CET

COMPETENCIES COVERED

Dispensing opticians: Refractive Management, Standards of Practice, Optical Appliances, Contact Lenses, Paediatric Dispensing

Optometrists: Assessment of Visual Function, Optical Appliances, Contact Lenses, Standards of Practice

Short-sighted about myopia?

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Optometrists examine and prescribe for myopic patients every day. Dispensing opticians provide optical appliances for those patients every day. But how much do we really know about myopia?

Myopia control is no longer a fringe aspect of optometry and ophthalmic dispensing but one that is being discussed at length in academia, optical manufacturing and by eyecare professionals working in community practices. During the 2017 Optometry Tomorrow conference, Ian Filtcroft, consultant ophthalmologist at the Temple Street Hospital, Dublin, stated that: "This current generation will be the most myopic ever." He went on to say that: "In 2000 1.4 billion people were myopes, but by 2050 we expect that to be four billion."

Figure 1: A glaucomatous optic disc in a myopic patient

Around the globe, a myopia epidemic appears to be developing with a seemingly ever increasing number of the world's population affected. We do not know why, or how. However, the most worrying consequence of an increase in the number of myopic patients is myopic visual impairment, where diseases such as glaucoma (**Figure 1**), retinal detachment (**Figure 2**) and myopic degeneration (**Figure 3**) cause sight loss despite optical correction.

Near-work activities, such as reading, writing, computer use, and playing video games, have been implicated as possible causes of the significant increase in the prevalence of myopia. However, some studies have reported a weak or absent association between a heavier load of near work and the prevalence or incidence of myopia. Outdoor activity has aroused much interest, although it is still not clear whether outdoor activity can help prevent the onset and progression of myopia. In this CET article, we will review recent papers from the literature concerning myopia, and discuss methods of myopia control along with advice that we may consider giving to our patients.

THE NICER STUDY

The Northern Ireland Childhood Errors of Refraction (NICER) study, is the largest ever study in the UK to examine changes in children's vision and cycloplegic refractive error over time. Conducted by researchers at Ulster University, this is a population-based longitudinal study of refractive error, ocular biometry and visual status.

This article has been approved for 1 CET point by the GOC. It is open to all FBDO members, and associate member optometrists. The multiple-choice questions (MCQs) for this month's CET are available **online only**, to comply with the GOC's Good Practice Guidance for this type of CET. Insert your answers to the six MCQs online at www.abdo.org.uk. After log-in, go to 'CET Online'. **Questions will be presented in random order.** Please ensure that your email address and GOC number are up-to-date. The pass mark is 60 per cent. The answers will appear in the December 2017 issue of *Dispensing Optics*. The closing date is 13 November 2017.

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Figure 2: A superior retinal detachment

The latest findings from this ongoing study are providing vital information on how children's eyes grow and change in the 21st century and the results may influence prescribing decisions and also the advice given to patients. The fact that the study is longitudinal makes it entirely relevant to community eyecare. The term 'longitudinal' means that the children taking part in the study (over 1,000 children selected to be representative of the population as a whole) were selected first and then tested thoroughly at ages six to seven through to 12 to 13 years, or 12 to 13 through to 18 to 20 years.

Using questionnaires, the researchers assessed the children's experiences, which included lifestyle, diet, home and school environment as well as their family's ocular history. The researchers needed to know if these factors were related to changes in the child's vision and refractive error.

