Myopia

Part 1

In the first of a three-part series looking at myopia, **Dr Peter Allen** and **Dr Hema Radhakrishnan** describe the reasons why for some people emmetropisation fails to occur, leaving them myopic. **Module C15072, one general CET point for optometrists and DOs**

Approximately 25 per cent of individuals in Caucasian populations are myopic.[1,2,3,4] Recent studies from Asia have shown an even higher prevalence of myopia.[5,6,7] Myopia seems to be on the increase worldwide.[5,8,9] The public health costs are considerable[10] due to the costs of optical correction and associated eye disease (glaucoma, cataract, retinal degeneration and retinal detachment) and partial sight and blindness.[11]

Emmetropisation

In early childhood refractive error is widely distributed with the mean refraction being around +3.00D (Figure 1). Emmetropisation is the process of eye development that involves an active matching of the axial length of the eye to the optical power of the cornea and lens. Normally, eye development proceeds from neonatal hypermetropia towards emmetropia, rapidly within the first year[12] and then more slowly for the next five to six years. Emmetropisation is visually driven and can be disrupted by environmental factors. Compensatory growth patterns (reduced eye growth with the introduction of positive spectacle lenses and increased eye growth with negative spectacle lenses) have been demonstrated in animals.[13]

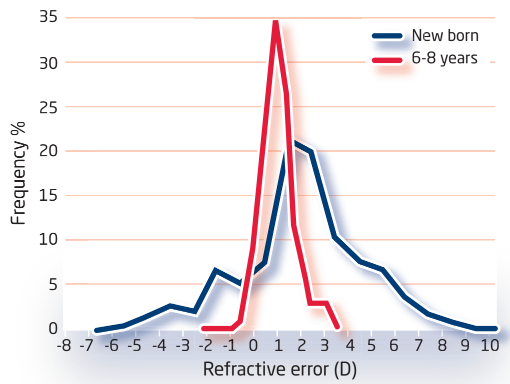

Figure 1 Distribution of refractive error in newborn and 6-8 year-old children. Re-plotted from Hirsch and Weymouth (1991)

Nature versus nurture

After many years of research there is still no consensus of opinion about whether myopia is caused by genetics, environmental factors, or a combination of the two.[15,16,17]

Genetics

In a study on monozygotic and dizygotic twins it was suggested that over 80 per cent of the variation in refractive error could be explained by genetic factors.[18] A significant link has been found between higher levels of myopia (greater than -6D) and genes present at various loci,[19,20] although studies investigating whether some of the same genes are responsible for both high and low myopia have indicated that this is not the case.[21] The PAX6 set of genes, which play an important role in various aspects of ocular development, are linked with low myopia.[22,23] Several studies have shown that parental myopia is one of the significant risk factors for myopia development.[24,25] In particular, the odds of becoming myopic are about six times greater in children with two myopic parents than in children with only one or no myopic parents.[22] In the past few weeks a large multi-centre study has identified the first myopia susceptibility gene called RASGRF1.[26] The research identified several variations around the RASGRF1 gene, which is associated with eye growth, and seems to be strongly associated with myopia, either preventing it or protecting against it. This study is a major breakthrough and may eventually lead to the development of treatments to prevent or stop myopia progressing.

However, genetics alone cannot explain the sudden increase in myopia prevalence. Evidence of environmental influence comes from a rapid increase in prevalence in certain populations[27,28] or in certain population sub-groups.[29,30]

Environment and near work

The concept that environmental factors, in particular near work, might cause myopia dates back many years.[31,32] More recently clinical studies on children have shown an association between myopia and higher levels of nearwork.[33,34,15,35] Although near work seems to have an important role to play, the exact mechanism by which near work relates to myopia has remained elusive. Several potential mechanisms have been suggested for myopia development with abnormal accommodative function being a popular hypothesis.

