Common Refractive Errors in School Aged Children

Mrs. Aneeshya.A, Research Scholar, Shri Venkateshwara University. Uttar Pradesh

Prof .Dr.Darling B Bibiana, Research Supervisor, Shri Venkateshwara University, Uttar Pradesh.

Introduction

Vision is important in development because it allows children to interact with their environment. Vision in preschool children is uniquely important because their visual system is still developing and they are at risk of developing amblyopia from some forms of uncorrected high ametropia or anisometropia. Deprivation may lead to long term visual impairment.

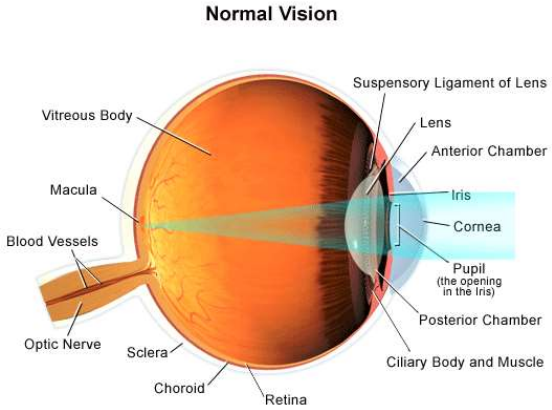
The presence of uncorrected refractive errors and an associated deficit in vision may be difficult to identify in young children. A vision deficit could be perceived by parents to be a problem with general development. Parents frequently discuss concerns about their child's development with the pediatrician. Such concerns, if carefully elicited, have been found predictive of developmental problems in children; with 80% sensitivity and 94% specificity. However, there is limited information evaluating the association between parental concerns about development and refractive errors in preschool children.

Myopia in school children is a critical public health problem, especially in Asian countries. After years of scientific research, the precise etiology of myopia remains elusive. Furthermore, there are no general and well-accepted guidelines followed by eye care practitioners for interventions that may decrease myopia development in children.

Myopia is a refractive error where the parallel rays of light from infinity come to focus in front of retina, when accommodation is at rest. Myopia, commonly referred to as shortsightedness, is a common cause of visual disability throughout the world. The World Health Organization (WHO) has grouped myopia and uncorrected refractive error with cataract, macular degeneration, infectious disease, and vitamin A deficiency among the leading causes of blindness and vision impairment in the world. Myopia, which is measured in diopters by the strength or optical power of a corrective lens that focuses distant images on the retina, has also been classified by degree or severity.

Normal Vision

To understand how certain problems can affect your child's vision, it’s important to know how normal vision happens. For children with normal vision, the following things occur in this order:



1. Light enters the eye through the cornea. This is the clear, dome-shaped surface that covers the front of the eye.
2. From the cornea, the light passes through the pupil. The amount of light passing through is controlled by the iris. This is the colored part of your eye.
3. From there, the light then hits the lens. This is the clear structure inside the eye that focuses light rays onto the retina.
4. Next, the light passes through the vitreous humor. This is the clear, jelly-like substance that fills the center of the eye. It helps to keep the eye round in shape.
5. Finally, the light reaches the retina. This is the light-sensitive nerve layer that lines the back of the eye. Here the image is inverted.
6. The optic nerve carries signals of light, dark, and colors to the brain's visual cortex. This part of the brain turns the signals into images .

Normal Refraction

Refraction is the bending of light rays as they pass from one transparent medium to another medium with a different density. During vision, light that is reflected from an object is refracted by the cornea and lens and focused on the retina.

In emmetropia (an eye with no refractive error), parallel light rays from a distant object are brought into focus precisely on the retina and a clear image is perceived . Perfect emmetropia rarely exists. The majority of individuals have some degree of refractive error, although most do not require correction.

Refractive Errors

Refractive errors are present when the optical image does not accurately focus on the retina.

There are three types: myopia , hyperopia , and astigmatism .

Refractive errors requiring correction are uncommon in preschool children. However, nearly 20 percent of children develop refractive errors that require the use of eyeglasses before late adolescence. Risk factors for refractive error include retinopathy of prematurity and family history of high refractive error.

