Patterns of Spectacle Use in Young Australian School Children: Findings from a Population-Based Study

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Purpose: To describe the patterns of spectacle use in a population-based sample of Australian Year 1 school children (mostly aged 6 years). ***Methods:*** Logarithm of the minimum angle of resolution (logMAR) visual acuity was measured in both eyes before and after pinhole correction, and using spectacles if worn. Cycloplegic autorefraction (cyclopentolate) and detailed dilated fundus examination were performed. Visual impairment was defined as visual acuity <40 logMAR letters (ie, <20/40 Snellen equivalent). Myopia was defined as spherical equivalent (SE) refraction ≤ −0.50 diopters (D), and hyperopia as SE refraction ≥ +2.0D, deemed significant when ≥ +3.0D. Astigmatism was defined as cylinder ≥1.0D and anisometropia as SE refraction difference between the two eyes at least 1.0D. ***Results:*** One thousand seven hundred forty predominantly 6-year-old school children were examined during 2003 to 2004. Spectacle use was documented in 77 children (4.4% of sample). Uncorrected visual impairment was found in the worse eye of 71 children (4.1%) and refractive error accounted for the majority (69.0%). Astigmatism was the most common refractive error causing visual impairment, accounting for 46.5%. Hyperopia, with or without astigmatism, was the most frequent reason for spectacle use, documented in 40.3%. Spectacle use in the absence of significant refractive error, amblyogenic risk factors, or visual impairment was noted in 26 children (33.8% of spectacle wearers). The prescription of spectacles could have benefited a further 26 children (1.5% of sample), mostly for correction of astigmatism. ***Conclusion:*** This study documents a significant disparity between spectacle use and need. Astigmatism was the most common cause of visual impairment due to refractive error. (J AAPOS 2005;9:579-583)

While correctable visual impairment due to refractive error is a common finding in childhood, few population-based studies[1-3] have described the patterns of spectacle use among children.

Spectacle use by children with normal vision and without significant refractive error is anecdotally noted by many eye practitioners. The prevalence of this phenomenon in the general population of children, however, is unknown. A recent report by Donahue[4] highlighted its extent among children aged 1 to 5 years who were referred for further examination following preschool vision screening in the state of Tennessee, United States; 24.7% of children who received a spectacle prescription had no significant refractive error, defined in that study as hyperopia ≤ +2.00 Diopters (D), myopia ≤0.75D, astigmatism ≤0.75D, or anisometropia ≤0.75D. This report aims to describe the distribution of preexisting spectacle use in a population-based sample of 6-year-old Australian school children while documenting some of the reasons for prescription of spectacles in young children. The prevalence and causes of visual impairment, before and after usual correction,[5] as well as the distribution of ocular biometry and refraction[6] in this population were recently described.

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Proprietary Interest: None.
Financial support: The Sydney Myopia Study is supported by the National Health & Medical Research Council (Grant 253732) and the Westmead Millennium Institute, University of Sydney.
Submitted February 10, 2005.
Revision accepted July 19, 2005.
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1091-8531/2005/$35.00 + 0
doi:10.1016/j.jaapos.2005.07.005

SUBJECTS AND METHODS

Population

The Sydney Myopia Study is a population-based survey of refraction and other eye conditions in a sample of 6-year-old school children resident in the Sydney metropolitan area. Methods used to identify and select the target sample, as well as a description of this sample and study procedures, were recently reported.[6] In brief, the study area was stratified by socioeconomic status (SES), using Australian Bureau of Statistics (ABS) 2001 national census data. These data were used to select 34 primary schools across Sydney, including five primary schools in the top SES decile, with the remaining schools randomly selected from the bottom nine SES deciles. A proportional mix of public and private/religious schools was included. The following report is based on data from children examined between August 2003 and October 2004.

Procedures

Written consent from at least one parent in addition to the assent of each child was obtained prior to examination. Approval for the study was obtained from the Human Research Ethics Committee, University of Sydney, and the Department of Education and Training, state of New South Wales, Australia.

Distance visual acuity was tested in each eye separately using a logarithm of minimum angle of resolution (logMAR) chart. The chart was retro-illuminated with automatic calibration to 85 cd/m^2 (Vectorvision CSV-1000 ™, Vectorvision, Inc., Dayton, OH) and read at 8 feet (244 cm). Visual acuity was assessed with and without spectacle correction, if worn, and with a 1.2-mm pinhole aperture for reduced vision (<20/25) or if there was more than a one-line (five-letter) difference between the two eyes. In addition, noncycloplegic autorefraction was performed on all children with reduced vision, and cylinder >0.50D was corrected by subjective refraction. A matching HOTV card was available for children unable to name the letters. For each eye, visual acuity was recorded as the number of letters read correctly from 0 (<20/200) to 70 (20/10). If no letters could be read at 8 feet (244 cm), the chart was moved to 3 feet (91 cm), giving four additional levels of visual acuity: 20/250, 20/320, 20/400, and 20/500. If no letters could be identified on the chart, the visual acuity was assessed as count fingers at 2 feet (61 cm), hand movements, perception of light, or no perception of light.

