopia and less residual myopia. A greater reduction in myopia was also associated with less axial elongation when controlling for other confounders.

P162: Improving Accommodation During Multifocal Soft Contact Lens Wear for Myopia Management in Children May Increase Treatment Efficacy

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Purpose: Nearwork has long been associated with myopia development as a risk factor. Home confinement and prolonged computer work during the COVID19 pandemic appears to further increase myopia prevalence and progression (Wang 2021). Multifocal soft contact lenses (MFCLs) are effective in slowing myopia progression but with variable efficacies. Reduced accommodation while wearing MFCLs (Kang 2016, Gong 2017, and Wagner 2020) may partly account for the differences in treatment efficacy. In this presentation we will summarize our recent studies on accommodation during MFCL wear for myopia management.

Methods: Myopic children with normal binocular functions and no history of myopia management were recruited. Subjects were fit with Biofinity MFCLs with a +2.00 D ADD Center Distance design OU and wore them for at least 10 hrs/d and 5 d/wk for 1 yr. Accommodative responses to 2, 2.5, and 4 D stimuli during MFCL wear were measured repeatedly under binocular conditions with a Grand Seiko autorefractor over 1 yr. The gains of the accommodative stimulus-response functions were estimated by the slopes of linear regressions fit to each subject's data. Wet refractive error (RE) and axial length were measured at the baseline and 1 yr later.

Results: Low to moderate myopes (5M:5F) were 10.80 yo when enrolled. While the accommodative gains were similar between paired eyes at the initial fit (OD 0.80 ± 0.14, OS 0.90 ± 0.12), they varied significantly among subjects (OD –0.10 to 1.42, OS 0.41 to 1.35; $p < 0.01$) and could predict future myopia progression and axial elongation: Lower accommodative gain was correlated with more myopia (OD $y = 0.84x – 1.09$, $p < 0.05$; OS $y = 0.61x – 0.86$, n.s.) and greater axial elongation (OD $y = –0.27x + 0.44$, OS $y = –0.33 + 0.46$; $p < 0.05$ for both) at 1 yr. There were fluctuations in the accommodative gain over time but did not change over time for each eye. This variability persisted over 1 yr.

Conclusions: Our findings suggest that children with higher accommodative gains during MFCL wear experience more ADD power leading to more effective myopia management, supporting data from a previous study (Cheng 2019), although some studies did not find correlations between accommodation and myopia progression (Lan 2008 and Chen 2020). In contrast to a previous study (Ozkan 2018), we did not find significant adaption to MFCLs in accommodative responses over 1 yr. Auditory accommodative biofeedback training during MFCL wear may help improve the efficacy of MFCLs for myopia management (Wagner 2020).

Assessing the contribution of genetic nurture to refractive error

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Purpose: Genetic nurture describes the indirect transmission of genetic susceptibility from parents (or other relatives) to offspring via the environment that parents create for their children. Genetic nurture is thus distinct from the direct transmission of risk alleles from parents to offspring. This study aimed to assess the contribution of genetic nurture to the genetic risk of refractive error.

Methods: The genetic risk of refractive error, also known as the 'single nucleotide polymorphism (SNP) heritability', was estimated in a sample of 1,944 pairs of adult siblings from the UK Biobank project. The contribution of genetic nurture was inferred from a comparison of a within-family estimate of the SNP heritability and a non-within-family estimate, following the approach of Brumpton et al. (doi: 10.1038/s41467-020-17117-4). The instrumented polygenic score approach of DiPrete et al. (doi: 10.1073/pnas.1707388115) was used to estimate SNP heritability.

Results: The non-within-family SNP-heritability for refractive error was estimated as 0.213 (95% confidence interval 0.134 to 0.310) while the within-family SNP-heritability was estimated as 0.250 (0.152 to 0.372). The similarity in these two estimates suggested minimal contribution from genetic nurture.

Conclusions: These results imply that the genetic contribution to refractive error is principally an intrinsic effect from alleles transmitted from parents to offspring.

Whole exome sequencing of known eye genes reveals genetic causes for high myopia

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Purpose: High myopia (refractive error ≤ -6 diopters (D)) is a heterogeneous condition, and without clear accompanying features it can be difficult to pinpoint a genetic cause. This observational study aimed to evaluate the utility of whole exome sequencing (WES) using an eye disorder gene panel in European patients with high myopia.

Methods: Patients with high myopia were recruited by ophthalmologists and clinical geneticists. Clinical features were categorized into isolated high myopia, high myopia with other ocular involvement or with systemic involvement. WES was performed and an eye disorder gene panel of ~ 500 genes was evaluated.

Results: 113 patients with high myopia (mean (SD) refractive error - 11.8D (5.2) were included. Of these, 53% were children younger than 12 years of age (53%), 13.3% were 12-18 years, and 34% were adults (aged over 18 years). 23 out of 113 patients (20%) received a genetic diagnosis of which 11 patients displayed additional ocular or systemic involvement. Pathogenic variants were identified in retinal dystrophy genes (e.g.GUCY2D, CACNA1F), connective tissue disease genes (e.g. COL18A1, COL2A1), non-syndromic high myopia genes (ARR3), ocular development genes (e.g. PAX6) and other genes (ASPH, CNNM4).

Conclusions: In 20% of our high myopic study population WES using an eye gene panel enabled us to diagnose the genetic cause for this disorder. Eye genes known to cause retinal dystrophy, developmental or syndromic disorders can cause high myopia without apparent clinical features.

Identification of genetic loci with differential effects on myopia and hyperopia using a case-case genome-wide association study

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Purpose
GWAS to date have largely used the quantitative trait of spherical equivalent to identify genetic loci which influence refractive error. A new genetic test, case-case GWAS (CC-GWAS, Peyrot et al, Nat Genet 2021) has been described to identify genetic differences between disorders. We used CC-GWAS to identify loci with stronger influences at one or other end of the spectrum (myopia or hyperopia).
Methods
We used results obtained from GWAS of directly measured spherical equivalent in 102,117 population-based UK Biobank participants, aged 40-70, creating case-control GWAS for myopia and hyperopia. CC-GWAS was used to test for differences in allele frequency between cases of hyperopia and myopia using summary statistics from the respective case–control GWAS. CC-GWAS weights the effect sizes from the respective case–control GWASs using weights that minimize the expected squared difference between estimated and true effect sizes, referred to as CC-GWAS ordinary least squares (CC-GWAS-OLS) weights.
Results
Genetic loci with the strongest differential influences across the refractive error spectrum included KCQN5 (rs7744813, OLS p=8.4E-56, exact p=2.9E-54), GJD2 (rs634990, OLS p=4.71E-52, exact p=1.0E-49), LRRC4C, RBFOX1, GNB3 and RASGRF1, and LAMA2 (rs12193446, OLS p=1.8E-70, exact p=3.3E-66), BLOC1S1-RDH5 (OLS p=3.5E-29, p exact=1.7E-28), PRSS56 and TOX genes.
Conclusions
This novel analysis has detected genetic effects that are unevenly distributed across the spectrum of spherical equivalent, namely SNPs that have stronger (or less strong) association with myopia than hyperopia. This may aid prioritisation in investigation of myopia-related genes and mechanisms.