Causes of Refractive Errors

The dioptric power of the eye is determined by two main factors:

- **The cornea and crystalline lens**: they provide the eye with its convergence ability, since it is through the cornea and lens that light passes and converges to focus the image on the retina
- **The axial length**: the distance between the anterior and posterior poles of the eyeball, which governs the need for greater or lesser convergence of light, depending on whether the eyeball is longer (myopic) or shorter (hyperopic)

Myopia can increase as the child develops. If the axial length of the eye increases, so does the degree of myopia. In contrast, hyperopia does not increase as the child develops, but can decrease if the eyeball lengthens.

Prevention of Refractive Errors

Refractive errors cannot be prevented, but it is important to detect them early at home, school or at the paediatrician's.

The problem will then need to be diagnosed by means of an eye examination performed by an ophthalmologist or optometrist. The child's vision is examined with the aid of dilating eye drops, which prevent the eye from focusing and compensating for the optical error, thus enabling the eye's optical power to be measured in dioptres.

Risk Factors

Myopia typically affects children. During a child's eye development, it can happen that the eye grows abnormally, causing myopia. However, many children grow out of this as the eyeball grows to fit the lens and cornea.

That being said, it isn't always the case. When childhood myopia is caused by the cornea or the lens, they won't necessarily grow out of it. Unless corrected, their poor vision will follow them into adulthood.

While this condition can affect children and adults, those most at risk are people with parents with hyperopia. Genetics don't always cause hyperopia, but the chances of a child being born with the condition are heightened when one or both of the parents have hyperopia.

Hyperopia is the result of the cornea and the lens being misshapen, however a shortened eyeball is not always to blame. An eye injury can also cause the eye to become misshapen permanently and leave a previously unaffected eye with a refractive error.

Symptoms

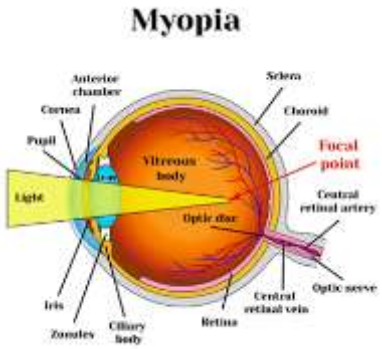
Parents, teachers and caregivers may notice that the child is having visual difficulties, if the following type of behaviour is exhibited:

- The child needs to hold objects close to the eyes to see them
- Moves in a clumsy way
- Does not notice things happening in the distance

The problem can also be detected after a school or paediatric check-up.

Myopia

Nearsightedness makes distant objects look out of focus. It is the most common refractive error needing correction that is seen in children. It may cause headaches or eye strain. With this condition, an image of a distant object becomes focused in front of the retina. This happens either because the eyeball axis is too long, or because the eye's refractive power is too strong. Eyeglasses or contact lenses may help to correct or improve nearsightedness by adjusting the focusing power to the retina.



Myopia (nearsightedness) occurs when the refracting power of the eye is too strong. It commonly occurs when the anterior-posterior diameter of the eye is too long relative to the refracting power of the cornea and lens. The focal point of the image is anterior to the retina, and the image that reaches the retina is blurred . Patients with typical levels of myopia have better near vision than distance vision when they are uncorrected.

The prevalence of myopia increases throughout childhood, with the greatest incidence occurring during and after puberty, when the eye undergoes its adolescent growth phase. In the United States, the prevalence of myopia among preschool children is 1 to 5 percent; among school-age children, it increases to approximately 9 percent; and among adolescents, the prevalence is approximately 30 percent.

The prevalence of myopia varies with ethnicity and is particularly high among East Asians, with reported prevalence of 70 to 85 percent among adolescents in China and Taiwan . Among the school-age population in the

United States, Asian children have the highest prevalence of myopia (18.5 percent), followed by Hispanic children (13.2 percent) . The rates of myopia in White (4.4 percent) and African-American children (6.6 percent) were not significantly different.

Myopia is corrected with a concave spherical lens to focus the light rays on the retina . Mild myopia often does not require correction. However, myopia of any magnitude should be corrected if it interferes with a child's education or social function. Severe myopia (approximately >5 diopters) should be corrected, even in an apparently asymptomatic child, because of the risk of developing bilateral refractive amblyopia (as known as isoametropic amblyopia). The absolute threshold for when a child should be corrected varies by the caretaker's preference, age of the child, and other factors. In general, treatment should be provided for school-age children with myopia >1.5 to 2 diopters. School children with low levels of myopia can usually compensate by sitting in the front portion of the classroom where they can more easily view material presented on the class whiteboard.

