General Optical Council Approved CET For Optometrists
General Optical Council Approved CET For Dispensing Opticians

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]

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]

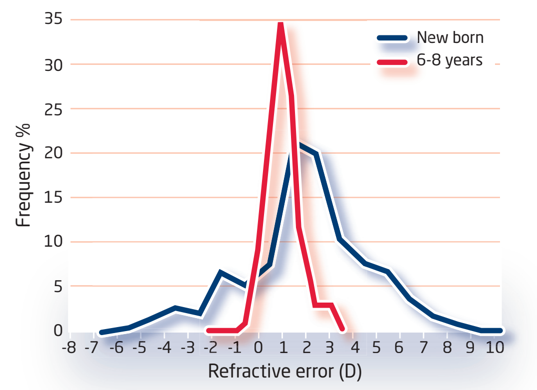

Figure 1 Distribution of refractive error in newborn and 6-8 year-old children. Re-plotted from Hirsch and Weymouth (1991)

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 ▶

18-24CETmyopia1 18
20/10/10 12:25:07

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

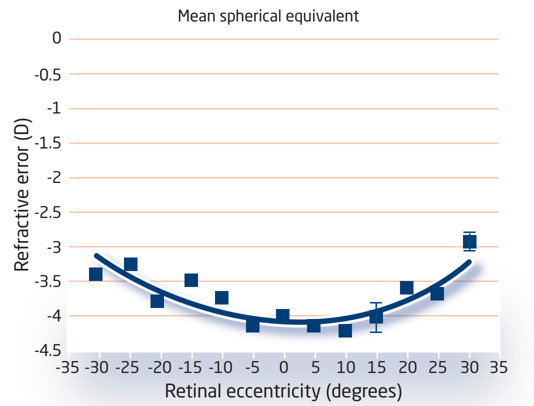

Figure 2 Peripheral refractive error of a -4D myope. Refraction at 30 degrees in the periphery is approximately 0.75D more hyperopic relative to the central refraction (Radhakrishnan & Charman 2008)

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.

1 Sperduto RD, Seigel D, Roberts J, Rowland M. Prevalence of myopia in the United States. *Arch Ophthalmol*, 1983;101:405-7.
2 Wang Q, Klein BE, Klein R, *et al*. Refractive status in the Beaver Dam Eye Study. *Invest Ophthalmol Vis Sci*, 1994;35:4344-7.
3 Katz J, Tielsch JM, Sommer A. Prevalence and risk factors for refractive errors in an adult inner city population. *Invest Ophthalmol Vis Sci*,

