Original Article

Prevalence of Amblyopia and Refractive Errors Among Primary School Children

Zhale Rajavi[1,2,3], MD; Hamideh Sabbaghi[4,5], MS; Ahmad Shojaei Baghini[2], MD; Mehdi Yaseri[6], PhD
Hamidreza Moein[4], MD; Shadi Akbarian[4], MS; Narges Behradfar[4], MS; Simin Hosseini[4], MS
Hossein Mohammad Rabei[2,3,4], MD; Kourosh Sheibani[2], MD

[1]Ophthalmic Epidemiology Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[2]Basir Eye Safety Research Center, Basir Eye Clinic, Tehran, Iran
[3]Department of Ophthalmology, School of Medicine, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[4]Ophthalmic Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[5]Department of Optometry, School of Rehabilitation, Shahid Beheshti University of Medical Sciences, Tehran, Iran
[6]Department of Epidemiology and Biostatistics, Tehran University of Medical Sciences, Tehran, Iran

Abstract

Purpose: To determine the prevalence of amblyopia and refractive errors among 7 to 12-year-old primary school children in Tehran, Iran.

Methods: This population-based cross-sectional study included 2,410 randomly selected students. Visual acuity was tested using an E-chart on Yang vision tester. Refractive errors were measured by photorefractometry and cycloautorefraction. Strabismus was checked using cover test. Direct ophthalmoscopy was used to assess the anterior segment, lens opacities, red reflex and fundus. Functional amblyopia was defined as best corrected visual acuity ≤20/40 in one or both eyes with no anatomical problems.

Results: Amblyopia was present in 2.3% (95% CI: 1.8% to 2.9%) of participants with no difference between the genders. Amblyopic subjects were significantly younger than non-amblyopic children (P=0.004). Overall, 15.9% of hyperopic and 5.9% of myopic cases had amblyopia. The prevalence of hyperopia ≥+2.00D, myopia ≤-0.50D, astigmatism ≥0.75D, and anisometropia (≥1.00D) was 3.5%, 4.9%, 22.6%, and 3.9%, respectively. With increasing age, the prevalence of myopia increased (P<0.001), that of hyperopia decreased (P=0.007), but astigmatism showed no change. Strabismus was found in 2.3% of cases. Strabismus (OR=17.9) and refractive errors, especially anisometropia (OR=12.87) and hyperopia (OR=11.87), were important amblyogenic risk factors.

Conclusion: The high prevalence of amblyopia in our subjects in comparison to developed countries reveals the necessity of timely and sensitive screening methods. Due to the high prevalence of amblyopia among children with refractive errors, particularly high hyperopia and anisometropia, provision of glasses should be specifically attended by parents and supported by the Ministry of Health and insurance organizations.

Keywords: Amblyopia; Refractive Error; Strabismus; Primary School; Iran

J Ophthalmic Vis Res 2015; 10 (4): 408-416.

INTRODUCTION

Amblyopia results from abnormal development of the visual system in early childhood. The visual cortex needs continuous, clear and focused visual impulses to develop normally.[1-7] Children with amblyogenic risk factors, if not treated, are vulnerable to functional reduction of visual acuity (VA), causing amblyopia.[1-3] The prevalence of amblyopia in the literature ranges from 0.7% to 5%, depending on the characteristics of study population, visual acuity criteria and measurement methods.[8-11] Amblyopia is the most common cause

Correspondence to:
Zhale Rajavi, MD. Flat 5, No 6, Third Shahrestan, North Pesian, Moghaddas Ardebili Avenue, Vali-ye-Asr Street, Tehran, Iran.
E-mail: zh_ra2000@yahoo.com

Received: 07-04-2015 Accepted: 02-06-2015

Access this article online

Quick Response Code:

Website: www.jovr.org

DOI: 10.4103/2008-322X.176909

of monocular visual impairment among children and young adults in Central Europe.[10] A prevalence of 4.4% has been reported in New Delhi and 1.9% in South China among 5- to 15-year-old children.[12,13] The prevalence of amblyopia in preschool and school-age population in different provinces of Iran has been reported to vary from 0.2% to 3%.[14-20] In a study conducted in 1994 on 1,310 children less than 10 years old in southeastern Tehran, the authors reported a prevalence of 3% for amblyopia with VA ≤ 20/40 as the screening criterion.[20] Known predisposing risk factors for amblyopia are strabismus, refractive errors (particularly anisometropia and high hyperopia), and visual deprivations such as ptosis and congenital cataract.[1] In a study by Thampson et al, both anisometropia and strabismus were present in 21% of cases,[21] while in a survey by Show et al, these causes were found in 35% of cases.[22] Furthermore, it is accepted that preschool screening has significantly decreased the prevalence of amblyopia among children.[23,24] The Vision 2020 strategy of the World Health Organization projects a 1% to 2% prevalence of amblyopia in preschool children who have previously been screened for amblyopia, compared to 3% in those who have not.[23,25]

The purpose of this survey was to determine the prevalence of amblyopia, refractive errors, and associated risk factors through screening of 7- to 12-year-old primary school children in Tehran, Iran in 2013 using the Yang vision tester, photorefractometry and cycloautorefraction.

METHODS

This population-based cross-sectional survey was performed on 2,410 children to determine the prevalence of amblyopia and refractive errors in Tehran, the capital city of Iran, among 7- to 12-year-old primary school students from January to April 2013. The study was approved by the Ethics Committee of the Ophthalmic Research Center at Shahid Beheshti University of Medical Sciences, Tehran, Iran. One day before the examination, a written informed consent form explaining the details of project was sent to the parents for agreement and signing.

The study team included one manager from the Ministry of Health, one coordinator, one ophthalmologist, three optometrists and one biostatistician.