Axial length generally increases during childhood, resulting in more severe myopia in adolescence and adulthood. Higher levels of myopia are associated with increased risk of sight-threatening complications later in life (eg, myopic macular degeneration and retinal detachment).

Strategies to prevent or slow the progression of myopia

- **Antimuscarinic eye drops** – Several randomized trials have demonstrated that topical antimuscarinic agents (eg, atropine, pirenzepine) are effective in slowing the progression of myopia in children. This treatment has been widely used in Asia and is increasingly prescribed for children with myopia in the United States. In a randomized trial of 400 children with myopia, low-dose atropine (0.01% ophthalmic solution) was more effective in slowing the progression of myopia and resulted in fewer visual side effects than higher doses of atropine .

Orthokeratology

Orthokeratology involves the placement of a rigid contact lens on the cornea of a patient with myopia during sleep. The contact lens temporarily alters the shape of the cornea, improving unaided vision during the day when the patient is not wearing the contact lens. Some studies have shown a reduction in myopia progression with orthokeratology .

Multifocal lenses

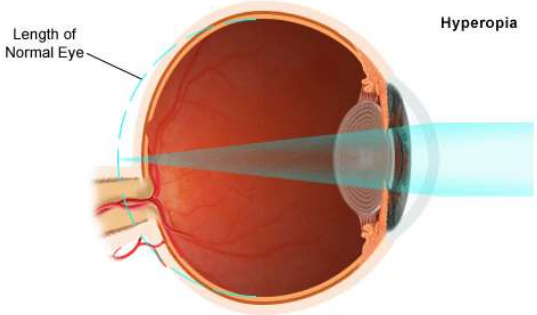
In randomized controlled trials, multifocal lenses (either bifocal or progressive) have yielded a small effect in slowing of myopia progression .

Outdoor activity

Increasing time spent outdoors is a simple strategy to reduce the risk of developing myopia and/or slow its progression and is supported by a number of observational studies and clinical trials . In a cluster randomized trial of 1913 school children (mean age of 6.6 years) in China randomized (by school) to an additional daily 40-minute outdoor class or usual activity, the cumulative incidence rate of myopia over three years was lower in the intervention group compared with the control group (30 versus 40 percent).

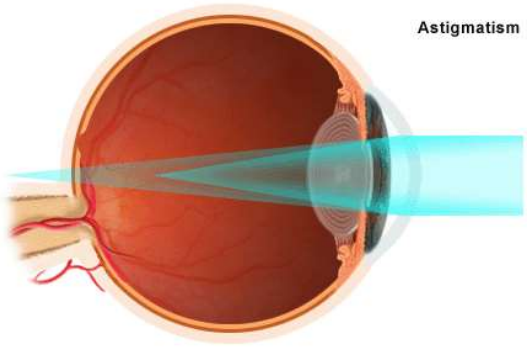
Hyperopia

Farsightedness makes close objects look out of focus. With this refractive error, an image of a distant object becomes focused behind the retina. This happens either because the eyeball axis is too short, or because the eye's refractive power is too weak. Farsightedness may cause headaches, eye strain, or extreme tiredness (fatigue). Squinting, eye rubbing, lack of interest in school, and trouble reading are often seen in children with this condition. Eyeglasses or contact lenses may help to correct or improve farsightedness by adjusting the focusing power to the retina.



Hyperopia (also termed hypermetropia or farsightedness) is the opposite of myopia. Hyperopia occurs when the refracting power of the eye is too weak. The hyperopic eye is too short relative to the refracting power of the cornea and lens. The focal point of the image is posterior to the retina, and the image is blurred when it reaches the retina. High degrees of hyperopia are associated with amblyopia and accommodative esotropia.
Mild hyperopia is the normal refractive state for infants and children. However, most children with mild hyperopia do not require refractive correction, because they have the ability to accommodate or focus by contracting the ciliary body. This steepens the curvature of the lens (ie, increases its power), which brings the focal point forward and focuses the image appropriately on the retina. Patients who cannot accommodate (eg, after cycloplegic drops) have better distance vision than near vision.
Hyperopia is corrected with a convex spherical lens to focus the light rays on the retina. Mild hyperopia generally does not require optical correction in children. Correction may be warranted in asymptomatic children with higher degrees of symmetric hyperopia (ie, >4 diopters) because it can interfere with school-related activities and because there is a risk of developing refractive amblyopia and/or accommodative esotropia. Any degree of hyperopia may warrant correction if the child is symptomatic.