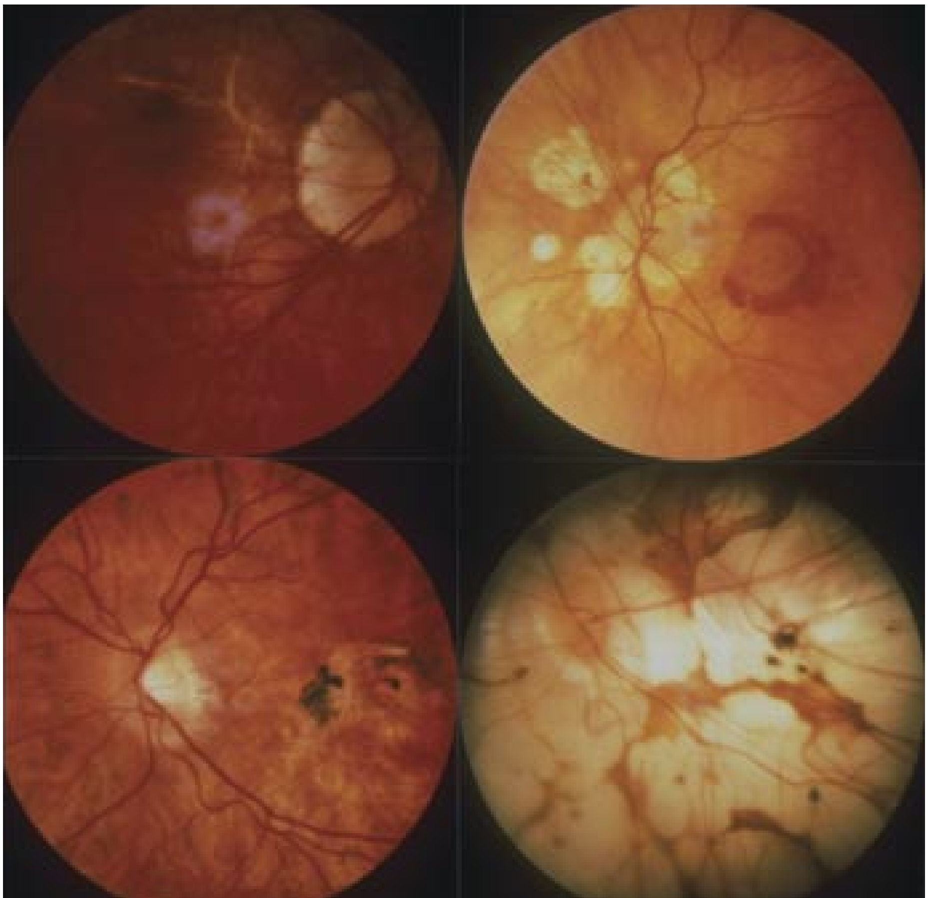

Figure 3: A montage of myopic degeneration

The fact that children were selected before any investigations took place made this study *prospective*, which meant that it was not possible to choose children with different levels of myopia to take part in the study. On the other hand, retrospective studies look at existing ametropes and try to find out what made them, for example, myopic. *Retrospective* studies are known to be more prone to 'confusing factors' than prospective ones; however, longitudinal studies can be adversely affected if participants move away or withdraw from the study for whatever reason.

The NICER study has, and is, providing evidence of what is actually happening in a population and, based on an individual's background, lifestyle or environment (or all three), predicting who is more likely to become myopic. This is crucial in understanding what might actually be causing a myopic increase, and what can be done to address it.

CURRENT RESEARCH FINDINGS

So, what does the literature tell us about the prevalence of myopia? Nearly one in five teenagers in the UK are myopic[1,2] and myopia is more than twice as prevalent among UK children now than in the 1960s (16.4 vs. 7.2 per cent)[3,9]. The prevalence of myopia in white children in the UK is similar to white children in other countries[1,4,5]. However, it is well known that the prevalence of myopia is much higher in Asian countries. In South Korea, for example, 96.5 per cent of 19-year-old males are myopic[6].

Family history has always been an important risk factor for myopia and other ocular and visual abnormalities, and the early teenage years have always been considered the classic time when children become myopic. Children with one myopic parent are almost three times more likely to be myopic by the age of 13 than a child without a myopic parent – and this increases to over seven times when both parents are myopes[7].