Education interacts with genetic variants near GJD2, RBFOX1, LAMA2, KCNQ5, TOX and LRRC4C to confer susceptibility to myopia

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Purpose: It has long been hypothesised that interactions between genetic variants and educational exposure could confer susceptibility to myopia, but few such interactions have been identified. We performed a two-step screening strategy consisting of a genome wide association study and follow-up variance heterogeneity analysis to prioritise genetic variants for subsequent genotype-by-education interaction tests.

Methods: Two samples of unrelated participants from UK Biobank were included in the study. All participants were of European ancestry. The first 'discovery sample' consisted of 88,334 participants (53% female, mean age 57.7 years) whose refractive error (avMSE) had been measured by autorefractometry. A second 'validation sample' of 252,838 participants (55% female, mean age 58.2 years) had not undergone autorefractometry but had self-reported their age-of-onset of spectacle wear (AOSW). The first step of the screening strategy in the discovery sample consisted of a genome wide association study for avMSE. The second step was a variance heterogeneity analysis for avMSE, with the variants identified in the first step. Finally, genotype-by-education interaction tests were performed in the validation sample for the AOSW outcome (a proxy for avMSE), where University education was coded as a binary exposure. 35% of participants in the validation sample reported University level education, and the average age for leaving full-time education was 17 years of age.

Results: In total, 29 genetic variants were prioritised by the 2-step screening strategy in the discovery sample after Bonferroni correction (variance heterogeneity $P < 5 \times 10\text{-}5$). We found evidence of genotype-by-education interaction for 6 genetic variants in the validation sample ($P < 1.72 \times 10\text{-}3$). These variants were located near the genes TOX, GJD2, LAMA2, RBFOX1, KCNQ5 and LRRC4C. University-level education was associated with increased effect of the risk allele for all 6 variants.

Conclusions: In this cohort, University-level education was associated with an enhanced effect of 6 genetic variants conferring susceptibility to myopia; these variants have roles including axon guidance and the development of neuronal synapses and neural circuits.

The major heritable risk factors for myopia and the implications for its mechanism and prevention

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Purpose
Specific haplotypes of the human long- and middle-wavelength cone opsin genes (OPN1LW and OPN1MW, respectively) cause mis-splicing and are associated with high myopia. These genes show extreme haplotype diversity. Thus, we investigated the potential role of OPN1LW in common myopia.

Methods
To determine whether single nucleotide polymorphisms (SNPs) that occur with high frequency in the normal population are significantly associated with exon 3 exclusion from mRNA, OPN1LW minigenes representing 128 exon 3 haplotypes were used in minigene assays to measure their effects on pre-mRNA splicing. We calculated spherical equivalent refractions (SERs) from Zeiss IOL Master measurements and sequenced exons 2, 3, & 4 of the OPN1LW and OPN1MW genes of males of European ancestry who were unselected for refractive errors. We compared SERs for subjects differing at exon skipping SNPs. We also explored the amount of common myopia explained by opsin gene polymorphisms with a split halves analysis.

Results
Three common SNPs were significantly associated with exon 3 skipping. For the SNP with the largest effect, there was a 12.7 fold difference in the median percentage of exon 3 skipping ($p<0.0007$). There was a 1.36 diopter mean difference in SER for the males who differed at this SNP. This is the largest effect size of an SNP associated with common myopia ever discovered. The split halves analysis revealed an association between common opsin exon 3 haplotypes and mean SER that was highly significant ($p = 4.51e-09$), and the amount of variance accounted for by polymorphism at the opsin locus was 4.9%. Thus, polymorphisms in these genes are the single major heritable risk factor for myopia, and they are the major source of unaccounted for heritability of myopia.

Conclusions
Cone photoreceptors expressing exon 3 skipping haplotypes of the OPN1LW and OPN1MW genes have substantially less photopigment than cones in the same retina expressing non-exon-skipping haplotypes. Thus, the defective gene causes the cones expressing it to be inefficient in absorbing light, so for patients with the mutations, the retina detects the disparate signals from adjacent normal and mutant cones as visual contrast. This suggests that abnormal contrast signaling causes genetically driven and environmentally induced myopia, and spectacles designed to reduce contrast can slow myopia. This has been borne out in a 3-yr randomized controlled multicenter clinical trial (ClinicalTrials.gov: NCT03623074).

A comparison of the role of different retinal cell lines in refractive error and myopia

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Purpose. Refractive errors and myopia are caused by different mechanisms involving multiple tissues and cell populations. Photoreceptors and other cells in the different retinal layers are believed to influence the population variation of spherical equivalent and participate in the pathophysiological mechanisms causing myopia. However, the exact influence of retinal cells in processes that determine the spherical equivalent has never been quantified and the roles of each cell subpopulation in myopia have never been compared.
Methods. We ran LD score regression-based enrichment analyses to estimate how the transcriptome profile of each retinal cell line is overrepresented and best explains the results of a large scale (N=542,934 subjects) genome-wide association study of refractive error. We obtained the transcriptomic profiles of the different cell subpopulations present from previously published scRNAseq experiments in samples obtained from human retinas.
Results. Among the refractive error GWAS results, we observed the strongest enrichments for genes expressed in cone cells (p=0.0008). Two of the several subpopulations of rod cells showed the second strongest enrichment (p=0.002 and 0.02 respectively). Other rod cell subpopulations were not significantly enriched. The retinal pigment epithelium (RPE) and Amacrine cells were also among the tissues with transcription profiles enriched in the refractive error GWAS results (p=0.006 and 0.01 respectively).
Conclusions. These findings confirm the important role played by photoreceptor cells in the pathophysiology of refractive error and myopia. Our analyses highlight important roles played by the retinal outer segment (RPE) and amacrine cells.

Identification of non-coding regulatory elements for myopia by genome-wide scans

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PURPOSE. To identify non-coding regulatory elements, such as microRNAs (miRNAs), miRNA-binding sites, putative enhancers and long non-coding RNAs (lncRNAs) associated with myopia on a genome-wide scale.

METHODS. First, we investigated the association between miRNAs, miRNA-binding sites, enhancers and lncRNAs with myopia by performing genome wide look-ups for genetic variants in these elements in the summary statistics of one of the largest GWAS meta-analysis of myopia and refractive error from the CREAM consortium and 23andMe. Significance threshold was determined using Bonferroni correction for multiple comparisons. We obtained the genetic variants of regulatory elements from publicly available databases: miRNASNP v2 (N=2420 miRNAs), PolymiRTS (N=401,000 miRNA-binding sites), VISTA (N=1913 enhancers), FANTOM5 (N=7944 enhancers) and lncRNASNP2 (N=10,205,295 lincRNAs). Second, we constructed biological plausibility scores for the role in myopia development for the genetic variants associated with miRNA-binding sites and enhancers. These scores were based on characteristics of the genetic variant, the target/host gene(s) and the characteristics of the non-coding regulatory element. Third, we investigated the correlation between all associated genetic variants in non-coding regulatory elements and clinically relevant parameters. We constructed genetic risk scores of these variants derived from GWAS data of an independent replication cohort, the child population cohort Generation R (N=3,638 children), and subsequently performed linear regression analysis on axial length (AL) elongation of the eye between 6-9 years, AL elongation between age 10 and 13, axial length/corneal radius (AL/CR) at age 13 and spherical equivalent (SphE) at age 13.

RESULTS. We found three miRNAs (PBonferroni= 1.36E-04; NSNPs=8), 46 miRNA-binding sites (PBonferroni=7.55E-07; NSNPs=78), 28 enhancers (PBonferroni-VISTA= 4.27E-06, PBonferroni-FANTOM5= 5.40E-06; NSNPs=44) and 245 lncRNAs (PBonferroni=1.15E-07, NSNPs=417) associated with refractive error and myopia. Interestingly, we found overlapping genetic variants in lncRNAs and miRNA-binding sites (n=7), and overlapping genetic variants in lncRNAs and enhancers (n=3). Furthermore, we found five enhancers near lncRNA coding regions. GRS of miRNAs and miRNA-binding sites were not significantly associated with myopia related traits in Generation R, while GRS of the enhancer candidates were significantly associated with AL progression between 9-12 years, AL/CR at 13 years and SER at 13 years ($P < 0.05$). Moreover, GRS of lncRNAs were significantly associated with all axial length traits ($P < 0.05$) and borderline significant with SphE ($P = 0.053$).

CONCLUSIONS. Our study is one of the first studies on non-coding regulatory elements for myopia development and the putative interplay of these elements. We prioritized several candidate non-coding elements for functional validation and our results indicate that enhancer elements could be of most importance as it is associated with childhood myopia.

Associations of gene polymorphisms and life style with anisometropia in children: the Hong Kong Children Eye Genetics Study

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Purpose: The roles of genetic and environmental factors in anisometropia are unclear. This study investigated the associations of gene polymorphisms and life style, especially near work and outdoor time, with anisometropia in school children.
Methods: Eight single-nucleotide polymorphisms (SNPs) in ZC3H11B, ZFHX1B, KCNQ5, MET, SNTB1, PAX6, GJD2 and BMP2, which have reported association with myopia, were analyzed in 1057 children aged 5-10 years on both baseline and 3-year follow-up data. Anisometropia was defined by an interocular difference (IOD) in spherical equivalent (SE) of ≥1D (Aniso-SE) and an IOD in axial length (AL) of ≥0.3mm (Aniso-AL), respectively. Genetic associations of individual SNPs, joint-SNP effects, and gene-environment interactions were analyzed.
Results: Only 2 of the 6 SNPs showed significant associations. At baseline, ZFHX1B rs13382811 was associated with Aniso-AL (OR=1.64, P=0.004). At the 3-year follow-up, it became nominally associated with Aniso-SE (OR=1.39, P=0.02) whilst association with Aniso-AL (OR=1.48, P=0.001) remained significant. The PAX6 rs644242 was significantly associated with Aniso-AL at 3-year (OR=1.45, P=0.002). In longitudinal analysis, PAX6 rs644242 was associated with the development Aniso-AL at 3-year follow-up in children who had no anisometropia at baseline (OR=1.61, P=0.0004) and nominally with Aniso-SE development (P=0.03). In joint-SNP analysis, children carrying the risk allele T of ZFHX1B rs13382811 and allele A of PAX6 rs644242 had a 4.5-fold and 6.66-fold of increased risk of Aniso-SE and Aniso-AL, respectively. Both SNPs had mildly significant interaction with near work and outdoor time.
Conclusions: This study has identified two susceptible loci for anisometropia development in children, with mild interactions with near work and outdoor time. The two genes could be involved in imbalanced refractive changes in the both eyes.

Axial length distributions in patients with genetically confirmed inherited retinal diseases

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Purpose
To investigate axial length (AL) variation, a proxy for refractive error, in patients with molecularly characterized Inherited Retinal Diseases (IRD), comparing with reference cohorts. IRDs are associated with a high prevalence of refractive error and the causal gene associated with retinal cell dysfunction is increasingly understood.

Methods
A cross-sectional natural history study of patients recruited from the IRD clinics at two centres (Moorfields Eye Hospital, London, UK; Medical College of Wisconsin, Milwaukee, WI, USA) was performed. Distributions of AL for each IRD were examined. Comparison was made against reference cohorts (TwinsUK, Raine Study Gen2-20, and published studies). Comparing against the Raine study Gen2 cohort, Firth's logistic regression models for an AL ≥ 26mm and ≤ 22mm were constructed with adjustment for age and sex in unrelated individuals.

Results
435 patients (median age 19.5 years) had available measurements. Of 19 different molecularly characterized IRDs, 10 had >10 participants: ABCA4 retinopathy; CNGB3- and CNGA3-associated achromatopsia; RPGR-associated disease; RPE65-associated disease; Blue Cone Monochromacy (BCM); Bornholm Eye Disease (BED); TYR and OCA2-associated oculocutaneous albinism; GPR143-associated ocular albinism. Compared to reference cohorts [TwinsUK - n=322, median age 65.1; Raine Study cohort - n=1335, median age 19.9], AL distributions were wider in IRD groups. Increased odds ratios for longer AL were observed for BCM, BED, RPGR, RPE65, OCA2 and TYR; the highest odds of an AL ≥ 26mm were seen for BCM (adjusted OR 51.67, p<0.001). Increased odds ratios for short AL were observed for RPE65, TYR and GPR143; the highest odds for a short AL were seen for GPR143-associated ocular albinism (adjusted OR 56.20, p<0.001). Sub-analysis of RPGR-associated disease, identified longer average AL in cone-rod dystrophy (n=5) than rod-cone dystrophy (p=0.002).

Conclusion
We identified increased odds ratios for a longer AL in several diseases (highest OR in BCM) and increased odds of a shorter AL in some (highest OR with GPR143). Albinism genes were associated with different effects on AL. Individuals with RPE65- and TYR-associated disease showed increased odds ratios for longer and for shorter eyes. These results can aid in the complete phenotypic assessment in inherited retinal disease, whilst exploration of errors in retinal signaling could provide insights into processes driving axial myopia and emmetropization.

Investigation of association between the myopia risk locus near GJD2 and electroretinogram responses

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Purpose

The common variant most strongly associated with myopia is near the GJD2 gene, which encodes gap junctions, mediating electrical coupling between retinal neurons. The electroretinogram (ERG) represents the electrical light-evoked retinal response. We tested the hypothesis that alterations in retinal electrophysiology might associate with allelic genotype at this myopia-susceptibility locus.

Methods

ERGs were analysed from adult twin volunteers who had been genotyped at the locus of interest. Participants underwent ERG recordings comprising international standard stimuli and experimental procedures. After adjusting for age, sex, and family structure, a mixed linear model was used to investigate the relationship between allelic dosage at the locus and international standard ERG parameters. Similar ERG procedures were conducted with patients with selective loss of post-receptoral neuron signals to investigate the origin of waveform components. Published human retinal single-cell transcriptome databases were analysed.

Results

Of 210 participants recruited for ERG recording, 186 had genotypes and interpretable recordings available (95% female; mean [SD] age, 64.2 [9.7] y). None of the dark-adapted ERG amplitudes revealed significant differences by genotype, whilst both light-adapted ERG a-wave and b-wave amplitudes showed significant associations (p=0.010 and 0.036 respectively). ERG responses from experimental protocols supported an association between cone-driven, but not rod-driven components. Recordings from a patient with loss of ON and OFF bipolar cell signals (due to prior central retinal artery occlusion) and from two patients with selective loss of ON-bipolar signals were consistent with the origin of the differences between GJD2 groups arising from cone-driven OFF-bipolar signals. Single-cell transcriptome data revealed strongest GJD2 expression in cone photoreceptors; bipolar cell expression was strongest in OFF bipolar cells.

Conclusion

Associations were found between cone-driven, but not rod-driven, electroretinogram signals and allelic genotype. Examination of responses to further, non-standard testing protocols, together with recordings from patients with selective loss of bipolar cell signals, point to an effect on cone-driven hyperpolarizing (“OFF”) signals, and human single-cell transcriptome data were consistent with this. Our findings support a possible role for altered signalling in cone-driven OFF pathways in myopia development.

Rare variant analyses across multiethnic cohorts identify novel genes for refractive error

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Purpose

Myopia is a complex refractive error trait with a rapidly increasing prevalence and visual burden world-wide. GWA studies have currently identified >500 common variants for refractive error, but they have not yet dissected many rare variants with potentially large effects. This study aimed to identify these variants using exome chip screening in a large multi-ancestry cohort.

Methods

A total of 13 population-based cohorts from CREAM were included in the current study and grouped into Indo-Europeans and East Asians. Exome array genotypes (Illumina HumanExome-12) were jointly called to increase the number of rare (i.e. MAF<1%) variants. Three other CREAM studies, the Raine Eye Health Study, Beaver Dam Eye study and EPIC-Norfolk, were used as replication cohorts. Different approaches to analyses are useful because they have different strengths in their ability to identify candidate genes. We analyzed spherical equivalent (SER in diopters (D)) using the EMMAX version of the variable threshold (VT) test, which increases power on rare variants (compared to single variant tests) by creating a new gene-based marker. We meta-analyzed the p-values of all datasets (discovery and replication) together using the method described by Fisher, implemented in the R package metap. We conducted an IPA pathway analysis to assess enriched pathways and to prioritize genes based on predefined criteria.

Results

The total discovery study included 17,904 (13,037 Indo-European and 4,867 East-Asian) individuals with a mean (SD) SER of 0.01 (2.30) D. In the meta-analysis, which combined the VT results across all cohorts, 43 genes were found to be genome-wide significant (defined as ≤ 1 x10-5). The most significant gene was GDF15 on chromosome 19 (P = 5.12 x10-9). 40% of the identified genes showed an association with a human ocular disease, 21% evidence of human ocular expression and 12% demonstrated an ocular phenotype in knock-out mice. Cell cycle processes and embryonic development were implicated as important underlying pathways. Among the most biologically plausible gene hits were CHST6 and GRHL2 (P=8.99x10-7 and P= 1.42x10-6 respectively); both associated with corneal dystrophies.

Conclusions

Using exome chip, we identified rare variants for refractive error in 43 novel genes. Further validation studies are necessary to evaluate their role in refractive error development.

Ocular aberration changes in children wearing smaller back optic zone diameter orthokeratology lenses over two years

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Purpose: Previous work suggests an association between ocular aberrations and orthokeratology (ortho-k) treatment zone (TZ) diameter with eye growth in myopic children. In this randomized clinical trial, myopic children wore ortho-k lenses with different back optic zone diameters (BOZD) for two years, and the association between ocular aberrations and axial length was investigated.
Methods: Forty-three Chinese children aged 6 to <11 years, with myopia between -4.00 to -0.75 D, were randomly allocated to use ortho-k lenses with 6 mm (6-MM group) or 5 mm (5-MM group) BOZD for two years. Ocular aberrations were measured using a Hartmann-Shack aberrometer with a Badal system and were rescaled to a 4 mm pupil and fitted with a 6th order Zernike expansion. Axial length was measured using the IOLMaster after cycloplegia. The TZ was defined as the central area of corneal flattening bordered by a circumferential ring of no tangential curvature change (E300, Medmont) determined using a customized software. Measurements were taken prior to commencing ortho-k treatment and then every 6 months over two years.
Results: After two years, the 5-MM group displayed a smaller horizontal TZ (by 1.15 ± 0.11 mm, $p < 0.001$) and less axial elongation (by 0.22 ± 0.07 mm, $p = 0.002$) compared with the 6-MM group. A greater increase in root-mean-square (RMS) of total higher-order aberrations (HOAs), RMS of total spherical aberration (SA), RMS of total coma, and primary SA (C(4, 0)), were observed in the 5-MM group compared to the 6-MM group at the 24-month visit. The horizontal TZ was significantly negatively associated with the changes in RMS HOAs, SA (RMS and primary), and RMS coma. After controlling for baseline parameters, RMS HOAs, RMS SA, and primary SA were significantly negatively associated with axial length over time.
Conclusions: Smaller BOZD ortho-k lenses created a smaller horizontal TZ, a significant increase in total HOAs, total SA, and primary SA, and enhanced myopia control efficacy.

Axial length shortening after combined repeated low-level red-light therapy in poor responders of orthokeratology in myopic children

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Purpose
Limited effective treatments have been reported regrading those who responded unsatisfactory to orthokeratology(ortho-k). We performed a retrospective, interventional clinical study to investigate the efficacy and safety of orthokeratology in combination with repeated red-light therapy on myopia control in poor-responders of ortho-k.

Methods
Axial elongation in 55 eyes of 55 participants who completed one year of ortho-k treatment was retrospectively reviewed. During their first six months of ortho-k treatment (phase one), they all demonstrated an axial elongation of 0.20 mm or greater (defined as poor responders to ortho-k). They were then divided into two groups: orthokeratology group (OK, n=27) continued to be treated with ortho-k monotherapy and combination group (OK-RLRL, n=28) being treated with repeated low-level red-light in addition to ortho-k for the following six months (phase two). Axial length change over time was compared between two groups.

Results
Baseline biometrics was similar between the two groups in phase one (all $p>0.05$). The mean age (10.36±1.46 years vs 10.45±2.12 years, $p=0.851$), male to female ratio (13:14 vs 17:11, $p=0.349$), axial length (25.39±1.12mm vs 25.54±1.22mm, $p=0.534$) and axial elongation in phase one (0.28±0.10 vs 0.28±0.10 mm, $p=0.850$) were comparable between OK and OK-RLRL group. During phase two, significant axial length shortening was observed in children in OK-RLRL group (-0.09±0.13 mm, $p<0.001$), while children in the OK group experienced an axial elongation of 0.17±0.10 mm. Greater baseline age ($r = -0.414$, $p = 0.029$) and axial length ($r = -0.420$, $p = 0.026$) were related to axial length shortening during phase two in the OK-RLRL group.

Conclusions
For poor responders of orthokeratology, repeated low-level red-light therapy could slow axial elongation in addition to ortho-k treatment effect without documented functional or structural damage. Those who respond poor to ortho-k with longer axial length and older age might benefit more from combined RLRL and ortho-k therapy.

Optic Zone in Myopia Control with Ortho-K; Size Matters

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Purpose: Optic zone treatment size in Orthokeratology is currently under high interest and deep study. We compared, in a retrospective study, the efficacy of controlling the annual increase in Axial Length (AL) in myopic Caucasian children based on two parameters: the back optic zone diameter (BOZD) of the orthokeratology (OK) lens and Plus Power Ring Diameter or mid-peripheral annular ring of corneal steepening.

Methods: Data from 71 myopic patients (mean age, 13.34 ± 1.38 years; range, 10–15 years; 64% male) corrected with different back optic zone diameters of OK lenses (DRL, Precilens) were collected retrospectively from a Spanish optometric clinic. The mean baseline myopia was −3.11 ± 1.46 D and the AL 24.65 ± 0.88 mm. The sample was divided into groups with back optic zone diameters above or below 5.00 mm and the induced Plus Power Ring Diameter above or below 4.5 mm, and the relation to AL and refractive progression at 12 months was analyzed. Three subgroups were analyzed, i.e., Plus Power Ring inside, outside, or matching the pupil.

Results: Significant ($p < 0.001$) differences were found after 12 months of treatment in the refractive error and AL for the back optic zone diameter and Plus Power Ring Diameter. AL changes in subjects with smaller back optic zone diameter decreased significantly regarding larger diameters (0.09 ± 0.12 and 0.15 ± 0.11 mm, respectively); in subjects with a horizontal sector of Plus Power Ring Diameter falling inside the pupil, the AL increased less ($p = 0.035$) than matching or outside the pupil groups by 0.04 ± 0.10 mm, 0.10 ± 0.11 mm, and 0.17 ± 0.12 mm, respectively. This means a 76% lesser AL growth of 0.13 mm/year in absolute reduction.

Conclusions: OK corneal parameters can be modified by changing the OK lens designs, which affects myopia progression and AL elongation. Smaller back optic zone diameter induces a reduced Plus Power Ring Diameter that slows AL elongation better than standard OK lenses. Further investigations should elucidate the effect of pupillary diameter, Plus Power Ring Diameter, and power change on myopia control.

Retrospective review of orthokeratology versus peripheral defocus contact lenses

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PURPOSE
The purpose of this retrospective chart review was to assess the real-world, comparative efficacy of peripheral defocus contact lenses (PDCLs) and orthokeratology (OK) in a contemporary myopia management service.

METHODS
Records from a university practice from January 2015 through January 2022 were retrospectively reviewed to identify patients, 5-18 years of age, who were treated with OK or PDCLs. Any patients with previous myopia management therapy, except for bifocal glasses, prior to their baseline visit at the university or were not compliant with their therapy were excluded. Non-compliance was defined as not using the prescribed myopia management therapy over a consecutive two-month period. The analyzed sample contained 523 visits from 135 patients. Axial length (Lenstar, Haag Streit) and cycloplegic spherical equivalent refractive error (WAM-5500, Grand Seiko) were obtained using a standardized protocol. Annualized rates of axial length progression (adjusted for corneal thickness) were calculated and used as the response variable in both linear mixed-effects (LME) and nonlinear regression models.

RESULTS
On average, children were 10.7 years at baseline (range 6.4 to 15.7 years, p = 0.144 between treatments), and most patients were female (62%, p = 0.664). More Asian children wore OK (p = 0.008). Overall, children had ~3.00 D of myopia and 0.75 D of astigmatism in both treatment groups (p > 0.200 between treatments). LME regression models showed no evidence that annualized change in axial length differed between OK and PDCLs, with or without inclusion of age, race, sex, or baseline axial length or spherical equivalent refractive error. Effect sizes for treatment condition ranged from 0.055 (95% CI = (-0.021, 0.131), p = 0.160) to 0.069 (95% CI = (-0.008, 0.146), p = 0.102) in the unadjusted and fully adjusted models, respectively. Age at baseline was statistically significant in models that did not include spherical equivalent refractive error with effect sizes ranging from -0.261 (95% CI = (-0.445, -0.078), p = 0.009) in an initial model with treatment and baseline age as the only predictors to -0.208 (95% CI = (-0.437, 0.146), p = 0.102) in the fully adjusted model. Sex, race, and baseline axial length and spherical equivalent refractive error were not significant in any of the LME models. Further, there was no statistical difference between parameters of an exponential decay model fitted within treatment using follow-up age as a time-varying predictor, indicating that the rate of annualized change in axial length was similar for OK and PDCLs.

CONCLUSIONS
Retrospective analysis of real-world clinical data found no difference in annualized axial length growth between PDCLs and OK. Despite inherent issues often common to retrospective clinical data, the axial length progression from this clinical setting is consistent with those reported in randomized clinical trials. Clinical data collected using standardized protocols may be further important as myopia control treatments become the standard of care, making subject recruitment for controlled clinical trials more difficult.

Development of Smart spectacles to monitor and modify myopia related health behavior in children

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Purpose: To develop a wearable, spectacle mounted, sensor-based device to monitor and control myopia risk factors in children, namely near work time & distance, sunlight exposure & time outdoors along with chromaticity. We tested the hypothesis that the spectacle mounted device can simultaneously measure viewing distance, light intensity, wavelength and spectral irradiance.
Methods: A wearable, spectacle mounted device has been developed which consists of inbuilt sensors, namely, i) Light sensor – to detect ambient light intensity ii) Diode laser range sensor – to detect distance & duration of near work; iii) Wavelength Sensor - to measure the different intensity value of the visible light spectrum; (iv) Microspectrograph - to measure spectral irradiance for 6 visible, namely Red, Green, Blue, Yellow, Orange and Violet, and (v) a GPS tracker - to track the location of the children wearing the device and to track the device when lost. The sensors were initially programmed to work with Arduino Nano, then connected to a breadboard, and further transferred to a PCB circuit fitted on a spectacle for pilot testing and clinical study. The spectacle is powered using two rechargeable 1000mAh batteries.
The sensors were programmed by Arduino Nano, and the whole circuit was fixed on a PCB fitted on a spectacle for pilot testing and clinical study. Pilot testing was done using a mannequin and measurements were obtained. The measured parameters were transferred to personal computer through Wi-Fi.
Results:
The indoor light levels measured using the device were below 1000 lux and the outdoor light levels were typically greater than 1000 lux with a maximum of about 1,88,000 lux. The device could record viewing distances as close a 6 cms and up to 99 cms. The spectral composition of indoor locations ranged from 530 nm to 595 nm. The spectral irradiance of indoor locations was predominantly higher for green channel (range: 33µW/cm2 - 45µW/cm2) & yellow channel (range: 42µW/cm2 - 55µW/cm2). The spectral composition of outdoor locations ranged from 445 nm to 590 nm. The spectral irradiance of outdoor locations was also highest for yellow channel (range: 43µW/cm2 - 55µW/cm2) followed by green channel (range: 36µW/cm2 - 43µW/cm2).
Conclusion:
The current spectacle mounted device could measure the viewing distance (in mm), light intensity (in lux), wavelength and spectral irradiance. This device can measure all myopia related risk factors and may provide new perspective into the potential role of all myopia risk factors in unison and help to elucidate the relative roles of daylight intensity, chromaticity and near work related factors in myopia development.

Catenary Optics for Myopia Progression Intervention

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Purpose: Animal and children's myopia progression control studies have shown dosage-dependent relationship with the myopia control treatment effect, with the magnitude of relative defocus being the dose. Contact lens design using catenary optics to maximize the amount of relative plus power with minimal visual disturbance have been used to manage myopia by eye care professionals. To evaluate the rate of progression of refractive error and axial length elongation by using this kind of contact lenses, a multi-centered cohort study on the impact of catenary optics induced myopic defocus in myopia progression was conducted and was used for the determination of a randomized controlled trial.
Methods: Contact lenses with a catenary optic were characterized with raytracing to understand the myopic defocus profile in relationship to the retina. 309 young progressing myopes from 15 clinical practices who were fitted with these lenses from Mar 2015 through Dec 2020 were identified through chart review. Patient record was excluded if the follow-up period was less than 6 months, or was using a myopic progression control treatment, leaving 196 patient records with baseline average age of 12.3±2.8 years (range 5-20 years). Initial spherical equivalent refraction (SER) was (Mean ±SD) -3.60 ±2.00D, and Axial Length (AL) 25.05 ±1.50. Follow-up data of Spherical Equivalent Refraction (SER) and Axial Length (AL) progression up to 72 months were analyzed against baseline value. An analysis using age and ethnicity matched Virtual Control Group data from a meta-analysis by Brennan et. al. was conducted.
Results:
Compared to the conic surface, the catenary surface tends to be spherical-like over a smaller central region, but has a much higher level of peripheral steepening. It effectively extends the depth of focus while producing a gentle halo. Raytracing of a lens on a model eye was conducted, and it shows that the myopic defocus covers greater than ±30 degrees of retina, while maintaining an extended depth of focus profile. During chart review, there was no report of discontinuation of lens wear due to visual quality and no adverse events were noted. Baseline SER progression reported averaged -1.01D/yr. The mean SER total cumulative change from baseline was approximately 0.25D or less at all annual visits: Y1: -0.16, Y2: -0.27, Y3: -0.24, Y4: -0.10, Y5: -0.05, Y6: -0.11. The change of SER were significantly different from baseline at all points in time ($p < 0.05$). The mean AL total cumulative change from baseline was: Y1: 0.07, Y2: 0.15, Y3: 0.18, Y4: 0.40, or approximately <0.10 mm/year through 48 M. The change of AL data was significantly different from baseline at all points in time ($p < 0.05$). A subset of the data (N=188 RE, N= 54 AL) was age and ethnicity matched to published control data for children ages 8 to < 13, with an average age of 10.5 ±1.3. At baseline, SER averaged -3.60 ±2.00D, AL 24.97 ±0.58mm, with average baseline progression of -1.03D/yr. Both SER and AL change were significantly less ($p < 0.05$) as compared to published age and ethnicity-matched virtual control group data. Using the age and ethnicity matched virtual control group data, a Cumulative Absolute Reduction in axial Elongation (CARE) value of 0.44mm less axial elongation over 3 years as compared to the age and ethnicity matched virtual control group was determined for this optical design. Stratification demonstrated treatment effect is independent of age (<10 vs 10 to <13), sex (female vs male) and race (Asian vs non-Asian).

Conclusions: Contact lenses with catenary optic provide high magnitude of myopic defocus with minimal optical disturbance. Cohort study with Real World data demonstrated high acceptability, safety and effectiveness. A multi-centered, randomized, double masked, 3-year prospective study has since been initiated to perform a Randomized Controlled Trial which is designed to rigorously quantify the catenary lens safety and effectiveness profile.

MiSight as a myopia control modality in young adults

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Purpose
The efficacy of MiSight on myopia control in children has previously been demonstrated (Chamberlain et. al, 2022, Ruiz-Pomeda et al., 2018), yet there is little evidence whether MiSight has any effect on myopia control in young adults. Here, we present some preliminary results from a study assessing the effect of MiSight as a myopia control modality in young adults.