Astigmatism
This condition makes objects up close and at a distance look blurry. It happens because an abnormal curvature of the cornea can cause two focal points to fall in two different locations. Astigmatism may cause eye strain and may be combined with nearsightedness or farsightedness. The condition can start in childhood or in adulthood. Some symptoms include headache, eye strain, or extreme tiredness. Eye rubbing, lack of interest in school, and trouble reading are often seen in children with astigmatism. Depending on the severity, eyeglasses or contact lenses may be needed.



Astigmatism occurs when the optical system of the eye, particularly the cornea, is not perfectly spherical. The refractive power of the eye is different in different meridians, and the light rays cannot be brought to a single point. Astigmatism may occur in combination with myopia or hyperopia. Children with moderate or more severe astigmatism typically have reduced visual acuity at both distance and near fixation.
Astigmatism is corrected with a cylindrical lens. Astigmatism should be corrected in symptomatic children and in asymptomatic children with large degrees of astigmatism (ie, approximately >1.5 to 2 diopters). The threshold for correcting astigmatism is lowered as the child gets older and visual demands increase.

Anisometropia
Anisometropia occurs when the two eyes have different refractive power. Anisometropia can cause amblyopia.

The threshold for anisometropia that is enough to cause amblyopia varies depending upon the type of refractive error:

- Myopia – 2 diopters
- Hyperopia – 1 diopter
- Astigmatism – 1.5 diopters

Anisometropia is treated with refractive correction. If the anisometropia is ≥3 diopters, the size of the retinal image produced by the correction may differ significantly from one eye to the other (ie, aniseikonia), which can cause difficulty in fusing the images. Hyperopic corrections tend to magnify the images, and myopic corrections tend to

minify them. Aniseikonia is minimized with contact lenses, which are closer to the optical center of the eye than glasses and thereby produce less image magnification or minification.

Anisometropia also can be treated with refractive surgery in selected children.

Treatment

Small refractive errors usually do not require treatment; the threshold for when a child should be corrected depends upon the severity of the refractive error, age of the child, caretaker's preference, and other factors. Symptomatic refractive errors, even if small, should be treated.

Corrective lenses

Most typical refractive errors can be adequately corrected with glasses or contact lenses. When glasses are prescribed, myopia and hyperopia are corrected with spherical lenses (concave and convex lenses, respectively). Concave lenses are minus or divergent; convex lenses are plus or convergent. Astigmatism is neutralized with cylindrical lenses. The details of how contact lenses correct refractive errors are beyond the scope of this topic review.

Refractive surgery

Refractive error can be reduced with extraocular surgical procedures and intraocular surgical procedures. The extraocular procedures include excimer laser procedures (photorefractive keratectomy [PRK], laser in situ keratomileusis [LASIK], and laser-assisted subepithelial keratectomy [LASEK]) and intrastromal corneal rings (INTACS). The excimer laser emits an ultraviolet beam that has sufficient energy to break intermolecular bonds within the cornea ("photoablation"), which results of changing the shape and thus the refracting power of the cornea.

The intraocular procedures include phakic intraocular lens implantation and refractive lensectomy or lens exchange. Phakic intraocular lens implantation is a procedure in which an artificial lens is inserted into the eye (anterior chamber or posterior chamber), while preserving the natural crystalline lens. Refractive lensectomy is a procedure that is essentially the same as cataract surgery, except that the crystalline lens is being replaced because of high refractive error rather than lens opacity.

Refractive surgical procedures are typically performed in adults. However, in select cases of severe refractive error, refractive surgery may be performed in children to prevent amblyopia, treat amblyopia that is not responding to standard therapy, or as a component of the treatment of amblyopia (e.g. In children with severe anisometropia or bilateral severe abnormal refraction [isoametropia] who cannot or will not wear refractive correction.

Effect of exercises in Refractive Errors

Self-directed eye exercise programs to improve vision have been promoted since 1912 with fluctuating level of interest. Vision therapy programs advocate different eye exercises, muscle relaxation techniques, biofeedback, eye patches or eye massages either alone or in combination and the use of under corrected prescription lenses or nutritional supplements.

