CLINICAL AND EXPERIMENTAL
OPTOMETRY

ORIGINAL PAPER

Spectacle use and reduced unaided vision in third grade students: a comparative study in different educational settings

Clin Exp Optom 2004; 87: 3: 175–179

Guy J Ben-Simon*† MD
Miriam Peiss§ MA RN
Emilia Anis§ MD MPH
Tanuj Nakra† MD
Ayala Luski§ MA
Abraham Spierer* MD
* Goldschleger Eye Institute, Sheba Medical Center, Tel Hashomer, Israel
† Jules Stein Eye Institute, David Geffen School of Medicine, UCLA, Los Angeles, USA
§ Department of Clinical Epidemiology, Sheba Medical Center, Tel Hashomer, Israel

Submitted: 25 September 2003
Revised: 4 March 2004
Accepted for publication: 8 March 2004

Background: The development of myopia is influenced by hereditary factors, environmental factors and gene-environment interaction. Reading and near-work activity are associated with myopia and myopic progression. This study sought to determine and compare the prevalence of reduced unaided vision and spectacle use among third grade Israeli students from three different educational settings.
Method: A sample of 917 students (mean age 8.5 years, range seven to 10 years) was drawn from the three Israeli educational streams: secular, Orthodox and ultra-Orthodox. Children in the ultra-Orthodox education pathway begin studying at the age of three years and their daily reading involves sustained near work with increased accommodative effort accompanied by head-rocking movements. Reduced distance vision was used to indicate the likely development of or an increase in the amount of myopia. Spectacle lenses were measured to determine the prevalence of myopia.
Results: Of the 917 students studied, 103 (11.2 per cent) wore spectacles (14.2 per cent of the males and eight per cent of the females); 82.5 per cent of those who wore spectacles were myopic. Males from ultra-Orthodox schools had the highest rate of reduced unaided vision (72.5 per cent) compared with males from secular schools (27.3 per cent), males from Orthodox schools (59.3 per cent) or with females from all three groups (average of 34.8 per cent, $p < 0.0001$, chi squared). Males had a higher rate of reduced unaided vision, especially in the Orthodox and ultra-Orthodox schools.
Conclusions: Our study suggests that Jewish ultra-Orthodox males have a higher prevalence and degree of myopia. The study habits of young children, including exposure to prolonged near tasks, high accommodative demands and possibly optical defocus induced by body sway, may contribute to the development of myopia.

Key words: accommodative effort, education, myopia, near work

The development of myopia is influenced by hereditary factors, environmental factors such as near work activity and the gene-environment interaction.[1-6] Many investigators have examined the possible association between near-work and the development of myopia, as well as the possible effect of chronic optical defocus on axial myopia.[7-10]

In Israel, routine vision screenings to detect vision problems first occur at three years of age at family health centres. Subsequent screenings occur within the school system in the first grade (age six years), third grade (age eight years) and fifth grade (age 10 years). In Israel, there are three major primary educational streams: secular schools, Orthodox and ultra-Orthodox schools, in which about 70 per cent, 20 per cent and 10 per cent of the students, respectively are enrolled each year. Before primary school, children in secular and Orthodox schools attend pre-kindergarten and kindergarten.

Children in the ultra-Orthodox stream do not enrol in kindergarten but commence formal schooling with an emphasis on intense studying and reading at the age of three years. The number of study hours is gradually increased to up to 16 hours a day in ultra-Orthodox teenagers. Sustained near work with increased accommodative effort accompanied by rocking movement back and forth to increase concentration is characteristic. There is emphasis on reading texts with varying font sizes, which may be as small as one millimetre in height. Further explanations of the type of work and working hours are described by Zylbemann, Landau and Berson.[10]

In secular schools, the school day is typically five to six hours, with regular breaks. Equal time is given to near-vision work and to other activities such as listening or play-based learning environments. Daily homework does not exceed two hours. Orthodox schools are similar to secular schools except for more emphasis on religious text study (approximately two to three hours per week) and single-sex education.