1997;38:334-40.
4 Wensor M, McCarty CA, Taylor HR. Prevalence and risk factors of myopia in Victoria, Australia. *Arch Ophthalmol,* 1999;117:658-63.
5 Lin LL, Shih YF, Tsai CB, Chen CJ, Lee LA, Hung PT, *et al.* Epidemiologic study of ocular refraction among schoolchildren in Taiwan in 1995. *Optom Vis Sci,* 1999;76:275-81.
6 Edwards MH. The development of myopia in Hong Kong children between the ages of 7 and 12 years: a five-year longitudinal study. *Ophthalmic Physiol Opt,* 1999;19:286-94.
7 Wu HM, Seet B, Yap EP, *et al.* Does education explain ethnic differences in myopia prevalence? A population-based study of young adult males in Singapore. *Optom Vis Sci,* 2001;78:234-9.
8 Zhao J, Pan X, Sui R *et al.* Refractive Error Study in Children: results from Shunyi District, China. *Am J Ophthalmol,* 2000;129:427-35.
9 Vitale S, Sperduto RD, Ferris FL. Increased prevalence of myopia in the United States between 1971-1972 and 1999-2004. *Arch Ophthalmol,* 2009;127:1632-1639.
10 Javitt JC, Chang YP. The Socioeconomic Aspects of Laser Refractive Surgery. *Arch Ophthalmol,* 1994;112:1526-1530.
11 Rose K, Smith W, Morgan I, Mitchell P. The increasing prevalence of myopia: implications for Australia. *Clin Experiment Ophthalmol,* 2001;29:116-20.
12 Mutti DO, Mitchell GL, Jones LA, Friedman NE, Frane SL, Lin WK, Moeschberger ML, Zadnik K. Refractive astigmatism and the toricity of ocular components in human infants. *Optom Vis Sci,* 2004;81:753-61.
13 Schaeffel F, Troilo D, Wallman J, Howland HC. Developing eyes that lack accommodation grow to compensate for imposed defocus. *Vis Neurosci,* 1990;4:177-183.
14 Smith EL, Hung LF. The role of optical defocus in regulating refractive development in infant monkeys. *Vis Res,* 1999;39:1415-1435.
15 Mutti DO, Mitchell GL, Hayes JR, *et al.* Accommodative lag before and after the onset of myopia. *Invest Ophthalmol Vis Sci,* 2006;47:837-46.
16 Saw SM. A synopsis of the prevalence rates and environmental risk factors for myopia. *Clin Exp Optom,* 2003;86:289-94.
17 Ip JM, Saw, SM, Rose KA, Morgan IG, Kifley A, Wang JJ, Mitchell P. Role of near work in myopia: Findings in a sample of Australian school children. *Invest Ophthalmol Vis Sci,* 2008;49:2903-10.
18 Hammond CJ, Snieder H, Gilbert CE, Spector TD. Genes and environment in refractive error; the twin eye study. *Invest Ophthalmol Vis Sci,* 2001;42:1232-1236.
19 Paluru P, Ronan SM, Heon E, Devoto M, Wildenberg SC, Scavello G, Holleschau A, Makitie O, Cole WG, King RA, Young, TL. New locus for autosomal dominant high myopia maps to the long arm of chromosome 17. *Invest Ophthalmol Vis Sci,* 2003;44:1830-6.
20 Farbrother JE, Kirov G, Owen MJ, Pong-Wong R, Haley CS, Guggenheim JA. Linkage analysis of the genetic loci for high myopia on 18p, 12q, and 17q in 51 U.K. families. *Invest Ophthalmol Vis Sci,* 2004;44: 2879-85.
21 Stambolian D, Ibay G, Reider L, Dana D, Moy C, Schlifka M, Holmes T, Ciner E, Bailey-Wilson JE. Genomewide linkage scan for myopia susceptibility loci among Ashkenazi Jewish families shows evidence of linkage on chromosome 22q12. *Am J Hum Genet,* 2004;75:448-59.
22 Mutti DO, Semina E, Marazita M, Cooper M, Murray JC, Zadnik, K. Genetic loci for pathological myopia are not associated with juvenile myopia. *Am J Med Genet,* 2002;112:355-60.
23 Hammond CJ, Andrew T, Mak YT, Spector TD. A susceptibility locus for myopia in the normal population is linked to the PAX6 gene region on chromosome 11: a genomewide scan of dizygotic twins. *Am J Hum Genet,* 2004;75:294-304.
24 Hui J, Peck L, Howland HC. Correlations between famialial refractive error and children's non-cycloplegic refractions. *Vision Res,* 1995;35:1353-58.
25 Wu MM, Edwards WH. The effect of having myopic parents: an analysis of myopia in three generations. *Optom Vis Sci,* 1999;76:387-92.
26 Hysi PG, Young TL, Mackey DA, Andrew T, Fernández-Medarde A, Solouki AM, Hewitt AW, Macgregor S, Vingerling JR, Li YJ, Ikram MK, Fai LY, Sham PC, Manyes L, Porteros A, Lopes MC, Carbonaro F, Fahy SJ, Martin NG, van Duijn CM, Spector TD, Rahi JS, Santos E, Klaver CCW, Hammond CJ. A genome-wide association study for myopia and refractive error identifies a susceptibility locus at 15q25. *Nature Genetics,* 2010; 42;902-905.
27 Young FA, Leary GA, Baldwin WR, West DC, Box RA, Harris E, *et al.* The transmission of refractive errors within eskimo families. *Am J Optom Arch Am Acad Optom,* 1969;46:676-85.