Subjects were selected by random stratified systematic cluster sampling among 555,446 primary school students. The sampling frame of all schools in Tehran (1,781 schools) and their number of students, geographical region (based on district), and type (public or private) was obtained from the Iranian Ministry of Education. To select the study subjects, the schools were sorted by region and type of school, and weighted according to their number of students. A total of 40 schools were randomly selected in a systematic manner to have a proportion-to-size chance of selection in each region and from different types of school. In each selected school, 60 students (10 students from each grade) were randomly chosen. No significant difference was detected between the mean age of our sample and the population.

Subjects with mental retardation (based on their performance for VA assessment, personal contact, and school health records), ptosis covering the pupil, media opacity, other factors leading to deprivation amblyopia, congenital ocular anomalies, impaired fixation such as nystagmus, eccentric fixation, and any other organic eye disorder were excluded; prematurity was defined as gestational age less than 37 weeks.[26] On the day of examination, each subject and the school health care instructor were interviewed to complete a questionnaire concerning past health history and demographic status of children. The general appearance of the students was evaluated particularly for the presence of ptosis, strabismus, head posture and any eye anomaly. Functional amblyopia was defined as best corrected visual acuity (BCVA) was 20/40 or less in the absence of anatomical problems.[9,12,14,15,18,20] Mixed amblyopia was diagnosed in the presence of both anisometropia and strabismus.

Visual Acuity Testing

Distance VA was tested separately in each eye using a Snellen LCD chart with tumbling E-optotypes on each line of the Yang vision tester (SIFI Diagnostic S.P.A-Via Castellana, 70/e-31100 T revise-Italy) in a room with natural daylight. This device can illustrate the different types of visual charts with constant background illumination equal to 120 cd/m^2 at different distances up to 9 meters. If the subject had glasses, visual acuity was assessed with their own correction (habitual VA). In cases with VA less than 20/40, VA testing was repeated through a 2mm pinhole aperture. If pinhole VA did not reach 20/40 and there were no anatomical problems, the subject was suspected to have functional amblyopia. Subjects suspected of amblyopia were referred to the Pediatric Eye Clinic at Imam Hossein Medical Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran. for assessing BCVA, performing cycloplegic refraction, and verifying a correct diagnosis of amblyopia [Figure 1].

Refractive Error Measurement

Refractive errors were determined using photorefractometry (PlusoptiX SO4 GmbH, Nuremberg, Germany, with reported sensitivity of 63% to 94% and specificity of 62% to 99%)[10] without cycloplegic drops by a trained optometrist in all subjects. Photorefractometry can measure refractive errors without cycloplegic drops in a very short time, even in young preverbal subjects, and hence simplifies early amblyopia screening. This method assesses both eyes simultaneously for refractive errors, pupil size, inter-pupillary distance (IPD), eye deviation, ptosis and

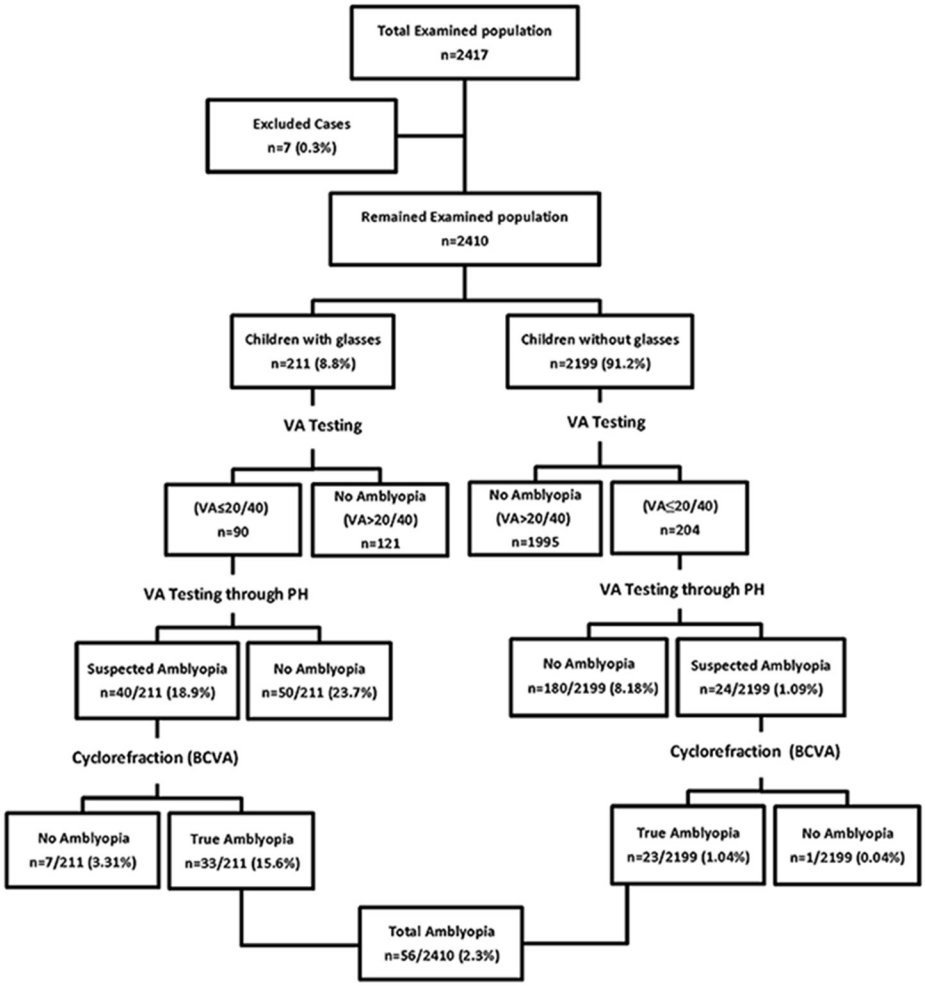

Figure 1. Flowchart of the study. VA, visual acuity; PH, pinhole; BCVA, best corrected visual acuity; n, number.