The amount of myopia in children within these particular school systems has been studied only once previously. Zylbermann, Landau and Berson[10] report a significantly higher prevalence and degree of myopia in Orthodox Jewish male teenagers compared with non-Orthodox teenagers (that is, 81.3 per cent of Orthodox males were myopic versus 27.4 per cent of the males attending general schools; with an average myopic correction of -3.78 ± 0.17 D in Orthodox males versus -2.1 ± 0.26 D for the general school males). They postulated that sustained near vision and frequent changes in accommodation may play a role in the development of myopia. The purpose of this study was to determine the prevalence of spectacle lens wear and reduced aided and unaided vision among third grade students in the three different educational streams. Given the data of Zylbermann, Landau and Berson,[10] we were interested to determine if the children in these education systems became myopic at a young age.

Group (education stream)	Males	VA defect		Females	VA defect	
	N	N	%	N	N	%
Secular	176	48	27.3	179	62	34.6
Orthodox	118	70	59.3	82	31	37.8
Ultra-Orthodox	193	140	72.5	169	54	32.0

Table 1. Percentage of children with reduced unaided vision in different educational streams

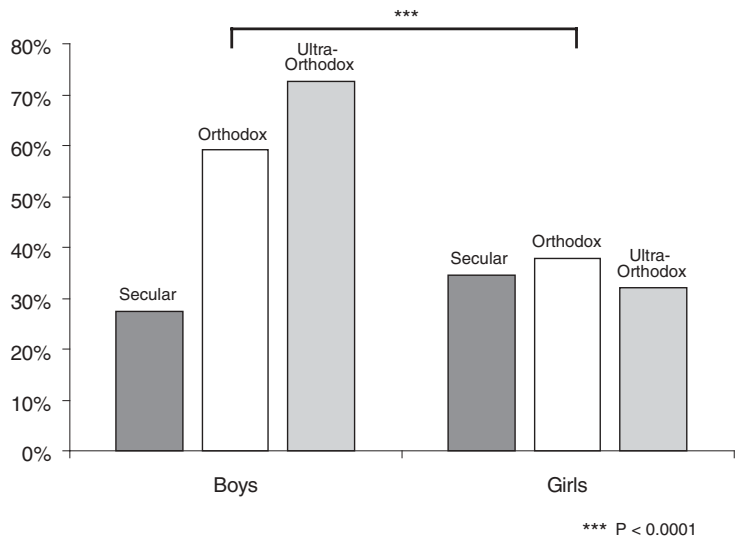

Figure 1. Distribution of reduced unaided vision in children studying in different educational settings in Israel (percentage of children in each group). Males from ultra-Orthodox schools had the highest rate of reduced unaided vision (72.5 per cent) compared with males from secular schools (27.3 per cent), males from Orthodox schools (59.3 per cent) or with females from all three groups (average of 34.8 per cent, p < 0.0001). This difference did not exist between the females of the three educational settings.

METHODS

Subjects

The study population included a sample of third grade students from two similar cities in central Israel. The children in each school were from similar socio-economic backgrounds. Subjects were enrolled in similar proportions from each educational stream.

Testing protocol

Visual acuity examinations were performed by a fourth year nursing student and by public health nurses from the Ministry of Health using a standard Snellen chart. All nurses were instructed on the procedures for visual acuity testing. Distance visual acuity (unaided and with correction) was examined at six metres in photopic lighting conditions; each eye was tested separately and credit given only for

Type of spectacles	Number	% of children
Myopic (-)	85	82.4
Hyperopic (+)	9	8.8
Unknown	9	8.8
Sum	103	100

Table 2. Refractive errors among children with spectacles

Gender	Group	Number	Wearing spectacles		Arrived without spectacles	VA < 6/6 with spectacles	
			N	%	N	N	%
Males	Secular	176	14	8.0	5	9	64.3
	Orthodox	118	19	16.1	4	14	73.7
	Ultra-Orthodox	193	36	18.7	8	25	69.4
Females	Secular	179	13	7.3	0	8	61.5
	Orthodox	82	11	13.4	2	7	63.6
	Ultra-Orthodox	169	10	5.9	0	9	90.0
	Total	917	103	11.2	19	72	69.9

Table 3. Reduced unaided vision with spectacles

full lines of letters read correctly. A value of 6/6 was used to determine if children passed or failed the vision screening. Reduced distance vision was used to indicate a likely increase in myopia or a child who was developing myopia. Spectacle lenses were measured to determine the prevalence of myopia.