A knowledge of age-related normal values for both refractive error and visual acuity are important when prescribing and dispensing spectacles to children, and a low to moderate hypermetropic correction for young children is considered to be normal. The NICER study has found that a cycloplegic spherical equivalent refractive error of +0.75D or lower at six to seven years is a good predictor of myopia[8]. In other words, the longer a child displays a low to moderate degree of hypermetropia, the better as the risk of future myopia is reduced.

Recently, there has been speculation about a link between myopia and the amount of time that a child spends out of doors, specifically the role of sunlight and dopamine levels in the brain. Epidemiological evidence suggests that children who spend more time outdoors are less likely to become myopic. However, this has not, to date, been endorsed by the NICER study. The author is aware of a school in China where one of the classrooms was constructed of clear and light-diffusing glass, with a user-controlled shade canopy which could be deployed in very sunny conditions.

With regard to the onset and progression of myopia, the literature suggests that myopia is most likely to occur between six and 13 years of age and children are becoming myopic at a younger age in the UK than in Australia[5,9]. Do Australian children spend more time out of doors? However, at ages 18 to 19 years, the prevalence of myopia in Australia and the UK is similar[9].

The progression of myopia appears to be more aggressive between the ages of six and 13 years when children become more myopic by, on average, -0.23D per year, as compared to an average change in myopia of -0.10D per year between the ages of 12 to 20 years[9].

Interestingly, current evidence suggests that more time spent on near vision tasks, including time spent using digital devices, does not have a strong influence on myopia development.

MYOPIA, NEAR WORK AND OUTDOOR ACTIVITIES

In a paper published in 2013, Wu and co-workers investigated the effect of outdoor activity during class recess on myopic changes among elementary school children in a suburban area of Taiwan[10]. Two schools were involved in the study and the participants were children aged seven to 11. Of the two schools, one participated in interventions and one acted as the control.

The interventions consisted of carrying out a recess outside the classroom (ROC) programme in which the classroom lights were turned off, classrooms emptied and all children were encouraged to go outside of the classroom for outdoor activities during the recess time. The total daily recess time in school was 80 minutes and the total weekly recess time was approximately 6.7 hours. The control school did not have any special programme during recess. Both schools had two hours for outdoor physical education per week. A total of 571 children were enrolled in this prospective study. There were 333 children in the ROC interventional group and 238 in the control group.

There were two interventional aspects to the ROC programme regarding the behaviour of the children. Firstly, it interrupted near and mid-range work during the time in the classroom. Ip *et al*[11] showed that continued reading is associated with myopia and that the intensity of near-range visual work is a more important factor for myopic progression compared with the total duration. The ROC programme provided a break from continued near-range work and reduced its intensity.

Secondly, the ROC programme gave the children more time to spend outdoors during the school day. Several studies indicate that outdoor activity can be considered a protective factor against myopia[12-15] although the exact mechanism is still under investigation. Brighter light may be one possible mechanism to protect against myopia. Two recent animal studies have shown that high ambient lighting retards the development of form-deprivation myopia in chicks and monkeys[16,17]. Brighter light potentially reduces the development of myopia through pupil constriction, resulting in less visual blur, or through stimulation of dopamine release (an eye growth inhibitor) from the retina.

Data was obtained by means of a parent questionnaire and ocular evaluations that included axial length and cycloplegic auto-refraction at the beginning and after one year. At the beginning of the study, there were no significant differences between the two schools with regard to age, gender, baseline refraction, and myopia prevalence (47.75 vs. 49.16 per cent).

After one year, new onset of myopia was significantly lower in the ROC group than in the control group (8.41 vs. 17.65 per cent). There was also significantly lower myopic shift in the ROC group compared with the control group (0.25 D/year vs. 0.38 D/year).

So, increased time spent outdoors appears to have a protective effect against myopia development and progression. It is not yet clear why outdoor activity has this effect but as outlined above, it is postulated that bright light triggers the release of dopamine, a retinal transmitter which is believed to prevent eye growth. Other theories suggest that the sunlight itself could play a role, increasing exposure to vitamin D, which has been shown to reduce eye growth. Finally, the increased viewing distances and the high luminance levels afforded by outdoor activities diminish accommodative demand and reduce pupil diameter/increase depth of focus, thereby increasing retinal image quality.