media opacities while maintaining the same amplitude of accommodation in both eyes for its working distance (one meter).[27]

Every examination was repeated 3 times, and the average result was considered. Spherical equivalent (SE) ≥ +2.00D was considered as hyperopia, SE ≤ -0.50D as myopia, and cylindrical power ≥ 0.75D as astigmatism, according to Refractive Error Study in Children (RESC) and our previous study.[12-14,28,29] With-the-rule (WTR) astigmatism axis was 180˚±30˚, against-the-rule (ATR) astigmatism axis was 90˚±30˚, and oblique astigmatism axis was between 30˚ and 60˚ or between 120˚ and 150˚.[14] Anisometropia was defined as SE difference of at least 1.00D between the right and left eyes.[8,14,18]

Although photorefraction is not able to accurately determine refractive measurements in eyes with myopia>7.00D or hyperopia>5.00D, these levels of refractive error are characterized on the printout as high myopia or high hyperopia. Therefore, patients with myopia>7.00D or hyperopia>5.00D were excluded based on the photorefractometer printout (out of limits) and thus not calculated in the prevalence of refractive errors, however such cases were not excluded from the prevalence of amblyopia, since amblyopia was defined according to VA testing.

At the next step, cycloplegic refraction was performed in all subjects suspected of amblyopia 30-45 minutes after administration of one drop cyclopentolate 1% and tropicamide 1%, 5 minutes apart in each eye using an autorefractometer (RM-8800; Topcon Medical, Oakland, NJ, USA).

Ocular Alignment Assessment

Alternate cover test or the Krimsky method was used to assess ocular alignment in subjects with visual acuity more or less than 20/200, respectively. These tests were performed at far (6 m) and near distances (33 cm) with an accommodative fixation target to detect deviation, if present. Ocular motility was checked in all gazes to detect any muscular dysfunction.[30]

Ophthalmoscopy

Examination of the fundus, red-reflex, and anterior segment components such as crystalline lens and its opacities was performed using a direct ophthalmoscope (HEINE BETA 200; US). If the size of central lens opacity was more than 1mm, the subject was suspected of having a cataract.[31] In addition, the optic nerve and macula were examined using direct ophthalmoscopy by the ophthalmologist to exclude possible fundus lesions.

Statistical Analysis

To determine the rate of amblyopia, direct standardization (for age and sex) was used in addition to assessing crude rates. To present characteristics of the patients, mean ± SD, median (range), frequency, and percent values were employed. To find the effective risk factors and obtain odds ratio (OR), logistic regression was used. Additionally, the simultaneous effect of different variables was obtained using multiple logistic regression analysis. Multilevel analysis was used in all the above calculations to consider design effect. The number of levels varied based on the type of variables. For example, subject-specific variables were evaluated at 3 levels (zone, school and subject) while eye-specific variables were evaluated at 4 levels (zone, school, subject and eye). All statistical analyses were performed using STATA (version 12.0). *P*-values less than 0.05 were considered as statistically significant.

RESULTS

In this population-based cross-sectional survey, a total of 2,417 school children 7 to 12 (mean, 9.4±1.7) years of age were included. 51.2% were girls and 49.8% of participants were boys. Seven subjects (4 girls, 3 boys) who had abnormal conditions such as mental retardation (*n*=1), retinal colobomas (*n*=3), organic blindness (*n*=1), ocular albinism (*n*=1), and traumatic cataract (*n*=1) were excluded from the study. Overall, 294 subjects showed reduced VA; of these, 64 had pinhole VA ≤20/40 and were suspected of amblyopia and referred to Imam Hossein Medical Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran to determine BCVA using cyclorefraction results [Figure 1].

Amblyopia

Amblyopia was diagnosed in 56 subjects (2.3%, 95% CI: 1.8% to 2.9%) who had BCVA ≤20/40. The percentage of amblyopia in different sexes and age groups is shown in Figure 2. Amblyopia significantly decreased with older age (*P*=0.014) [Figure 2]. There was no statistically significant difference between boys and girls in the prevalence of amblyopia at different age groups (*P*=0.079, based on interaction analysis). Thirty-six (64.3%) subjects had unilateral amblyopia while twenty (35.7%) had bilateral amblyopia. There was no significant difference between right (*n*=43, 56.5%) and left eyes (*n*=33, 43.5%) in the prevalence of amblyopia. 93.4% of amblyopic eyes had BCVA in the range of 20/40 to 20/100 (71/76 eyes), and the rest had BCVA less than 20/100.

The prevalence of amblyopia was 15.6% among subjects using glasses and 1.04% among those with no prescribed glasses [Figure 1]. Figure 3 shows the prevalence of amblyopia with different types of refractive errors and anisometropia. The percentage of amblyopia was 15.9% in hyperopic eyes, 5.9% in myopia and 5.1% in astigmatism. In addition, 16.1% of anisometropic cases were amblyopic. The calculated OR for hyperopia and myopia as risk factors of amblyopia were 11.87 and 3.98, respectively.

Amblyopia was found in 34.8% and 15.6% of esotropic and exotropic subjects, respectively, while only 1.8% of orthotropic ones had amblyopia [Table 1]. In addition, amblyopia was observed in 25% of subjects with anisometropia and strabismus (mixed amblyopia).

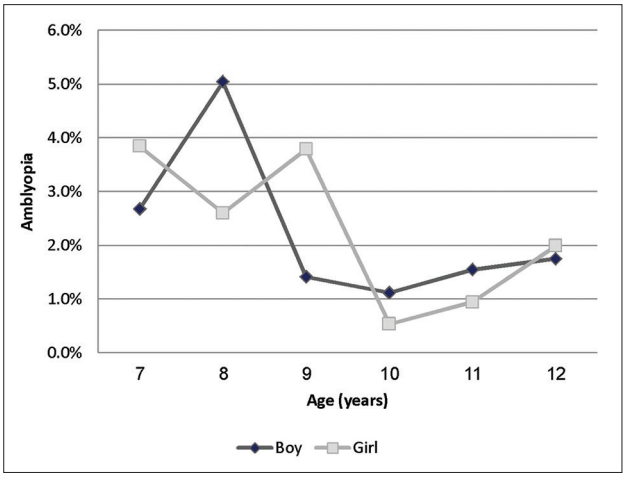

Figure 2. Amblyopia prevalence according to age and sex of children.