The assumption was made that reduced vision was due to uncorrected myopia. The degree of myopia was not measured directly; refraction was not performed. In patients with spectacles, the prevalence of myopia and hyperopia was determined based on the presence of a positive or negative dioptric power of the corrective lenses. The study complied with the ethics policies of the local institute review board.

Data analysis

SPSS and Microsoft Excel software were used for data analysis. Statistical analysis was performed using the non-parametric Chi-squared test to evaluate the differences in prevalence of reduced unaided vision and spectacle use among different groups and between the genders in each group. Multivariate analysis was used to analyse the risk factors for reduced unaided vision in the different educational streams and in females and males.

RESULTS

The total number of third year students in the two cities during the year the vision screenings were conducted was 1,484 in secular schools, 527 in Orthodox and 2,532 in ultra-Orthodox schools. A total sample of 917 students with a mean age of 8.5 ± 0.5 years (range seven to 10 years) was recruited: 355 students from secular schools, 200 from Orthodox schools and 362 from ultra-Orthodox schools. The proportion of students who were tested in each group was 24 per cent for secular schools, 38 per cent in Orthodox schools and 14 per cent in ultra-Orthodox schools.

Males from ultra-Orthodox schools had the highest rate of reduced unaided vision (72.5 per cent) compared with males from secular schools (27.3 per cent), males from Orthodox schools (59.3 per cent) or with females from all three groups (average of 34.8 per cent, $p < 0.0001$, Chi squared) (Table 1, Figure 1). This difference did not exist between females of the different educational streams.

Of the 917 students examined in the study, 103 (11.2 per cent) wore spectacles (14.2 per cent of the males and eight per cent of the females). Of this group, 82 per cent were myopic and 8.8 per cent were hyperopic (Table 2).

Eighteen per cent of males in ultra-Orthodox schools and 16.1 per cent of males in Orthodox schools wore spectacles, more than twice the number in secular schools (eight per cent) ($p < 0.0001$, Chi squared). The percentage of children with vision less than 6/6 (undercorrected with spectacles) was similar among females in secular and Orthodox schools and in males of secular schools (61.5 per cent, 63.6 per cent and 64.3 per cent, respectively) but was higher among females of ultra-Orthodox schools (90 per cent), as well as males of Orthodox and ultra-Orthodox schools (73.7 per cent and 69.4 per cent, respectively) (Table 3). This apparently larger group of under-corrected ultra-Orthodox schooled females was not statistically significant in comparison to Orthodox and secular schooled females ($p = 0.068$ and $p = 0.09$, respectively).

The number of children who reported to school without their spectacles on the day of testing ('forgot their spectacles') was significantly higher among males from all groups compared with females from all groups, 17 of 69 males (24.6 per cent) failed to report with their spectacles, compared with only two of 34 (5.9 per cent) of the females ($p < 0.0001$, Chi squared) (Table 3).

The percentage of children with unaided vision less than 6/30 in at least one eye was higher in males than in females. Within the group of males, children from Orthodox and ultra-Orthodox schools had the highest rate of unaided vision less than 6/30 in at least one eye (5.1 per cent and 15.4 per cent respectively), compared with all other groups ($p < 0.0001$).

The percentage of children who had normal unaided vision (6/6) was much lower in males from Orthodox and ultra-Orthodox (48.0 per cent and 33.3 per cent, respectively) compared with males from secular schools, of whom 79.0 per cent had normal visual acuity ($p < 0.0001$). Such a difference did not exist between females of the three educational groups ($p = 0.35$).

Multi-variate analysis to assess risk factors for reduced unaided vision showed that males had a 2.2 times higher risk compared with females. Furthermore, children in Orthodox and ultra-Orthodox schools had a 2.3 times and 2.6 times, respectively, higher risk for reduced unaided vision compared with children in secular schools.

