Amblyopia and Refractive Errors Among School-Aged Children With Low Socioeconomic Status in Southeastern Turkey

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ABSTRACT

Purpose: To investigate the prevalence of refractive errors and other eye diseases, incidence and types of amblyopia in school-aged children, and their relation to gender, age, parental education, and socioeconomic factors.

Methods: A total of 21,062 children 6 to 14 years old were screened. The examination included visual acuity measurements and ocular motility evaluation. Autorefraction under cycloplegia and examination of the external eye, anterior segment, media, and fundus were performed.

Results: There were 11,118 females and 9,944 males. The average age was 10.56 ± 3.59 years. When all of the children were evaluated, 3.2% had myopia and 5.9% had hyperopia. Astigmatism 0.50 D or greater was present in 14.3% of children. Myopia was associated with older age, female gender, and higher parental education. Hyperopia was inversely proportional with older age. Spectacles were needed in 4,476 (22.7%) children with refractive errors, and 10.6% of children were unaware of their spectacle needs. Amblyopia was detected in 2.6% of all children. The most common causes of amblyopia were anisometropia (1.2%) and strabismus (0.9%).

Conclusion: Visual impairment is a common disorder in school-aged children. Eye health screening programs are beneficial in early detection and proper treatment of refractive errors.

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INTRODUCTION

School screening programs are crucial and beneficial for children, especially for their long-term health.[1-3] Ocular screening programs in children, primarily at preschool age, may enable detection of amblyopia and amblyogenic risk factors such as strabismus, refractive errors, and media opacities earlier. Thus, it facilitates the prophylaxis and treatment of amblyopia.[2,4] It also has positive effects on the psychosocial development of children.[5] In addition, large populations can be screened in a faster, cheaper, and more effective way during school screening programs.

The school-based sampling strategy and associated prevalence estimates do not represent the population of the rest of the country. This is more appar-

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ent in that refractive and visual acuity (VA) status of children attending school significantly varies from that of children not attending school.[6] Thus, a child with poor vision, especially at the level of blindness, could not attend school and this may lead to underestimating the prevalence of visual impairment within the whole country. Similarly, if near work and other aspects of schooling are associated with myopia development,[7,8] those not attending school would be less likely to be myopic or experiencing visual impairment. The result of this would be an overestimate of the prevalence of myopia in the rest of the country.[6] On the other hand, investigation of the prevalence and causes of visual impairment allows the planning of preventive ophthalmologic programs that can provide more precise interventions directed to the preservation of ocular health.[9] Early detection of ocular disorders in children prevents permanent damage to VA and binocular vision.

Diagnosis and treatment of amblyopia at an earlier age may result in a better and more stable final VA in connection with shorter treatment periods, rapid improvement of VA, and better overall compliance with treatment regimens.[4] Holmes et al.[3] found children between the ages of 7 and 13 years less responsive to the amblyopia treatment than children younger than 7 years. Flynn et al.[10] also reported the reduced response to amblyopia treatment in older children.

The aims of the current study were to establish the prevalence of refractive errors, eye diseases, and amblyopia and their causes in school-aged children (6 and 14 years old) and to examine associations with gender, age, parental education, and socioeconomic factors around Diyarbakir, Turkey.

PATIENTS AND METHODS

Study Population and Sampling Method

This study was approved by the Ethics Committee of Dicle University School of Medicine, and was conducted in accordance with the tenets of the Declaration of Helsinki. Sixteen schools (446 classes and 21,525 students) randomly selected by the Turkish Ministry of Education during the 2008-2009 academic year among the 51 schools from the rural part of Diyarbakir, a southeastern city in Turkey where people have poor economic income, were enrolled in this study. All of the students attending these schools were examined. Of these, 21,062 with sufficient documentation were included and 463 with inadequate documentation were excluded from the study. The population included in the screening program was selected from primary schools (between ages of 6 and 14 years) according to data from the Turkish Ministry of Education.

The information consisting of child's name, age, and sex, parent/guardian's name, parental educational status, and home address was completed 2 or more days prior to the scheduled examination date. The data including parent/guardian's name, socioeconomic status, parental education, and home addresses of the children were collected by a questionnaire answered by their parents or guardians. All selected school administrators received information regarding the study and agreed to participate. Detailed information about examination, including the side effects of pupillary dilation and cycloplegia, were given to the parents and guardians of the children and they were asked to sign an informed consent form. The data gathered from the screening were also shared with the Turkish Ministry of Health by operation of law.