Cycloplegia was obtained after two cycles of cyclopentolate 1% (one drop) and tropicamide 1% (one drop) instilled 5 minutes apart, after corneal anesthesia with amethocaine hydrochloride 1%. In a small proportion of children who were slow to dilate, phenylephrine hydrochloride 2.5% was used to maximize mydriasis. Cycloplegia was considered full when the pupil was fixed and at least 6.0 mm diameter. Children had a comprehensive eye examination, which also included a cover test, prism bar cover test, and mydriatic digital retinal photography.

Definitions

Visual impairment was defined in the better and worse eyes using an uncorrected visual acuity cutoff of 0.3 logMAR units (ie, <40 letters, equivalent to Snellen acuity <20/40). Myopia was defined as spherical equivalent (SE) refraction ≤ -0.50D. Hyperopia was defined as SE refraction $\geq +2.0$D and was deemed significant when $\geq +3.0$D. Astigmatism was defined as cylinder $\geq$1.0D and anisometropia as SE refraction difference between the two eyes at least 1.0D. Absence of ametropia was defined as SE refraction < -0.50D to $< +2.0$D together with cylinder <1.00D; these children were deemed not to have a significant refractive error. All definitions refer to values obtained after cycloplegic autorefraction.

TABLE 1 Sociodemographic associations with spectacle wear

Associated Factor	Proportion Wearing Spectacles % (CI)
Gender	
Boy	4.0 (2.5–6.1)
Girl	6.2 (4.7–8.3)
Ethnicity	
Caucasian (European)	5.0 (3.8–6.7)
East Asian	6.4 (3.6–11.3)
Other	4.3 (2.7–6.7)
Parental employment status	
Both employed	4.8 (3.6–6.4)
One employed	4.3 (2.8–6.4)
Other status*	8.0 (4.4–14.6)
Home ownership	
Yes	5.2 (4.1–6.6)
No	3.9 (2.5–5.9)
Parental education	
University or higher degree	4.6 (3.4–6.2)
Technical college diploma	5.2 (3.6–7.6)
Completion of secondary school	5.3 (3.6–8.0)
Noncompletion of secondary school	4.0 (1.5–10.7)

*Includes unemployment, retirement, or unpaid work.

Data Handling and Statistical Analysis

Data were entered into a Microsoft Access database. All statistical analyses were performed using Statistical Analysis System (SAS V8.2. SAS Institute, Cary, NC, USA). Mixed models and generalized estimating equations were used to adjust for clustering within schools. Where cluster effects were not significant, chi-square tests and *t*-tests were used.

RESULTS

Subjects

Of 2238 eligible children, 1765 (78.9%) children were given parental permission to participate and questionnaire data were provided by parents. Of the 1765 children with questionnaires completed, 25 were not examined, as they were absent from school during the examination period; data on spectacle wear was available for 1723 of the remaining 1740 children. The mean age of participants was 6.7 (range: 5.5 to 8.4 years); 49.4% of children were female and 50.6% were male. Most (70.4%) were aged 6, while a quarter (25.5%) were aged 7 years.

Current Spectacle Use

Current use of spectacles was reported by 77 children (4.4% of the sample): 30 (39.0%) were boys and 47 (61.0%) were girls. This difference was statistically significant ($P = 0.04$). Table 1 shows the prevalence of spectacle

TABLE 2 Prevalence of Cycloplegic Refractive Errors in either eye, proportion wearing spectacles and magnitude of spectacle prescriptions in the worse eye of these children

Cycloplegic Refractive Error	Prevalence *n* (%)	Known Spectacle Wear (%)	Magnitude of Spectacle Correction (D)	
			Mean Sphere Correction (range)	Mean Cylinder Correction (range)
Myopia (SER ≤ −0.50D)	27 (1.6)	9/25 (36.0)	−2.06 (−1.00 to −5.75)	0.94 (0.00 to 2.50)
Hyperopia (SER ≥ +2.00D)	228 (13.2)	31/198 (15.7)	+3.08 (−1.00 to +8.00)	0.70 (0.00 to 3.00)
Astigmatism (Cyl ≥ 1.00D)	131 (7.6)	8/109 (20.2)	+1.60 (−5.75 to +8.00)	1.32 (0.00 to 3.00)
No significant refractive error (−0.50 < SER < +2.00, cyl < 1.00D)	1379 (80.0)	26/1199 (2.2)	+0.65 (+0.25 to +1.25)	0.29 (0.00 to 1.25)

SER = spherical equivalent refraction; Cyl = cylinder.