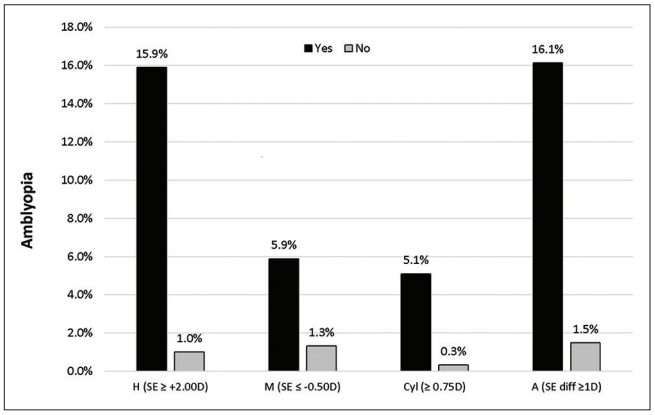

Figure 3. Amblyopia prevalence in different refractive errors and anisometropia. H, hyperopia; M, myopia; Cyl, cylinder; A, anisometropia; SE, spherical equivalent; diff, difference; D, diopter.

Table 1. Basic characteristics and amblyopia risk factors among participants

Associated factor	Level	Total (%)	Nonamblyopia (%)	Amblyopia (%)	Crude OR	95% CI of OR		Crude *P**
						Lower	Upper	
Age (years)	Mean±SD	9.4±1.7	9.5±1.7	8.8±1.7	0.81	0.7	0.93	0.004†
	Median (range)	9 (7-12)	9 (7-12)	8 (7-12)				
Sex	Boy	1199 (49.8)	1171 (97.7)	28 (2.3)	1.04	0.66	1.63	0.873
	Girl	1211 (50.2)	1183 (97.7)	28 (2.3)	1			
Gestational and pediatric factors								
Prematurity	Yes	4 (.2)	3 (75.0)	1 (25.0)	14.05	2.72	72.65	0.002
	No	2405 (99.8)	2350 (97.7)	55 (2.3)	1			
Twin	Yes	45 (1.9)	41 (91.1)	4 (8.9)	4.26	1.47	12.37	0.008†
	No	2364 (98.1)	2312 (97.8)	52 (2.2)	1			
Seizure	Yes	47 (2.0)	43 (91.5)	4 (8.5)	4.07	1.43	11.6	0.009†
	No	2362 (98.0)	2310 (97.8)	52 (2.2)	1			
Ocular factors								
Anisometropia (SE difference ≥ 1D)	Yes	93 (3.9)	78 (83.9)	15 (16.1)	12.87	8.16	20.31	<0.001†
	No	2287 (96.1)	2253 (98.5)	34 (1.5)	1			
Strabismus	Yes	55 (2.3)	42 (76.4)	13 (13.6)	17.9	9.32	31.69	<0.001†
		23 (1.0)	15 (65.2)	8 (34.8)	29.5	13.28	65.52	<0.001†
		32 (1.3)	27 (84.4)	5 (15.6)	10.32	3.58	29.75	<0.001†
	No	2354 (97.7)	2311 (98.2)	43 (1.8)	1			
Mixed§	Yes	8 (0.3)	6 (75.0)	2 (25.0)	14.95	3.73	59.95	<0.001†
	No	2397 (99.7)	2343 (97.7)	54 (2.3)	1			
Ptosis	Yes	6 (.2)	5 (83.3)	1 (16.7)	8.35	0.9	77.8	0.062†
	No	2403 (99.8)	2348 (97.7)	55 (2.3)	1			
Parental factors								
Parents sanguinity	Yes	481 (20.0)	468 (97.3)	13 (2.7)	1.22	0.69	2.15	0.49
	No	1928 (80.0)	1885 (97.8)	43 (2.2)	1			
Family glasses	Yes	781 (32.4)	762 (97.6)	19 (2.4)	1.02	0.57	1.81	0.955
	No	1628 (67.6)	1591 (97.7)	37 (2.3)	1			

§Mixed: Combination of anisometropia and strabismus, *Based on logistic regression, †Remained statistical significant in simultaneous effect evaluation in multiple logistic regression. Discrepancy of total number in different variables caused by missing values. SD, standard deviation; OR, odds ratio; CI, confidence interval; P, probability; D, diopter; SE, spherical equivalent

Table 1 presents the basic characteristics and risk factors for amblyopia among amblyopic and non-amblyopic groups. According to univariate analysis, strabismus, anisometropia, prematurity, being twins, and seizures were found to be amblyogenic risk factors in our study, but multivariate analysis did not confirm prematurity. There was a statistically significant difference regarding age between subjects with amblyopic and non-amblyopic cases in both univariate and multivariate analysis (P=0.004).

Refractive Errors

In this study, the prevalence of hyperopia, myopia, astigmatism and anisometropia in all students using photorefraction was 3.5% (95% CI: 2.7% to 4.3%), 4.9% (95% CI: 3.9% to 5.9%), 22.6% (95% CI: 21.1% to 24.1%, WTR: 18.5%, ATR: 3.3% and oblique: 0.8%) and 3.9% (95% CI: 3.1% to 4.7%), respectively, while these percentages were 47.4% for hyperopia, 14.5% for myopia, 75% for astigmatism (WTR: 63.2%, ATR: 7.9% and oblique: 3.9%), and 69.6% for anisometropia based on cycloplegic refraction among subjects with amblyopia.