Various studies had been done on effectiveness of exercises in treatment of myopia among which many scientific studies on vision training have produced favorable results. The implication of the study may justify the efficacy of various exercises programme in myopia.

Summary

- Refractive errors are present when the optical image is not focused on the retina by the natural optical system of the eye. Risk factors for refractive error include retinopathy of prematurity and family history of high refractive error.
- Myopia (nearsightedness) occurs when the refracting power of the eye is too strong, most commonly when the anterior-posterior diameter of the eye is too long relative to the refracting power of the cornea and lens. The prevalence of myopia increases throughout childhood, particularly during and after puberty. Patients with severe myopia can develop amblyopia, though this occurs less commonly in patients with myopia compared with those with hyperopia. Myopia is corrected with a concave spherical lens. Strategies to prevent or slow the progression of myopia in children include antimuscarinic eye drops (eg, atropine, pirenzepine), multifocal lenses (either bifocal or progressive), and outdoor activities.
- Hyperopia occurs when the refracting power of the eye is too weak, most commonly when the eye is too short relative to the refracting power of the cornea and lens (movie 3). Low and moderate degrees of hyperopia can

be overcome by the patient through accommodation, and low degrees of hyperopia are typical in infants and young children. High degrees of hyperopia are associated with amblyopia and accommodative esotropia. Hyperopia is corrected with a convex spherical lens.

- Astigmatism occurs when the optical system of the eye, particularly the cornea, is not perfectly spherical. Astigmatism is corrected with a cylindrical lens. Astigmatism should be corrected in symptomatic children and in asymptomatic children when it is ≥1.75 to 2 diopters.
- Anisometropia occurs when the two eyes have different refractive power. Uncorrected anisometropia may lead to amblyopia. Anisometropia is treated with refractive correction.
- Small refractive errors often do not require treatment. The threshold for when a child should be corrected depends upon the severity of the refractive error, age of the child, caretaker's preference, and other factors. Symptomatic refractive errors, even if small, should be treated.

References:

1. Giordano L, Friedman DS, Repka MX, et al. Prevalence of refractive error among preschool children in an urban population: the Baltimore Pediatric Eye Disease Study. Ophthalmology 2009; 116:739.
2. Maly E. Frequency and natural history of retinopathy of prematurity (ROP). A prospective study in a Swedish city 1986-1990. Acta Ophthalmol Suppl 1993; :52.
3. Rudnicka AR, Kapetanakis VV, Wathern AK, et al. Global variations and time trends in the prevalence of childhood myopia, a systematic review and quantitative meta-analysis: implications for aetiology and early prevention. Br J Ophthalmol 2016; 100:882.
4. Vitale S, Sperduto RD, Ferris FL 3rd. Increased prevalence of myopia in the United States between 1971-1972 and 1999-2004. Arch Ophthalmol 2009; 127:1632.
5. Kleinstein RN, Jones LA, Hullett S, et al. Refractive error and ethnicity in children. Arch Ophthalmol 2003; 121:1141.
6. Wen G, Tarczy-Hornoch K, McKean-Cowdin R, et al. Prevalence of myopia, hyperopia, and astigmatism in non-Hispanic white and Asian children: multi-ethnic pediatric eye disease study. Ophthalmology 2013; 120:2109.
7. Lin LL, Shih YF, Tsai CB, et al. Epidemiologic study of ocular refraction among schoolchildren in Taiwan in 1995. Optom Vis Sci 1999; 76:275.
8. Li SM, Li SY, Liu LR, et al. Peripheral refraction in 7- and 14-year-old children in central China: the Anyang Childhood Eye Study. Br J Ophthalmol 2015; 99:674.
9. Repka MX. Prevention of Myopia in Children. JAMA 2015; 314:1137.
10. Walline JJ, Lindsley K, Vedula SS, et al. Interventions to slow progression of myopia in children. Cochrane Database Syst Rev 2011; :CD004916.
11. Chua WH, Balakrishnan V, Chan YH, et al. Atropine for the treatment of childhood myopia. Ophthalmology 2006; 113:2285.
12. Siatkowski RM, Cotter SA, Crockett RS, et al. Two-year multicenter, randomized, double-masked, placebo-controlled, parallel safety and efficacy study of 2% pirenzepine ophthalmic gel in children with myopia. J AAPOS 2008; 12:332.
13. Tan DT, Lam DS, Chua WH, et al. One-year multicenter, double-masked, placebo-controlled, parallel safety and efficacy study of 2% pirenzepine ophthalmic gel in children with myopia. Ophthalmology 2005; 112:84.
14. Chia A, Chua WH, Cheung YB, et al. Atropine for the treatment of childhood myopia: safety and efficacy of 0.5%, 0.1%, and 0.01% doses (Atropine for the Treatment of Myopia 2). Ophthalmology 2012; 119:347.
15. Chia A, Lu QS, Tan D. Five-Year Clinical Trial on Atropine for the Treatment of Myopia 2: Myopia Control with Atropine 0.01% Eyedrops. Ophthalmology 2016; 123:391.
16. Pauné J, Morales H, Armengol J, et al. Myopia Control with a Novel Peripheral Gradient Soft Lens and Orthokeratology: A 2-Year Clinical Trial. Biomed Res Int 2015; 2015:507572.
17. VanderVeen DK, Kraker RT, Pineles SL, et al. Use of Orthokeratology for the Prevention of Myopic Progression in Children: A Report by the American Academy of Ophthalmology. Ophthalmology 2019; 126:623.
18. Wu PC, Tsai CL, Wu HL, et al. Outdoor activity during class recess reduces myopia onset and progression in school children. Ophthalmology 2013; 120:1080.
19. Rose KA, Morgan IG, Ip J, et al. Outdoor activity reduces the prevalence of myopia in children. Ophthalmology 2008; 115:1279.
20. Sherwin JC, Reacher MH, Keogh RH, et al. The association between time spent outdoors and myopia in children and adolescents: a systematic review and meta-analysis. Ophthalmology 2012; 119:2141.