The study by Wu *et al*[10] concluded that outdoor activities during class recess have a significant effect on the control of myopia onset and myopic shift in non-myopic children, but not in myopic children. This may point to possible future considerations for the prevention of myopia.

Another study published by Low and co-workers in 2010[18] set out to investigate the risk factors for myopia, including near work and outdoor activity, in Singapore Chinese pre-school children. This study concluded that a family history of myopia was the strongest factor associated with pre-school myopia. In contrast, neither near work nor outdoor activity was found to be associated with early myopia. The results suggested that genetic factors may play a more substantial role in the development of early-onset myopia than key environmental factors.

MYOPIA CONTROL

Logan[19] provides an excellent review of myopia prevalence and development along with a discussion of intervention using spectacles contact lenses and pharmacological methods.

Traditionally, most of the methods that have been used clinically and/or tested in research studies to prevent or reduce myopia are based on the view that accommodation is at least a part of the cause. These methods include the use of spectacle lenses (or contact lenses) to under-correct the myopia, the prescribing of bifocals or progressive lenses, visual training and the use of pharmaceutical agents. The use of contact lenses to control myopia by influencing the curvature of the cornea is the one approach that is not directly related to the assumption that myopia has an accommodative cause.

A long-standing method used by clinicians to slow down the progression of myopia is to under-correct the myopic eye by as much as a dioptre, in an attempt to avoid excessive accommodation. The theory is that under-correction of myopia reduces the accommodative demand for near work and the accommodative lag associated with development of myopia. Evidence from animal studies supports the under-correction as a means of arresting myopia progression; however, studies on humans have produced conflicting results.

Ong and colleagues[20] showed that spectacle intervention, in terms of whether young myopes wore their corrections full-time, part-time or not at all, had no effect on the progression of myopia, while Chung, Mohidin and O'Leary[21] found that an under-correction of 0.75D resulted in a more rapid progression of myopia.

Similar findings were observed in a separate study where children were under-corrected by 0.50D[22]. If it is the case that accelerated myopic progression occurs with binocular under-correction, then optometrists should prescribe the full myopic prescription for children.

TREATMENT MODELS

Based on the theory of near work and lag of accommodation, several treatment models for slowing myopia progression have been evaluated in intervention studies involving bifocal and progressive addition spectacle lenses as a means to decrease accommodative lag during near work. A review of the literature will show that the results of these studies are both variable and contradictory, with some studies showing a significant reduction in the progression of myopia[23] while others showed no significant difference[24].

Smith and colleagues[25] suggested that peripheral image quality may be used as a treatment strategy to control eye growth and the subsequent refractive development of the eye. Clinical trials involving children do, in fact, indicate that myopic progression, in terms of change in both refractive state and axial length, can be slowed by wearing lenses that provide relatively more peripheral positive power.

A spectacle lens designed to manipulate the curvature of the so-called 'peripheral image shell' while maintaining clear central vision is available in the Far East (Zeiss *MyoVision*). Work in animal studies which indicates that retinal defocus (and in particular, hyperopic defocus where the image shell falls behind the retina) has a role to play in the development of myopia.

In young chicks fitted with two-zone concentric lenses, each combining plano power with either +5.00DS or -5.00DS in the other zone, significant differences in eye growth have been reported. The lens which was plano in the centre but with +5.00DS in its periphery inhibited eye growth, whereas the other power combinations caused changes to eye growth[26]. This supports the notion that

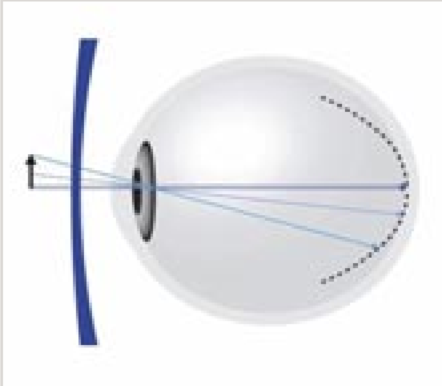

Figure 4: The MyoVision lens from Zeiss

myopic defocus in the periphery (where the image shell is suspended within the eye) is associated with the reduced progression of myopia compared to hyperopic defocus.