Figure 4 shows the prevalence of different types of refractive errors in both sexes according to age. With increasing age, the prevalence of myopia increased (P<0.001) and that of hyperopia decreased (P=0.007). In addition, the prevalence of astigmatism was significantly higher than other refractive errors at all age groups (P<0.001) and was higher among boys as compared to girls (P=0.001, Table 2). There was a higher prevalence of esotropia among hyperopic subjects (P<0.001), while exotropia was more prevalent in myopic cases (P=0.001) [Table 2].

Photorefraction testing was not possible in 30 eyes, and 7 had pupillary disorders. Esotropia, exotropia and corneal opacity were seen in 5, 1, and 3 cases, respectively. The results of 6 eyes were missed, and unexplained failure to perform photorefraction was found in 8 eyes,

Table 2. The relation between basic characteristics and refractive errors among participants

Character	Level	Refractive error (D)					Astigmatism (D)		
		E (−0.50 ≤ SE ≤ +2.00) (%)	M (SE ≤ −0.50) (%)	*P**	H (SE ≥ +2.00) (%)	*P**	No	Cyl ≥ 0.75 (%)	*P**
Age (years)	Mean±SD	9.4±1.7	10.3±1.6	<0.001†	9.1±1.6	0.007†	9.5±1.7	9.4±1.8	0.083
	Median (range)	9 (7-12)	11 (7-12)		9 (7-12)		9 (7-12)	9 (7-12)	
Sex	Boy	2183 (91.6)	108 (4.5)	0.365	92 (3.9)	0.392	1783 (74.8)	600 (25.2)	0.001†
	Girl	2206 (91.6)	127 (5.3)		74 (3.1)		1930 (80.2)	477 (19.8)	
Gestational and pediatric factors									
Prematurity	Yes	6 (75.0)	0 (0.0)	-	2 (25.0)	0.058	7 (87.5)	1 (12.5)	0.474
	No	4383 (91.7)	235 (4.9)		164 (3.4)		3706 (77.5)	1076 (22.5)	
Twin	Yes	81 (91.0)	2 (2.2)	0.508	6 (6.7)	0.199	58 (65.2)	31 (34.8)	0.013†
	No	4308 (91.6)	233 (5.0)		160 (3.4)		3655 (77.7)	1046 (22.3)	
Seizure	Yes	82 (89.1)	2 (2.2)	0.419	8 (8.7)	0.964	55 (59.8)	37 (40.2)	0.002†
	No	4307 (91.7)	233 (5.0)		158 (3.4)		3658 (77.9)	1040 (22.1)	
Ocular factors									
Strabismus	ET	30 (75.0)	0 (0.0)	0.001†	10 (25.0)	<0.001†	21 (52.5)	19 (47.5)	<0.001†
	XT	49 (76.6)	10 (15.6)		5 (7.8)		34 (53.1)	30 (46.9)	
	No	4310 (92.0)	225 (4.8)		151 (3.2)		3658 (78.1)	1028 (21.9)	
Ptosis	No	4386 (91.7)	233 (4.9)	0.258	165 (3.4)	0.04	3709 (77.5)	1075 (22.5)	0.128
	Yes	3 (50.0)	2 (33.3)		1 (16.7)		4 (66.7)	2 (33.3)	

†Remained statistical significant in simultaneous effect evaluation in multiple logistic regression, *Based on multilevel analysis (three levels), in these comparisons emmetropia and no astigmatism considered as reference group. E, Emmetropia; M, myopia; H, hyperopia; Cyl, cylinder; SD, standard deviation; SE, spherical equivalent; *P*, probability; D, diopter

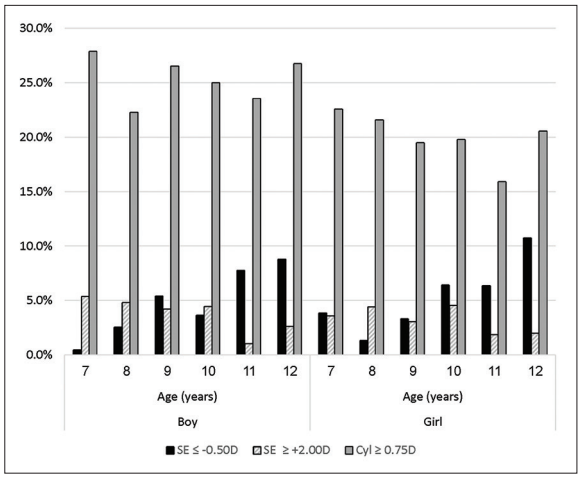

Figure 4. Refractive error prevalence according to age and sex of students' eyes. SE, spherical equivalent; Cyl, cylinder; D, diopter.

2 of which were amblyopic. Therefore, the real missing rate of photorefractometry was estimated at 0.16% (8 out of 4,820 eyes) in the present study.

Ocular Deviation

Strabismus was present in 2.3% (95% CI: 1.7% to 2.9%) of the examined population, including esotropia in 1% (95% CI: 0.7% to 1.3%) and exotropia in 1.3% (95% CI: 0.8% to 1.9%). In our study, thirteen subjects with strabismus had amblyopia (13/55, 23.6%). This percentage was significantly higher in girls as compared to boys (37.5% versus 12.9%, *P*=0.006).

DISCUSSION

Prevalence of Amblyopia

The prevalence of amblyopia in different studies from Iran and other countries are summarized in Table 3. In the current survey, amblyopia was present in 2.3% of cases, which is comparable to other reports from Iran[16,17,19] and Malaysia[32] [Table 3]. In a 1994 study by Rajavi et al on 1,310 children less than 10 years old, the rate of amblyopia was reported to be 3% using the same VA criterion.[20] This reduction in amblyopia prevalence from 3% to 2.3% may be attributed to annual amblyopia screening among 3- to 6-year-old children in Iran in recent years, as well as increased parental knowledge about amblyopia; better public education and web-based information may have also played a role in this regard. Although the prevalence of amblyopia has decreased, we are still far from reaching the rate in developed countries like Sweden[8] and Australia,[9] where the prevalence is a mere 0.7%. In the present study, no difference was found between the genders, similar to some other previous studies.[9,14,16,17] Our findings indicate that amblyopia significantly decreased with older age; however, Faghihi et al[33] found no

statistically significant correlation between amblyopia and age.

The reason for amblyopia among subjects with no glasses (1.04%) might be attributed to not participating in screening programs, the financial burden of glasses, lack of tendency to use the glasses due to cosmetic problems, strabismus, and idiopathic etiologies.

The rate of habitual amblyopia in the present study (15.6%) was similar to some other studies [Table 3].[13,28,32] The presence of amblyopia, even with correction, might be due to inappropriate or wrong glasses, high refractive errors, anisometropia, low optical quality of glasses, irregular use of glasses, late prescription, non-compliance with patch therapy, or simultaneous ocular deviation.

Amblyopia Risk Factors

The higher percentage of amblyopia in hyperopia (15.9%) as compared to myopia (5.9%) was similar to the report by Faghihi et al[33] who found that 27.8% of hyperopic and 3.7% of myopic cases were amblyopic. The lower percentage of amblyopia in our study may be attributed to the myopic shift which occurs with photorefraction as compared to cycloautorefraction, different VA criteria (ours was 20/40 and theirs was 20/30), and population age range (6-21 years). In addition, 5.1% of our population with astigmatism had amblyopia, which is in line with the above mentioned study (6.5%).[33]

Anisometropia was one of the amblyogenic risk factors in our study, similar to a study by Robaei et al from Australia.[9]

In our study, 23.6% of subjects with strabismus had amblyopia. Rajavi et al[20] in Iran and Robaei et al[9] in Australia have reported strabismus in 15% and 37.5% of amblyopic cases, respectively. In our study, 34.8% of esotropic and 15.6% of exotropic subjects had amblyopia, which is similar to other studies.[9,20] This high rate of amblyopia among our subjects with strabismus was due to coexisting high refractive errors and anisometropia. Robaei et al[9] found deviation to be a risk factor for amblyopia (OR=65). In our study, we found an OR of 29.5 for esotropia and 10.32 for exotropia. Although exotropia is the most common ocular deviation in different societies, esotropia was the most prevalent deviation among subjects with amblyopia[8,9] as our study.

Robaei et al[9] showed that children born before 37 weeks gestation had a greater risk of amblyopia (OR=5.4) which is similar to our findings (OR=2.5). Schalij-Delfos et al[26] also indicated that infants with 24 weeks gestational age or less were at a higher risk of refractive errors, strabismus and amblyopia as compared to normal children. In the present study, there were only a few premature children (n=4); therefore, our results should be considered with caution. In univariate analysis, prematurity was found to be one of the amblyogenic risk factors (P=0.002); however, this was not confirmed by multivariate analysis.

Refractive Errors

In the present study, the prevalence of hyperopia was 3.5%, which is in line with reported prevalence rates from South Africa,[34] Southern China,[13] and Northeastern Iran,[14] but lower as compared to some other studies.[8,28] This might be due to the fact that we used photorefraction, which usually causes a myopic shift compared to cyclorefraction. We also found that an increase in age decreases the prevalence of hyperopia. This finding is similar to other studies[12,13,28,32] presented in Table 4.

Table 3. The prevalence of amblyopia among different studies from Iran and other countries

Authors	Region	Year	Age range (year)	Sample size	VA criteria	Percent of amblyopia	Habitual Amblyopia
Studies in Iran							
Rajavi et al[20]	Tehran	1994	3-10	1310	20/40	3	
Fotouhi et al[15]	Dezful	2007	6-18	5544	20/40	0.3	1.7
Jamali et al[18]	Shahrood	2009	6	815	20/40	1.7	
Yekta et al[16]	Shiraz	2010	6-18	2638	20/30	2.29	
Yekta et al[17]	Bojnourd	2010	6-17	1551	20/30	2.3	
Faghihi et al[19]	Varamin	2010	14-18	1133	20/30	2.1	
Rezvan et al[14]	Bojnourd	2011	6-17	1551	20/40	0.2	1
Rajavi et al	Tehran	2013	7-12	2410	20/40	2.3	15.6
Studies in other countries							
Maul et al[28]	Chile, La Florida	2000	5-15	5303	20/40	7.4	14.7
Murthy et al[12]	Asia, New Delhi	2002	5-15	6447	20/40	4.4	4.9
Naidoo et al[34]	South Africa	2003	5-15	4890	20/40	0.32	1.2
He et al[13]	Asia, China	2004	5-15	4364	20/40	1.9	10.3
Goh et al[32]	Asia, Malaysia	2005	7-15	4634	20/40	2	10.1
Grönlund et al[8]	Europe, Sweden	2006	4-15	143	20/30	0.7	
Robaei et al[9]	Australia	2006	6	1741	20/40	0.7	

The studies have been reported by the year they have been conducted. VA, visual acuity

Table 4. Refractive errors prevalence in different studies according to their age range