28 Lam CS, Goh WS, Tang YK, Tsui KK, Wong WC, Man TC. Changes in refractive trends and optical components of Hong Kong Chinese aged over 40 years. *Ophthalmic Physiol Opt,* 1994;14:383-8.
29 Zylbermann R, Landau D, Berson D. The influence of study habits on myopia in Jewish teenagers. *J Pediatr Ophthalmol Strabismus,* 1993;30:319-22.
30 McBrien NA, Adams DW. A longitudinal investigation of adult-onset and adult-progression of myopia in an occupational group. Refractive and biometric findings. *Invest Ophthalmol Vis Sci,* 1997;38:321-33.
31 Donders FC. *On the anomalies of accommodation and refraction* (translated by WD Moore). 1864 New Sydenham Society.
32 Landolt E. *The refraction and accommodation of the eye* (translated by C.M. Culver). 1886 Edinburgh. Pentland.
33 Angle J, Wissmann DA. The epidemiology of myopia. *Am J Epidemiol,* 1980;111:220-228.
34 Richler A, Bear JC. Refraction, nearwork and education. A population study of Newfoundland. *Acta Ophthalmol,* 1980;58;468-478.
35 Goldschmidt E. The mystery of myopia. *Acta Ophthalmol,* 2003;81;431-6.
36 Gwiazda J, Thorn F, Bauer J, Held R. Myopic children show accommodative response to blur. *Invest Ophthalmol Vis Sci,* 1993;34,690-694.
37 McBrien NA, Millodot M. The effect of refractive error on the accommodative response gradient. *Ophthalmic Physiol Opt,* 1986;6:145-9.
38 Allen PM, O'Leary DJ. Accommodation functions: co-dependency and relationship to refractive error. *Vision Res,* 2006;46:491-505.
39 Mutti DO, Mitchell GL, Hayes JR, Jones LA, Moeschberger ML, Cotter SA, *et al.* Accommodative lag before and after the onset of myopia. *Invest Ophthalmol Vis Sci,* 2006;47:837-46.
40 Leung JT, Brown B. Progression of myopia in Hong Kong Chinese schoolchildren is slowed by wearing progressive lenses. *Optom Vis Sci,* 1999;76:346-54.
41 Fulk GW, Cyert LA, Parker DE. A randomized trial of the effect of single-vision vs bifocal lenses on myopia progression in children with esophoria. *Optom Vis Sci,* 2000;77:395-401.
42 Edwards MH, Li RW, Lam CS, Lew JK, Yu BS. The Hong Kong progressive lens myopia control study: study design and main findings. *Invest Ophthalmol Vis Sci,* 2002;43:2852-8.
43 Gwiazda J, Hyman L, Hussein M, Everett D, Norton TT, Kurtz D, *et al.* A randomized clinical trial of progressive addition lenses versus single vision lenses on the progression of myopia in children. *Invest Ophthalmol Vis Sci,* 2003;44:1492-500.
44 Hasebe S, Ohtsuki H, Nonaka T, Nakatsuka C, Miyata M, Hamasaki I, Kimura S. Effect of progressive addition lenses on myopia progression in Japanese children: A prospective, randomised, double-masked, crossover trial. *Invest Ophthalmol Vis Sci,* 2008;49:2781-2789.
45 Yang Z, Lan W, Ge J, Wen L, Chen X, Chen L, Yu M. The effectiveness of progressive addition lenses on the progression of myopia in Chinese children. *Ophthalmic Physiol Opt,* 2009;29:41-8.
46 Gwiazda JE, Hyman L, Norton TT, Hussein ME, Marsh-Tootle W, Manny R, Wang Y, Everett D. Accommodation and related risk factors associated with myopia progression and their interaction with treatment in COMET children. *Invest Ophthalmol Vis Sci,* 2004;45: 2143-51.
47 O'Leary DJ, Allen PM. Facility of accommodation in myopia. *Ophthalmic Physiol Opt,* 2001;21:352-5.
48 Radhakrishnan H, Allen PM, Charman WN. Dynamics of accommodative facility in myopes. *Invest Ophthalmol Vis Sci,* 2007;48:4375-4382.
49 Allen PM, Charman, WN, Radhakrishnan H. Changes in dynamics of accommodation after accommodative facility training in myopes and emmetropes. *Vision Res,* 2010; 50: 947-955.
50 Seidel D, Gray LS, Heron G. Retinotopic accommodation responses in myopia. Invest *Ophthalmol Vis Sci,* 2003;44:1035-1041.
51 Day M, Strang NC, Seidel D, *et al.* Refractive group differences in accommodation microfluctuations with changing accommodation stimulus. *Ophthalmic Physiol Opt,* 2006;26:88-96.
52 Wallman J, Winawer J. Homeostasis of eye growth and the question of myopia. *Neuron,* 2004;43:447-68.
53 Jiang BC. Integration of a sensory component into the accommodation model reveals differences between emmetropia and late-onset myopia. *Invest Ophthalmol Vis Sci,* 1997;38:1511-6.
54 Rosenfield M, Abraham-Cohen JA. Blur sensitivity in myopes. *Optom Vis Sci,* 1999;76:303-7.
55 Collins MJ, Buehren T, Iskander DR. Retinal