Lag of accommodation

Gwiazda *et al*[36] were the first to suggest that an increased lag of accommodation found in myopes (resulting in hypermetropic retinal defocus) may stimulate axial elongation and therefore myopia progression. This finding of myopes exhibiting an increased lag of accommodation when compared to non-myopes has been replicated in many studies,[37,38] although it has been suggested that the increased accommodative lag may be a consequence rather than a cause of myopia.[39] Multifocal spectacle lenses have been evaluated as a treatment attempting to arrest myopia development in multiple clinical trials[40,41,42,43,44,45] with the rationale being to decrease accommodative lag during near work and thereby reduce hypermetropic retinal blur. The various clinical trials were of limited success with treatment effects being greatest in participants with a high lag of accommodation and near esophoria.[46]

Dynamic accommodation

Reduced accommodative facility or dynamics of accommodation have been shown to be associated with myopia[47,48,49] and myopia progression.[50,38] An increased accommodative variability in myopes[50,51] that results in retinal defocus during near work could be integrated over time, resulting in axial elongation and hence myopia.[52]

Sensitivity to blur

This increased variability in accommodation may be related to the low sensitivity to blur exhibited by myopes.[53,54,55,56] The reduced sensitivity to blur is associated with a reduced effect of defocusing lenses on visual performance.[57] Unlike emmetropes, myopes have significantly different sensitivities to positive and negative lens-induced defocus.[58,59] Moreover, myopes are also found to adapt to blur ▶

when left uncorrected.[60] However, another study by Schmid[61] failed to find any significant difference in the blur detection abilities of myopic and non-myopic children, although myopic children showed greater individual variation. Myopes have also been shown to demonstrate significant improvements in blur sensitivity after relatively short periods of blur adaptation.[62]

Near-work-induced transient myopia

Near-work-induced transient myopia (NITM) refers to a small, transient, near shift in the far point of the eye after a period of sustained near work. The exact mechanism that causes NITM has still to be resolved although biomechanical hysteresis of the crystalline lens, a neuromuscular effect that prevents complete relaxation of the ciliary muscle following near work, and sympathetic inhibitory dysfunction have all been suggested.

In the normal population, the mean magnitude of NITM is typically small (approximately 0.3D) and remains within the depth of focus of the eye, thus producing no perception of blur. Myopes exhibit both larger and longer NITM when compared to emmetropes.[63,64] Moreover, this NITM has been shown to be additive selectively in myopes.[65] Historically, early onset myopes have been thought to be primarily influenced by genetic factors whereas late onset myopes are susceptible to environmental factors. Interestingly, NITM appears to represent a more global myopic tendency.[65] There are several different ways that NITM may cause myopia progression including (a) NITM can affect the steady-state accuracy of accommodation and increase retinal defocus and (b) the incremental retinal defocus theory[66] suggests that repeated cycles of incompletely decayed NITM may by myogenic.

Monochromatic aberrations

It has been suggested that optical aberrations may be a cause of some of the accommodative anomalies discussed above.[58,59] While some have found myopes to have elevated higher-order aberrations when compared to emmetropes,[67,68] others have found no correlation between refractive error group and spherical aberration[69] or between refractive error magnitude and total root mean square higher-order error or spherical aberrations.[70] Several studies have examined the changes in both spherical aberration and other higher-order aberrations with accommodation with somewhat equivocal results. He *et al*[71] found that ocular aberrations decreased

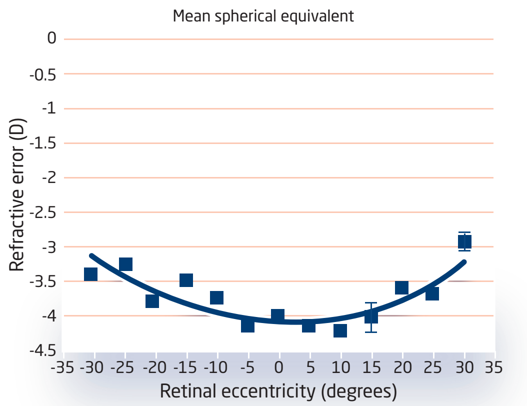

Figure 2 **Peripheral refractive error of a -4D myope. Refraction at 30 degrees in the periphery is approximately 0.75D more hyperopic relative to the central refraction (Radhakrishnan & Charman 2008)**

with accommodation in emmetropes, but in myopes aberrations increased or did not change. This suggests that, at near, myopes will have greater amounts of higher-order aberrations than emmetropes. However, Hazel *et al*[72] found that emmetropes and myopes both demonstrated an increase in negative spherical aberration with accommodation. Higher-order optical aberrations may affect the accommodative response by causing a degradation of the retinal image (which extends the depth of field of the eye), by altering the sensitivity to negative defocus[73] or by assisting in the detection in the direction of defocus.[74]