Assessment of Refractive Error

The examinations were performed on working days in temporary stations set up in each school by a clinical team of one ophthalmic nurse and nine ophthalmologists. VA was measured by Snellen visual acuity chart at 6 meters by the nurse. The anterior segment (eyelid, conjunctiva, cornea, iris, and pupil) was examined by an ophthalmologist with a slit lamp (SM-70N; Takagi, Nagano, Japan). Ocular motility and strabismus were evaluated with a cover–uncover test at 0.5 and 4.0 m, and corneal light reflex was used to detect the degree of deviation. Color blindness was measured by Ishihara charts. Cycloplegia was induced with two drops of 1% cyclopentolate, administered 5 minutes apart, and a third drop administered after 15 minutes. Thirty minutes after the last drop, five consecutive refraction readings were obtained with an autorefractor (AR-310A; Nidek, Tokyo, Japan). Pupils were considered fully dilated when 6 mm or greater dilatation was achieved, and cycloplegia was considered complete if complete cycloplegia disappeared. Cycloplegic refraction was performed with an autorefractor with daily calibration. Examination of the lens, vitreous, and fundus was performed by an ophthalmologist, after cycloplegic dilation, with a slit lamp and direct/indirect ophthalmoscope.

Patients having a VA less than 20/20 were re-

TABLE 1
Distributions of Age and Gender

Age (Y)	Male	Female	Total
6	181	152	333 (1.6%)
7	1,505	1,687	3,192 (15.2%)
8	1,596	1,553	3,149 (15.0)%
9	1,498	1,445	2,943 (14.0%)
10	1,432	1,351	2,783 (13.2%)
11	1,183	1,305	2,488 (11.8%)
12	917	1,258	2,175 (10.3%)
13	890	1,318	2,208 (10.5%)
14	742	1,049	1,791 (8.5%)
All	9,944 (47.2%)	11,118 (52.8%)	21,062 (100%)

examined 3 days after the cycloplegia and the best-corrected VA was determined. Amblyopia is defined as best-corrected VA of 20/40 or worse in at least one eye or at least two lines of interocular difference on Snellen chart without an apparent organic cause. When amblyopia was detected, children were referred to the ophthalmology outpatient clinic of Dicle University Faculty of Medicine for medical treatment or surgical interventions with follow-up.

VA categories were defined as normal/near-normal vision (≥ 20/32 in both eyes), unilateral visual impairment (≥ 20/32 in one eye only), mild impairment in the better eye (≤ 20/40 to ≥ 20/63 in the better eye), moderate impairment in the better eye (≤ 20/80 to ≥ 20/160), and blindness (≤ 20/200 in both eyes). Myopia was defined as spherical equivalent refractive error of at least -0.50 diopters (D) and hyperopia as +2.00 D or more. Refractive error data were presented only for eyes with successful cycloplegic dilation. Children were considered myopic if one or both eyes were myopic and hyperopic if one or both eyes were hyperopic, so long as neither eye was myopic, and emmetropic if neither eye was myopic or hyperopic. Astigmatism was examined at cylinder values of 0.50, 1.00, 2.00, and greater than 2.00 D. Estimates of refractive error prevalence were based on successful cycloplegia in both eyes.

Statistical Analysis

SPSS statistical software, version 11.5 (SPSS, Inc., Chicago, IL), was used for the statistical analysis. The Student's *t* test was used to test for continuous variables and the chi-square test for categorical variables. Pearson correlation analysis was used to calculate the correlation between factors. A *P* value of less than .05 was accepted as significant.

TABLE 2
Education Level of Parents

Education Level	Mother	Father
Illiterate	16,358 (77.6%)	8,278 (39.3%)
1st–5th grade	3,469 (16.5%)	10,615 (50.4%)
6th–8th grade	387 (1.8%)	1,151 (5.5%)
9th–11th grade	503 (2.4%)	707 (3.4%)
University	233 (1.1%)	223 (1.0%)
Missing	112 (0.5%)	88 (0.4%)
Total	21,062 (100%)	21,062 (100%)

RESULTS

The female-to-male ratio was 1.11:1 (11,118:9,944). The average age was 10.56 ± 3.59 years (range: 6 to 14 years). Distributions of age and gender of the examined populations are shown in Table 1.

Education levels of the parents are described in Table 2. A total of 16,358 (77.6%) of the mothers and 8,278 (39.3%) of the fathers were illiterate. A correlation was determined between the increase of education level of the fathers and myopia of the children ($P < .001$).