image quality, reading and myopia. *Vision Res,* 2006;46:196-215.
56 Vasudevan B, Ciuffreda KJ, Wang B. Objective blur thresholds in free space for different refractive groups. *Curr Eye Res,* 2006;31:111-8.
57 Thorn F, Cameron L, Arnel J, Thorn S. Myopic adults see through defocus better than emmetropes, Proceedings of the 6th International Conference on Myopia, Springer-Verlag, Tokyo (1998).
58 Radhakrishnan H, Pardhan S, Calver RI, O'Leary DJ. Unequal reduction in visual acuity with positive and negative defocusing lenses in myopes. *Optom Vis Sci,* 2004;81:14-7.
59 Radhakrishnan H, Pardhan S, Calver RI, O'Leary DJ. Effect of positive and negative defocus on contrast sensitivity in myopes and non-myopes. *Vision Res,* 2004;44:1869-78.
60 Rosenfield M, Hong SE, George S. Blur adaptation in myopes. *Optom Vis Sci,* 2004;81:657-62.
61 Schmid KL, Iskander R, Li RW, Edwards MH, Lew JK. Blur detection thresholds in childhood myopia: single and dual target presentation. *Vision Res,* 2002;42:239-47.
62 Wang B, Ciuffreda KJ. Depth-of-focus of the human eye: theory and clinical implications. *Surv Ophthalmol,* 2006;51:75-85.
63 Ciuffreda KJ, Wallis DM. Myopes show increased susceptibility to nearwork aftereffects. *Invest Ophthalmol Vis Sci,* 1998;39:1797-1803.
64 Ciuffreda KJ, Lee M. Differential refractive susceptibility to sustained nearwork. *Ophthal Physiol Opt,* 2002;22:372-379.
65 Vasudevan B, Ciuffreda KJ. Additivity of nearwork-induced transient myopia (NITM) and its decay characteristics in different refractive groups. *Invest Ophthalmol Vis Sci,* 2008;49:836-841.
66 Hung GK, Ciuffreda KJ. Incremental retinal-defocus theory of myopia development - schematic analysis and computer simulation. *Comput Biol Med,* 2007;37:930-946.
67 He JC, Sun P, Held R, *et al.* Wavefront aberrations in eyes of emmetropic and moderately myopic school children and young adults. *Vision Res,* 2002;42:1063-70.
68 Kirwan C, O'Keefe M, Soeldner H. Higher-order aberrations in children. *Am J Ophthalmol,* 2006;141:67-70.
69 Porter J, Guirao A, Cox IG, *et al.* Monochromatic aberrations of the human eye in a large population. *J Opt Soc Am A Opt Image Sci Vis,* 2001;18:1793-803.
70 Cheng X, Bradley A, Hong X, *et al.* Relationship between refractive error and monochromatic aberrations of the eye. *Optom Vis Sci,* 2003;80:43-9.
71 He JC, Gwiazda J, Thorn F, Held R. Wavefront aberrations in accommodated eyes of emmetropes and myopes. *Invest Ophthalmol Vis Sci,* 2003;44: E-Abstract 2122.
72 Hazel CA, Cox MJ, Strang NC. Wavefront aberration and its relationship to the accommodative stimulus-response function in myopic subjects. *Optom Vis Sci,* 2003;80:151-158
73 Charman WN. Aberrations and myopia. *Ophthalmic Physiol Opt,* 2005;25: 285-301.