Peripheral refraction

In a study of groups of existing adult ametropes, Millodot[75] showed that, at least for field angles up to about 30 degrees, both oblique astigmatic image surfaces in hyperopic eyes along the horizontal meridian tended to show relative peripheral myopia with respect to the axial refraction, whereas in myopic eyes there was relative hypermetropia: in emmetropes the two astigmatic image surfaces tended to lie on opposite sides of the retina (Figure 2). Similar results have been obtained by several subsequent studies.[76,77,78] Some of these studies also show differences between the patterns of refraction in different meridians. In addition, Tabernero and Schaeffel[79] found that conventional spectacle lenses used to correct myopia induce significant relative hypermetropia in the periphery. Only Calver *et al*[80] found no strong differences between refractive groups. This study used custom-made trial lenses to correct myopia. Recently, a study on over 2,000 eight- to nine-year-old children found little evidence of an influence of peripheral refraction on myopia progression except in a subgroup of children of Asian ethnicity.[81] Moreover, Sankaridurg *et al*[82] conducted a clinical trial where participants wore spectacles designed to reduce peripheral hypermetropic retinal defocus. They found that altering field curvature to minimise peripheral hypermetropia made no significant difference to refractive development except in a small subgroup of participants.

The observed differences in peripheral refraction of existing ametropes might either be predictive of future refractive change,[83] or they might simply be properties of eyes whose refractive error is already fully developed. Mutti *et al*,[84] in a longitudinal study of almost 1,000 children aged between six and 14 years, found that children who became myopic had more hypermetropic relative peripheral refractive errors than did emmetropes from two years before onset through five years after onset of myopia. The third article in this series will look at evidence for peripheral correction as a means to reducing myopic progression.

Outdoor activity

Recent work has suggested that time spent outdoors has an impact on myopia development and progression.[85,86,87] These studies show that children who spent more time in outdoor activities were less likely to develop myopia. This reduction in the chance of becoming myopic with increased outdoor activity occurred even when other risk factors such as quantity of near work, parents with myopia and ethnicity had been accounted for. However, this effect has not been replicated in pre-school children. Low *et al*[88] show that a family history of myopia was the strongest factor associated with myopia in pre-school children, with neither near work nor outdoor activity playing a significant role. The authors suggest that genetic factors may therefore play a more substantial role in the development of early onset myopia than quantity of near work or outdoor activities.

● Part 2 will discuss the prevalence of myopia and its impact both medically and sociologically. The final part will consider correction and treatment including details of the latest dual focus treatment lenses.

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● **Dr Peter Allen** is a principal lecturer and director of clinics at Anglia Ruskin University while **Dr Hema Radhakrishnan** is a lecturer based at Manchester University

MULTIPLE-CHOICE QUESTIONS – take part at opticianonline.net

1 What percentage of Caucasians are myopic?
A 10 per cent
B 25 per cent
C 50 per cent
D 85 per cent

2 Which of the following statements about emmetropisation is true?
A A child is born myopic and tends towards emmetropia by the first year
B A baby is born hyperopic and reaches emmetropia within 12 months
C A baby undergoes a rapid myopic shift in the first 12 months and then more slowly approaches emmetropia by age six
D A baby is born emmetropic

3 Which of the following statements about accommodative lag is true?
A Correction of myopes with multifocals has some limited success in reducing progression in esophores and those with high lags
B Near work has no influence on myopia
C Accommodative lag will tend to result in a myopic shell of focus
D Myopic retinal defocus stimulates axial length growth

4 In the normal population, what is the mean magnitude of near-work induced transient myopia?
A Zero
B 0.3D
C 1.3D
D 2.3D

5 What did Mutti's study of hypermetropic relative peripheral refractive error in children show?
A No influence at all
B Those with the errors tended to develop more hyperopia
C Those with the errors tended to be more myopic
D Those with myopic peripheral shells tended to have increases in axial length

6 Which of the following statements about outdoor activity and myopia is true?
A Outdoor activity increases myopic progression
B Outdoor activity reduces myopic progression in pre-school infants
C Outdoor activity has no impact on myopia as it is purely genetically driven
D Outdoor activity appears to reduce myopic progression in school-age children

Successful participation in this module counts as one credit towards the GOC CET scheme administered by Vantage and one towards the Association of Optometrists Ireland's scheme.
The deadline for responses is November 18 2010