DISCUSSION

The Israeli ultra-Orthodox educational system is unique in that children start studying at the relatively young age of three years. There is emphasis on sustained near-work activity and prolonged accommodative effort, specifically in reading texts, often with small font sizes. The number of study hours gradually increases from six hours for three-year-olds to 16 hours for 13-year-olds. In this study, the prevalence and degree of myopia was found to be higher among children from the ultra-Orthodox educational schools compared with children in non-ultra-Orthodox schools. Other studies have also described the association of prolonged near-work activity to the development of myopia.[7-15]

A similar proportion of children, though older, was examined by Zylbermann, Landau and Berson[10] to determine the prevalence of myopia among Jewish teenagers in Orthodox schools (this group was referred to as ultra-Orthodox in our work). There was a statistically significant higher prevalence and degree of myopia in a group of 193 Orthodox Jewish male students compared with non-Orthodox teenagers. They found 81.3 per cent of Orthodox males to be myopic versus 27.4 per cent of the males attending general schools. It was suggested that sustained near vision, frequent changes in accommodation due to the swaying behaviour during study and the presence of small fonts may play a role in myopic development. We have found similar rates for males attending general schools (27.3 per cent) and a slightly lower prevalence in ultra-Orthodox males (72.5 per cent). Therefore, it seems that the prevalence of myopia is even higher with increasing age in boys attending ultra-Orthodox schools. The prevalence of reduced unaided vision was similar for females from different educational streams in both studies and it ranged from 32 per cent to 38 per cent.

Accommodative effort and the development of myopia were examined by several investigators.[7-15] Saw and colleagues[8] describe a higher prevalence of myopia in urban schoolchildren compared with rural schoolchildren. Myopic children in both urban and rural areas spent more time reading and writing compared with non-myopic children. A similar effect of near-work activity and myopia was also shown in older age groups.[9] A quantitative analysis of the rate of refractive change found a significant relationship between myopic shift and time spent reading and near-work.[11]

Although the prevalence of myopia is influenced by environmental factors, the relative influence compared with genetic factors is still controversial. Some studies have failed to show the effect of early near-work activity and the development of myopia.[12-13]

Parissnen and Lyyra[13] examined myopic progression among 238 schoolchildren and found that myopia progressed faster in females than in males. In that study, the authors found that the factors most significantly related to myopic progression besides gender were age of onset (earlier age associated with increased progression) and the degree of myopia at the beginning of the study period. Although myopic progression and final refractive status were related to time spent reading, reading distance and close work, it was not related to accommodative stimulus.

Animal models of visual deprivation or chronic optical defocus may shed some light on the pathogenesis of myopic development. Visual deprivation in chicks leads to enlargement of the vitreous chamber of the eye and thus may contribute to axial myopia.[5,6,15] Wallman and associates[15] found that when occluding only part of the retina in chicks (nasal half or temporal half) the resulting myopia is limited only to the deprived part of the retina, leaving the non-deprived part nearly emmetropic, resulting in individually asymmetric eyes. Their hypothesis regarding the association of reading and myopia is based on the assumption that the larger receptive fields of the non-foveal retinal neurons cannot resolve individual letters on a printed page. Thus, less retinal neuronal activity occurs during reading than during most other forms of visual stimulation. This decreased activity may imitate the experimentally sensory-deprived retina, leading to myopia.

Hepsen, Evereklioglu and Bayramlar[7] found that reading and near-work might cause refractive myopic shifts in emmetropic school-age males. They compared two groups of 13-year-old children, one with a mean of six hours of reading and near work, while the other consisted of skilled labourers. The magnitudes of the myopic shift and the myopic progression were significantly higher in children in the group involved in more reading and near-work activity. Moreover, the refractive change was higher in those subjects with a higher baseline refractive error. The myopic shift was related significantly to increases in the anterior chamber depth, the vitreous chamber depth and axial length.

In our study, males from ultra-Orthodox schools had the highest rate of reduced unaided vision (72.5 per cent). In addition, they had the highest rate of reduced unaided visual acuity less than 6/30 (15.4 per cent). These data imply that early near-work activity may initiate myopic progression and this progression may be more

rapid. Consistent with this conclusion, many of the males in the ultra-Orthodox schools had undercorrected spectacles.

Chronic optical defocus caused by sustained near work accompanied by frequent changes in accommodation induced by swaying during study and reading varying font size may be one of the mechanisms of the development of myopia as postulated by Zylbermann, Landau and Berson.[10] They found a higher prevalence and degree of myopia among Jewish Orthodox male teenagers. We describe similar findings in Jewish Orthodox males at younger ages, implying that even shorter periods of near-work activity may induce myopia in these children.

