Prevalence and Risk Factors of Refractive Errors among schoolchildren in Mashhad, 2006-2007

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Abstract

Purpose: To determine the prevalence of refractive condition and its risk factors among students in Mashhad.

Methods: A total of 2510 students representing a cross-sectional of the population of Mashhad were sampled using random cluster sampling strategy. Primary and middle school students underwent cycloplegic refraction. The refractive errors of high school students were measured using non-cycloplegic autorefraction. Myopia was defined as spherical equivalent (SE) of -0.5 diopter (D) or more, and hyperopia was defined as SE of +0.5 diopter (D) or more, and astigmatism of 0.75 cylinder diopter or greater. Examination was carried out in the school using standardized testing protocols.

Results: 2150 students (group 1: 1163 primary and middle school, group 2: 947 high school students and 13 missed data) participated. The prevalence of refractive errors in the 1st group was: myopia=2.4%, hyperopia=87.9%, astigmatism=9.8% and anisometropia=3.0% (SE difference at least 1.00 D), and in the 2nd group myopia=24.1%, hyperopia=8.4%, astigmatism=11.8% and anisometropia=5.6%. There was significant difference in refractive errors between girls and boys (P<0.001). In primary and middle school prevalence of myopia increased with age (OR=1.3 95% CI: 1.03 to 1.7 and P=0.013).

Conclusion: The prevalence of refractive errors among students in Mashhad is high. Effective detection and treatment of these refractive errors is expected to reduce the incidence of amblyopia and strabismus and also can prevent substantive effects on academic performance.

Keywords: Prevalence, Refractive Error, Myopia, Hyperopia, Astigmatism, Anisometropia

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Introduction

A refractive error is an error in the focusing of light on the retina and a frequent reason for reduced visual acuity. The term refractive error encompasses myopia (nearsightedness), hyperopia (farsightedness), and astigmatism. The prevalence of refractive errors has been reported over a wide range in different countries; from a prevalence of less than 1% up to as much as 75%. According to the World Health Organization (WHO), 5 million of the 124 million people with refractive errors are blind.[1,2] The highest prevalence of blindness due to refractive errors has been found in the over 50 year old age group of a Chinese population (59%).[3] Uncorrected refractive errors in school children can negatively affect their learning abilities, and their physical and mental health.[4,5] Refractive errors can impose a heavy financial burden on the society. The American Academy of Ophthalmology reported that myopia alone has the same destructive effect on the society as headaches and common cold, and that refractive examinations and glasses annually cost patients 1 and 1.5 billion dollars, respectively.[6] The prevalence of different refractive errors in Iran is not exactly known. In 2002, the Tehran Eye Study was performed and the prevalence of myopia and hyperopia based on cycloplegic refraction was estimated 7.2% and 76.2%, respectively, in those younger than 15 years of age.[7] Several studies with a similar methodology have been conducted in different countries including Nepal, China, India, and Chili.[8-11] The details of the methodology, including sampling and protocol have been published and it was recommended that similar studies be conducted in different areas of other countries. In light of the above introduction, considering the study that was performed in Dezful with the same methodology,[12,13] and the necessity of conducting such studies in different populations in our country, we here report the prevalence of refractive errors in students of district one in Mashhad.

Methods

In this cross-sectional study, the prevalence of refractive errors among students of the first district in Mashhad was studied in the 2006-2007 school year.

Study population and sample

Using random cluster sampling, 21 schools were selected from 370 schools (clusters) in this district. A total of 2510 students were selected from 21 randomly selected clusters of the first district in Mashhad. Calculated for an estimated refractive error prevalence rate of 17% (P), a precision of 0.02 (D), and 95% confidence interval (CI) (Z1-α/2=1.96). Considering a design effect of 1.5 and a response rate of 80%, the total sample size was calculated as 2437.

Examinations

Exclusion criteria were parents' unwillingness, diseases of the cardiovascular or nervous system, and opacity in the eye that would interfere with accurate refraction tests.

The team of examiners included 5 optometrists who had been settled in schools as planned before, and performed complete vision tests on students who were included in the study. After the initial interview, all participants in this study underwent vision tests. These examinations included tests of uncorrected visual acuity (UCVA), best corrected visual acuity (BCVA), presenting visual acuity, and also the cover-uncover test and lensometry on presenting glasses. For every student, visual acuity was measured in good lighting conditions using tumbling "E" log minimum angle of resolution (LogMAR) charts for each eye separately, according to the standard protocol. Students with a UCVA of $^{20}/_{20}$ underwent refraction tests, but if the UCVA was less than $^{20}/_{20}$, subjective refraction was tested beforehand. