Points de Vue, the International Review of Ophthalmic Optics created by Essilor in 1979, is committed to providing prescribers (all eye care professional involved in prescription throughout the world) with forward-looking and useful information for their practices and effective patient care.

Points de Vue is an expert-to-expert publication, sharing the latest knowledge on scientific evidence, clinical practice, market insights, patient needs and innovative solutions.
Surprisingly enough for a non-infectious condition, myopia is reaching pandemic proportions across the world.

Record-breaking figures. In the US and Europe, the prevalence of myopia has doubled over the last century, reaching 40-50% of young people (aged < 35) today. East Asia has been hit particularly badly. In countries such as Singapore, China and Korea, myopia affects around 80-90% of urban teenagers, compared to 10-20% sixty years ago. Recent work from the Brien Holden Vision Institute (BHVI) estimates that by 2050, five billion people, or half the world’s population, will be myopic and one billion, or 10%, highly myopic.1 A record-high myopia of -108 diopters has recently been compensated in Slovakia, Europe, representing new challenges for eye care practitioners and the ophthalmic industry.2 While the direct global socio-economic impact of myopia has not yet been determined, the economic burden of uncorrected refractive error (URE), which is largely caused by myopia, is estimated to be more than US$269 billion (per annum) – and this number is growing as the pandemic spreads.3

The good news. Over the past few months there has been a notable increase in alarming publications in scientific journals and the media on the myopia crisis. However, leading research centers and medical universities have been vigorously focused for some time on furthering understanding of the condition and developing new treatments for it.4 Etiology investigations have uncovered that myopia onset and its progression in children are correlations of both hereditary (nature) and environmental factors (nurture). The latter can be modified by encouraging greater exposure to natural light through outdoor activities5 and adopting good reading posture. We take the opportunity in this issue to share some perspectives from 25 experts – scientists and eye care practitioners – taking a look at their approach to understanding, correcting6 and treating myopia, plus preventing its progression in children.7

Hope in sight. Biochemical research for the myopia pathogenic mechanism will continue to be a hot topic. Luckily, the progress made over the past decade gives us reason for hope. At present, the overwhelming majority of myopia cases can be corrected with regular prescription eyeglasses, contact lenses or refractive surgery. There are also the solutions that correct and control myopia progression in children. Specific multifocal contact lenses, Myopilux® ophthalmic lenses8 and orthokeratology (Ortho-K) are all recognized as safe and effective procedures in the long term.9 While pharmacological interventions such as atropine eye drops at low concentration do not correct myopia, they effectively control its progression. There is no doubt tailor-made solutions help patients live their life to the fullest. One need look no further than Mr. Miskovic, the man with the world’s highest degree of myopia at -108D – as a successful photographer, he is pursuing his dream!10

3. Cavanagh M. Myopia rise and vision health issues left in its wake - Page 49
4. Lu F. A look at myopia research in China - Page 12
5. Read AS. Light exposure and childhood myopia - Page 20
6. Franchi Ch, Longo A, Mosk D. High Myopia: The specificities of refraction and optical equipment - Page 34
7. Garcia S, Herzberg CM, Leung D, Prada J, Williams BT. Orthokeratology in clinical practice across the world - Page 28
8. Yeo A, Koh P, Paille D, Drobe B. Myopia and Effective Management Solutions - Page 56
9. Herzberg CM, Carucaedo G. A look at progress in orthokeratology - Page 06
10. Miskovic J. Practicing the art of photography with -108 D myopia - Page 72
“THE MYOPIA EPIDEMIC CREATES A SIGNIFICANT PUBLIC HEALTH PROBLEM AROUND THE WORLD.”

MAUREEN CAVANAGH
article page 49

“PEOPLE WITH MYOPIA, ESPECIALLY HIGH MYOPIA, ARE AT HIGHER RISK OF DEVELOPING OTHER VISION DISORDERS THAT CAN LEAD TO BLINDNESS.”

PROF. KOVIN NAIDOO
quotation used in M. Cavanagh’s article page 49

“MYOPIA USUALLY RESULTS FROM INHERITED GENES INTERACTING WITH ENVIRONMENTAL FACTORS.”

PROF. FAN LU
article page 12

“LESS THAN 60 MINUTES OF BRIGHT OUTDOOR LIGHT EXPOSURE APPEARS TO BE A RISK FACTOR FOR FASTER EYE GROWTH AND HENCE MYOPIA DEVELOPMENT AND PROGRESSION IN CHILDHOOD.”

PROF. SCOTT A. READ
article page 20

“OUR MISSION IS IN PART TO HELP FIND SOLUTIONS TO THE MYOPIA EPIDEMIC WHICH THREATENS THE EYE HEALTH OF PRESENT AND FUTURE GENERATIONS”

DR. CARY HERZBERG
article page 6

“1 IN 10 PEOPLE WORLDWIDE WILL BE AT RISK FOR PERMANENT BLINDNESS BY THE YEAR 2050.”

PROF. KOVIN NAIDOO
quotation used in M. Cavanagh’s article page 49
03 EDITORIAL

06 EXPERTS’ VOICE

06. A LOOK AT PROGRESS IN ORTHOKERATOLOGY OVER THE LAST DECADE
Dr. Cary M Herzberg, Dr. Gonzalo Carracedo

12. A LOOK AT MYOPIA RESEARCH IN CHINA
Prof. Fan Lu

19 SCIENCE

20. LIGHT EXPOSURE AND CHILDHOOD MYOPIA
Prof. Scott Read

27 CLINIC

28. ORTHOKERATOLOGY IN CLINICAL PRACTICE ACROSS THE WORLD
Bruce T. Williams, Sergio Garcia, Javier Prada, Dennis Leung, Dr. Cary M Herzberg

34. HIGH MYOPIA: THE SPECIFICITIES OF REFRACITION AND OPTICAL EQUIPMENT
Christian Franchi, Adèle Longo, Dominique Meslin

43 MARKET WATCH

44. MYOPIA: A PUBLIC HEALTH CRISIS IN WAITING
Dr. Monica Jong, Prof. Padmaja Sankaridurg, Prof. Kovin Naidoo

49. MYOPIA RISE AND VISION HEALTH ISSUES LEFT IN ITS WAKE
Maureen Cavanagh

55 PRODUCT

56. MYOPIA AND EFFECTIVE MANAGEMENT SOLUTIONS
Dr. Anna Yeo, Patricia Koh, Dr. Damien Paillé, Dr. Björn Drobe

66. RECORD-HIGH MYOPIA SOLVED BY AN ALLIANCE OF EXPERTS: -108.00 D
Sebastian Chrien, Alain Massé, Leonel Pereira, Stanislas Poussin, Monika Remiašová

71 ART AND VISION

72. PRACTICING THE ART OF PHOTOGRAPHY WITH -108 D MYOPIA
Jan Miskovic

WE THANK ALL AUTHORS AND CO-AUTHORS FOR THEIR VALUABLE AND VOLUNTARY (UNPAID) CONTRIBUTION TO POINTS DE VUE. TO ENSURE BOTH CREDIBILITY AND IMPARTIALITY OF THE CONTENT, WE DO NOT FUND SIGNED ARTICLES, AND IN THE SAME WAY WE OFFER THE MAGAZINE FOR FREE TO READERS, BOTH THROUGH PRINT AND ONLINE.
Corneal reshaping through orthokeratology as a means to control myopia progression has made tremendous progress over the past decade. Below, Dr. Cary M Herzberg, president of the International Academy of Orthokeratology and Myopia Control (IAOMC), discusses the developments that have been made in the field and how the IAOMC hopes to continue to push the scientific envelope in the years to come.

Dr. Gonzalo Carracedo of the University Complutense in Madrid then details how orthokeratology has come to be recognized worldwide as a safe and effective procedure in the long term.

Dr. Cary M Herzberg
OD FIAO, president of the International Academy of Orthokeratology and Myopia Control (IAOMC), USA.

Dr. Herzberg has been practicing Orthokeratology and myopia control for over thirty-five years. He has lectured extensively on the topic, written numerous articles and holds a patent on the first scleral Orthokeratology design. He is co-founder, President, board member and fellow of the International Academy of Orthokeratology & Myopia Control (IAOMC) and the founder, President and a board member American Academy of Orthokeratology and Myopia Control(AAOMC) formerly The Orthokeratology Academy of America(OAA). He is an advisory board member of the Gas Permeable Lens Institute (GPLI) and a former contact lens design consultant to C&H Contact Lens. He has visiting Professor status at Tianjin Medical University, Shandong Medical University and He Eye Hospital/University.

Dr. Gonzalo Carracedo
OD, MsC, PhD, University Complutense of Madrid, Spain.

Dr. Gonzalez Carracedo joined the University Complutense of Madrid as an assistant professor of optometry and contact lenses in 2006. He is also currently a lecturer at the European University of Madrid, where he teaches about specialty contact lenses. He obtained his PhD (European mention) with a thesis entitled “Adenine dinucleotides as molecular biomarkers of dry eye”. He belongs to the Ocupharm Diagnostics research group, which focuses on the ocular surface, contact lenses and dry eye research and development. He is also a member of the GICO research group, which is specialized in myopia control, corneal aberrations and vision. His PhD thesis dealt with nucleotides as a marker of dry eye in different conditions, including when wearing contact lenses or in the context of refractive surgery and systemic disease related to dry eye. He is the author of 38 papers (some related to myopia control and orthokeratology) in peer-review journals such as IOVS, Current Eye Research and Experimental Eye Research. He has also been a reviewer for these journals, plus the Journal of Optometry and the Journal of Ocular Pharmacology and Therapeutics. He has been involved in 16 research projects (four as the main researcher) regarding the ocular surface (i.e. keratoconus, dry eye myopia and contact lenses) and glaucoma.

KEYWORDS
Orthokeratology, Ortho-K, myopia control, corneal reshaping, peripheral defocus
Three overriding themes stand out in the past decade of progress in orthokeratology. They are technologies, safety/efficacy and myopia control. “The progress in these three areas has been nothing short of astounding and has cleared the path forward to an exciting new era for the non-surgical treatment of refractive states of the human visual system,” says Dr. Herzberg.

The last decade has seen phenomenal growth in the technologies that impact orthokeratology design. It’s difficult to comprehend how much progress has been made in such a short period of time. Little more than a decade ago the FDA approved Bausch&Lomb’s Vision Shaping Treatment (VST) for applications of low to moderate myopia and astigmatism. This came just a couple of years on the heels of the...
certification of Paragon Vision Sciences’ CRT® contact lenses. What would prove even more significant was the approval of topographical mapping, combined with CAD/CAM (computer-aided design and computer-aided manufacturing) technology for state-of-the-art Ortho-K lens designing. This meant the imagination became the limit for exciting new breakthroughs in orthokeratology.

Having FDA approval of corneal reshaping was a major advance, but what took place after was inspired by an industry poised to develop the vast potential promise that had been lying dormant for decades. Almost ten years prior to the FDA’s decision new lens fabrication technologies experienced a new era of accuracy in producing products that had better process tolerance than the equipment utilized to measure the human visual system for them. Along with this was the use of computer-assisted lathing systems to make a reality of even the most complex designs, themselves the product of powerful new technologies. The FDA approval allowed research and development to focus on more accurate and faster procedures for the Ortho-K effect. At the same time, research and development of non-FDA approved areas – specifically high myopia and astigmatism – brought new investment and products. Lastly, developments in hyperopia and presbyopia seemed more likely in light of recent success in more conventional designs, which pointed to potential ways these new applications would be possible.

Hard as it is to believe, less than a decade ago Ortho-K was illegal in China. This was because of a laissez-faire attitude and risks present in the care of lenses that existed at the time. Dozens of cases of corneal scarring with sight loss led to the government ban as the new century dawned. “Today, a much different picture exists due to the regulation of the industry and the elimination of questionable and dangerous behavior in the care of Ortho-K lenses,” Dr. Herzberg explains. “The numbers coming out of China speak for themselves – over 1.5 million lenses have been fit with zero incidences of sight-threatening outcomes.” The Ortho-K environment in the US has always been focused on safety first, and the experiences there with corneal molding reflect that. In addition, numerous studies have shown that risks inherent in wearing Ortho-K lenses only at night are no more significant than with any soft lens worn overnight.

Most practitioners who perform corneal reshaping do so for myopia control. Surprisingly, the first landmark study demonstrating this procedure was the one on Longitudinal Orthokeratology Research In Children (LORIC) by Pauline Cho a little more than a decade ago. Since its publication many more have been done providing an unequivocal answer to the growing myopia epidemic that affects young people, damaging their visual system as they age. Along with low dose atropine, bifocal soft contacts and a change in lifestyle, Ortho-K is set to play a huge role going forward in slowing down myopic progression and its sight-threatening complications.
The academy will place more emphasis on research in the field of myopia control and Ortho-K in the next decade. Indeed, the change in our name was only one small part in this process, as structurally the organization changed as well, opening up vast new funding resources for further research. “The future looks especially bright – we will continue in our worldwide efforts to help contain the disease of myopia, which threatens the health and well-being of our children,” concludes Dr. Herzberg.

The evidence-based effectiveness and safety of orthokeratology

The role of peripheral refraction in myopia progression control and how the peripheral defocus image influences eye growth has been studied for the past decade (Smith EL, 2013). 1 “The development of animal models of refractive errors has made a huge contribution to our understanding of the regulation of eye growth,” explains Gonzalo Carracedo, OD, MsC, PhD, University Complutense of Madrid, Spain.

This field has also generated a huge body of literature linking retinal defocus and eye growth. The first evidence that visual experience has an influence on eye growth was discovered by...
“IN THE COMING YEARS, RESEARCH SHOULD BE FOCUSED ON UNDERSTANDING THE WHOLE MECHANISM (PHYSICAL OR OPTIC AND BIOCHEMICAL) TO DEVELOP BETTER, MORE EFFICIENT SOLUTIONS, TO COMPLETELY HALT THE PROGRESSION OF MYOPIA”

DR. GONZALO CARRACEDO

Wiesel and Raviola in 1977. They demonstrated that the sutured eyes of monkeys developed myopia associated with expansion of the posterior segment both equatorially and axially, postulating that this was due to lack of a clear retinal image. The evidence that the peripheral retinal image can influence eye growth has recently been provided by experiments in rhesus monkeys (Smith EL, 2005). These experiments demonstrated that deprivation of the peripheral retina can stimulate axial eye growth despite normal central vision and indicates that influences on the peripheral retina can outweigh signals from the central retina.

More recently lens-induced peripheral hyperopia has also been shown to produce central myopia (Smith EL, 2009). In humans, the role of the peripheral retina in relation to refractive error and eye growth has largely been evaluated, with numerous studies examining the relationship between foveal refraction and off-axis or peripheral refraction (Flitcroft DI., 2012). Current research interest is centered heavily around the influence of peripheral refraction on myopic progression. Based on this theory different optical treatment strategies have been proposed and tested, and as with orthokeratology (Ortho-K), used to reshape the cornea of a myopic eye.

There are several studies performed since 2004 linking orthokeratology and myopia control. Walline et al. in the CRANYON study found that children who wore orthokeratology for two years showed less axial length growth and therefore less myopia progression (57%) than children who wore monofocal soft contact lenses (Walline et al., 2009). However, the MICOS...
study only found a 32% reduction in myopia in the ortho-K group compared to the eyeglasses group (Santodoming et al., 2012).™

Regarding orthokeratology safety, there have been a total of 123 instances of microbial keratitis in orthokeratology patients reported between 1997 and 2007. Most of the reported cases were found in East Asian children ranging in age from 9 to 15 years of age, mainly due to inappropriate lens care, the patient not following practitioner’s instructions and continuation of lens wear despite discomfort. Common organisms found were Pseudomonas aeruginosa and Acanthamoeba. Other studies have found an incidence of microbial keratitis of 7.7 per 10,000 patients per year of wear, making orthokeratology wearers only slightly more susceptible to infection than daily soft contact lens wearers (4.1 per 10,000) and better than 30-day extended wear silicone hydrogel lens wearers (14.4 per 10,000 patients) wear. Also, the incidence for orthokeratology is slightly less than with LASIK surgery, which has an incidence of 9 per 10,000 patients per year (Solomon et al., 2003).™ In conclusion, the long-term safety and efficacy of orthokeratology use has been demonstrated, with few cases of severe adverse incidents reported and a high efficacy in reducing and controlling the progression of myopia.

Remaining scientific and clinical challenges ahead

Although peripheral refraction is the most accepted hypothesis, results from all studies show that other mechanisms are involved in myopia control with orthokeratology. Accommodation, high-order aberration as well as light power could be participating in the complex task to control eye growth. Moreover, these are just the physical mechanisms, which trigger a biochemistry signal pathway (Young et al., 2009).™ “In the coming years, research should be focused on understanding the whole mechanism (physical or optic and biochemical) to develop better, more efficient solutions, to completely halt the progression of myopia,” suggests Dr. Carracedo. In terms of the clinical challenges, the current question to answer is not if orthokeratology controls myopia progression but when this treatment must be applied. How much growth of myopia every year is necessary to make orthokeratology treatment mandatory? In this matter, clinicians should develop an international protocol suggesting the best way to use myopia control devices such as Ortho-K.

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KEY TAKEAWAYS
• In the past decade orthokeratology has progressed in leaps and bounds to non-surgical advanced engineering of the corneal surface.
• The IAOMC is set to enjoy exponential growth, with a focus on orthokeratology and myopia control in the next decade.
• Several studies over the past 12 years have linked orthokeratology to myopia control.
• Orthokeratology has been shown to be effective in reducing and controlling the progression of myopia.
• The question today is not whether orthokeratology halts myopia progression but rather when should it be applied.
A LOOK AT MYOPIA RESEARCH IN CHINA

Wenzhou Medical University (WMU) is one of the leading educational and research medical universities in China. Beyond its academic excellence and high-end medical services, WMU is a leader in advanced research in ophthalmology and optometry. Against the backdrop of an unprecedented rise in myopia in East Asia, several research programs at WMU have been vigorously dedicated to furthering understanding of the condition and developing new treatments for it. This interview with Professor Lu Fan, the president of Wenzhou Medical University, explores in depth the scope of the latest scientific and clinical efforts to slow down the myopia pandemic.

Points de Vue: Professor Lu Fan, what are the key challenges regarding myopia in China? What have been the most significant achievements in scientific and clinical practice over the past ten years?

Prof. Fan LU: Myopia control and management still face significant challenges. First, an increasing number of patients with progressing myopia tend to be younger than in the past. Second, the overuse of smartphones has dramatically changed people’s behavior. Children, for example, tend to spend a lot of time reading at a very short distance. The prevalence of myopia among both urban and rural children has gone up as a result. Third, the impact of high myopia on an individual’s eyesight is unpredictable and uncontrollable.

We have done a lot of scientific and clinical research work focusing on myopia in the past decade. As to the basic research, we have found that the level of dopamine (DA) and its receptors affect the occurrence of myopia. Interventions regarding myopia have made large steps forward. Many new concepts and techniques appear to help control myopia, such as the correction of peripheral refraction errors, the usage of orthokeratology and atropine eye drops. In addition, adequate outdoor activities are critical for myopia prevention.

KEYWORDS
Myopia, high myopia, myopia control, myopia management, dopamine (DA), peripheral refraction errors, orthokeratology (Ortho-K), atropine, outdoor activities, eyeglasses, contact lenses, myopia prevention, genetic therapy, refractive surgery, keratoconus, posterior scleral reinforcement (PSR), etiology, ocular bio-imaging.
Progress is made step by step in the field of biochemical mechanisms for human myopia. However, there is much still to be done. For example, the results of the animal model need to be studied further when applied to human beings. Myopia is not the outcome of a single gene and pathway, and the potential target of pharmacological approach may need more detection. Therefore, a lot of work still has to be done to develop an effective treatment for myopia.

How would you define the current scope of myopia research at Wenzhou Medical University (WMU)?

The entire project of myopia research at WMU combines resources from the eye hospital with those of the school of optometry and ophthalmology. The research fields cover clinical practices, genetic studies, biology, innovation in medicine, ocular imaging developments, etc. The top three research areas are: 1) fundamental research, including establishing animal models, dopamine effects and genetic therapy, which are supported by the National Basic Research Program of China (973 Program); 2) clinical studies on the correlation of child behavior and myopia, epidemiological investigations, myopic function changes and visual acuity after refractive surgery; 3) optometric interventions, such as optical corrections, rigid gas permeable (RGP) lenses and orthokeratology, which are always the areas most beneficial to the public.

What can be learned from research on biochemical mechanisms regarding myopia onset and its progression?

Although myopia is the most common human eye disorder in the world, the exact cause is still unclear. Myopia usually results from inherited genes interacting with environmental factors. Multiple genetic myopic loci and pathways have been identified. The onset of myopia and its progression interact as an entity and a complex disorder.

What are the top three research areas?

The refractive surgery center at WMU’s eye hospital is one of the biggest and most important refractive surgery affiliations in China today. About five thousand patients undergo refractive surgery annually in our center. A full 98% are myopia patients. Among the myopia patients, 88% are aged 20 to 30.

What are WMU’s key areas of research on refractive surgery in myopia treatment?

How would you define the key clinical challenges and post-operative concerns in patients, especially those with high myopia?

The refractive surgery center at WMU’s eye hospital is one of the biggest and most important refractive surgery affiliations in China today. About five thousand patients undergo refractive surgery annually in our center. A full 98% are myopia patients. Among the myopia patients, 88% are aged 20 to 30.

"MANY NEW CONCEPTS AND TECHNIQUES APPEAR TO HELP CONTROL MYOPIA, SUCH AS THE CORRECTION OF PERIPHERAL REFRACTION ERRORS, THE USAGE OF ORTHOKERATOLOGY AND ATROPINE EYE DROPS. IN ADDITION, ADEQUATE OUTDOOR ACTIVITIES ARE CRITICAL FOR MYOPIA PREVENTION."

Experts’ Voice

"Many new concepts and techniques appear to help control myopia, such as the correction of peripheral refraction errors, the usage of orthokeratology and atropine eye drops. In addition, adequate outdoor activities are critical for myopia prevention."

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As to the key clinical challenges and post-operative concerns when it comes to refractive surgery, safety is the most important and persistent issue. Although the techniques and surgical skills at the facility are mature and advanced, there is still a small group of patients that suffer from severe complications. One of the worst complications is keratoconus. The most possible reason is that these patients are not suitable candidates and they might already have sub-clinical keratoconus before the refractive surgery. Therefore, strict candidate screening is critical. Given this, we did research focusing on sub-clinical keratoconus filtering. Using the study results, we built the diagnostic indices for sub-clinical keratoconus detection. In addition, longitudinal parts are still ongoing to prove our custom-designed indices can discriminate effectively. We do hope the results will be helpful when selecting candidates and improving safety.

In terms of the patients with high myopia, intraocular refractive surgery is preferable to surgery on the cornea. The anterior/posterior chamber implantation of intraocular lenses (IOLs) might cause severe endothelial cell loss. As a consequence, cataract surgery is more recommended for the older patients with high myopia. Moreover, monitoring the fundus changes is quite important as well. Currently, we also try surgery of posterior scleral reinforcement (PSR) for very high myopia control. The PSR aims to reduce the posterior segment structure changes induced by high myopia. We do find the PSR is helpful for delaying axial length elongation and improving visual acuity after surgery. Above all, high myopia and its complications are more likely to cause blindness. More efforts are being made with respect to refractive surgery to ensure visual health.

There are many optical methods to correct and control myopia progression in clinical settings. What is the current research focus with regard to optical solutions at WMU? How will the latest findings in this area influence future clinical practice?

At WMU’s eye hospital, eyeglasses, soft contact lenses, daytime RGP lenses and orthokeratology (Ortho-K) are all used for the correction of myopia in patients. One of the influential research areas is orthokeratology. The mechanism of how orthokeratology slows myopia progression is a hot topic. According to our studies, wearing Ortho-K lenses over the long term can improve accommodation amplitude, change wavefront aberration and correct peripheral refractive errors. All factors combined together slow the axial length elongation, which delays myopia progression.

“According to our studies, wearing Ortho-K lenses over the long term can improve accommodation amplitude, change wavefront aberration and correct peripheral refractive errors. All factors combined together slow the axial length elongation, which delays myopia progression.”

Experts’ Voice
What can we learn from etiology findings? What are the most myopigenic conditions for myopia onset and its progression in children? What factors can/can’t be modified?

In terms of the etiology, it is very complicated. Myopia is not only caused by a hereditary factor, but it is also affected by environment factors. A lot of different theories, such as genetic loci changes, RNA alterations during the process of transcription and translation and various pathways, have been constructed to interpret the occurrence of myopia. The most myopigenic condition is always the hereditary one. A child with two myopic parents has a greater likelihood of being myopic than a child with only one myopic parent. However, at present this cannot be controlled when the baby is born. Luckily, there are some environmental factors that can be modified to postpone the onset of myopia and its progression, such as good reading habits, enough outdoor activities and a healthy diet.

What are the key vision functions that have been studied in myopic children, and what specificities have already been uncovered through WMU’s research? What do we know about the relationship between visual and behavioral functions – such as posture – in children with regard to myopia progression?

The key vision function that we have studied is lag of accommodation. Near vision posture is indirectly linked to myopia through lag of accommodation, peripheral defocus, light and contrast. Based on our previous studies, tasks done at short distances significantly influence posture. Video games produce the shortest working distance and the highest head tilt. Illuminance and contrast significantly influence near posture. The worst posture comes when there is low illumination and contrast. Thus, recommendations for parents should be: 1) work in a bright environment (≥ 300lux); 2) ensure a high contrast for the text when reading; 3) make sure there is an adequate working distance, especially for video games. In addition, the lens type, such as single vision lenses or progressive addition lenses (PALs), and the near-phoria status affected near vision posture. During reading, myopic esophoric children used a lower portion of their PALs compared with exophoric children, resulting in greater addition power, which might partially explain why myopic children with near esophoria exhibited superior treatment effects in myopia control clinical trials using PALs. Therefore, I think the near-work posture plays an important role in the development of myopia progression in children.

"THE KEY VISION FUNCTION THAT WE HAVE STUDIED IS LAG OF ACCOMMODATION. NEAR VISION POSTURE IS INDIRECTLY LINKED TO MYOPIA THROUGH LAG OF ACCOMMODATION, PERIPHERAL DEFOCUS, LIGHT AND CONTRAST."
What are the key collaborative projects and partnerships that WMU has initiated to accelerate research on myopia?

Myopia research is a big project, including the mechanism, image recording, visual functions and corrections. We collaborate with Prof. Xiongli Yang from the Chinese Academy of Sciences on the myopic mechanism and pathway study and Zeng Changqin from the Chinese Science Academy for studying the genetics of high myopia. Also, we work together with ESSILOR to study the visual function in myopic students.

Beyond research, how would you define the key educational challenges in optometry and ophthalmology with regard to myopia? How can education be helpful in growing eye care services and preventing the pandemic of myopia?

The way optometry and ophthalmology for myopia correction and treatment are studied needs to be rethought. Talented individuals with a medical background are the optimal backups for specialized training. Both the clinical skills and human concerns are required for professional proficiency.
A COMMITMENT TO PUBLIC HEALTH BY ALL OF SOCIETY WILL POSITIVELY PROMOTE HIGH MYOPIA MANAGEMENT. ENHANCING THE LEVEL OF PUBLIC EDUCATION IS AN ESSENTIAL STEP, AND THE PARTICIPATION OF DIFFERENT MEDIA SHOULD BE ENCOURAGED.

However, with the increasing demand of public eye care, system training at present is still insufficient. Training for optometrists and ophthalmologists is desperately needed at different angles and levels. The standardized clinical flow, including the doctors, sales assistants, dispensers and after-service staff, should be established as a team work. A personalized and accurate prescription is the basic guarantee of the entire process. Therefore, only when prevention, control and treatment are based on high qualifications will myopia management reach a high standard.

What other initiatives do you believe are required to improve the level of public awareness and that of the public health services to reduce the rates of high myopia?

A commitment to public health by all of society will positively promote high myopia management. Enhancing the level of public education is an essential step, and the participation of different media should be encouraged. Combining the basic awareness of myopia with the elementary education of children is a critical step. Next, a basic medical insurance system will bring the public a brand-new concept. The most significant way is to ensure primary eye care is covered by the basic medical insurance system. Once there is awareness of myopia, the appropriate medical advice and diagnosis can be provided. Lastly, establishing a triple-level patient transferring system will support prompt treatment for high myopic patients when complications and emergencies occur.

What, in your opinion, is the key role ophthalmic clinicians (i.e. ophthalmologists, optometrists and optical dispensers) should be playing in preventing the complications of high myopia?

Ophthalmic clinicians working as a team is key to ensuring a high medical quality. Medical consultation and specialized guidance at the hospital are the basis for managing high myopia. Patients will then learn to step up their vigilance for the complications of high myopia. It is a beneficial way to guarantee timely awareness and treatment for high myopia complications.

Where to next?
What are the key areas in scientific research, clinical practice and medical education with regard to myopia in next decade?

We have already made big steps forward in myopic research and clinical work in the past decade. In the coming future, medical education for ophthalmic clinicians must be a priority. China’s rapid economic development means the need for the primary eye care is growing fast. Strict and standard training of myopia management is critical. On the other hand, biochemical research for the myopia pathogenic mechanism will continue to be a hot topic. Transforming achievements in the lab into clinical practice is the ultimate goal of all researchers and physicians. •

Interview by Eva Lazuka-Nicoulaud
Wenzhou Medical University is a well-known medical science university under the joint governance of the Zhejiang Provincial Government, the National Health and Family Planning Commission and the Chinese Ministry of Education. Its origins extend back to the establishment of Zhejiang Medical School in 1912. In 1958, part of this school moved from Hangzhou to Wenzhou in southeastern China, becoming Zhejiang Second Medical College and later Wenzhou Medical University. Covering 1.27 km², the four-campus university is a key higher-education institution in Zhejiang province.

WMU has medical doctoral degree programs in ophthalmology and the visual sciences, surgery, obstetrics & gynecology, laboratory medicine, internal medicine, pediatrics, gerontology, neurology, psychiatry & mental health, dermatovenerology, imaging & nuclear medicine, otolaryngology, oncology, rehabilitation medicine, sports medicine, anaesthesiology, emergency medicine, biological therapy & reproductive medicine. WMU also has eight primary-discipline master’s degree programs. Its five affiliated hospitals offer high-quality medical service to some 20 million people.

“WE HAVE ALREADY MADE BIG STEPS FORWARD IN MYOPIC RESEARCH AND CLINICAL WORK IN THE PAST DECADE. IN THE COMING FUTURE, MEDICAL EDUCATION FOR OPHTHALMIC CLINICIANS MUST BE A PRIORITY.”
Several research programs have already made significant progress in understanding and developing new treatments for myopia in the past decade. Recent studies have evidenced a clear link between myopia progression and environmental factors. They suggest new preventive measures in childhood myopia.
There is evidence in many countries globally that the prevalence of myopia is on the rise. Advances in measurement technology now allow many environmental factors potentially associated with the development and progression of myopia to be quantified reliably and sampled densely. Our recent prospective longitudinal study of Australian schoolchildren, utilising wearable sensor technology has provided the first direct evidence of a significant relationship between personal ambient light exposure and eye growth in childhood; demonstrating that greater daily light exposure is associated with slower eye growth. These findings support the potential for interventions aimed at increasing daily outdoor light exposure, to reduce the development and progression of myopia in childhood.
normal growth of the eye and hence the development and progression of myopia in childhood is likely to be critical for the development of effective myopia control interventions.

A move to outdoors
Over the years, a range of different environmental factors have been proposed as potentially playing a role in human myopia development, with factors related to near-work, education and academic achievement being a major focus of many studies. More recently, perhaps spurred on by the sometimes equivocal findings of studies examining the association between myopia and near work, a shift in the focus of refractive error research has occurred, with a move away from traditional near work measures and a broader focus on additional potential environmental factors (e.g. outdoor activities).

Evidence has been emerging from both human epidemiological studies, and research with animals, that ambient light exposure may be an important additional environmental factor that plays a role in myopia. Animal studies demonstrate that normal eye growth appears to be influenced by environmental light levels, since rearing young chickens in dim ambient light environments has been shown to result in more rapid eye growth and the development of more myopic refractive errors compared to rearing animals in bright ambient light conditions. Similarly, exposure to bright ambient light conditions appears to block the development of experimental (form deprivation) myopia in chickens and primates. In humans, evidence of a potential role of light exposure in myopia has arisen from a number of epidemiological studies that have shown that children who report spending greater time outdoors also exhibit a significantly lower prevalence and incidence of myopia compared to children reporting less daily outdoor time (see Sherwin et al for a review of recent studies examining the association between myopia and outdoor activities). Childhood eye growth and myopia progression is also known to vary according to the time of the year, with slower eye growth documented in summer months (where more environmental light and thus opportunities to spend time outdoors is available), and faster eye growth is documented in winter months (where less environmental light is available).

Since spending time outdoors also typically involves exposure to high intensity outdoor light (often more than 100 times brighter than the typical indoor light levels), it has been hypothesised that the associations found between more outdoor activity and less myopia, support a potential role for light exposure in myopia development. However, it is important to note that the majority of the previous studies examining outdoor activity and childhood myopia (and studies of seasonal variations in childhood eye growth) have not objectively assessed the habitual ambient light levels experienced by the children in their studies. Instead, this previous work has relied upon questionnaires to quantify children’s activities and make

“Our findings support the potential for interventions aimed at increasing daily outdoor light exposure to reduce the development and progression of myopia in childhood.”
estimates of their daily outdoor time, which does not provide an objective assessment of light exposure. Based on this research it is difficult to know conclusively whether the mechanism underlying the protective effects of outdoor activities is due to light exposure or another factor related to being outdoors (e.g. more physical activity or less near focussing).

Seeing the light
Our recent research, taking advantage of wearable light sensor technology, has therefore aimed to improve our understanding of the factors underlying eye growth and myopia in childhood by examining for the first time the relationship between objectively measured ambient light exposure and children’s eye growth. The Role of Outdoor Activity in Myopia study (ROAM study) was an 18-month prospective longitudinal study of eye growth in myopic and non-myopic children. The experimental procedures and outcomes from the ROAM study have been reported in detail in a number of recent publications. One hundred and one children, aged between 10 and 15 years of age, were enrolled in the study, including 41 myopic children (mean spherical equivalent refraction -2.39 ± 1.51 D) and 60 non-myopic children with refractive errors close to emmetropia (mean spherical equivalent refraction of +0.35 ± 0.31 D). Each participant in the study had a series of ocular measurements, including measures of axial eye length collected every six months over the 18 month study period. Additionally, objective measurements of each child’s individual ambient light exposure and physical activity were also collected twice in the first 12 months of the study (approximately six months apart). These measures were collected using Actiwatch-2 devices (Philips Respironics, USA), a wrist watch sized device that contains a light sensor and an accelerometer, programmed to collect simultaneous measures of ambient light exposure and physical activity every 30-seconds of the day over each of the two 14-day periods of sensor wear (Fig. 1). This represents over 80,000 individual measures of light exposure and physical activity from each child over the course of the study. These measures allowed us to examine the potential association between longitudinal changes in eye growth and children’s habitual ambient light exposure and physical activity. Analysis of these densely sampled light exposure and physical activity data revealed differences in the typical daily pattern of activities of the myopic and non-myopic children in the study. Although the daily variations in
environmental light exposure and physical activity were observed to closely follow the pattern of children’s typical school day (with peaks in activity and light exposure found before and after school and during lunch breaks in the school day), myopic children were found to exhibit significantly lower average daily light exposure compared to the non-myopic children, with the largest differences being found at times immediately before and after school and at lunchtime (Fig. 2). This is indicative of less outdoor activities for the myopic children over these times. Although there were trends observed for the myopic children to also have slightly lower daily physical activity levels, differences associated with physical activity were not statistically significant.

The average axial eye growth observed in the myopic and non-myopic children in the study is illustrated in Figure 3. Analysis of these data revealed a number of statistically significant predictors of eye growth in this population of children, including the presence of myopia (where, as expected myopic children showed faster eye growth, indicative of myopia progression in this group), younger age (where younger children showed more rapid eye growth than older children) and gender (where boys showed slightly faster eye growth than girls). Additionally, axial eye growth was also significantly associated with the children’s average daily light exposure, with lower daily light exposure being associated with faster axial eye growth. To examine the relationship between light exposure and eye growth in more detail, the children in the study were further categorised (based upon a tertile split of their individual average daily light exposure levels, regardless of their refractive status) as being habitually exposed to low, moderate or high ambient light levels (Fig. 4). Children habitually exposed to low daily ambient light levels (who on average were exposed to only 56 minutes of bright outdoor light per day) were found to exhibit significantly faster axial eye growth. These analyses included adjustments for refractive status, which suggests that these effects of light exposure on eye growth are occurring independent of refractive error. Over the 18 months of the study, children exposed to low daily light levels, exhibited approximately 0.1 mm greater eye growth than children habitually exposed to moderate and high ambient light levels, which equates to a clinically significant ~0.3 D more myopic progression in refraction.

![Graph](image-url)
FIG. 3 | Average axial eye growth observed over the 18 month study in the myopic and non-myopic children. Error bars represent standard error of the mean. Linear mixed models analyses revealed that the presence of myopia, younger age, male gender and lower daily light exposure were all significantly associated with the rate of axial eye growth.15

FIG. 4 | Average axial eye growth over the 18 month study after categorising children based upon their average daily light exposure as being habitually exposed to high, moderate or low ambient light levels (regardless of their refractive status). Children exposed to low daily light levels exhibited significantly faster eye growth. Error bars represent standard error of the mean.15
The use of wearable sensor technology in this study provides important new insights into the mechanisms underlying the previously documented relationship between more myopia and less outdoor activities. Our findings support an important role for bright ambient light exposure in the protective effects of outdoor activities and suggest that increased physical activity outdoors is not a key factor involved. These results provide us with the first direct evidence of a relationship between ambient light exposure and the rate of eye growth in childhood and suggest that low light exposure is a risk factor for more rapid eye growth and hence myopia development and progression.

An important aspect of ambient light exposure as a risk factor for myopia is the fact that it is a modifiable environmental factor. Children can modify their activities/behaviour in order to change their daily light exposure and potentially have an impact upon their rate of eye growth and hence risk for development and progression of myopia. These findings therefore support the potential for public health interventions aimed at increasing daily light exposure to reduce myopia development and progression in childhood.

Clinical recommendations
While the ROAM study has provided new insights into the factors influencing eye growth in childhood, the study also provides us with empirical evidence regarding light exposure and eye growth that can be used to guide clinical recommendations to children and their parents. The children in the study categorised as habitually experiencing low daily light exposure, on average spent less than 60 minutes per day in bright outdoor light levels and also exhibited significantly faster eye growth than the other children in the study. This suggests that less than an hour of bright outdoor light exposure per day appears to predispose children to faster eye growth and hence risk for myopia development and progression. Significantly slower eye growth was seen in the children, who on average spent ~120 minutes per day exposed to bright outdoor light levels, which suggests that increasing daily bright light exposure by an additional 60 minutes per day is likely to have an impact upon slowing axial eye growth (and hence reducing the risk of myopia development and progression). This is supported by two recent studies where interventions to increase children’s outdoor time (by either 40 minutes or 80 minutes per day) were found to significantly reduce the incidence of myopia in populations of East Asian children.

“These results provide us with the first direct evidence of a relationship between ambient light exposure and the rate of eye growth in childhood and suggest that low light exposure is a risk factor for more rapid eye growth and hence myopia development and progression.”
Conclusions
The work summarised in this article helps to improve our understanding of the role of light exposure in the regulation of human eye growth and refractive error development and progression and supports the potential for future myopia control interventions aiming to increase daily bright light exposure. However, more research is still needed to further our understanding of a range of aspects regarding light exposure and myopia. These factors include the relative importance of the spectral composition of light, the optimum timing of light exposure and the specific intensity of light that is most important in the regulation of human eye growth. Additional knowledge from further research in this field may allow more targeted myopia control interventions to be developed in the future, which from the perspective of myopia control, looks to be bright.

Acknowledgements: This work was supported by an Australian Research Council Discovery Early Career Research Award (DE120101434). I gratefully acknowledge my co-investigators Michael Collins and Stephen Vincent for their contributions to the work presented in this paper.

KEY TAKEAWAYS
• There is evidence of a rapid increase in myopia prevalence in recent decades in many developed countries.
• An improved understanding of the environmental factors underlying eye growth and myopia in childhood is crucial for developing effective myopia control interventions.
• Recent work utilising wearable sensors demonstrates the first direct evidence of a relationship between lower daily light exposure and faster axial eye growth.
• Less than 60 minutes of bright outdoor light exposure appears to be a risk factor for faster eye growth and hence myopia development and progression in childhood.
• These results support the potential for myopia control through increased daily light exposure (e.g. interventions to increase daily time outdoors).

REFERENCES
The Increasing prevalence of myopia may significantly influence clinical practice in the future. Vision care professionals are looking for the latest technologies in screening, correcting and treating the condition. They also have to adapt protocols and pay special attention to patients with high myopia.

P.28 How does Orthokeratology (Ortho-K) practice develop across the world?
P.34 What are the specificities of refraction and optical equipment in patients with high myopia?
Many factors must be taken into account when controlling myopia progression. There is no doubt genetics plays a role in the development of myopia in children. But lifestyle is also an important factor to consider. In terms of safe and effective treatment, orthokeratology is now known to be successful in controlling myopia and has even been shown to slow down progression in individuals with high myopia. While it has developed substantially in Latin America, it is effectively mainstream in the US and a common treatment in China, where there are numerous orthokeratology clinics in city hospitals. Currently, orthokeratology is also on the rise in Europe.

The has been a tremendous increase over the past few decades in the prevalence of myopia worldwide. Practitioners are more and more concerned with regard to the increased incidence of patients moving into the category of high myopia. The ocular health consequences of sequelae related to high myopia can be devastating in later life. Many clinicians are implementing a systematic approach to establish a control protocol for their patients with rapidly progressing myopia.

A comparative survey of methods for controlling progressive myopia

“Looking at ways to manage progressive myopia first requires identifying those who are at highest risk,” explains Dr. Bruce T. Williams, OD, FIAO. Some of the risk factors include whether or not one or both parents are myopic, especially if one or both are highly myopic. Other factors to consider are myopic siblings or a family history of ocular disease associated with myopia. Ethnicity is important, as the literature shows us that Asians are at a much higher risk.

It is becoming increasingly apparent that lifestyle plays a significant role in how myopia develops in young individuals. Several studies have shown that time spent outdoors has a protective effect.\textsuperscript{1,2,3,4,6,7,8} Whether it is higher levels of illumination, less near-distance tasks or increased levels of vitamin D, the effect has been clearly demonstrated. Limiting the amount of near work like reading and the use of electronic devices, could be beneficial, especially for kids that have higher associated risk factors.
Most children should reach emmetropia by the age of eight-years-old. A six-to-eight-year-old child at approximately -1.00 diopter will typically add a half diopter per year and end up at -5.00 to -6.00 by the mid-teens. It is important to initiate a protocol to limit the progression of myopia. By reducing the rate of progression by 1/3, you reduce the likelihood of the individual developing high myopia by 70%. If you can reduce the rate by 50%, the likelihood is reduced by 90%.

When designing a strategy to develop a protocol for myopia prevention, encouraging the patient and parents to incorporate beneficial lifestyle changes should be the first priority. The practitioner can then look at the available options for implementing a plan for the individual. We know that correcting the refractive error with traditional single vision spectacle lenses or regular soft/rigid contact lenses will inherently cause more peripheral hyperopic defocus, encouraging axial elongation and an increase in myopia.

Progressive addition lenses have been shown to reduce progression by 14% (and up to 37.2% in esophoric children, with high lags of accommodation when compared to the regular single vision lens group). This is certainly an alternative, but it is not as effective as we would like. The industry is working on developing executive-style bifocals that contain a prismatic component, which makes them a more effective spectacle lens alternative (they show three-year results of myopia progression reduction of 51% when compared to regular single visions lenses).

Pharmacological intervention has had a profound effect. It is as much as 90% effective in reduction rates. There are certainly concerns, especially in children, when starting with pharmaceutical agents. A six-year-old child on anti-muscarinic drug therapy for the next 12 years could face serious unknown consequences. Proper dosage for safe and effective treatment has not been firmly established, and there are reports of a significant rebound effect after discontinuation.

Soft multifocal lenses have recently shown promise but have some disadvantages, such as blurred distance vision and dryness, not to mention they limit some of the activities in which children can participate.

Orthokeratology has consistently been shown to reduce the progression by approximately 45%. Orthokeratology has the advantage of only being worn overnight while sleeping. Parents are usually there to supervise insertion and removal, and the child wears no lenses while at school during the day. Orthokeratology sets up a unique topographical shape on the anterior cornea. The central cornea is flattened to focus on the fovea, and the mid-peripheral cornea is steepened to create a myopic defocus on the peripheral retina, reducing the stimulus of the normal hyperopic defocus for axial elongation and subsequent increases in myopia (Fig. 1 and Fig. 2).

By designing lenses with specific optic zone diameters, radii and reverse curve radii and widths, effective treatment can be accomplished for most minus refractive errors and astigmatic components. Fortunately, the positive effect of myopia control is even greater for patients that have already progressed to higher states of myopia. This procedure can literally stop further progression of those already in the category of high myopia.

The following pictures show the axial (Fig. 3) and tangential (Fig. 4) topographical plots of a high myope. Note the area under the reverse curve is much steeper and rises above the original reference sphere, producing a peripheral add power of well over the recommended minimum of +4.00 diopters. This produces a substantial myopic peripheral defocus to eliminate the stimulus for axial elongation and progressive myopia.

The advantages of orthokeratology over other forms of myopia prevention are clear and numerous. It has proven to be safe and effective when compared to all forms of contact lens wear. Even in cases where full myopic correction could not be achieved, the rate of progression
has been slowed by greater than 50%, as in a study published by Pauline Cho at Hong Kong Polytechnic University. The child has parental supervision; the lenses are only worn in a closed eye environment, reducing the chance for loss or foreign body involvement. The child is free to participate in swimming and all kinds of activities that might be limited by the use of other solutions.

Orthokeratology should be presented to all young patients with progressive myopia as the safest and most effective strategy to reduce the progression of myopia to proven “safe” levels. If that turns out not to be accepted, then other forms should be presented as well. Some form of progressive myopia reduction should become the standard of care for these patients to reduce the possibility of eventual sight-threatening complications.

Latest achievements in orthokeratology
In 2010, Bourne et.al estimated that 108 million people were affected by myopia, making it the leading cause of vision impairment worldwide. He also noted that it was the second most common cause of blindness. This is estimated to cost US$202 billion per annum. That said, what are rank-and-file eye care professionals doing to address the problem? “If any one of us had a patient sitting in the chair with a known sight-threatening condition, which was in anyway treatable, would we tell them that we were going to cover the symptoms and just watch the condition progress until it reached the end point? Of course not. Yet this is what many of us are doing today,” explains Dr. Williams.

The worldwide epidemic of progressive myopia is gaining strength every day. In the article “Global Prevalence of Myopia and High Myopia and Temporal Trends from 2000 through 2050,” authors stated: “Myopia and high myopia estimates from 2000 to 2050 suggest significant increases in prevalence globally, with implications for planning services, including managing and preventing myopia-related ocular complications and vision loss among
almost 1 billion people with high myopia. A study conducted in Shanghai, China, of more than 5,000 subjects published in November 2012 found that 95.5% of university students were myopic. Of them, 19.5% were highly myopic, greater than -6.00 diopters. Myopic prevalence in the United States rose from 25% in the early 1970s to 41.6% in the early 2000s. Study after study in virtually every sector of the planet has shown an alarming increase in the number of people with myopia.

For years clinicians and scientist have debated whether myopia is a result of genetics (nature) or environmentally induced (nurture). Studies have shown that having one or two myopic parents significantly increases a child’s chance of becoming myopic. Children today have significantly increased near demand and tend to spend less time outdoors in natural light. It has been shown that spending more time outdoors results in less myopia. This is possibly due to less near demand, pupil constriction or the release of retinal transmitters such as dopamine and vitamin D that may inhibit eye growth. It stands to reason that if we subscribe to the theory of emmetropization being regulated by visual feedback, the majority of the feedback should come from some distance substantially greater than 20cm.

Walline (2012) suggests that a 50% reduction in the rate of myopia progression of -0.75D/yr. would keep a seven-year-old -1.00 diopter child at -3.62D instead of -7.00D in the span of just eight years. This would significantly reduce the possibilities of developing severe ocular manifestations of myopia-related intraocular disease.

These increases are not going unnoticed by industry. Many companies are hurriedly trying to develop specialty lenses for both contacts and spectacles to in some way slow or stop the progression of myopia in those patients that are at high risk of reaching severe myopia.

Today, there are several ways to halt the formerly inevitable process that leads to severe myopic degenerative disease. There are many controlled studies that prove effective measures can be taken to slow the steady rate of increasing axial elongation and the devastating consequences thereof. These include pharmaceutical agents such Atropine and Pirenzpine, multifocal contact lenses, executive bifocals, progressive spectacle lenses, prismatic multifocal spectacle lenses and vision therapy.

One method that has been shown to be particularly effective in reducing the myopia progression rate by 50% is orthokeratology. This is the programmed use of specially designed contact lenses to flatten the central cornea while steepening the mid-peripheral cornea to temporarily reduce myopia. This procedure has the beneficial side effect of altering the peripheral retinal defocus from a hyperopic posture to a myopic posture. That, in effect, removes the stimulus for axial elongation. Hence, the progression of myopia is significantly reduced and sometimes stopped altogether.

Orthokeratology has evolved significantly over the last 50+ years since George Jessen first suggested it. It started as a programmed sequential fitting of flatter and flatter contact lenses to alter the anterior corneal curvature to temporarily correct myopia. We now have designs that can
address nearly every scenario that is presented. Designs that correct low myopia and high myopia, astigmatism and mixed astigmatism, hyperopia and ectasia. We can produce lenses that have toric base curves, toric alignment curves, oval treatment zones and varied return zone depths. The reverse geometry lenses have moved from the original 3 curve designs to 4, 5 and 6 curves. There are computer-assisted programs that import topographies and design lenses to align up to 8 semi-meridians of the cornea to optimize the fluid forces behind the lens for maximum treatment. There is work going on to decenter the treatment zone to align better with the line of sight instead of the geometric center of the cornea so as to reduce induced astigmatism and higher order aberrations.

As the technology advances so will our ability to design lenses that do the best job possible to retard the progression of myopia, increasing the odds of sparing the vision of so many.

Ortho-K in Latin America

In Latin America, orthokeratology (Ortho K) formally began to be practiced after the first global Ortho-K meeting held in Toronto, Canada in 2002. A small group of innovators from different countries, including Mexico, Guatemala, Costa Rica, Colombia, Venezuela, Uruguay, Chile and Brazil, went and participated in the first meetings, although only few of them decided in the coming years to offer the treatment to patients. This was mostly due to the lack of digital or CNC (Computer Numerical Control) lathes in Latin America needed to produce the lenses, which have a reversed curve (they cannot be manufactured with common lathes).

Today, there are have fitters in Mexico, Guatemala, Costa Rica, Colombia, Peru, Brazil, Argentina, Uruguay and Chile, although recent studies from the one-year-old Academia Latino Americana de Ortho K y Control de Miopia (ALOCM), showed that the most cases fitted and currently in use are in Costa Rica and Colombia, with around one thousand patients using the treatment with success.

Evidence has been provided for both countries that the orthokeratology is a safe treatment, with an about 55% rate of myopia progression control (three-year study by Javier Prada et al. in Costa Rica, presented at WCO in Medellin in 2015) reported on 50 patients, with an average of 20/20 for both eye and without infections.

The academy is working on statistics and screening in the different countries to develop a Latin American sample census of the percentage of the prevalence of myopia. This will help prevention and treatment with different methods to avoid a rise in high myopia in the future.

Ortho-K in the US & China

In the United States, the FDA approved nightwear Ortho-K by Paragon CRT in June 2002. Since then, Ortho-K has become a mainstream practice in optometry. Today, there are thousands of Ortho-K fitters that use CRT lenses and also other innovative Ortho-K designs such as GOV, Ortho-tools and Wave, to name a few. Many experienced Ortho-K specialists find that by the off-label use of these other designs, they can correct the degree of myopia at a much higher range than that approved for CRT lenses. It is not unusual for a patient with myopia of 8 diopters or even higher to see 20/20 after just one week of treatment using these custom designed lenses.

The American Academy of Ortho-K and Myopia Control also fuels the enthusiasm for use of Ortho-K in the US, and there are more than 500 members. Each year, the academy hosts the Vision By Design (VBD) conference in different locations around the country. The next VBD will be held in April 2017 in Dallas, Texas; the event is expected to attract hundreds of old and new Ortho-K fitters. They will learn and share knowledge about fitting techniques and concepts regarding myopia control and prevention. Custom soft lenses and diluted Atropine treatment have been introduced in recent years at VBD, which adds more tools to address the growing trends in myopia.

On the opposite side of the globe in Asia and the Pacific Rim, due to the large percentage and high degree of myopia among Asians, Ortho-K is most often promoted as a means of myopia control. In China, a large number of hospitals in all of the major cities have specialized Ortho-K clinics. The number of patients successfully treated by Ortho-K is greater than that in the rest of the world. However, due to government restrictions, many new design innovations available in US are not available in China. Other countries in the Pacific Rim where
Ortho-K are very popular include Taiwan, Singapore, Hong Kong and Australia, where the Orthokeratology Society of Oceania will host its annual congress in September 2016. While the number of eye care providers in Asia and the Pacific Rim practicing Ortho-K is likely to outnumber the US it is certain the number of patients that need treatment for myopia may be many times higher.

Ortho-K in Europe
Unlike in the US or China, it is much easier in Europe to bring a new product to market, especially one that is innovative and groundbreaking. The CE certification required to sell a product in the European market has been in place since 1985. It guarantees the manufacture’s product meets the requirements of the applicable European community directives. This environment brings the ultimate in innovative new products to Europe’s doors much more quickly in certain cases, especially those that fall in between the “cracks”. A classic example is the new versions of lens design software, which can be accessed for yearly fees and provide state-of-the-art lens designing possibilities. This would be illegal in China if the product hadn’t first been approved by the CFDA, a process that is expansive and time consuming. Ortho-K prescriptions for myopia control have been on the rise these last few years, but they still trail behind China and the US. This can be attributed in part to the lower incidence of myopia in Europe, especially when compared with China.

REFERENCES
The specific needs of highly myopic patients require special attention from eye care professionals. This article describes both the visual discomfort and main visual disorders associated with high myopia and explains the risks of visual impairment. It also discusses the specificities of refraction and the choice of optical equipment. In addition, it makes recommendations on frame selection and advise on the optimal selection of ophthalmic lenses.

**High Myopia: The Specificities of Refraction and Optical Equipment**

Christian Franchi graduated from the EOL (Ecole d’Optique et Lunetterie - School of Optics) in Lille, France, and trained at the ICO (Institut et Centre d’Optometrie – International College of Optometry) in Bures sur Yvette, France. He has practiced in Paris as an optician since 1979. Throughout his professional experience in tending to his wearers’ visual health, Christian has continued to deepen his technical expertise. He was particularly interested in ophthalmic optical surfaces, their designing and implementation in optical equipment. With the advent of digital surfacing technologies in 2006, Christian has worked on methods of detecting a wearer’s actual visual axes and on tracking the eye’s center of rotation behind a corrective lens. He patented the OPHTAGYRE process in 2008. Christian Franchi is also a lecturer at several training seminars.

Adèle Longo worked in an optical store while pursuing her studies at the Institut des Sciences de la Vision (Institute of Vision Sciences) in St Etienne, France, where she obtained her optometrist certification. In 2011, she joined the Research and Development department at Essilor International in the Low Vision Research Center within the Paris Vision Institute. In this context, she has worked to improve the functional assessment of patients with low vision. Currently with Essilor Instruments, Adèle is working on upstream studies and works as a low vision consultant at the same time in order to teach at the university and in centers for visually impaired patients.

Dominique Meslin graduated from the University of Paris Sud, and spent most of his professional career at Essilor. He began in Research and Development working on physiological optics and then held various positions in technical marketing and communication for Essilor International in Europe and also in the USA. He was the Director of Varilux University (now Essilor Academy Europe) for more than 10 years, and is now the Director of Professional Relations and Technical Affairs for Essilor Europe. Throughout his career, Dominique has facilitated numerous training seminars for eye care professionals worldwide. He is the author of several scientific articles and various technical publications for Essilor, including the “Ophthalmic Optics Files” series.

**KEYWORDS**
- High myopia
- Pathological myopia
- Retinopathy
- Maculopathy
- Vision loss
- Visual acuity
- Contrast sensitivity
- Night vision
- Glare
- Recovery time from glare
- Quality of life
- Refraction
- Special lenses
- Lenticular lens
- Myopic rings
- Accommodation
- Minification effect
In recent years, the prevalence of myopia has been increasing in all regions of the world. As reported in many studies, myopia's pandemic trends are putting researchers, clinicians and the industry of ophthalmic optics on the alert. Two aspects are emphasized in the mid-term projections: the number of people affected by myopia worldwide will increase steadily and, among them, the proportion of cases with high myopia is also going to increase. Thus, the prevalence of myopia (individuals with mild to high myopia) in the world’s population could reach 25% by 2020 and nearly 50% by 2050, and the average prevalence of high myopia (over -5.00 D) would increase from 2.7% to almost 10% by 2050. In other words, myopic individuals would account for five billion people in 2050 and highly myopic individuals would account for one billion people (Fig. 1). These figures show the significance of the phenomenon that is now considered a major public health problem, and compel us to better understand the day-to-day discomfort felt by slightly and highly myopic people so as to improve their eye care management.

1 Visual concerns of high myopia

1.1. Reduced visual acuity
One of the difficulties frequently encountered by highly myopic people is the difficulty to read small print, despite wearing optimal correction. Karen Rose measured the maximum acuity attained by 120 subjects with various degrees of myopia, which was offset by their usual correction (contact lenses, eyeglasses, etc.). The results showed an average loss of two acuity lines on a logarithmic scale (0.2 on the Minimum Angle of Resolution [MAR] log) between medium myopia (-1.50 to -3.75) and high myopia (beyond -10.00 D), objectifying the subjects’ problems.

1.2. Reduced contrast sensitivity
The Melbourne Department of Optometry and Vision Sciences has measured the contrast sensitivity of various myopic subjects. Even after adjusting for the lenses’ minification effect, the contrast sensitivity determined for the 10 most myopic subjects (greater than -4.00 D) appears worse than for the others (Fig. 2). This explains the difficulty of deciphering low contrast characters, which is necessary in everyday life – when reading certain forms or newspapers, for example. This shows us the importance of measuring contrast sensitivity during a patient’s visual management in order to offer the proper solutions: for example, adding additional lighting can be useful, since it allows for an increase in the apparent contrast of objects viewed.

1.3. Deteriorated vision thresholds under low and bright lights
The study by Mashige on 100 subjects tells us about the need to suggest lighting that is neither too weak nor too strong for these myopic individuals. To that effect, he measured night vision thresholds and vision thresholds under glare. For measuring night vision thresholds (light...
1.4. Increased recovery time after glare
In addition, the recovery time after glare, defined as the time required to regain the initial performance after being exposed to glare, is longer for myopic than for hyperopic subjects (Fig. 4), especially in subjects with a high degree of myopia. This shows, for example, the difficulties experienced by these highly myopic at the exit of a tunnel.

1.5. Decline in the quality of life and social impact
The VF-14 (result between 0-100) and the VQOL (0-5) are two questionnaires on quality of life that have been completed by subjects with different degrees of myopia. The results showed that the highest myopia levels are directly associated with lower general satisfaction in the achievement of all day-to-day living activities due to visual difficulties, particularly when driving. The study of these questionnaires reveals that the difficulties are not only visual, but also concern aesthetics, practical and financial aspects. This decline in quality of life is essentially measured in subjects affected with high myopia (<-10.00 D). Accordingly, the social and psychological impact, resulting from their anguish of losing sight, is very significant.

2. Risks of visual impairment in high myopia
2.1. Pathologic myopia (retinopathy and maculopathy)
A person with high myopia presents a very significant risk of developing eye diseases, which can sometimes cause serious retinal damage leading to various eye complications and subsequent deficiencies in the visual field. Indeed, the excessive axial elongation of the highly myopic eye may cause the mechanical stretching of the outer layers of the eyeball, resulting in such various
much more significant. Very often, highly myopic people remove their glasses for near vision. This allows them to avoid viewing too small objects (reduced in size by their lenses), as well as bringing documents too close to their eyes to magnify them.

When the need for magnification is more significant due to visual impairment, it is interesting to suggest a bright field magnifier, an optical system that is placed directly on a document, thus allowing for magnification of the text and offering a high apparent contrast via concentration of light. Note that it is imperative to adapt the magnifier in relation to the focus distance of the myopic readers when they take off their glasses.

Electronic systems can, in the same way, meet even greater magnification requirements and are the only ones able to offer colorful image processing or reversed contrasts to optimize the vision of those with high myopia.

Significant light sensitivity as reported in high myopia and visual impairment involves testing color filters that can optimize vision while reducing the risk of glare. The analysis of lighting environments at work and at home, the elimination of sources of glare, and the addition of spotlights can help highly myopic people in achieving their daily tasks.

3. Specificities of refraction in high myopia

In the case of high myopia, it is important to practice comprehensive measurements of visual functions and to prioritize those functions that are the most impacted (e.g., visual acuity, contrast sensitivity, glare, etc.). Attention should be paid to day-to-day situations in which patients experience discomfort (low and bright lights, night vision, etc.). The refraction of high myopia requires special precautions, especially complete control of the distance between the glass and the eye (Fig. 6). It is therefore preferable for the prescription to be filled, or at least finalized, with trial frames. The lenses should be placed near the eye and, if possible, to the rear of the trial frame to ensure the closest simulation of the conditions in which the final frames will be worn. If the prescription is of a very high power and is beyond the capabilities of the refractor or the trial lenses, the refraction will be carried out over the...
patient’s current glasses (over-refraction technique) with an additional lens support placed on the patient’s frames. A person with high myopia often suffers from relatively low visual acuity and is therefore not very sensitive to small variations of sphere and a cylinder of 0.25 D; 0.50 D variations will thus be preferred during examination. As with any conventional refraction\(^{13}\), it can be started with measurements from the autorefractometer’s refraction or the prescription previously worn by the patient. To determine the sphere the fogging method can be used, with a high fog (+2.50 D) and larger increments of 0.50 D. To confirm the axis and the power of the astigmatism, a ± 0.50 D cross cylinder will be more efficient than a ± 0.25 D cross cylinder.

A very important aspect of the refraction of high refractive errors is the inclusion of the vertex distance: it can significantly alter the value of the prescription. The closest the lens is to the myopic eye, the lesser its power needs to be concave; the principle is to always match the lens’ image focal point with the far point of the eye (Fig. 6). A person with -20.00 D myopia with a prescription based on a 12 mm vertex distance will thus need a prescription of -19.25 D if the lens is placed at 10 mm and of -20.75 D if it is placed at 14 mm.

Conversely, presbyopic people with high myopia can help their near vision by creating an additive effect by simply pushing their glasses farther away: for example, a person with -20.00 D myopia who pushes his or her glasses away by 4 mm thus creates an addition of about 1.50 D.

4. The importance of frame choice

The choice of frames is especially important with high myopia. The frame should be small to allow its positioning close to the patient’s eyes and, if possible, with offset joints that reduce the size of the lenses and ensure proper distribution of the lenses around the eyes. The optician will adjust it to ensure that the lens is perpendicular to the direction of the gaze when the eye is in its primary position. The choice of the frame will also take into account the insertion height of the temples in the frame front according to the frame position on the nose and the ears; the temples will be adapted accordingly. Before measuring the right and left pupillary distances and heights, the final frame is to be perfectly adjusted to the patient’s face. Finally, the vertex distance will be systematically measured or otherwise evaluated in order to confirm the refraction.

<table>
<thead>
<tr>
<th>Corrective power</th>
<th>Vertex variation</th>
<th>Effect Power variation</th>
</tr>
</thead>
<tbody>
<tr>
<td>10.00 D</td>
<td>4 mm</td>
<td>0.50 D</td>
</tr>
<tr>
<td>15.00 D</td>
<td>4 mm</td>
<td>1.00 D</td>
</tr>
<tr>
<td>20.00 D</td>
<td>4 mm</td>
<td>1.50 D</td>
</tr>
</tbody>
</table>

FIG. 6: Variation in the correction of myopia with the vertex distance (d). The lens movement from L0 to L1 causes defocusing. The focal length of the corrective lens becomes \(f'_{L1} > f'_{LO}\). To compensate myopia, the power should be decreased if the lens is closer to the eye.
5. Special lenses for high myopia

To meet the needs of high myopia, manufacturers offer special lenses designed to reduce the edge’s thickness, commonly covering a power range of up to -40.00 D in single vision and -25.00 D for progressive lenses. Different techniques are used, sequentially or simultaneously, to reduce the thickness at the edge of the lens (Fig. 7): an increase of the refractive index causes the flattening of the two surfaces, thereby thinning the lens’ edge; for example, with an n = 1.67 index material, a -15.00 D lens can have a thickness that is close to that of a -10.00 D lens made of a classic material with an n = 1.50 index (Fig. 7a and b); the reduction of the optical aperture or a “lenticular” lens will allow the thickness to be reduced even more significantly. It involves the creation of a facet at the rear edge of the lens, which divides the lens into two parts — a central, “optical” zone and a peripheral “facet” — and considerably improves aesthetics (Fig. 7c to e). This facet can be optically concave (negative power), plano (no power) or convex (positive power), according to the desired thickness reduction (Fig. 7c, d, e). Moreover, the smoothing of the edge (Fig. 8) improves aesthetics and minimizes the image’s doubling effect at the limit of the optical zone. It nevertheless creates a blurred vision zone that is often far enough to the side so as to avoid hindering the wearer whose lenses are placed close to the eye.

The higher the power of the prescription, the more the central optical zone is reduced (30, 25 and 20 mm) in order to achieve prescriptions of up to -40.00 D (Fig. 7f). For such a power, one can opt for bi-concave lenses whose power is negative on both sides and can achieve extreme power that can even exceed -100 D with a bi-concave and bilenticular lens. The front faces of these lenses are very flat, generating lots of reflections that are very visible; it is therefore indispensable for their surfaces to be treated with antiglare (anti-reflective) coating as long as it is technically feasible.

5.1. Concave lenticular lenses

In order to achieve a high power lens with great aesthetics, manufacturers are producing so called “lenticular” lenses. They are composed of a central optical zone and a non-corrective annular zone on the periphery, called the facet. These two zones can be either separate, with a visible edge separation, or continuously connected via the smoothing of this edge (Fig. 8).
Lenticular lenses: optimum diameter of the optical zone

The goal of using lenticular lenses is to reduce the thickness of the lenses without limiting the visual comfort of the wearer. Indeed, optical apertures that are too small hinder visual comfort. Conversely, optical apertures that are too big unnecessarily increase thickness. To manage this compromise, it is useful to determine the optimum diameter for the optical zone.

The visual comfort is linked to the angular object field available behind the lens, which typically needs to be ± 30° for the central optical field. Depending on the wearer’s individual habits, it is necessary to consider a certain margin when defining this central optical field.

Once determined, the target object half-field, the diameter of the useful optical zone, can be calculated. It is a function of the distance of the lens to the eye’s center of rotation to the lens ($LQ'$) and the power of the lens $P$.

The results are summarized in Table I.

The temporal field is the most compelling: in case of astigmatism, the $P$ power to be used for the calculation is the power of the 0°-180° meridian.

<table>
<thead>
<tr>
<th>Lens Power (P)</th>
<th>-10.00</th>
<th>-15.00</th>
<th>-20.00</th>
<th>-25.00</th>
<th>-30.00</th>
<th>-40.00</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ø ZO with $\omega = 30°$</td>
<td>23</td>
<td>21</td>
<td>19</td>
<td>18</td>
<td>16.5</td>
<td>14.5</td>
</tr>
<tr>
<td>Ø ZO with $\omega = 40°$</td>
<td>33.5</td>
<td>30.5</td>
<td>28</td>
<td>26</td>
<td>24</td>
<td>21</td>
</tr>
<tr>
<td>Ø ZO with $\omega = 45°$</td>
<td>40</td>
<td>36</td>
<td>36</td>
<td>31</td>
<td>28.5</td>
<td>25</td>
</tr>
<tr>
<td>Ø ZO with $\omega = 50°$</td>
<td>48</td>
<td>43</td>
<td>40</td>
<td>36.5</td>
<td>34</td>
<td>30</td>
</tr>
</tbody>
</table>

Table I. Diameter that has to be given to the optical zone (ZO) depending on the lens power (P) to get an object half-field of $\omega$.

6. Vision of a person with high myopia that has been corrected with ophthalmic lenses

During the optical correction of high myopia, several specific optical phenomena occur. They can be summarized as follows:

6.1. Lesser accommodation and lesser convergence

Through his or her ophthalmic lenses, a highly myopic person will accommodate and converge less than would an emmetropic or hyperopic person and less than if fitted with contact lenses. Indeed, the vertex distance plays a significant role, and its effects are all the more significant when the power is strong. For example, a person with -20.00 D myopia, who would apparently accommodate to 5.00 D to focus at an object 20 cm from his or her glasses, actually accommodates to approximately 3.10 D if the lens is placed at 12 mm from the eye. Similarly, although it seems as though such patients converge substantially to look 20 cm away, their convergence effort is actually much less due to the basic internal prismatic effects provided by their lenses at near vision.

6.2. Reduced visual acuity

With high myopia, the vertex distance causes a minification effect (reduction in size) in both the images seen by wearers through their lenses and the wearer’s eyes as seen by other people. Due to this reduction in size, wearers with
6.3. Peripheral image duplication

Image duplication occurs at the edge of lenses with strong negative power. Indeed, the last beam of light passing through the lens is refracted towards the outside and the first external beam of light on the outside of the lens is not refracted. The same object is thus seen twice, once sharply within the lens and once blurred on the outside of the lens. For the wearer, this means that the peripheral image, or its perception, is doubled at the edge of the lens (or the edge of the central optical zone), especially if the edge of the frame is thin or missing (rimless frames or those with a nylon thread).

6.4. Phenomenon of the myopic rings

One of the particularities of the correction of high myopia with ophthalmic lenses is the emergence of unsightly rings on the periphery of the lens, which are more visible when looking at the wearer sideways. These rings are the images at the edge of the lens reflected multiple times on the front and back of the lens. Polishing the lens edge and/or reducing the optical aperture considerably decreases them.

7. The convenience of special lenses for high myopia

Surgical treatment or contact lenses cannot be used for all highly myopic patients, and ophthalmic lenses are still relevant for high myopia. A wide range of lenses with powers commonly reaching -40.00 D in single vision lenses and -25.00 D in progressive lenses are available, and the technical know-how of the lens manufacturer can go even further. Recently, a record -108.00 D myopia was corrected with ophthalmic lenses by an alliance of French-Slovak experts. With careful, precise implementation by the optician, the wearer benefits from a comfortable visual experience. These special lenses, meant for extreme prescriptions, remain insufficiently known of and used by eye care professionals, and would be of great service to the highly myopic population, which continues to grow in numbers.
The specific needs of highly myopic people require special attention from visual health specialists.

The main discomforts of those with high myopia include:
- Reduced visual acuity
- Reduced sensitivity to contrast
- Deteriorated vision thresholds under low and bright lights
- Elongation of recovery time after glare
- Decline in quality of life and social impact.

High myopia is often associated with risks of high visual impairment and eye diseases such as retinopathy and maculopathy (staphylomas, atrophic lesions, chorioretinal cracks, choroidal neovascularization, macular degeneration, glaucoma, etc.).

The refraction of high myopia requires special precautions, comprehensive measures of visual functions and the inclusion of the vertex distance.

The optical equipment of those with high myopia should be tailored to their needs. The practitioner will choose an appropriate frame and opt for special lenses in a range dedicated to high myopia.

References:

A large body of market research shows alarming data on myopia development around the world. These trends raise important questions on the implications for planning comprehensive eye care services, improving practitioner and patient education and anticipating a reduction of the myopia burden.

P.44 What do the myopia trends predict for the future?
P.49 Is myopia a growing health issue? Why is it so?
The prevalence of myopia and high myopia is on the rise across the world. Recent work from the Brien Holden Vision Institute estimates that by 2050, five billion (50%) people will be myopic, one billion (10%) highly myopic. This may have important implications for planning comprehensive eye care services, including refractive services such as spectacles and contact lenses for correcting and slowing myopia progression. Optical and environmental interventions can help in preventing and managing high myopia related ocular complications and reduce the burden of myopia.

**KEYWORDS**
myopia, high myopia, vision impairment, myopic macular degeneration, myopia control, myopia management, public health issue
In recent times, the issue of myopia has featured heavily in mainstream media with headlines such as “the myopia boom” and “night time contact lenses stop children becoming short-sighted”. The growing concern surrounding myopia has already led to governments in some parts of the world taking measures to ameliorate this problem. In Taiwan, a law was passed “banning too much screen time,” and public health campaigns in Singapore encouraged children to spend more time outdoors. Given these messages, we may be left wondering about the size of the burden of myopia, and the strategies and/or solutions required to reduce it.

The size of the problem
Recent work from the Brien Holden Vision Institute estimates that the prevalence of myopia (≤ -0.50 D) will increase worldwide, from 28% (2 billion) of the global population in 2010, to nearly 50% (5 billion) of the world population by 2050. As a consequence, the prevalence of high myopia (≤ -5.00D) is also likely to increase from 4% (277 million) in 2010, to nearly 10% (1 billion) by the year 2050. Figure 1 illustrates the prevalence of myopia and high myopia from 2000 through to 2050.

The shift towards myopia
The shift towards myopia has been rapid in some parts of the world, such as the USA, where the prevalence of myopia increased from 26% to 42% from 1972 to 2004. In Singapore, the prevalence of myopia was 47% in adults in their 20s, and 26% in adults in their 50s. High myopia (≤ - 7.90 D) in the USA has already increased 8-fold over 30 years from 0.2% to 1.6%. In 18-year-old Taiwanese students, 21.0% had high myopia (≤ -6.00 D) in 2000 compared with 10.9% in 1983. Globally in 2000, most people with myopia were below age 40, and little myopia was seen in those over 40. By 2030, the prevalence of myopia is projected to be approximately 50% for all age groups above 20 years, and by 2050 to 68% (Fig. 2). Regions with traditionally little myopia, such as Eastern Europe and Southern Africa will also see a large shift towards myopia in the near future, approaching prevalences of 50% and 30% by 2050. This is likely due to lifestyle changes as a result of urbanisation and development (Fig. 3).

What are the consequences?
Uncorrected refractive error is the leading cause of distance vision impairment globally, affecting 108 million people, and is the second most common cause of global blindness. The economic burden of uncorrected distance refractive error was estimated to be US$202 billion per annum, of which myopia is the main cause. With the rising prevalence of myopia, the economic burden of uncorrected refractive error associated with myopia will rise. In addition, myopia is associated with ocular complications such as myopic macular degeneration, retinal detachment, cataract and glaucoma, which impose a significant health and economic burden. Myopic macular degeneration is already a frequent cause of vision impairment in Japan, China, Netherlands and Denmark. It is important to note that any level of myopia...
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FIG. 1] The estimated global prevalence of myopia and high myopia per decade from 2000 to 2050 based on current trends. The number of people in millions is listed on the y-axes. Adapted from Holden et al. 3

FIG. 2] The global generational shift in myopia indicates that in the earlier decades of 2000 up to 2030, the majority of myopia is occurring in those under forty years with little myopia seen in those over forty. After 2030, the prevalence of myopia will be affecting all age groups. Adapted from Holden et al. 3

FIG. 3] The increasing prevalence of myopia estimated across the world from the year 2000 to 2050. Modified from Holden et al. 2016. 1
increases the risks of the above mentioned problems compared to emmetropes, but the risk increases exponentially once you reach high myopia.\textsuperscript{14} For myopia of -5.00 D to -7.00 D, the risk of glaucoma is 3.3 times higher, the risk of cataract is 5.5 times higher, the risk of retinal detachment is 21.5 times higher, and the risk of myopic macular degeneration is 40.6 times higher.\textsuperscript{14} The future estimates of myopia suggest that at least one billion people are potentially at risk of developing permanent vision impairment and blindness associated with high myopia.\textsuperscript{15}

**Strategies to manage the burden**

Both environmental and genetic factors are thought to contribute to the onset and progression of myopia, but it has been suggested that environmental factors have a larger role to play in the rapid increase in the prevalence of myopia. A heavily indoor and near-activity based lifestyle\textsuperscript{16,17}, with less time outdoors\textsuperscript{16}, combined with the intense education commencing at very young ages, as is occurring in many East Asian countries, are major contributing factors.\textsuperscript{16}

Evidence is now growing to support the use of interventions in slowing myopia progression. Optical interventions that modulate the visual feedback and environmental interventions promoting increased outdoor time can successfully delay and slow the progress of myopia in an individual. Optical strategies shown to slow the progress of myopia include ortho-K (30\% to 57\%\textsuperscript{13,20}), multifocal-type soft contact lenses (25\% to 72\%\textsuperscript{20}), and executive bifocals (39\% to 51\%).\textsuperscript{21} Progressive addition spectacles are limited to 15\% to 20\%.\textsuperscript{22} Time outdoors has successfully reduced the number of new cases of myopia by up to 50\%, and can effectively delay the onset of myopia, but its ability to slow the rate of progression of myopia is not clinically significant.\textsuperscript{22,23} In addition, certain pharmaceutical approaches have also shown promise, with low dose atropine (0.01\%) slowing the progress of myopia by almost 59\%.\textsuperscript{24} The long term effects of atropine use are not yet clear.

**Future needs**

An effective myopia management strategy that combines the individual’s needs, based on their risk profile (for example, age, lifestyle, familial history), and matched to the appropriate intervention strategy is required to reduce the burden of myopia, both at the individual and the community level. Recognising the need, the World Health Organisation (WHO) convened a Global Scientific Meeting on Myopia in collaboration with the Brien Holden Vision Institute in Sydney, Australia in 2015. At this forum, leading experts in myopia met to examine the latest evidence, identify gaps in knowledge, and define policies for the management of myopia. It is expected that this report will be published soon and will provide myopia management guidelines for governments, industry, health care workers, and practitioners.

**Conclusion**

Close to five billion and one billion people will be affected by myopia and high myopia respectively by 2050. This will have important implications for planning comprehensive eye care services, including refractive services such as spectacles and contact lenses for correcting and slowing myopia progression, as well as preventing and managing high myopia related ocular complications. The optical industry also has a key role to play in education, developing, and supporting appropriate myopia management strategies to help reduce the burden of myopia. •

**More information**

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• The prevalence of myopia and high myopia is on the rise across the world.

• Estimates suggest that by 2050, five billion (50%) people will be myopic, one billion (10%) highly myopic.

• Increasing myopia is associated with increased risk of sight threatening complications such as myopic macular degeneration, glaucoma and cataracts.

• There is evidence that optical and environmental interventions can slow the progress of myopia and reduce the burden of myopia.

REFERENCES
MYOPIA RISE AND VISION HEALTH ISSUES LEFT IN ITS WAKE

Myopia continues to be a growing problem around the world. A recent study\(^1\) predicts that by 2050 about half of the world’s population will be myopic. While genetics plays a role, researchers point to the increasingly digital lifestyles of young people as one culprit of the epidemic. The sheer volume of this vision impairment will have consequences not only for those with it, but also for the communities and nations where they live, work or go to school.

As our world grows and develops, our vision is getting worse. That’s the takeaway from an important body of research data about the world’s vision, with a laser focus on myopia and its impact.

The statistics are alarming – myopia is projected to affect almost half of the world’s population by 2050.\(^1\) The consequences are just as unsettling, as myopia, when left uncorrected, can lead to severe vision impairment and even blindness. By mid-century, nearly five billion will have the vision impairment with about one billion suffering from high myopia. In the United States and Canada, the number of myopic is estimated to climb to 260 million, or close to half of the population, up from 89 million in 2000; and high myopia cases jump an astounding five times to 66 million by that year.\(^1\)

These are part of the findings of a meta-analysis by the Brien Holden Vision Institute of 145 studies covering 2.1 million people.\(^1\) Also known as nearsightedness, myopia is a refractive error that causes items close by to be seen distinctly while distance vision is blurry. High myopia is a severe form in which the eyeball becomes too long and can lead to retinopathies or even retinal detachment.

Young people are becoming myopic at an alarming rate in many countries – insuring that they will have a lifetime of blurry vision unless they get the aid of optical prescription (eyeglasses, contact lenses, ortho-k) or have refractive surgery. This will have long-term consequences for public health around the globe, especially in less-developed regions where healthcare delivery is more challenged.

Maureen Cavanagh is the president of the Vision Impact Institute. She joined Essilor in 2005 and has held various executive leadership positions within the company. Cavanagh has extensive experience in vision healthcare, having worked for Johnson & Johnson’s Vistakon and Spectacle Lens divisions before joining Essilor. Cavanagh earned her bachelor’s degree from Bridgewater State University. She has received numerous industry awards, including the Optical Women’s Association (OWA) Pleiades Award in 2015 and Jobson’s Most Influential Women in Optical 2012. Cavanagh was appointed President of the OWA in July 2016.
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“Two things are extremely worrying about these projections,” said Professor Kovin Naidoo, CEO of the Brien Holden Institute and Vision Impact Institute advisory board member. “First, the accelerated growth of cases of myopia is incredible, which speaks to how our contemporary lifestyles are affecting our behavior. And second is that people with myopia, especially high myopia, are at higher risk to develop other vision disorders that can lead to blindness.”

He said that 1 in 10 people worldwide will be at risk for permanent blindness by the year 2050, as high myopia especially increases the risk of cataracts, glaucoma, retinal detachment and myopic macular degeneration – all of which can cause irreversible vision loss.

**Myopia epidemic in parts of Asia**

Research indicates there are regional variations in the prevalence of myopia. Asia – the world’s largest and most populous continent – is perhaps where its impact is more widespread. And East Asia – comprised of China, Japan, Hong Kong, Mongolia, North Korea, South Korea and Taiwan – is experiencing an epidemic with reports as high as 40 percent in Japan and 50 percent in Taiwan. The prevalence of myopia is more than two times higher among East Asians than white people of the same age.

China is especially hard hit. As it is the most populous country on Earth, it also has the largest population with vision defects. The results of the recent domestic white paper on China’s National Vision Health, (conducted by Prof. Li Ling, Head of the China Center for Health Development) are alarming. In 2012, close to 500 million people over the age of five had an uncorrected visual defect in China, among which 450 million had myopia. By 2020, nearly 700 million people are expected to have myopia in China – twice the population of the United States. Undeniably, there is a huge increase from 60 years ago when the country was still isolated from the global economy and only 10-20 percent of its population had myopia.

A comparative study of six- and seven-year-old students of Chinese ethnicity in Singapore and Sydney had interesting results when it explored the prevalence of myopia among the focus population and possible risk factor. The major finding was that myopia was more prevalent in Singapore...
(29.1 percent) and significantly lower in Sydney (3.3 percent). Hereditary influences were about the same in both locations: one or more parents reported having myopia for 68 percent of the students in Sydney and 71 percent in Singapore parents. The primary lifestyle difference between the two student groups was that the children in Sydney spent more time outdoors each week (average of 13.75 hours) than those in Singapore (3.05 hours on average). The researchers also hypothesized that academic pressure in Singapore schools played a role in the difference.

However, myopia is not limited to Asian nations. A retrospective examination of 13 repeated prevalence studies analyzed data about the changing prevalence of myopia over 13 years with Israelis from 16 to 22 years old. The overall occurrence of myopia increased significantly to 28.3 percent in 2002 from 20.3 percent in 1990. The causes of this increase were not certain; however, evidence pointed to genetic as well as environmental components, such as higher amounts of near work and more years of education.

Research shows similar results in the United States. One study compared myopia rates from 1971-72 to the period of 1999-2004, with the later period showing substantially higher myopia rates than 30 years earlier.

Some regions and ethnicities report very low rates of myopia, such as among Australian Aborigines and Solomon Islanders, where occurrence was in the 2-5 percent range. And a comparative study of urbanites in the United States showed that African-Americans were significantly less likely to have myopia than whites.

**Lifestyle factors into the spread of myopia**

Once thought to be only a matter of genetics, several of the studies point to lifestyle and environmental considerations as contributing to the increasing occurrence of myopia.

According to the Brien Holden Institute meta-analysis of myopia research data, “The projected increases are widely considered to be driven by environmental factors (nurture), principally lifestyle changes resulting from a combination of decreased time outdoors and increased near-work activities, among other factors.”

Many researchers are pointing to the advent of digital devices in the past 30 years as contributing to the prevalence of myopia (due to short working distance). There are now more mobile devices in use around the globe than there are people on the planet.

The Holden study points to the under-40 age group, especially in Asia, as being extremely susceptible to myopia because of reliance on smartphones, personal computers and related technology for communications, entertainment, news and education.

The competitive education systems in Singapore, Korea, Taiwan and China are another factor, according to the study, causing students to spend more time studying at
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“Myopia will have long-term consequences for public health around the globe, especially in less-developed regions where healthcare delivery is more challenged.”

computers. The comparative study of young students in Sydney and Singapore also referred to this, noting the competitive academic environment of the island city-state.4

Socio-economic impact of myopia

While the direct socio-economic impact of myopia has not been determined yet, the effect of poor vision on the global economy is well documented. This myopia epidemic creates a significant public health problem around the world. The economic burden of uncorrected refractive error (URE), largely caused by myopia, is estimated to be more than $269 billion per year, and that number will grow as the epidemic spreads. It is affecting developing nations as well as the developed world. Actually, the Brien Holden study mentions that developed nations are seeing a faster rise in myopia because of increased urbanization and development, which usually means more digital device use and higher education levels.

The World Health Organization (WHO) reports that URE for distance is the main cause of low vision and the second leading cause of blindness after cataracts. WHO estimates point to URE as a bigger cause of productivity loss globally than any other preventable vision disorders, with 0.8-4.0 percent of the world’s population affected by visual impairment in 2007 at an estimated cost of more than $269 billion per year.8

Research from 2006 showed that more than 3.6 million Americans suffered from visual impairment, blindness or other eye diseases in 2004 – creating a financial burden totaling $35.4 billion. And $8 billion of that total was loss of productivity. The annual impact to the U.S. government budget was $13.7 billion.9

The National Medical Research Council of Singapore commissioned a study of the economic cost of myopia. In 2009, the mean annual direct cost of myopia for school-aged children in Singapore was $148 (U.S. dollars) annually, with the median cost at $125 (U.S. dollars) per student.10

Public health consequences

This spreading myopia scourge will have a long-term impact on public health and productivity around the world in the decades ahead. While the number of myopia cases may be rising faster in developed nations, the impact could be greater in less-developed countries, where corrected vision could be the key to getting an education for a child or an escape from poverty for an adult.
More research is required to determine the exact causes and consequences of myopia. The projections of the spread of myopia are cause for concern for public health officials worldwide. As the young people with myopia grow into middle age, they will be more susceptible to the pathological effects of the condition, especially those with high myopia, which will have an impact on public health services. Officials should start planning and budgeting now for the coming need.

The antidotes

The growing body of research about the spread of myopia is giving us reason for hope. The overwhelming majority of myopia cases can be corrected with prescription eyeglasses, contact lenses or refractive surgery.

Beyond optical solutions that correct myopia, research points to increased time outside in sunlight as the antidote to the condition. In one study, a randomized clinical trial in Guangzhou, China, researchers followed 952 children in the intervention group and 951 in the control group with a mean age of 6.6 years. The cumulative rate of myopia was 30.4 percent in the intervention group and 39.5 percent in the control group. The important finding was that 40 minutes of additional activity outside in natural light resulted in a reduced incidence of myopia during the next three years.11

More time spent outside playing also means less time inside in front of a computer or smartphone screen. Modern lifestyles spent in front of digital screens do have an impact on vision. The Vision Council reports that 75 percent of Americans who use two or more devices simultaneously report digital eye strain symptoms, such as blurry vision and eye fatigue.12

Admittedly, people around the globe are not going to give up their digital devices. We are hooked. However, certain precautions can help avoid digital eye strain, according to the Vision Council. For students and desk-bound workers, the optimal optical arrangement is to have the computer screen at an arm’s length (20-24 inches) distance from the eyes. Computer eyewear can filter out the potentially harmful blue light that digital screens emit, as well as eliminate glare and alleviate eyestrain.13

Finally, we need to remember that the most important action in the fight against myopia and its related damage is to visit a trained eyecare professional for an annual comprehensive eye examination. This is especially important for children as their eyes are still developing and early intervention is key. •
MARKET WATCH

• Myopia is projected to affect half of the world’s population by 2050.
• Young people in Asia are especially susceptible to myopia.
• There are links between myopia and the increasing use of digital devices, such as smartphones and personal computers.
• Research shows that increased time spent outside can reduce the onset of myopia in young people.

“The most important action in the fight against myopia and its related damage is to visit a trained eyecare professional for an annual comprehensive eye examination.”

REFERENCES
There are several options to manage myopia. The solutions can be classified depending on their ability to correct and/or control myopia progression in childhood. In the case of extremely high myopia, optical interventions require new creative methods in prescribing and manufacturing.

P.56 What are the solutions and their efficacy in myopia management?
P.66 How did optical experts solve the record-high myopia of -108.00 D?
Myopia is becoming a real public health concern across the world. The number of myopic people is increasing rapidly. The prevalence of high myopia is also expected to rise. Understanding myopia development and methods to slow its progression is currently one of the biggest stakes for researchers and clinicians from around the world. In this paper, a few Vision Scientists at Essilor have put together a general overview of myopia condition. In this article they review the definition of myopia, its evolution and causes. They describe available solutions for myopia management and discuss the relative efficacy for each solution. Finally, they focus on Myopilux®, the specific range of ophthalmic lenses which have been proven to effectively correct and control myopia progression in children.

**MYOPIA AND EFFECTIVE MANAGEMENT SOLUTIONS**

Myopia is a condition where the eye cannot focus light on the retina, causing blurred vision. The prevalence of myopia is increasing worldwide, with higher levels of myopic individuals in younger age groups. Understanding the causes and progression of myopia is crucial to developing effective management strategies.

**KEYWORDS**

Myopia, myopia control, myopia correction, high myopia risks, hyperopic defocus, accommodative lag, heredity, lifestyle, blue light, dopamine, atropine, Ortho-K, orthokeratology, prismatic bifocal lenses, multifocal contact lenses, progressive addition lenses, refractive surgery, outdoor light exposure, Myopilux

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Dr. Anna Yeo Chwee Hong joined Essilor R&D Asia in May 2013 as a Senior Vision Scientist after teaching optometry for 23 years at the Singapore Polytechnic. Her current research interest is adult myopia, on which she has conducted research internally at C&T Asia and in collaboration with other teaching institutions such as Zhongshan University and Singapore and Ngee Ann Polytechnics. She is also a member of the Scientific Committee in Wenzhou-Essilor International Research Centre (WEIRC) for which she helps to review research protocols and scientific publication. Dr. Anna Yeo has been a member of the Optometry and Opticianry Board (OOb) in Singapore and the Chairperson for the Credentials Committee, OOb since 2008.

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Dr. Björn Drobe obtained a B.Sc in Optometry, a M.Sc in Cognitive Sciences and a Ph.D. in Vision Sciences in Paris, France. He joined the French Essilor Int. research team in 1998, working mainly on the interaction between ophthalmic lenses and the human visual system, as well as on progressive myopia in children. From 2007 to 2013, Dr. Drobe relocated to Essilor R&D Singapore for a higher involvement in myopia research. Since June 2013, he is the associate director of WEIRC (Wenzhou Medical University – Essilor International Research Center), managing an international research team on myopia in children.
Although high rates of myopia have been reported in some Asian cities for years, recent publications have highlighted the importance of and increases in this condition throughout Asia, as well as in the US and in Europe. As a result, the number of myopic people is expected to exceed a third of the world’s population by 2020, or 2.5 billion people out of a total population of 7.6 billion. The loss of quality in vision, not only affecting daily life, has also raised the biggest concern due to an expected increase in eye pathologies and blindness associated with the severity of myopia. Therefore, it is of great importance to understand myopia development and methods to slow its progression. In this paper we focus on: 1/ Myopia definition, evolution and causes, 2/ Available solutions for myopia management, 3/ Myopilux® new range of ophthalmic lenses for myopic children.

1. Myopia

1.1. A worldwide phenomenon

A recent Asian meta-analysis of 50 studies covering countries from Iran to Japan has reported an average myopia rate of ~28%\(^1\), with strong disparities based on age and geographical region. The highest prevalence is reported among urban young people in Korea, where the rate reaches 96.5% among 19-year-old adults\(^2\), whereas in Beijing, the prevalence of myopia is 74% among 17- to 18-year-olds.\(^3\)

On the other hand, the rate is as low as 5.0% among schoolchildren in rural China (5-18 y.o.)\(^4\) and 10.8% among the 15-year-olds in New Delhi.\(^5\)

In the US, the literature highlights an increase in myopia, with its prevalence among 12- to 54-year-olds increasing from 25.0% between 1971-1972 to 41.6% between 1999-2004; the highest rate is reported to be 44.0% among 25- to 34-year-olds between 1999-2004.\(^6\)

More recently, in Europe, the prevalence of myopia has been estimated to be 30.6% among 25- to 90-year-olds, with the highest prevalence of 47.2% observed in the 25- to 29- year-old age group.\(^7\)

1.2. What is myopia?

In most cases, myopia occurs because the eyeball is too long relative to the focusing power of the cornea and lens of the eye. This is called axial myopia.

Figure 1 shows an emmetropic eye and a myopic eye. In an emmetropic eye, light rays from far objects are focused on the retina resulting in a clear image. In a myopic eye, light rays from far objects are focused in front of the retina resulting in a blurred image.

In practice, without any correction, a myope experiences blurry vision when looking at far-away objects. The higher the level of myopia, the shorter the distance of clear vision from the eye. Typically, a -2.00 D myope will see clearly at approximately 50 cm, whereas a -5.00 D myope will see clearly only at approximately 20 cm.

1.3. From myopia to high myopia and longer term risks

Myopia is a progressive phenomenon in which onset and strongest progression are mainly reported during childhood.\(^8\) On average, myopia progression rates are 0.55 D per year among Caucasian children, and at a higher rate of -0.82 D per year among Asian children.\(^9\)

With such a rapid progression during childhood, the risk to become highly myopic in adulthood is high (currently, high myopia is defined as below -6.00 D). In Taiwan, the prevalence of high myopia has increased from 10.9% in 1983 to 21.0% in 2000 among 18-yea-rol students.\(^10\)

In Singapore, the prevalence of high myopia increased from 13.1% between 1996-1997 to 14.7% between 2009-2010 among 17-29-year-old men.\(^11\) In Europe, a 5.9% prevalence of high myopia prevalence is reported among 15- to 19-year-olds olds, according to data collected in 2013.\(^7\)

FIG. 1 | Emmetropic (top) and myopic (bottom) eyes
Although myopia may not have any eye health impact, being highly myopic may have a great impact on ocular health. It has been shown that a -8.00 D myope has 10 times more risk for the development of retinal pathologies than a -4.00 D myope (Fig. 2). High myopia has also been reported to be a risk factor for other ocular pathologies, including glaucoma, choroidal neovascularization, and myopic macular degeneration. Regarding cataract, there are divergent studies on its link with high myopia. Overall, high myopia is a leading cause of visual impairment worldwide.

Therefore, it is of great importance to understand myopia development and to find ways to slow the progression of myopia during childhood.

1.4. Myopia, a multi-factorial refractive error

Myopia development during childhood (onset and progression) is due to multiple factors, which are commonly split into two groups: heredity and lifestyle, often referred to as nature and nurture.

Regarding heredity, it has been shown that children with two myopic parents are on average two to three times more likely to be myopic than children with non-myopic parents. More specifically, genetic studies have identified numerous candidate genes and loci that may contribute to myopia development.

Regarding lifestyle, near-vision-demanding tasks and limited time spent outdoors are known to influence myopia development.

Intense near vision activities performed by children have been associated with myopia development in many studies. When looking at a near object, the accommodative response of a myopic child is lower than the proximity of the object, resulting in a slightly defocused image; light rays from near objects are focused behind the retina. This phenomenon is called the accommodative lag. It has been found to be higher in myopes than in emmetropes.

The accommodative lag increases with proximity (Fig. 4) and creates a stimulus for the eye to elongate, leading to myopia progression. The risk of developing myopia increases as the working distance is shorter and the amount of near work is greater.

A large amount of near work combined with a lack of outdoor activities are also highly associated with higher myopia prevalence in children. It is still unclear how outdoor activities impact myopia, and several hypotheses have been raised. Recent studies have suggested the existence of interactions between light conditions and myopia development. As light intensities are much higher outdoors than indoors, pupils are more constricted outdoors. This would result in a greater depth of field and less image blur, resulting in less myopia progression.
Another hypothesis is the release of dopamine from the retina, which would act as an inhibitor for eye growth, and which is known to be stimulated by blue light in the range of 460-500 nm. With higher amounts of light outdoors, dopamine secretion would prevent the eye from elongating.33

In practice, modern lifestyle in cities, associated with limited outdoor activities and intense near vision tasks, favors myopia development. In particular, higher educational levels and hand-held digital device use tend to favor indoor work while exerting a higher demand on our eyes. For instance, research has shown that when using hand-held video games, children adopt closer working distances, which in turn may favor myopia onset and progression.34

2. Solutions for myopia management
There are currently several options available to manage myopia. They can be classified according to their ability to correct and slow myopia progression during childhood as shown in Figure 5.

2.1. Solutions that correct myopia but do not control its progression
Single vision lenses are the most common non-invasive solutions for myopia correction. Contrary to common belief, under-correction of myopia does not prevent it from progressing. One study showed that undercorrection of 0.75 D led to a 30% more myopic prescription after 2 years, which was statistically significant.35 Another study showed that undercorrection of 0.50 D led to a 21% more myopic prescription after 1.5 years.36 Other studies also showed that over-correction is not recommended for myopia control either.37,38 As a consequence, to correct myopia and to avoid the risk of more rapid myopia progression, full correction should always be chosen based on regular eye examinations.

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**FIG. 4** Influence of proximity on accommodative response

**FIG. 5** Solutions for myopia management, classified according to their ability to correct myopia progression
Contact lenses have long been used to correct myopia. However, the clinical efficacy of wearing standard soft contact lenses in myopia control has not been demonstrated.39

As an alternative, refractive surgery, such as LASIK, offers a proven solution for correcting myopia in adulthood. However, the method is invasive and does not control myopia or limit the risks of developing ocular pathologies linked to high myopia. Indeed, refractive surgery modifies the shape of the cornea at the front part of the eye, but it does not change the axial length of the eyeball.

2.2. Solutions that control myopia progression but do not correct it
The least invasive method for myopia control is undoubtedly to increase the time spent outdoors. A meta-analysis performed on the association between time spent outdoors and the risk of developing myopia in children has indicated that spending one hour outdoors per week during childhood reduces the risk of developing myopia by 2%: in other words, a child spending 10 hours more per week outdoors than another child has 20% less chance to become a myope later on.40

Atropine eye drops are also used in some countries in clinical practice to slow down myopia progression. Initially it had been suggested that paralyzing accommodation would result in less myopization, but later studies showed alternative mechanisms and sites of action for atropine at either the retina or the sclera.41 Atropine has thus been studied in several clinical trials. One of them compared several dosages of atropine.42 The high dosages (above 0.1%) were efficient during treatment but were associated with a myopic rebound after the cessation of treatment. The lowest dosage (0.01%) showed a moderate myopia slowing effect that was more sustained after cessation of the treatment. Unfortunately, this study did not include a control group to be able to quantify the effects. Moreover, in addition to its short-term side effects (photophobia due to pupil dilatation, and reduced accommodation power), atropine’s long-term side effects have not been documented in children to date.

2.3. Solutions that correct myopia and control myopia progression
Ophthalmic lenses with near vision addition have been shown to be efficient in both correcting and slowing myopia progression and will be detailed in part 3. These lenses have dedicated additional optical power in the near vision zone that compensates for accommodative lag in the myopic eye while the upper part of the lens allows full myopia correction for far vision (Fig. 6). These lenses can either be prismatic bifocal lenses or progressive addition lenses with an addition value and a design adapted to children’s physiology. As of today, an addition value of 2.00 D has been shown to be the most efficient compared to lower addition values for myopia control,43 with up to 62% reduction in myopia evolution for prismatic bifocal lenses.44

Other ophthalmic lens designs, such as peripheral addition lenses, have also been studied. The elongated shape of myopic eyes results in a defocused image in the periphery even with a perfect central focus (Fig. 7).45 It has been shown that this can cause elongation of the eyeball.46 Peripheral addition lenses are thus intended to compensate for the peripheral hyperopic defocus and include two visual zones: the central zone of the lens allows full myopia correction and the peripheral zone of
the lens presents a power addition for correcting the hyperopic defocus. In the main study conducted on this concept, no statistically significant differences were observed with the new designs compared to single vision lenses. However, for the subgroup of younger children with at least one myopic parent, myopia progression was reduced by ~30. Nonetheless, it was only a one-year study. Moreover, a two-year clinical trial showed that peripheral addition lenses do not enhance the therapeutic efficacy in slowing myopia progression versus near vision addition lenses only.48

As an alternative, in recent years, various multifocal contact lenses have been designed to retard the progression of myopia. Two one-year studies have shown a reduction of ~35% in myopia progression with multifocal soft contact lenses.49,50 Although these studies showed promising results, there are no available results beyond the first year, thus no evaluation of rebound risks upon the cessation of wearing multifocal soft contact lenses. Several new clinical trials are currently in progress.

Another option is Orthokeratology (Ortho-K), also known as corneal reshaping. The patient wears rigid contact lenses overnight, with a specific reversed geometry; this flattens the cornea temporarily to push the focal point back to the retina (Fig. 8). With a proper fitting protocol, Ortho-K can correct myopia up to -6.00 D during daytime. Several recent meta-analyses also showed that Ortho-K slows down myopia progression by approximately 40% with careful education and regular monitoring to ensure safety.51-53 Nonetheless, the long-term efficacy (including a possible rebound effect) as well as the long-term side effects have not been assessed yet and should be evaluated through further large-scale studies.

3. Focus on Myopilux® lenses
Myopilux® is an all-in-one non-invasive range of near vision addition ophthalmic lenses for both myopia correction and myopia control throughout childhood.

3.1. More than 10 years of research
Resulting from more than 10 years of exploratory research by Essilor International myopia experts, Myopilux® lenses are based on a deep understanding of myopic children’s natural posture and physiology to ensure good ergonomics and comfortable vision and provide a non-invasive solution for myopia control.

Regarding children’s posture, two studies were conducted in China and Singapore. Children were asked to perform their usual reading and writing tasks while their posture was recorded in real time.54,55 The results highlighted that when performing near vision activities, children adopt a closer working distance than adults, leading to higher convergence between far and near vision tasks, and that children also prefer to use head over eye declination. These findings were taken into consideration when designing the lateral and vertical positioning of the visual zones in Myopilux® lenses.

Regarding children’s physiology, the Myopilux® range has been defined by taking into account children’s near phoria: esophoria (tendency to “over convergence”), and exophoria (tendency to “under convergence”) (Fig. 9).56

When wearing near vision addition lenses, as accommodation drives convergence, the reduction in accommodation will result in less convergence in the eyes, meaning an exophoric shift.57
For esophoric profiles, near vision addition lenses will be comfortable because the exophoric shift induced by the addition will partially compensate for their natural esophoria.

However, for exophoric profiles, near vision addition lenses lead to discomfort as they add exophoric shift and require a higher fusional vergence demand. Nonetheless, it has been shown that near base-in prisms can reduce the exophoria induced by near vision addition lenses. More precisely, a 3D base-in prism combined with a +2.00 D near addition on each lens brings visual comfort to the child, with a phoria at its initial state. It results in an efficient usage of these near vision addition eyeglasses.

3.2. An innovative range of ophthalmic lenses

Based on the above long-term exploration, as well as on sophisticated lens surface calculation methods, high performance production means and efficient methods for controlling lens manufacturing processes, the Myopilux® range of lenses is protected by six Essilor patents and is available in three product versions: Myopilux® Lite, Myopilux® Plus, and Myopilux® Max.

**Myopilux® Lite:**
Myopilux® Lite lenses are recommended for esophoric children with progressive myopia. Its design includes a progressive optical design, with a recommended addition of +2.00 D for better efficacy in myopia control (Fig. 10).

- The lens is adapted to children’s posture; its inset is higher and its progression length is shorter than those for adults. This is to fit to children’s closer working distance and preferred usage of head over eye declination (Fig. 11).

**Myopilux® Plus:**
Myopilux® Plus lenses should be chosen by parents looking for an advanced solution for their esophoric children with progressive myopia. In addition to Myopilux® Lite lenses, it is tailored to each child’s specific visual ergonomics and benefits from Wave Technology point-by-point calculation. It ensures tailored lateral positioning of the whole visual zones for enhanced visual comfort and it provides the child with better visual resolution (Fig. 10).

**Myopilux® Max:**
Myopilux® Max lenses are highly recommended for children whose myopia progression is more than -1.00 D per year. Its design includes a prismatic bifocal made of two wide and aberration-free optical zones separated by a segment line (Fig. 10):
- The upper part of the lens offers the visual correction adapted to the prescription.
- The lower part is dedicated to near vision with an addition of +2.00 D and 3D base-in prism.
- The wide visual zones as well as the short segment height have been designed specifically for children.
3.3. Validation through clinical trials on 600 children

Myopilux® lenses' concept has been validated through two major clinical trials with approximately 600 children, with third party ethics committees approval.

The concept at the heart of Myopilux® Lite and Myopilux® Plus lenses was tested in the Correction of Myopia Evaluation Trial (COMET) study. The purpose was to evaluate the effect of progressive addition lenses (PALs) compared with single vision lenses (SVLs) on the progression of juvenile-onset myopia. A total of 469 children were recruited in this study. The children were randomly assigned to either wearing single vision lenses or PALs with +2.00 D addition. The children were monitored for three years with six monthly follow-up visits. The primary outcome measure was progression of myopia, which was determined by auto-refraction after cycloplegia. The retention rate was extremely high with only 1% dropout rate. At the end of three years, the overall PALs group had a statistically significant reduction of 14% in myopia progression compared with single vision lenses (SVLs) that served as a control. However, a better effect of the PALs was observed in esophoric children with high lags of accommodation, whereas there was a statistically significant reduction of 37.2% in myopia progression compared to the SVLs group.

The concept of the Myopilux® Max lens was tested in a 3-year clinical trial. The objective of this study was to determine whether bifocal and prismatic bifocal spectacles control myopia progression in children with high rates of myopia progression compared to SVLs. A total of 135 children aged seven to 13 years old were recruited and randomly assigned to wear SVLs, bifocal and prismatic bifocal lenses. The children were monitored for three years with visits every six months. The primary outcome was cycloplegic auto-refraction and the secondary outcome was axial length growth.

The two-year and three-year results were published in the Archives of Ophthalmology in 2010 and in the Journal of the American Medical Association Ophthalmology in 2014.

At year two, the progression of myopia in children wearing prismatic bifocal lenses was reduced by 55% compared to children wearing SVLs. This difference was highly significant. The best results were seen in the exophoric group of children; those in the prismatic bifocal group had a reduction of 62% in myopia progression compared to those wearing SVLs.

At year three, children in the prismatic bifocal group had their myopia progression reduced by 51% (Fig. 12). Moreover, contrary to other myopia control spectacle lenses, prismatic bifocals were efficient in slowing myopia progression for all children in different age groups, near phoria types, lag of accommodation or number of myopic parents.

![Myopia progression of children wearing bifocal prismatic addition lenses vs. single vision lenses over three years.](image)
Conclusion

Based on the current scientific state of the art and the scope of clinician’s practice, a number of options for myopia correction and myopia control are worthy of consideration. As far as non-invasive solutions are concerned, ophthalmic lenses such as Myopilux® can be prescribed for effective myopia correction and control.

In terms of protocol, the ideal recommendation would be:
1/ Practice eye examinations at least annually
2/ Update child corrections when needed
3/ In case of ophthalmic lens prescription, choose near vision addition lenses with a design adapted to children needs (see chapter 3.2 for Myopilux® designs)
4/ Encourage outdoor activities.

*Myopilux*: a non-invasive range of near vision addition ophthalmic lenses designed by Essilor for both myopia correction and myopia control. The availability of Myopilux lenses can vary depending on country and should be checked locally by contacting an Essilor representative.

- Myopia is a progressive phenomenon in which onset and strongest progression are mainly reported during childhood.
- Myopia development during childhood (onset and progression) is due to multiple factors, which are commonly split into two groups: heredity and lifestyle, often referred to as nature and nurture.
- Regarding heredity, it has been shown that children with two myopic parents are on average two to three times more likely to be myopic than children with non-myopic parents.
- Regarding lifestyle, near-vision-demanding tasks and limited time spent outdoors are known to influence myopia development.
- There are currently several options available to manage myopia and they can be classified according to their ability to correct and slow myopia progression during childhood:
  - Solutions that correct myopia but do not control its progression are: single vision ophthalmic lenses, regular contact lenses, refractive surgery
  - Solutions that control myopia progression but do not correct it are: time spent outdoors, atropine eye drops
  - Solutions that correct myopia and control myopia progression are: ophthalmic lenses with near vision addition (such as Myopilux® offer), various multifocal contact lenses and Orthokeratology (Ortho-K).
- Myopilux® is an all-in-one non-invasive range of near vision addition ophthalmic lenses (prismatic bifocal and progressive designs) for both myopia correction and myopia control throughout childhood.
- Resulting from more than 10 years of exploratory research by Essilor International myopia experts, Myopilux® lenses are based on a deep understanding of myopic children’s natural posture and physiology to ensure good ergonomics and comfortable vision.
Record-breaking! With lenses of -108.00 D sphere and 6.00 D cylinder, an alliance of experts in Slovakia and France has made significant advances in the correction of severe myopia. An expertise that will benefit many who have out-of-the-ordinary visual needs. We revisit an exceptional human and technological adventure, as we dive into the story of Jan Miskovic, a Slovak photographer, and his search for a 100+ diopter myopia correction.

An exceptional prescription for out-of-the-ordinary needs: RE: -106.00 (+6.00) 0°; LE: -108.00 (+6.00) 25°. Collaboration between Franco-Slovak experts enabled the need evaluation, design, manufacture and fitting of -108 diopter lenses to correct what is probably the world’s highest degree of myopia. This record, set in February 2016, topped the previous achievement of -104 diopters set by the same team in January 2015. The story goes back nearly two years ago, when a veritable chain of vision expertise was set up between professionals in Slovakia and France with the aim of pooling skills to push back the boundaries of what is possible in optometry and optics. The team has already proved their skill twice, and their work is intimately linked to the unique case of Jan Miskovic, a 59-year-old Slovak who has suffered since childhood with severe myopia, amblyopia in two eyes, astigmatism, strabismus and keratoconus. This combination of conditions made treatment highly complex, particularly since his myopia is still progressing, with an average loss in recent years of 4 to 5 diopters per year.

Optometric skills at challenge of technical limits
Via a chance meeting 30 years ago, Jan Miskovic consulted the ophthalmologist who was destined to support him professionally throughout his life. In fact, over the years that his ophthalmic disorders have been progressing, Miskovic has never given up hope and has regularly tested different treatments and optical solutions and consulted numerous experts, even abroad. But he remains loyal to his ophthalmologist and optometrists in Slovakia, who provide the only solution that is effectively working for him: the prescription of ophthalmic lenses as close as possible to his correction requirements.
“We are beyond standards in optics and optometry; therefore we inevitably choose non-standard means...”

However, these requirements are not easy to evaluate. His correction went from -45 diopters in 2001 to -53 diopters in 2008 and -80 diopters in 2012, which at the time required the bonding of two lenses together, one on top of the other, via polymerization. At the time, the limits of technology seemed to have been reached, but the patient’s vision nevertheless continued to deteriorate creating new challenges for the eye care professionals. “We are beyond standards in optics and optometry; therefore we inevitably choose non-standard means of measurement,” explains Sebastian Chrien, optometrist in Banská Bystrica in Slovakia, who is currently taking care of Jan Miskovic. “There are no instruments capable of measuring his myopia level, so we place trial lenses in front of his glasses and ask for his subjective reaction to estimate the required correction as closely as possible. Nevertheless, we are guided by a single golden rule; the subjective improvement of any aspect of his sight,” pursues Mr Chrien. They met each other thanks to photography five years ago. Mr Chrien is convinced that photography and optometry combined together, can help in greater understanding of visual needs and explain the ability of functional seeing despite such a considerable visual impairment: “As a professional photographer, Jan Miskovic is perfectly able to perceive little nuances and changes. This definitively helps in subjective opticometric evaluation. He is knowledgeable about image and its different forms. He understands the mechanism of optical aperture, which may help him in enhancing depth of field. When he works, he can find a compromise between visual aspects such as sharpness, contrast, luminosity, and movement. His photographic perception of the world enables him to analyse elements such as perspective, while differentiating subjects with unequal size and clarity and thus estimating distances. Usually, we do not perceive all of that; we unconsciously take all elements for granted, so we do not even notice them. Jan’s vision is different. It is as if he was trained to watch with his mind,” Mr Chrien concludes.