In relation to axial length, it is thought that this myopic defocus sends a 'stop signal' to the eye. Techniques that reduce this peripheral hyperopic defocus and potentially slow myopia progression have been trialled in children[27] the hypothesis being that these lenses would reduce peripheral hyperopic defocus to slow myopia progression. The efficacy of three designs was assessed, with an asymmetrical lens type showing a slowing of myopia progression in younger children with a family history of myopia.

Figure 4[28] shows a myopic eye corrected with *MyoVision*. Note that the image is projected on the retina centrally, but in front of the retina peripherally. Trials with *MyoVision* lenses conducted in Asia have shown that 40 per cent of pre-teenagers with a family history of myopia taking part in the study demonstrated a reduction in myopia of up to 0.75D.

One potential problem with this approach using spectacle lenses is that of centration. Eyes of course rotate behind a spectacle lens and it is likely that wearers of such lenses would become head movers

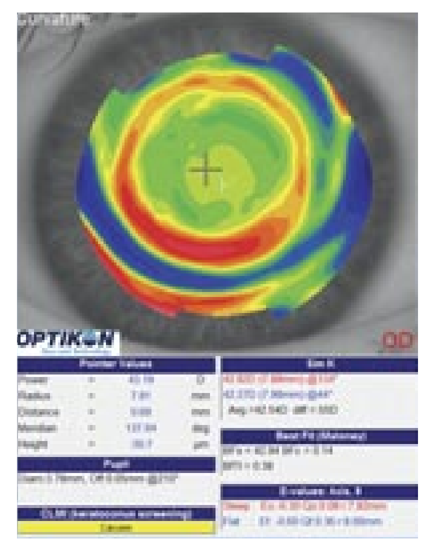

Figure 6: Ortho-k post-wear topography

as opposed to eye movers as vison would be optimal in the central region of the lens. Contact lenses are well suited to this approach as they are usually centred on the visual axis and move with the eye. This may well provide a more satisfactory optical correction when compared with spectacles.

Orthokeratology (ortho-k) (**Figure 5**) is a technique that uses reverse geometry RGP contact lenses to remodel the anterior corneal surface in order to provide a temporary reduction in refractive error particularly in low to moderate myopes (**Figure 6**). However, a number of studies reported slower progression of myopia in children wearing overnight ortho-k compared with other methods of optical correction.

It is important to emphasise that this method of contact lens correction was designed to correct myopia as opposed to control or treat it. The slowing of myopia progression with ortho-k may be a result of the conversion of relative peripheral hyperopia to relative peripheral myopia, resulting once more in the formation of an image shell within the eye (**Figure 7**). This

Figure 5: An on-eye ortho-k lens

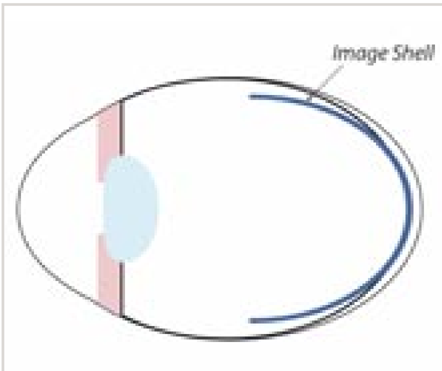

Figure 7: Peripheral myopia induced using ortho-k

occurs because of the corneal remodelling associated with ortho-k contact lenses. Over a five-year period, Hiraoka and co-workers[29] found that myopia control was maintained. However, further studies are required to investigate myopia progression on cessation of treatment.