Pupillary dilation of at least 6 mm and absence of complete cycloplegia were achieved in 20,546 right eyes (97.5%) and absent pupillary light reflex without full dilation in 464 eyes (2.2%). Fifty-two right eyes (0.3%) did not satisfy either criterion, and cycloplegic dilation was not attempted in one eye because of traumatic pupillary deformation and corneal opacity. In left eyes, the respective numbers were 20,620 (98.9%), 395 (1.9%), and 47 (0.2%).

Distribution of uncorrected and best-corrected VAs in children wearing glasses are presented in Table 3. A total of 17,375 (82.5%) children had uncorrected normal/near-normal VA (≥ 20/32) in at least one eye. There were 3,687 children (17.5%) with visual impairment (≤ 20/40) in both eyes and 1,043 (5.0%) of these were blind (≤ 20/200). At the examination, 2,539 (12.1%) children were wearing spectacles. With best-corrected VA, it was pos-

TABLE 3

Distribution of Uncorrected and Best-Corrected Visual Acuities (VAs)

VA Category	Uncorrected VA	Patients With Previous Spectacles	Best-Corrected VA
⩾ 20/32 both eyes	15,762 (74.8%)	146 (0.9%)	19,740 (93.7%)
⩾ 20/32 one eye only	1,613 (7.7%)	132 (8.1%)	572 (2.7%)
⩽ 20/40 to ⩾ 20/63 better eye	1,503 (7.1%)	567 (37.7%)	353 (1.7%)
⩽ 20/80 to ⩾ 20/160 better eye	1,141 (5.4%)	823 (72.1%)	211 (1.0%)
⩽ 20/200 better eye	1,043 (5.0%)	871 (83.5%)	186 (0.9%)
All	21,062 (100%)	2,539 (12.1%)	21,062 (100%)

TABLE 4

Myopia and Hyperopia Prevalence by Age

Age (Y)	Myopia (%)	Hyperopia (%)
6	14 (4.2)	25 (7.5)
7	49 (1.6)	291 (9.1)
8	81 (2.6)	251 (8.0)
9	76 (2.6)	197 (6.7)
10	79 (2.8)	142 (5.1)
11	75 (3.0)	108 (4.4)
12	83 (3.8)	98 (4.5)
13	92 (4.2)	68 (3.1)
14	123 (6.9)	67 (3.7)
All	672 (3.2)	1,247 (5.9)

sible to further reduce bilateral visual impairment to 750 (3.6%) children (⩽ 20/40). Accordingly, 2,937 (79.6%) of the 3,687 children with bilateral visual impairment based on uncorrected VA could achieve normal/near-normal vision in at least one eye with best correction. A total of 2,237 (10.6%) children were unaware of their need to wear spectacles.

Myopia and hyperopia prevalence of the children by age are presented in Table 4. The mean spherical equivalent was not significantly different between right and left eyes ($P = .127$) or between genders ($P = .08$). Frequency of myopia in 6- and 14-year-old children was 4.2% and 6.9%, respectively. Frequency of hyperopia in 6- and 14-year-old children was 7.5% and 3.7%, respectively. A total of 3.2% of the screened children had myopia and 5.9% had hyperopia. Of the patients with myopia, 369 (54.9%) were female and 303 (45.1%) were male. The increase in frequency of the myopia with age was statistically significant ($P = .034$). Of the patients with hyperopia, 597 (47.9%) were female and 650 (52.1%) were male. However, the frequency of hyperopia decreased significantly with advancing age ($P < .001$). The prevalence of myopia was found to be significantly higher among females compared to males ($P = .023$), whereas the prevalence of hyperopia was found to be significantly higher among males compared to females ($P = .025$).

Prevalence of astigmatism in the right and left eyes is presented in Table 5. Astigmatism 0.50 D or greater was found in 2,873 (13.6%) right eyes and 2,995 (14.2%) left eyes. Astigmatism 0.50 D or greater was present in 3,032 (14.3%) children. There was no statistically significant relationship between astigmatism and gender, parental education status, or family income ($P > .05$).