TABLE 3 Mean Cycloplegic Refraction for Children who Wore Spectacles (n = 77) in Categories of Ametropia

Eye	Myopia (SER ≤ −0.50) ± Astigmatism Mean SER (D) (range)	Hyperopia (SER ≥ +2.00D) ± Astigmatism Mean SER (D) (range)	Astigmatism (Cylinder ≥ 1.00D) ± Other Refractive Error Mean Cylinder (D) (range)	No Significant Refractive Error (−0.50 < SER < +2.00D) Mean SER (D) (range)
Right eye	−2.62 (−0.67 to −4.88)	+4.14 (+1.75 to +8.59)	−1.56 (−0.28 to −3.59)	+1.27 (+0.25 to +1.92)
Left eye	−2.52 (−0.91 to −5.97)	+3.83 (+1.14 to +8.96)	−1.60 (−0.39 to −3.38)	+1.25 (+0.12 to +1.86)

SER = spherical equivalent refraction.

wear in association with various sociodemographic factors; none was statistically significant. Spectacles were prescribed by a pediatric ophthalmologist in 13 cases (16.9%), a general ophthalmologist in 4 cases (5.2%), and by an optometrist in 46 cases (59.7%). The prescribing eye practitioner could not be ascertained in the remaining 14 children (18.2%).

Table 2 shows the distribution of cycloplegic refractive errors in either eye as well as the proportion of children in each category that wore spectacles. The magnitude of the prescriptions for these children is also shown. Nine children, or 11.7% of all children wearing spectacles, did so for the correction of myopia, 31 children (40.3%) for the correction of hyperopia, and 8 (10.4%) for astigmatism. Five children (6.5%) wore spectacles for reduction of heterotropias and 19 children (24.7%) had concurrent amblyopia.

Mean uncorrected visual acuities in the right eye were significantly lower for children wearing spectacles (41.4 ± 3.0 logMAR letters) than other children in the sample (49.5 ± 0.4 logMAR letters, $P < 0.0001$). However, 26 children (33.8% of those wearing spectacles; 1.5% of the sample) had no refractive error and no visual impairment without their glasses; optometrists had prescribed the spectacles in all these cases. Table 3 shows mean cycloplegic refraction findings in right and left eyes for children who wore spectacles for myopia or hyperopia, with or without astigmatism. Mean refraction for both eyes is also shown for the 26 children who had no significant refractive error. Their spherical equivalent refraction was +1.27D and +1.25D in right and left eyes, respectively; the mean value for the entire sample was +1.26D and +1.31D in right and left eyes, respectively.

The majority of children who wore spectacles in the absence of significant refractive error or amblyogenic risk factors were asymptomatic of headaches, blurred vision, double vision, or "sore eyes," although data were incomplete for a fifth (19.4%) of this group. Of the 26 children who wore spectacles in the absence of significant refractive error, 3.8% reported suffering headaches and 15.4% reported other symptoms such as blurred vision or "sore eyes" prior to the prescription of spectacles, while 23.1% reported a combination of symptoms. In addition, learning difficulty at school, as noted by their parents, was reported in 34.6% of cases. Corresponding reported rates for the entire sample were 1.2% for headaches, 9.0% for other symptoms, and 2.2% for a combination of the two; 10.2% of the entire sample reported learning difficulty at school.

Visual Impairment Due to Refractive Error and Requirement for Spectacles

Uncorrected visual impairment was found in the worse eye of 71 children (4.1%) and refractive error accounted for the majority (49 children, 69.0%). Astigmatism alone was the most frequent cause of visual impairment due to refractive error, found in17 children (34.7%). When present in combination with other refractive errors, this proportion increased to 67.3%. Based on the presence of visual impairment as well as significant refractive error (as defined in the Methods section) in at least one eye, a further 26 children (1.5% of the sample) could have been likely to benefit from the prescription of spectacles and to achieve a corrected visual acuity ≥20/40. Of these, 16 children had astigmatism and 7 had hyperopia.

DISCUSSION

We have documented the prevalence of spectacle use to be 4.4% in our sample of predominantly 6-year-old children. The corresponding rate among 7-year-old children in the 1958 British birth cohort was 6.2%[3]; 10.7% of 10-year-old children in the 1970 British birth cohort were found to wear spectacles,[2] while 25.4% of children aged 6 to 18 years in a nationally representative survey carried out in the United States in 1998 had corrective lenses.[1] The Refractive Error Study in Children, a population-based study of 5- to 15-year-olds in 7 Asian,[7-11] African,[12] and South American[13] countries documented a widely varying prevalence of spectacle use, which ranged from 0.19% in Nepal to 18.4% in Southern China.