Work carried out by Walline *et al*[30] has shown that the use of centre-distance soft bifocal contact lenses can produce a statistically significant reduction in myopia progression. A centre-distance dual-focus soft contact lens, with a central correction zone and concentric treatment zones that simultaneously create myopic retinal defocus, was used by Anstice and Phillips[31]. This lens design has been shown to reduce the progression of both the myopic refractive error and the corresponding axial length of the eye.

A distance centre design of dual-focus soft contact lens, with a central correction zone and concentric treatment zones that simultaneously create myopic retinal defocus is now available from CooperVision as the *MiSight* lens[32]. *MiSight* is a soft, daily disposable contact lens manufactured using Coopervision's Proclear material. Daily disposable contact lenses are, of course, an ideal option when considering contact lenses for children. Results of studies published by CooperVision so far show a high degree of efficacy for myopia control using the *MiSight* contact lens and further results are due to be released in 2017.

An alternative method of myopia control is that of pharmacological intervention using anti-muscarinic drugs such as atropine and pirenzepine. The reason why myopia control occurs is unclear, but the mechanism of action is thought to be retinal, choroidal or scleral as opposed to accommodative[33]. The use of atropine appears to be the most effective treatment for minimising an increase in axial length progression, however, the side effects of anti-muscarinic drugs which include mydriasis and cycloplegia means that its appeal is not universal. However, very low dose atropine (0.01 per cent) does appear to be effective and has fewer side effects and has little effect on accommodation.

CONCLUDING POINTS

Myopia has been described as an 'invisible epidemic'. The prevalence of myopia varies somewhat between studies on similar populations because of different definitions, but in the adult population in the UK, continental Europe and the USA, a prevalence of at least 30 per cent is supported by multiple studies with myopia prevalence in 19-year-old South Korean males reaching 96 per cent.

The goal of any potential treatment for myopia must be that myopes become as low a myope as possible and, therefore, have a reduced risk of developing myopia-related ocular pathology in later life. We know from the literature that the prevalence of myopia is increasing and aside from causing a reduction in uncorrected distance acuity, presents a real threat to sight.

Small reductions in myopia or a slowed myopia development can have a significant impact on the risk of retinal pathology and each dioptre less is associated with a reduced risk of severe retinal change. Although a reduction of 1.00D may not seem to have an enormous benefit for an individual patient who is -5.00DS, it is important to remember that their risk of complications increases as their myopia increases.

In summary, the literature concerning myopia control and progression validates the following:

- Under-correction of a myopic refractive error is not effective at reducing the progression of myopia
- Outside activity appears to be beneficial and should be encouraged
- Time spent on near vision tasks (studying or screen time) does not have a strong influence on myopia development
- Pharmacological agents demonstrate encouraging results and may be used in the future. Current drugs are not, of course, licensed for myopia control
- Research has consistently shown that conventional spectacle lenses and single vision contact lenses are not effective methods of myopia control
- Family history has a strong influence on myopia development. Parents who are myopic should be told to expect myopia in their children and ensure they get their children's eyes tested regularly in the early years of primary school

Perhaps it is time for UK eyecare practitioners to change their approach to the management of myopia by considering the longer-term consequences of this seemingly innocuous condition. Should myopia be considered to be a public health issue? Should eyecare practitioners become more proactive in discussing myopia control with children and parents?

In Asia, ortho-k is regarded as an effective method of treatment for myopia and there is evidence of proactive prescribing of ortho-k in countries such as Hong Kong where myopia is much more prominent as a public health concern. The website www.myopiacare.org is a useful source of information for the parents of myopic children or indeed myopic parents.

Myopia control may become part of mainstream optometric and dispensing practice in the UK. As worldwide myopia rates increase, management of myopic progression could become part of the day job using low dose atropine and peripheral defocus optical appliances.

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