The ocular abnormalities that cause reduced vision other than refractive errors are listed in Table 6. Amblyopia was present in 554 (2.6%) of the children. The causes of amblyopia were anisometropia (251 patients, 1.2%), strabismus (198 patients, 0.9%), deprivation (47 patients, 0.2%), ametropia (40 patients, 0.2%), and idiopathic (18 patients, 0.1%). The presence of amblyopia was not affected by the type of refractive error ($P = .264$). Among patients with amblyopia, 306 (55.2%) were diagnosed for the first time and 248 (44.8%) had been diagnosed earlier and somewhat treated before.

Strabismus was present in 510 (2.4%) of all cases. The causes of strabismus were esotropia (253 patients, 1.2%), exotropia (187 patients, 0.9%), fourth nerve palsy (27 patients, 0.1%), sixth nerve palsy (25 patients, 0.1%), and third nerve palsy (18 patients, 0.08%). Exotropia was higher in patients with myopia and esotropia was higher in patients with hyperopia ($P = .011$ and .010, respectively). Two hundred twenty-seven of these children with strabismus (44.5%) had been previously diagnosed and somewhat treated, whereas 283 (55.5%) were diagnosed for the first time at our screening program.

TABLE 5

Prevalence of Astigmatism in the Right and Left Eyes

Cylinder Value (Diopters)	Right Eye (%)	Left Eye (%)	All (%)
⩾ 0.5 to < 1.00	2,114 (10.0)	2,167 (10.3)	2,083 (9.9)
⩾ 1 to < 2.00	563 (2.7)	617 (2.9)	726 (3.4)
⩾ 2.00	196 (0.9)	211 (1.0)	223 (1.0)
All	2,873 (13.6)	2,995 (14.2)	3,032 (14.3)

TABLE 6

Ocular Abnormalities Other Than Refractive Errors Causing Reduced Vision

Abnormality	Right Eye	Left Eye	One or Both Eyes	Prevalence in the Population (%)
Amblyopia	265	289	554	2.6
Pseudophakia	14	13	21	0.1
Cataract	10	13	19	0.1
Corneal opacity	14	7	18	0.1
Keratoconus	8	9	12	0.06
Nystagmus	9	9	9	0.04
Retinal disorder	4	4	5	0.02
Unexplained cause	96	113	127	0.6
All	420	457	765	3.6

In the whole cohort, 930 children had color blindness; 576 of them were male and 354 were female. The rate of color blindness was higher among males (2.7%) than females (1.7%). The frequency of the color blindness was statistically higher in patients with myopia ($P < .001$). Other ocular abnormalities included 17 patients with trachoma (0.8%), 15 patients with vernal conjunctivitis (0.7%), 4 patients with blepharophimosis (0.02%), 4 patients with ptosis (0.02%), 4 patients with dacryocystitis (0.02%), 2 patients with entropion (0.01%), 2 patients with ectropion (0.01%), and 1 patient with chalazion (0.005%).

DISCUSSION

Refractive errors are responsible for more than half of the impaired vision in the majority of surveyed populations.[11,12] They affect a large proportion of the population worldwide, irrespective of age, sex, or ethnic group. They can be easily diagnosed, measured, and corrected with spectacles and other refractive corrections to obtain normal vision. Unless corrected, they cause low vision and even blindness.[9,12,13] The prevalence of refractive errors varies according to race and geographic location,[11,12] gender,[12,14] age,[12,14] educational level, amount of near work,[15] and parental education.[15]

In a Far East population, He et al. examined 2,454 children and reported that myopia (-0.50 D or more) affected 36.8% of 13 year olds and 53.9% of 17 year olds, hyperopia (+2.00 D or more) affected approximately 1.0% in all age groups, and astigmatism (⩾ 0.75 D) was present in 25.3% of all children.[6] According to Goh et al., myopia was present in 9.8% of 7 year olds, increasing to 34.4% of 15 year olds, and hyperopia was present in 3.8% of 7 year olds.[12] Saw et al. reported the prevalence rates of myopia as 24.7% in 7 year olds, 31.3% in 8 year olds, and 49.7% in 9 year olds; twice as many of the 9 year olds were already myopic compared with 7 year olds.[16] Fan et al. reported the prevalence of myopia increased almost 10-fold (from 4.6% to 43.5%) over 5 years.[17]