Authors	Region	Year	Age range (year)	Sample size	Examination method	Hyperopia (SE ≥+2.00D)	Myopia (SE ≤-0.50D)	Astigmatism (SE ≥0.75D)	Anisometropia (SE difference)
Maul et al[28]	Chile, La Florida	2000	5-15	5303	Cyclo-retinoscopy	22.7-7.1	3.4-19.4	27	0.82 (≥2D)
Murthy et al[12]	Asia, New Delhi	2002	5-15	6447	Cyclo-autorefraction	15.6-3.97	4.67-10.8	14.6-7.0	0.41 (≥2D)
He et al[13]	Asia, China	2004	5-15	5053	Autorefraction	17-1	5.7-78.4	42.7	0.39 (≥2D)
Goh et al[32]	Asia, Malaysia	2005	7-15	4634	Cyclo-autorefraction	3.8-1	9.8-34.4	21.3	
Grönlond et al[8]	Europe, Sweden	2006	4-15	143	Cyclo-autorefraction	9	6	22	3 (≥1D)
Jamali et al[18]	Iran, Shahrood	2009	6	815	Cyclo-autorefraction	20.5	1.7	19.6	2.2 (≥1D)
Rezvan et al[14]	Iran, Bojnourd	2011	6-17	1551	Cyclo-autorefraction	4.3	5.4	11.5	2.7 (≥1D)
Rajavi et al	Iran, Tehran	2013	7-12	2410	Photorefraction	4.5-2.3	2.1-9.8	20.9-19.2	3.9 (≥1D)

The studies have been reported by the year they have been conducted. SE, spherical equivalent, D, diopter

The prevalence of myopia (4.9%) in our study was similar to some other reports,[8,14,28,34] but lower than the Southern Chinese population with a similar age.[13] In addition, the prevalence of myopia increased with age in our series, which is in line with other studies[12,13, 28,32] [Table 4].

Astigmatism was found in 22.6% of our population, which was similar to studies by Grönlund et al,[8] Goh et al[32] and Maul et al[28] who reported 21.3%, 22% and 27% rates, respectively. There are some other reports within the same age range indicating higher[13] or lower[12,14,34] rates of astigmatism compared to our findings. Although in our study astigmatism did not change with age which is similar to a study by He et al,[13] some other reports have found a statistically significant association between astigmatism and age.[12,14,28,34] The rates of WTR, ATR, and oblique astigmatism were 18.5%, 3.3%, and 0.8%, respectively, , which is similar to Rezvan et al study (9.3%, 2.1% and 0.1%).[14]

The prevalence of anisometropia was 2.2% in Shahrood[18] and 3.8% in Varamin, Iran.[19] In our study, it was 3.9% which is somehow higher than other reports.[8,14,18] This may be due to employing different criteria for anisometropia and methods in various studies.

There was a higher percentage of different types of refractive errors in subjects with amblyopia as compared to the total population. In our study most subjects with amblyopia had hyperopia, astigmatism and anisometropia which is similar to a study by Robaei et al[9] who indicated a higher percentage of hyperopia and astigmatism in amblyopic subjects as compared with non-amblyopic cases. Among different axes of astigmatism, WTR has been reported as the most prevalent type of astigmatism; however Robaei et al[9] indicated no significant difference in the prevalence of different types of astigmatism between amblyopic versus non-amblyopic subjects.

One advantage of our study was applying the Yang vision tester with VA chart in unified background illumination at a specific distance. In most previous studies, retro-illuminated visual acuity charts, which cannot determine VA as precisely as Yang, were used. Additionally, photorefractometry was employed to check refractive status of all students to report the prevalence of refractive errors. We employed cyclorefraction for suspected amblyopic cases as the gold standard along with cover test and examination of external ocular muscle function to uncover amblyogenic risk factors.

The photorefractometer has a limited diagnostic range for measuring refractive errors (-7.00D to +5.00D) and cannot measure refractive errors in patients with miotic (<3 mm) or mydriatic pupils (>8 mm) and ocular media opacity which may be considered as limitations of our study.

In summary, the higher prevalence of amblyopia in our study compared to that in developed countries reveals the necessity for applying timely and sensitive screening methods. Due to the high prevalence of amblyopia among subjects with refractive errors, particularly high hyperopia and anisometropia, provision of glasses should be specifically attended by parents and supported by the Ministry of Health.

ACKNOWLEDGMENTS

This study was supported by the Ophthalmic Research Center, Shahid Beheshti University of Medical Sciences and, Basir Eye Safety Research Center,Tehran, Iran.

We would like to thank all the children and their families who participated in this study, as well as Masoumeh Kalantarion, Simin Kalantarion, Bahar Kheiri, Shirin Mohebi and Bahar Safdari for their efforts in coordinating the fieldwork and their assistance in data collection.