Methods
Participants aged 16–26 with spherical equivalent refraction between -0.75D and -6.00D, normal binocular vision, and good ocular and general health are being included in this a single center study of MiSight. The first participants were recruited in 2019, and participants are still being recruited through the university clinic.
Exclusion criteria are as follows: astigmatism < -1.50DC, the presence of strabismus, amblyopia, and ocular pathology. A battery of clinical tests is being performed at baseline to assess eligibility, including refraction, visual acuity, binocular and colour vision. Ocular health is assessed with slit-lamp biomicroscopy, Oculus Pentacam HR, Nidek AFC-330 non-mydriatic auto fundus camera, and Zeiss CIRRUS HD-OCT Model 5000.
Ocular biometry is measured (IOLMaster 700, Carl Zeiss Meditec) at baseline and every 6 months over a three-year period. At baseline and 12-month follow-ups, cycloplegic subjective and auto-refraction (Huvitz HRK-8000A, Huvitz Co) is assessed after administering Cylcopentolat 1%. Contact lens fit and ocular health are assessed at each follow-up visit at 4 months, 6 months, and thereafter every 6 months.

Results
Of the 15 recruited participants so far, 6 have discontinued wearing MiSight for the following reasons: 3 were bothered with halos and did not obtain acceptable vision, 2 suffered from asthenopia due to uncorrected astigmatism (-1.25 DC), and 1 preferred monthly lens. Four of the participants also complained about dryness when using MiSight. Nine participants have been followed for 12 months, 6 of whom have been followed for 24 months: 8 females and 1 male (mean ±SD 20.9 ±3.1). Seven participants are Caucasian, two are Asian/mixed. The mean cycloplegic spherical equivalent refraction (SER ±SD) and axial length (mm ±SD) at baseline was OD -2.05 ±1.36 and 24.76 ±0.99, OS -2.41 ±1.45 and 24.87 ±1.05. There was no difference in corneal curvature or SER after 12 nor 24 months ($p>0.05$, paired t-test). Axial length increased significantly at both follow-ups ($p<0.05$, paired t-test), however, for 83% of these eyes the increase was less than that expected from coordinated growth this age group (Hagen et al., 2019).

Conclusions
MiSight seems to have a positive effect on controlling myopia in young adults with no change in refraction, and less-than-expected axial elongation.

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Zone of clear single binocular vision in myopia controlling contact lenses

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Purpose. To examine the zone of clear single binocular vision (ZCSBV) at near in myopic young adults wearing a variety of soft myopia control contact lenses (MCCL), compared with a single vision (SV) soft contact lens, and to compare results with historical data for orthokeratology (OK).
Methods. Twenty-six myopes (19 to 25 years, spherical equivalent refraction -0.50 to -5.75D) with normal binocular vision function and no history of myopia control were fitted, in random order, with Proclear SV distance contact lenses and three soft MCCLs: MiSight concentric dual focus (+2.00D), a distance centre aspheric (Biofinity, +2.50D)(CooperVision lenses) and NaturalVue aspheric (Visioneering Technologies). After lens settling, testing included negative and positive relative accommodation and horizontal fusional vergence at near (33cm). The ZCSBV, a graphical representation of the range of accommodation and vergence function at near, was constructed. The ZCSBV can be used to demonstrate any significant differences in binocular vision function between MCCL lens types. A comparison was then made to the previously published ZCSBV in young adult myope OK wear.
Results. Compared with SV soft contact lenses, the aspheric MCCLs reduced the range of accommodation by 9% (p=0.001) whereas the concentric MiSight did not alter it. All soft MCCLs increased the vergence range by 4% (p=0.004). Previously OK was shown to increase the range of accommodation by 43% and range of vergence by 18% compared to SV SCLs. All soft MCCLs increased base-in (divergent) (p=0.004) but did not influence base-out (convergent)(p=0.23) fusional vergence ranges. OK also increased base-in (divergent) but not base-out (convergent) fusional vergence. Aspheric soft MCCLs reduced negative relative accommodation (ability to clear plus-powered defocus) (p=0.001) whereas the concentric MiSight and OK wear did not alter it. OK increased positive relative accommodation (ability to clear minus-powered defocus), whereas all soft MCCLs did not alter it (p=0.36). An increased depth of focus in OK wear is not matched by similarly powered soft MCCLs.
Conclusion. In myopic adults of similar age and refraction, soft MCCLs minimally altered the ZCSBV whereas OK expanded it. Differences in how soft MCCLs impact binocular vision function are based on their optical design (aspheric vs concentric), and effects are much less than with OK.

Oral administration of caffeine metabolite 7-methylxanthine is associated with slowed childhood myopia progression

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Purpose: The caffeine metabolite 7-methylxanthine (7-MX), licensed in Denmark since 2009 as a treatment to reduce the rate of childhood myopia progression, is the only orally-administered therapy available. The purpose of the current study was to assess the rate of myopia progression in children taking 7-MX.

Methods: This was a retrospective study of all longitudinal data collected from myopic children seen at one ophthalmology unit in Denmark over the period June 2000 to January 2021, excluding data from children using other myopia control methods than 7-MX. Cycloplegic refraction and axial length data for 711 myopic children from Denmark treated with varying doses of oral 7-MX (0-1200 mg per day) were analysed using linear mixed models. Among the 711 children were 87 children who did not take 7-MX.

Results: The median age at baseline was 11.1 years (range 7.0 to 15.0 years) and the mean refractive error at baseline was -2.43 D (median -1.94; range -9.00 to -0.50 D). Children were followed for an average of 3.6 years (range 0.9 to 9.1 years) and the average myopia progression was -1.34 Diopters (D) (range -6.50 to +0.75 D). Treatment with 7-MX was associated with a reduced rate of myopia progression ($p<0.001$) and axial elongation ($p<0.002$).
Modelling suggested that a 7-year-old child taking 1000 mg 7-MX daily would develop -2.65 D of myopia over the next 6 years, compared to -3.49 D if untreated. Axial length in this child would increase by 1.63 mm over 6 years when taking a daily dose of 1000 mg of 7-MX, compared to 1.80 mm if untreated.
An 11-year-old child taking 1000 mg 7-MX daily would develop -1.43 D of myopia over the next 6 years, compared to -2.27 D if untreated. Axial length in this child would increase by 0.84 mm over 6 years when taking a daily dose of 1000 mg of 7-MX, compared to 1.01 mm if untreated.
No adverse effects of 7-MX therapy were reported.

Conclusions: Oral intake of 7-MX was associated with reduced myopia progression and reduced axial elongation in myopic children from Denmark. The question of causality and the size of a possible treatment effect can only be determined through a randomised trial.
The model predicts around 0.07 mm less axial elongation during the first year for children taking 1000 mg per day compared with children not taking 7-MX. For comparison, low-concentration atropine eye drops (<0.1 %) reduce eye elongation by around 0.1 mm during the first year of treatment.
Existing myopia control intervention methods are not fully effective in preventing children from progressing to high myopia which is associated with increased risk of permanent vision loss. 7-MX may become a valuable supplement if causality and efficacy can be confirmed in future randomised controlled trials.