In a Middle East population, Jamali et al. reported the prevalence of hyperopia, myopia, astigmatism, and anisometropia among 6-year-old children as 20.5, 1.7, 19.6, and 2.2%, respectively.[18] Nacouzi et al. reported the prevalence of hyperopia, emmetropia, and myopia in patients between 15 and 45 years of age as 50%, 16.5%, and 33.5%,

respectively, after cycloplegia with a prevalence of amblyopia of 19.8%.[19] Rezvan et al. reported the prevalence rates of myopia, hyperopia, and astigmatism among 6- and 17-year-old school children as 4.3%, 5.4%, and 11.5%, respectively, and these were found to be not related to gender.[20] Yekta et al. reported the prevalence rates of myopia, hyperopia, and astigmatism in school children 5 to 15 years of age as 4.35%, 5.04%, and 11.27%, respectively.[21]

In the current study, the rate of myopia was 3.2% and the rate of hyperopia was 5.9%. Astigmatism 0.50 D or greater was present in 14.3% of the study population. The rate of myopia was found to be lower than the Far East population but similar to the Middle East population, which suggests that geographic factors such as climate and diet may be responsible for this similarity.

Refractive errors show some differences between urban and rural areas. In a previous study from India,[22] the prevalence of myopia was 51.4% in urban children and 16.7% in rural children. In the same study, hyperopia was 3.3% in the urban and 3.1% in the rural group. The rate of myopia among children attending urban schools is higher when compared with those in rural areas[8,23,24] and it was thought to be related to the different amount of time spent on near work and outdoor activities outside school hours in children attending the schools in urban and rural areas. Rose et al. reported that the critical factor is time spent outdoors rather than the sport itself. Indoor sport activity has no effect, whereas outdoor sports and activities are associated.[25] Brighter light could reduce the development of myopia through pupil constriction, resulting in less visual blur, or through stimulation of the release of dopamine from the retina, which is known to act as an eye growth inhibitor.[26] It is also possible that gender contributes to the differences in myopia prevalence. Differences between boys and girls are considered to be related to their involvement in outdoor leisure activities.[6,27,28] In the current study, we found the rates of myopia and hyperopia to be less than in the literature. This may be due to the selection of a rural setting for the screening program.

Differences in educational level may have a considerable impact on the early appearance of myopia.[29] Zhao et al. reported that 52% of myopic 13 year olds progressed by -1.00 D or more over the 28.5-month study period.[14] It was also claimed that higher IQ scores and parental myopia are associated with myopia.[16,30] A similar study showed the prevalence of myopia rose from 8% to 31% for those with low to high IQ scores.[31] In addition, reading more books, meaning more near work, may promote aberrant eye growth and myopic refractive error.[32] Myopia was also found to be associated with every hour of near work reported per week (reading for pleasure, studying outside school hours, watching television, working on a computer, and sewing).[15]

Ethnicity was another major factor related to the development of myopia.[33,34] The risks of myopia are lower in Singapore Malay compared with Singapore Chinese children, despite the high myopia prevalence rates among all major ethnic groups in Singapore.[34] In addition to the ethnicity, female gender was also a significant risk factor, paralleling the Refractive Error Study in Children surveys conducted in Shunyi District.[35] However, Goh et al. reported that gender was not relevant among children of Chinese ethnicity in the Gombak District (Kuala Lumpur) survey.[12] In our study, the rate of myopia was significantly higher in females, whereas the rate of hyperopia was significantly higher in males. The frequency of myopia was positively correlated with the level of education of the father.

Amblyopia is one of the major causes of vision loss in children. There is no consensus regarding the criteria and methodology.[36] Many cases of amblyopia cannot be detected without effective screening.[4] The prevalence of amblyopia ranges between 1.44% and 5.0% in the literature.[6,12,36,37] This may be related to the differences in the definition of amblyopia. In our study, the amblyopia rate was 2.6%. The treatment of amblyopia is more successful before the age of 8 years. Because only 16.8% of the children in our study were younger than 8 years, after this age the benefits of amblyopia treatment are limited. The rate of color blindness in our study was higher among males (2.7%) than females (1.7%). This high rate of color blindness among girls (1.7%) may be associated with higher consanguinity among the population in the studied area.

The current study is limited by the selection of the schools only from the rural area of the city and leaving the preschool children out of the screening program. We found the rate of myopia similar to that in Middle Eastern countries but lower than that of Far Eastern countries. The different results of the studies may be due to variable definition of refractive errors, racial and geographic differences, paren-

tal education, and performing the refraction with or without cycloplegia. We found increased frequency of myopia and decreased frequency of hyperopia with age (grade/level of school). This is most probably due to normal growth of the eye and also to cumulative time spent in near work.

Visual impairments are frequent among school-aged children. Eye health screening programs become more useful in early diagnosis and proper correction of refractive errors.

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