The Essilor network in action
In 2014, Jan Miskovic participated in an event organized by Essilor Slovakia for World Sight Day and the new optical solution presented itself almost by chance. He questioned Essilor’s team there about the possibility of making special lenses for high prescriptions, and his outlook immediately brightened. “Of course, we had never before received a request like this. But at the time we were starting to develop our special lenses offer so we made preliminary contact with Essilor’s SL Lab (Special Lenses Laboratory) in France, which draws on Essilor’s latest technological advances to provide solutions for patients suffering from severe ametropia (refractive error),” explains Monika Remiasova, marketing specialist of the Group’s Slovak subsidiary. Remiasova contacted Benoit Herpeux, her dedicated customer service representative at SL Lab, who in turn forwarded the request to Alain Massée, head of special lens projects at SL Lab. This new demand represented no small challenge for this first collaboration: -104 D sphere, 6.00 D cylinder (and -103 D for the right eye)! Even so, the response was not long coming back. “I sent an e-mail on 9 October in the morning and received an enthusiastic “yes” the same day. In the meantime, the SL team had to adapt its calculation software to three-digit figure correction (it only went up to -99 diopters), check that it had the right glass raw materials and begin to think about the design of new surfacing tools,” explains Remiasova.

The SL Lab, an expert in exceptional requirements
In fact, the Slovak request fostered a spirit of competition in the workshop of Essilor’s French laboratory at Les Battants, in Ligny-en-Barrois, which made it possible to set a first record (of -104 diopters) in 2015. The new target in 2016 was clear: meet the various technical and industrial challenges to reach -108 diopters with 6.00 diopters cylinder to prove that the Group can provide customized solutions for all eyeglass wearers, with no exceptions. “The lens design stage was the most complex,” reveals Léonel Pereira, Workshop Manager, Surfacing and Special Lenses, SL LAB. “A lens of this power has to be biconcave. The main constraint concerns the rear surface and its short radius, which supports most of the power in its spherical curve. A toric surface was created on the front side, with a substantial but less pronounced curve.” These specifics spurred the team to opt for a high-index (1.807) mineral material, a biconcave Superdiafal (=antireflective coating) with an asymmetrical facet, which provides optimal optical performance for this correction level. The design calculations were made possible using the Special Lens Calculator (SLC), specifically developed to meet the requirements of special lenses.
The inner surface (eye side) of the lens was designed with a power of -77 diopters and an optical aperture 18 mm in diameter, combined with a base curve of +2.50 diopters, unpolished to absorb unwanted reflection. The remainder of the correction was produced on the external surface by a -31 diopter curve (to obtain the total power of -108 D) with a cylinder correction of 6.00 diopters, associated again here with a base curve of +6.00 diopters and an inverted torus to create a perfectly round optical aperture of 24 mm diameter. “This optical aperture gives the wearer a field of view of about +/- 30°, which is satisfactory given the power of the lens. The curvature of the front facet was selected to make a thinner lens possible, but also to facilitate the mounting of the lens at an ideal eye-lens distance,” Pereira concludes.

Creative know-how in lens manufacturing and quality assurance

The manufacturing expertise called upon to produce Miskovic’s lenses can be seen primarily in the creation of the inner surface. A manual ramp-up process was used with a tool specially designed by the SL Lab team to rough out, smooth and polish a radius of about 10 mm, using very precise manual technical moves. This initial optical surface was then measured by reflection with a radiuscope to one-hundredth of a millimeter, and this radius measure was used to calculate the base curve of the outer surface. “This stage is highly sensitive, since achieving a toric surface over a very short distance requires a high level of expertise and perfect technical mastery. The process is adapted for pressure, cycle speed, tooling. Each curve achieved is measured with the radiuscope, which is how we obtain such a high degree of precision,” comments Pereira.

Once the lenses were finalized, they then had to go through quality assurance to verify that power deviation from precision is less than 2%. Since no frontofocometer is capable of measuring such a high level of optical power, a radiuscope was once again used to validate the radii of the base curves of the inner and outer surfaces to enable calculation of the total refractive power of the lens (taking into account the material index) with less than 0.2% margin of error. Verdict: the challenge was successfully met! Moreover, the Slovak subsidiary was able to follow each step in real time and in pictures. “We communicated throughout the process, sending photos to enable our Slovak colleagues to better understand the development of these lenses. It was also a good way to forge closer ties between the teams, which will have more and more opportunities to work together,” Massée concludes.
Optician and optometrists at work to deliver unique lenses

It only took two weeks to manufacture the lenses and send them to Essilor Slovakia, which entrusted the edging and mounting to its partner, an independent optical store run by two brothers. The store also provides edging and mounting services for the Slovak subsidiary. “Every precaution was taken during the shipping, handling, marking, blocking, edging and mounting of these unique lenses. The last step in particular proceeded without a hitch on Essilor’s Mr Blue digital edger, which proved perfect for this unusual task,” explains Monika Remiasova. The selection of the frame required a great deal of consideration since it had to be able to accommodate these unique lenses with proper centering and an optimum vertex distance.

Living generous and passionate life, while lenses meet satisfaction

The precision work was masterfully accomplished by the optometrists and Essilor Slovakia’s team, according to Mr Miskovic, who was delighted to recover visual acuity of 1/10 in each eye, which for him was highly satisfactory compared to his initial condition (1/20). Despite his residual visual impairment, he keeps on living with outstanding energy and incredible generosity towards others. “His vivacity and his focus on helping others are exceptional. He is looking for children and adults with considerable visual impairments to support them and find a way to help them see better. His diverse activities and social commitments seem prevent him from resigning to his condition. By doing sports, he discovered that the possibilities are endless and only depend on our will and perseverance,” comments his optometrist, Mr Chrien. He also keeps on living his passions. “It is quite amazing to hear Mr Miskovic talk about the improvement in his day-to-day vision. With these new lenses, which he uses primarily for distance vision during outdoor activities, he can continue to work as a photographer and move about freely for his reporting work (he even climbed Mount Chopok, to an altitude of over 2,000 m!). What better way to illustrate our mission,” enthuses Stanislas Poussin, manager of the Essilor Group’s special lenses business unit.
An achievement that offers new hope

Naturally, the story of how a network of experts mobilized to help Jan Miskovic and his severe myopia does not end here. The progression of his disorder has prompted the various professionals contributing to his care to develop their expertise further and work ever more closely together to meet his needs. After initial feedback from Mr Miskovic in 2015, the SL Lab quickly proposed an improvement to his lenses by reducing unwanted reflections (via the expertise of Essilor’s Irish subsidiary, which specializes in anti-reflective coatings for mineral lenses) and by moving the lenses closer to his eyes.

In fact, the SL Lab has committed to always finding a solution and developing all the instruments needed to meet Miskovic’s visual needs and those of others who suffer from severe ametropia. Rather than record-breaking achievements, the international team effort around Jan Miskovic is all about human and technological advances that will benefit all those individuals with out-of-the ordinary visual needs.

• An international collaborative effort was initiated between Slovak ophthalmologist and optometrists, the Essilor Slovakia subsidiary, Essilor’s SL Lab in France, and the edging service of Essilor in Slovakia to meet the needs of an eyeglass wearer suffering from progressive high myopia.
• The Essilor teams responded in 2015 to a first record-setting request to manufacture lenses with -104 D sphere and 6.00 D cylinder. This extraordinary feat was surpassed in 2016 with the production of -108.00 (+6.00) lens.
• To respond to this particular request, Essilor’s SL Lab developed special techniques and innovative tools.
• The progression of Miskovic’s myopia is spurring vision-care professionals and Essilor teams to push back the technical limits of their offer and develop new solutions for severe ametropia.
Creative work and especially the art of photography require an optimal quality of vision. How to get to that level in case of record-high myopia? When a tailor-made optical solution provides a photographer with compensation for his vision disability, his talent and intuition can do the rest.

P.72 The Incredible story of Mr. Miscovic: how does he practice the art of photography with -108 D myopia?
Jan Miskovic’s name is well-known in model-making, hydro-racing, professional photography and the ophthalmic optics market! In fact, this energetic Slovak has a record-high degree of myopia: measured at -108 diopters. Despite his visual disability, however, he is a true phenomenon who lives life to the fullest and has even made his disability a motivating factor for his artistic creativity.

At first contact, this jovial Slovak almost comes across as a cartoon character or some kind of prankster, with good reason: Jan Miskovic’s impressive -108 diopter facet lenses transform his eyes into intriguing black dots. After exchanging a few words and anecdotes, though, it only takes a few minutes to realize that appearances can be deceiving, and that, in reality, his gaze is extremely sensitive and sharp. And that’s exactly what you would expect from a passionate professional photographer, who proves by example that the practice of his art and impaired vision are perfectly compatible thanks to modern technology.

Living in harmony with his passions

“As a child, I developed a number of vision problems, including amblyopia, astigmatism, strabismus, keratoconus and, primarily, progressive myopia. These problems became more severe and advanced more rapidly following a racing accident in a hydroplane (a cross between a motorcycle and a powerboat designed for offshore racing), which caused severe injuries to both eyes, not to mention the side effects of the antibiotics I was forced to take, which also contributed to my declining vision,” Jan explains. As a result, his myopia, measured at -45 diopters in 2001, with a loss of 4-5 diopters per year, has now (as he is about to turn 60) reached a record-setting degree of severity: -108 diopters. And even though...
advances in ophthalmic optics along with an international Franco-Slovak collaboration between Essilor’s teams have made it possible to design and manufacture corrective lenses to meet his visual requirements (see article p. 66), his continued ability to express his artistic talent primarily depends on proper management of his disability and his unshakeable optimism. Indeed, Jan is not the type of person to let life’s vagaries slow him down. He seizes every opportunity to express himself, enrich his creativity, and broaden his experience.

Sensations, both strong and gentle

“After earning an engineering degree and a doing a stint in a state agency dedicated to coaching competitive athletes, I started a company specializing in scale model-making and moulding. This early professional ‘artistic’ endeavour gave me a chance to indulge my passion for building miniature remote-controlled racing boats and testing them in competition. I was a member of the national team for a long time before becoming a coach, first for Czechoslovakia, and then for Slovakia after the dissolution.” At the same time, Jan’s attraction to nautical activities led him to develop a passion for another, more physical type of racing: hydroplane racing, which he practiced from the mid-1990s up until his accident in 2001. Forced to adapt once again following this accident, Jan was more determined than ever and decided to become a coach – and a winning one at that, since his protégé was none other than Marian Jung, a tenfold European hydroplane-racing champion and a six-time world champion. It’s obvious the man is addicted to speed and thrills, but his favourite hobby demanded another, gentler kind of feeling: photography has fascinated him ever since he was a child, when he spent many Saturdays with his father developing photos in the transformed family bathroom. He practiced photography for a long time as a hobby before taking the plunge and applying for his licence as a professional sports photographer in the early 2000s, motivated by the rapid development of digital technologies, which offered him a way to overcome his visual limitations – and even turn them into a plus! This proved to be a winning transition, as evidenced by the many awards he has won throughout the world, in such diverse places as China, Qatar, Austria, Monte Carlo and the United States.

An instinctive photographer

The first question that comes to mind in view of the severity of his myopia is, “Does he really see what he is photographing?” He answers frankly: “No! I can’t see the subject through the viewfinder, but I don’t need to see it;
it is enough to know what I want to photograph. I know where to position myself and when to press the shutter button. It’s all about experience and feeling. My perception of the environment is different, but I try to free myself from the limitations people with good vision impose on themselves, such as their focus on subject, framing, lighting and so on.”

“Digital technology lets me shoot in burst mode – in general six to seven perfectly clear shots – and select the most expressive photos on my computer. For near vision, I wear a pair of telescopic magnifying glasses designed for computer work.” This connoisseur of strong emotions and distinctive representations feels that nothing is more important than the expressiveness of the subjects and scenes he immortalizes. Jan regrets the current trend in photographic circles that applauds clarity and technical perfection over the raw emotion that he feels should emanate from a photo.

**Capturing unique moments**

Jan claims that he doesn’t have any failed or insipid photos to toss out. This is all the more surprising given that his chosen field is sports photography. Here again, it’s all about experience, knowledge of the subject, creative spirit and a proper command of the equipment. “I’ve always liked sports. I’ve practiced or coached a good number of them and I’m in contact with several federations. To take good photos of athletes, you need to understand the mechanisms of their discipline and basic movements in order to capture the very essence of their sport. You also need to look for an original angle, a unique point of view, as close as possible to the action without disrupting it. Many sports photographers are content to stick to one position. I don’t hesitate to move around, to diversify my compositions. I also like to gradually zoom in on a scene, to get closer to the main subject and the energy he or she gives off.” He particularly likes to express this sensitivity in water sports as well as in mountain sports, including dogsled races, track athletics – and rodeos.
Jan likes to immortalize memorable moments, so it’s not surprising that a large share of his collection of portraits is devoted to music, singers and instruments. “I like to calmly listen to jazz, in good company, but I can’t resist picking up my camera from time to time.”
Of course, Jan has other strings to his photographic bow, some of which are more intimate. Attracted to “faces with character,” he admits to a special fondness for portraits and boasts a fine collection of photographs of Slovak and international celebrities, nearly 900 of which are autographed.

Focusing on the future

He has collaborated with numerous national magazines and has had exhibitions throughout the world, including in Lake Alfred (Florida), Monte Carlo, Budapest and Bratislava. Recognition and a promising future in photography are likely in the cards for this artist who, in any case, does not like to look back. “I have some wonderful memories, but I am not a fan of nostalgia. Living in the past and regretting ‘the golden age of analogue photography,’ for instance, is counter-productive, especially for someone like me who owes so much to modern technology. And I’m not the only one who feels this way! The new cameras and the array of possibilities opened up by digital technology have made a huge contribution to the development of sports photography,” insists this inveterate Nikon fan, who works extensively with the D4S, an SLR perfect for motion photos, and who has been greedily eyeing the brand-new D5.

Visions of hope

As energetic as he is, Jan is convinced that work – even pleasant, artistic work – is not all there is to life. He therefore engages in a wide range of activities, including travel, exploration, and charitable commitments, particularly in support of the blind and visually impaired. For example, he is a member of the Lions Club in his hometown of Banska Bystrica, where he works to raise awareness and funds for children suffering from severe disabilities (including visual and mental disabilities) and for everyone suffering from severe refractive errors (i.e. ametropia). His activism also led him to support and participate in the Cesta světla (Way of Light), an annual charitable event organized by the Slovak Union for the Blind, which is set to celebrate its 13th event. “Both the sighted and visually impaired can participate in this big annual photo competition, which generates some absolutely superb, highly original photos,” Jan explains, pointing out that the event is followed by a travelling exhibition that he hopes, one day, will travel beyond Slovakia’s borders.

These are just a few examples, among many, of the philanthropic endeavours of a man in a day-to-day struggle to improve his own condition via the practice of visual yoga. “I spent six months mastering the technique, and I have now been practicing these exercises for over three years to train my eyes and prevent excessive fatigue. The results are palpable, and I feel like my vision is deteriorating less rapidly than before. I would advise all visually impaired people to try these exercises."

With his big heart, enormous energy and overflowing enthusiasm, Jan Miskovic is a real phenomenon, which in his eyes is perfectly normal. He likes to recharge his batteries near the water, listen to jazz, and spend quality time with friends and family. He’s a man like any other, but also a consummate artist whose record of achievements includes a singular summit: undoubtedly the world’s highest degree of myopia! •

“I don’t need to see it; it is enough to know what I want to photograph... It’s all about experience and feeling.”
Always looking for the best possible angle of view, Jan took advantage of the abundant snow to dig a hole and position himself at ground level. “It was only when I saw the photo on my computer that I realized the dogs were literally flying above the snow!”
Hydroplane races are the only passion that Jan no longer indulges in since his accident. “I miss the adrenaline, but I content myself with taking photos. I am especially attracted to water and try to get as close to it as possible whenever I can.”
From a painful attack in Muay-Taï combat to a high jumper’s flop technique and the disturbing choreography of a rodeo, Jan strives to capture movement, the essence of sports. “You need to look for an original angle, a unique point of view, as close as possible to the action, but without disrupting it.”
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