21. Jin JX, Hua WJ, Jiang X, et al. Effect of outdoor activity on myopia onset and progression in school-aged children in northeast China: the Sujiatun Eye Care Study. BMC Ophthalmol 2015; 15:73.
22. He M, Xiang F, Zeng Y, et al. Effect of Time Spent Outdoors at School on the Development of Myopia Among Children in China: A Randomized Clinical Trial. JAMA 2015; 314:1142.
23. The Ophthalmic News & Education (O.N.E.) Network. Preferred Practice Pattern® guidelines. American Academy of Ophthalmology. http://one.aao.org/CE/PracticeGuidelines/PPP.aspx (Accessed on April 17, 2012).
24. Daoud YJ, Hutchinson A, Wallace DK, et al. Refractive surgery in children: treatment options, outcomes, and controversies. Am J Ophthalmol 2009; 147:573.
25. Gardner, Martin (1957). "Chapter 19: Throw Away Your Glasses!". Fads and Fallacies in the Name of Science. Courier Dover Publications. pp. 230–241. ISBN 0-486-20394-8.
26. Marg, E. (1952). "Flashes" of clear vision and negative accommodation with reference to the Bates Method of visual training" .Am J Opt Arch Am Ac Opt 29 (4): 167– 84. doi:10.1097/00006324-195204000-00001 .
27. Vandana J Rathod, Devanshi P Desai, Jagatheesan Alagesan. Effect of Eye Exercises on Myopia- Randomised controlled study. J Pharm Biomed Sci. 2011, 10(12). Available from: https://www.researchgate.net/publication/52005 328_Effect_of_Eye_Exercises_on_Myopia_-_Randomized_Controlled_Study
28. Mohan M, Pakrasi S, Zutshi R. Myopia in India. Acta Ophthalmol Suppl 1988;185:19-23.
29. Kleinstein RN, Jones LA, Hullett S, Kwon S, Lee RJ, Friedman NE, Manny RE, Mutti DO, Yu JA, Zadnik K. Refractive error and ethnicity in children. Arch Ophthalmol. 2003;121(8):1141
30. The Truth about Accommodation as Demonstrated by Experiments on the Eye Muscles of Fish, Cats, Dogs, Rabbits and Other Animals. Available from: http://www.iblindness.org/books/bates/ch4.html
31. Introductory. Refractive error and ethnicity in children. Available from: http://www.iblindness.org/books/bates/ch1.html.
32. Robyn E. Bradley. Advocates see only benefits from eye exercises.pdf. The Boston Globe (MA), September 23, 2003. Available from: http://visioneducators.com/articles/advocates_see_only_benefits_from_eye_exercises