Effects of different Frequency Dose of 0.05% Atropine in Retarding the Progression of Myopia in Chinese Children

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Purpose: Atropine eye drops prevent the progression of myopia, but their use has no data on frequency of different medication. Here, we evaluate the effects of different frequency dose of 0.05% atropine in retarding the progression of myopia in Chinese children.

Methods: This was a randomized,self-control study. A total of 60 children aged 6 to 14 years with myopia of -1.00D to -6.00D in both eyes were enrolled between April 2021 and October 2021 at Changsha Aier Eye Hospital,Changsha,China.Patients were randomly assigned to once per day(A,n=20), once per week(B,n=20), or twice per week(C,n=20) groups to be administered to both eyes for half a year.Primary and secondary efficacy endpoints were changes in Spherical equivalent (SE) and axial length (AL), respectively, from baseline to month 6.Adverse events were also recorded.

Results: Data from 60 subjects were analyzed. At month 6, compliance was similar in three groups (A 93.3%; B 95.7%;C 94.6%). Of 60 participants, 33 were girls (55%), and the mean (SD) age was 10.25 (1.92) years.The average initial age and refraction were identical between three groups.The mean (SD) baseline refractive error and axial length were -3.18 (1.92) D and 24.79 (1.28) mm. Follow-up at half a year ,the least squares mean change in SE and AL from baseline were 0.03(0.19)D and 0.00(0.07)mm for group A(once per day), -0.03(0.13)D and 0.02(0.06)mm for group B(once per week), -0.11(0.24)D and 0.03(0.07)mm for group C(twice per week). There was no statistically significant difference among three groups for SE and AL from baseline to 6 months(F=0.202,P=0.817 and F=0.320,P=0.727). No serious adverse events related to atropine were reported.

Conclusion: We found that different frequency dose of 0.05% atropine in retarding the progression of myopia were identical in Chinese children with half a year. We will continue to study for the next two years.

Low-concentration atropine for the treatment of myopia in multi-racial Western Australian children (WA-ATOM study): first two years of treatment

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Purpose: Low-concentration atropine eyedrops have been shown to be an effective method of myopia control in Asian children. This randomised placebo-controlled trial tests the hypothesis that 0.01% atropine eyedrops are a safe and effective myopia control approach in multi-racial Australian children.
Methods: Children with documented myopia progression (n=153; 6–16 years at baseline; ~42% boys) were randomised to receive either 0.01% atropine or placebo eyedrops (2:1 ratio) nightly, over 2 years. Eye examinations, including ocular biometry and cycloplegic autorefraction, were conducted every 6 months. The change in spherical equivalent (SE) and axial length (AL) from baseline was explored using linear mixed-effects models.
Results: At 12 months, mean SE and AL change from baseline were -0.31D (95% confidence interval [CI]=-0.39 to -0.22) and 0.16mm (95%CI=0.13 to 0.20) in the atropine group, and -0.53D (95%CI=-0.66 to -0.40) and 0.25mm (95%CI=0.20 to 0.30) in the placebo group (group difference p≤0.01). At 12 months, subgroup analyses revealed that 0.01% atropine eyedrops had limited myopia control effects in children of East or South Asian ancestry (n=50), while myopia control effects were greater in children of White or other/mixed ancestries (n=75 and 18 respectively). At 24 months, mean SE and AL change from baseline was -0.64D (95%CI=-0.73 to -0.56) and 0.34mm (95%CI=0.30 to 0.37) in the atropine group, and -0.78D (95%CI=-0.91 to -0.65) and 0.38mm (95%CI=0.33 to 0.43) in the placebo group. The group difference at 24 months was not statistically significant (p=0.10). At 24 months, children of other/mixed ancestries benefited significantly from 0.01% atropine eyedrops, while minimal treatment effects were observed in White, East or South Asian children. At 24 months, the atropine group had reduced accommodative amplitude and pupillary light response compared to the placebo group. There was no significant treatment by race effects on accommodative or pupillary measures.
Conclusions: In Australian children, 0.01% atropine eyedrops were safe and well-tolerated. On average, 0.01% atropine treatment was associated with a statistically significant reduction in myopia progression at 12 months, but not at 24 months. Treatment effect was minimal in East or South Asian children, and greatest in children of other/mixed ancestries. An apparent decrease in treatment efficacy between 18 and 24 months is likely driven by a higher dropout rate in the placebo group.

Effect of high dose atropine for progressive myopia is age-dependent

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Purpose
Atropine has become standard of care for myopia control in the Netherlands; high dose is recommended for those at risk of high myopia. A risk factor for progression of myopia despite therapy is a young age. In our 3 year follow up study, we evaluated the effect of age on spherical equivalent of refraction (SER) and axial length (AL) change in myopic children receiving atropine 0.5%.
Methods
Children aged 4-16 years with progressive myopia ≥ 1D/year or myopia ≤ -2.5D were prescribed atropine 0.5% at baseline. Children with additional ocular pathology were excluded. Examination including cycloplegic refraction and AL measurement was performed at baseline and follow-up. Outcome measures were AL and SER; annual progression of Al and SER were compared between age groups 4-6, 7-9, and 10-16 years. Differences in progression of AL and SER between age groups were calculated with linear regression adjusted for gender. Correlation of progression rates between first year and second or third year was calculated with the Pearson's correlation.
Results
A total of 116 patients were enrolled in the study (mean age: 9.26, ±2.2 years). At baseline, mean SER was -3.47, ±1.73D; mean AL was 24.92, ±0.90mm. 90 (77.6%) children continued therapy throughout the 3-year follow-up. Mean AL annual progression was 0.41 mm ±0.23 (SER -0.75D ±0.08) for 4-6 year-olds; 0.15 mm ±0.12 (-0.22D ±0.35) and for 7-9 year-olds and 0.08 mm ±0.08 (-0.14D ±0.23) for 10-16 year-olds. Children aged 4-6 years progressed faster in AL than those aged 7-9 years (P =0,001) or 10-16 years (P <0.001), for SER faster progression was found between 4-6 and 10-16 year old's (P =0.04). Children with higher AL progression in the first year of therapy were also the faster progressors in the second and third year of therapy (r =0.40 and r =0.40 1st vs 3rd). Due to the hyperopic shift of SER in the first year of therapy only the 2nd and 3rd year of therapy was a predictor of response to therapy (r =0.14 and r =0.24 1st vs 3rd).
Conclusions
Despite 0.5% atropine, children younger than 7 years of age for progressive myopia progressed up to three times faster in both SER and AL than older children. The latter also had a more consistent protection by this concentration of atropine during the 3 year regimen. Myopia progression in young children may need more stringent control, such as atropine 1% or combination therapy, in particular since they are at risk for the more extreme values of myopia.