74 Wilson BJ, Decker KE, Roorda A. Monochromatic aberrations provide an odd-error cue to focus direction. *J Opt Soc Am,* 2002;19:833-9.
75 Millodot M. Effect of ametropia on peripheral refraction. *Am J Optom Physiol Opt,* 1981;58:691-5.
76 Mutti DO, Sholtz RI, Friedman NE, Zadnik K. Peripheral refraction and ocular shape in children. *Invest Ophthalmol Vis Sci,* 2000;41:1022-30.
77 Seidemann A, Schaeffel F, Guirao A, Lopez-Gil N, Artal P. Peripheral refractive errors in myopic, emmetropic, and hyperopic young subjects. *J Opt Soc Am A Opt Image Sci Vis,* 2002;19:2363-73.
78 Atchison DA, Pritchard N, Schmid KL. Peripheral refraction along the horizontal and vertical visual fields in myopia. *Vision Res,* 2006;46:1450-1458.
79 Tabernero J, Schaeffel F. More irregular eye shape in low myopia than in emmetropia. *Invest Ophthalmol Vis Sci,* 2009;50:4516-4522.
80 Calver R, Radhakrishnan H, Osuobeni E, O'Leary DJ. Peripheral refraction for distance and near vision in emmetropes and myopes. *Ophthalmic Physiol Opt,* 2007;27:584-93.
81 Mutti DO, Sinnott LT, Mitchell GL, Jones-Jordan LA, Moeschberger ML, Cotter S, Kleinstein RN, Manny RE, Twelker D, Zadnik K. Relative peripheral refractive error and the risk of onset and progression of myopia in children. *Invest Ophthalmol Vis Sci,* 2010; (published ahead of print).
82 Sankaridurg P, Donovan L, Varnas S, Ho A, Chen X, Martinez A, Fisher S, Lin Z, Smith EL, Ge J, Holden B. Spectacle Lenses Designed to Reduce Progression of Myopia: 12-Month Results. *Optom Vis Sci,* 2010;87: 631-641.
83 Hoogerheide J, Rempt F, Hoogenboom WP. Acquired myopia in young pilots. *Ophthalmologica,* 1971;163:209-15.
84 Mutti DO, Hayes JR, Mitchell GL, Jones LA, Moeschberger ML, Cotter SA, Kleinstein RN, Manny RE, Twelker JD, Zadnik K. and CLEERE Study Group. Refractive error, axial length, and relative peripheral refractive error before and after the onset of myopia. *Invest Ophthalmol Vis Sci,* 2007;48:2510-2519.
85 Rose KA, Morgan IG, Ip J, Kifley A, Huynh S, Smith W, Mitchell P. Outdoor activity reduces the prevalence of myopia in children. *Ophthalmology,* 2008;115:1279-85.
86 Rose KA, Morgan IG, Smith W, Burlutsky G, Mitchell P, Saw SM. Myopia, lifestyle, and schooling in students of Chinese ethnicity in Singapore and Sydney. *Arch Ophthalmol,* 2008;126:527-30.
87 Dirani M, Tong L, Gazzard G *et al.* Outdoor activity and myopia in Singapore teenage Children. *Br J Ophthalmol,* 2009;93:997-1000.
88 Low W, Dirani M, Gazzard G, Chan YH, Zhou HJ, Selvaraj P, Au Eong KG, Young TL, Mitchell P, Wong TY, Saw SM. Family history, near work, outdoor activity, and myopia in Singapore Chinese preschool children. *Br J Ophthalmol,* 2010;94:1012-1016.

● **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