The pattern of spectacle use is directly related to the prevalence of significant refractive error in the population, which is partly dependent on the age group examined; a higher prevalence of spectacle use would be expected with the onset of myopia in early adolescence. Further, the pattern of spectacle use is also likely to change with increasing age of a given population. The prevalence of astigmatism is known to reduce over time up to age 6 years[14-16] and, as such, is likely to account for a smaller proportion of prescribed spectacles in older age groups in whom myopia is far more common.

This, to our knowledge, is the first population-based study to document the patterns of spectacle use in the context of visual impairment and different categories of refractive error. The 1970 British birth cohort study[2] could only make limited conclusions about the adequacy and appropriateness of spectacle prescribing because subjects in that study did not undergo refraction. For example, myopia was inferred by the presence of "defective distance vision," and significant hyperopia was inferred by "defective near vision." This could have led to significant misclassification of children, particularly those with high amounts of hyperopia or significant astigmatism. Similarly, the 1958 British birth cohort[3] did not undergo refraction. The 1998 Medical Expenditure Panel Survey,[1] which is the other population-based study to document spectacle use among children, relied solely on parental report. Children were not examined and no attempt was made to classify the reasons for spectacle use.

Optometrists prescribed the majority of spectacles worn by children in our sample. This is in keeping with the fourfold greater number of practicing optometrists in Australia compared with ophthalmologists. Optometrists currently provide three-quarters of all eye examinations given by eye-care professionals in Australia.

An important finding of our study, confirming anecdotal experience by some ophthalmologists, is the significant proportion of children (33.8% of all spectacle wearers; 26 children) who had been prescribed spectacles in absence of a significant refractive error, visual impairment, or an amblyogenic risk factor such as anisometropia or strabismus at the time of our examination. Interestingly, the same number of children (26, or 1.5% of the entire sample) had significant refractive errors (mainly astigmatism) with uncorrected visual impairment in at least one eye. These children could possibly have benefited from the prescription of spectacles.

The observed findings in this study point to a disparity in prescribing patterns for children who possibly need spectacles and those who wear them. Although an amount of variability is inherently present in visual acuity testing of young children. Manny et al[17] examined the repeatability of ETDRS visual acuity in 6- to 11-year-old children recruited into the COMET study and concluded that a difference in visual acuity of less than 0.15 logMAR units (8 logMAR letters) did not constitute significant change in visual acuity. While a similar value for Snellen acuity does not exist, this inherent variability needs to be kept in mind when faced with a child who has minimally reduced visual acuity on a single examination.

The higher frequency of reported general symptoms such as "headaches," "blurred vision," or "sore eyes," together with "learning difficulty at school" prior to the prescription of spectacles in wearers than nonwearers, suggests that some eye-care practitioners may be more influenced by these symptoms than examination findings. Stewart Brown similarly reported a higher prevalence of spectacle use in children whose mothers reported that they experienced headaches, compared with those who did not. This difference remained even after the presence of visual defects were taken into account.[2]

An important issue to consider when prescribing spectacles is the visual demands of the child as well as the likelihood of compliance with spectacle use. The visual demands of a child are low when young. Correcting refraction with spectacles to the arbitrary level of 20/20 imposed by the Snellen chart may be inappropriate in young children, and in the absence of amblyogenic risk factors, the prescription of spectacles could arguably be postponed even if vision is less than 20/40.[18] Compliance with spectacle wear, however, has been shown to be relatively high in children less than 8 years of age.[19] Lack of compliance should therefore not pose an obstacle to the prescription of spectacles when these are genuinely required.

Few published guidelines exist for prescribing spectacles for children in the absence of amblyogenic risk factors. The American Academy of Pediatric Ophthalmology and Strabismus (AAPOS) surveyed the spectacle-prescribing patterns of its members and found that, for children aged 4 to 7 years, 1.50D of myopia, 4.00D of hyperopia, 1.50D of astigmatism, and 1.50D of anisometropia were likely to be corrected by 50% of responding ophthalmologists.[20] The Committee on Practice and Ambulatory Medicine, with the endorsement of AAPOS and the American Academy of Ophthalmology, recommends that hyperopia does not necessitate correction in children unless it is sufficient to cause accommodative strabismus or reduced vision. Similarly, correction of astigmatism is recommended if it causes significant decreased vision or is of such severity to be amblyogenic.[21] What constitutes a "significant" reduction in vision, however, remains undefined and will likely depend on individual circumstances.

In conclusion, our study has documented the patterns of spectacle use in a population-based sample of 6-year-old Australian school children, building on the recent report by Donahue[4] for a sample of children aged 1 to 5 years. Astigmatism was the most commonly uncorrected refractive error causing visual impairment, while a surprisingly large proportion of children wore spectacles in the absence of visual impairment, amblyogenic risk factors, or significant refractive error. The prescription of spectacles in this context represents a significant economic burden both for the child's family and for the wider community. This report highlights the need for further research into factors that could motivate eye-care practitioners to prescribe spectacles.

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