REFERENCES

1. Webber AL, Wood J. Amblyopia: Prevalence, natural history, functional effects and treatment. *Clin Exp Optom* 2005;88:365-375.
2. Simons K, Preslan M. Natural history of amblyopia untreated owing to lack of compliance. *Br J Ophthalmol* 1999;83:582-587.
3. Woodruff G, Hiscox F, Thompson JR, Smith LK. The presentation of children with amblyopia. *Eye (Lond)* 1994;8(Pt 6):623-626.
4. Simons K. Preschool vision screening: Rationale, methodology and outcome. *Surv Ophthalmol* 1996;41:3-30.
5. American Academy of Ophthalmologists Amblyopia is a Medical Condition. AAO; 2006. Available from: http://www.aao.org/about/policy/upload/Amblyopia_2006.pdf. [Last accessed on 2013 Nov 08].
6. Hatt S, Antonio-Santos A, Powell C, Vedula SS. Interventions for stimulus deprivation amblyopia. *Cochrane Database Syst Rev* 2006;(3):CD005136.
7. Epelbaum M, Milleret C, Buisseret P, Dufier JL. The sensitive period for strabismic amblyopia in humans. *Ophthalmology* 1993;100:323-327.
8. Grönlund MA, Andersson S, Aring E, Hård AL, Hellström A. Ophthalmological findings in a sample of Swedish children aged 4-15 years. *Acta Ophthalmol Scand* 2006;84:169-176.
9. Robaei D, Rose K, Ojaimi E, Kifley A, Huynh S, Mitchell P. Visual acuity and the causes of visual loss in a population-based sample of 6-year-old Australian children. *Ophthalmology* 2005;112:1275-1282.
10. Schimitzek T, Haase W. Efficiency of a video-autorefractometer used as a screening device for amblyogenic factors. *Graefes Arch Clin Exp Ophthalmol* 2002;240:710-716.
11. Salcido AA, Bradley J, Donahue SP. Predictive value of photoscreening and traditional screening of preschool children. *J AAPOS* 2005;9:114-120.
12. Murthy GV, Gupta SK, Ellwein LB, Muñoz SR, Pokharel GP, Sanga L, et al. Refractive error in children in an urban population in New Delhi. *Invest Ophthalmol Vis Sci* 2002;43:623-631.
13. He M, Zeng J, Liu Y, Xu J, Pokharel GP, Ellwein LB. Refractive error and visual impairment in urban children in southern china. *Invest Ophthalmol Vis Sci* 2004;45:793-799.
14. Rezvan F, Khabazkhoob M, Fotouhi A, Hashemi H, Ostadimoghaddam H, Heravian J, et al. Prevalence of refractive errors among school children in Northeastern Iran. *Ophthalmic Physiol Opt* 2012;32:25-30.
15. Fotouhi A, Hashemi H, Khabazkhoob M, Mohammad K. The prevalence of refractive errors among schoolchildren in Dezful, Iran. *Br J Ophthalmol* 2007;91:287-292.
16. Yekta A, Fotouhi A, Hashemi H, Dehghani C, Ostadimoghaddam H, Heravian J, et al. Prevalence of refractive errors among schoolchildren in Shiraz, Iran. *Clin Experiment Ophthalmol* 2010;38:242-248.
17. Yekta A, Hashemi H, Azizi E, Rezvan F, Ostadimoghaddam H, Derakhshan A, et al. The prevalence of amblyopia and strabismus among schoolchildren in Northeastern Iran, 2011. *Iran J Ophthalmol* 2012;24:3-10.
18. Jamali P, Fotouhi A, Hashemi H, Younesian M, Jafari A. Refractive errors and amblyopia in children entering school: Shahrood, Iran. *Optom Vis Sci* 2009;86:364-369.
19. Faghihi M, Ostadimoghaddam H, Fatemi A, Heravian J, Yekta A. The prevalence of refractive errors, strabismus and amblyopia in schoolboys of Varamin, Iran, in 2010. *Iran J Ophthalmol* 2012;24:33-39.
20. Rajavi J, Ghadim HM, Monfared MH. Evaluating of refractive errors and their changes in 0-10 children living in Southeastern of Tehran (Iran) in 1994. *Bina Ophthal J* 1994;2:9-15.
21. Thompson JR, Woodruff G, Hiscox FA, Strong N, Minshull C. The incidence and prevalence of amblyopia detected in childhood. *Public Health* 1991;105:455-462.
22. Shaw DE, Fielder AR, Minshull C, Rosenthal AR. Amblyopia – Factors influencing age of presentation. *Lancet* 1988;2:207-209.
23. Williams C, Northstone K, Harrad RA, Sparrow JM, Harvey I; ALSPAC Study Team. Amblyopia treatment outcomes after screening before or at age 3 years: Follow up from randomised trial. *BMJ* 2002;324:1549.
24. Eibschitz-Tsimhoni M, Friedman T, Naor J, Eibschitz N, Friedman Z. Early screening for amblyogenic risk factors lowers the prevalence and severity of amblyopia. *J AAPOS* 2000;4:194-199.
25. Newman DK, East MM. Prevalence of amblyopia among defaulters of preschool vision screening. *Ophthalmic Epidemiol* 2000;7:67-71.
26. Schalij-Delfos NE, de Graaf ME, Treffers WF, Engel J, Cats BP. Long term follow up of premature infants: Detection of strabismus, amblyopia, and refractive errors. *Br J Ophthalmol* 2000;84:963-967.
27. Miller JM, Dobson V, Harvey EM, Sherrill DL. Cost-efficient vision screening for astigmatism in Native American preschool children. *Invest Ophthalmol Vis Sci* 2003;44:3756-3763.
28. Maul E, Barroso S, Munoz SR, Sperduto RD, Ellwein LB. Refractive Error Study in Children: Results from La Florida, Chile. *Am J Ophthalmol* 2000;129:445-454.
29. Rajavi Z, Parsafar H, Ramezani A, Yaseri M. Is noncycloplegic photorefraction applicable for screening refractive amblyopia risk factors? *J Ophthalmic Vis Res* 2012;7:3-9.
30. von Noorden GK, Campos EC. Binocular Vision and Ocular Motility: Theory and Management of Strabismus. 6th ed. St. Louis, MO: Mosby; 1990. p. 199-200.
31. Ceyhan D, Schnall BM, Breckenridge A, Fontanarosa J, Lehman SS, Calhoun JC. Risk factors for amblyopia in congenital anterior lens opacities. *J AAPOS* 2005;9:537-541.
32. Goh PP, Abqariyah Y, Pokharel GP, Ellwein LB. Refractive error and visual impairment in school-age children in Gombak District, Malaysia. *Ophthalmology* 2005;112:678-685.
33. Faghihi M, Ostadimoghaddam H, Yekta AA. Amblyopia and strabismus in Iranian schoolchildren, Mashhad. *Strabismus* 2011;19:147-152.
34. Naidoo KS, Raghunandan A, Mashige KP, Govender P, Holden BA, Pokharel GP, et al. Refractive error and visual impairment in African children in South Africa. *Invest Ophthalmol Vis Sci* 2003;44:3764-3770.

How to cite this article: Rajavi Z, Sabbaghi H, Baghini AS, Yaseri M, Moein H, Akbarian S, Behradfar N, Hosseini S, Rabei HM, Sheibani K. Prevalence of amblyopia and refractive errors among primary school children. J Ophthalmic Vis Res 2015;10:408-16.

Source of Support: Nil. **Conflict of Interest**: None declared.