The significantly higher percentage of undetected and uncorrected myopia among students in the ultra-Orthodox system may be due to their daily routine: the ultra-Orthodox students spend the majority their time reading and writing and so their uncorrected myopia does not cause significant interference in their daily life. This is in contrast to the students enrolled in secular and Orthodox schools who spend more time outdoors or watching television after school; in these environments, uncorrected myopia will cause substantial difficulty.

We did not examine the parents of the children and therefore, their refractive status is unknown. We cannot eliminate hereditary factors in the development of myopia. The females enrolled in ultra-Orthodox schools, who did not start intensive reading at the same early age as the males in the ultra-Orthodox school system, have the same socio-demographic background but do not have the same high rate of myopia as the males. This result may imply that early near-work activity and not hereditary factors may be more important for myopic development. Moreover, females in the ultra-Orthodox school system had the same rate of myopia as females in other groups (Figure 1).

Finally, our study shows that children may be unaware of their need for spectacles or they may wear undercorrected spectacles. Therefore, it is important to continue testing visual acuity of schoolchildren frequently and on a regular basis.

REFERENCES

1. Saw SM, Chuna WH, Wu HM, Yap E, Chia KS, Stone RA. Myopia: gene-environment interaction. *Ann Acad Med Singapore* 2000; 29: 290-297.
2. Young FA. The nature and control of myopia. *J Am Optom Assoc* 1977; 48: 451-457.
3. Dumphy EB, Stoll MR, King SH. Myopia among American male graduate students. *Am J Ophthalmol* 1968; 65: 518.
4. Berson D, Iedwab E, Stollman EB. Incidence of myopia among theological and high school students in Jerusalem. *Harefuah* 1982; 102: 16-17.
5. Trolio D, Li T, Glasser A, Howland HC. Differences in eye growth and the response to visual deprivation in different strains of chickens. *Vision Res* 1995; 35: 1211-1216.
6. Schaeffel F, Howland HC. Properties of the feedback loops controlling eye growth and refractive state in the chicken. *Vision Res* 1991; 31: 717-734.
7. Hepsen IF, Everekliogiu C, Bayramlar H. The effect of reading and near-work on the development of myopia in emmetropic males: a prospective, controlled, three-year follow-up study. *Vision Res* 2001; 41: 2511-2520.
8. Saw SM, Hong RZ, Zhang MZ, Fu ZF, Ye M, Tan D, Chew SJ. Near-work activity and myopia in rural and urban schoolchildren in China. *J Pediatr Ophthalmol Strabismus* 2001; 38: 149-155.
9. Saw SM, Chia SE, Chew SJ. Relation between work and myopia in Singapore women. *Optom Vis Sci* 1999; 76: 393-396.
10. Zylbermann R, Landau D, Berson D. The influence of study habits on myopia in Jewish teenagers. *J Pediatr Ophthalmol Strabismus* 1993; 30: 319-322.
11. Kinge B, Midelfart A, Jacobsen G, Rystad J. The influence of near-work on development of myopia among university students. A three-year longitudinal study among engineering students in Norway. *Acta Ophthalmol Scand* 2000; 78: 26-29.
12. Goldschmidt E, Lam CS, Opper S. The development of myopia in Hong Kong children. *Acta Ophthalmol Scand* 2001; 79: 228-232.
13. Parssinen O, Lyyra AL. Myopia and myopic progression among schoolchildren: a three-year follow-up study. *Invest Ophthalmol Vis Sci* 1993; 34: 2794-2802.
14. Saw SM, Wu HM, Hong CY, Chuna WH, Chia KS, Tan D. Myopia and night lighting in children in Singapore. *Br J Ophthalmol* 2001; 85: 509-510.
15. Wallman J, Gottlieb MD, Rajaram V, Fugate-Wentzek LA. Local retinal regions control local eye growth and myopia. *Science* 1987; 237: 73-77.

Author's address:
Guy J Ben-Simon
Jules Stein Eye Institute
David Geffen School of Medicine
UCLA
100 Stein Plaza
Los Angeles
CA 90095-7006
USA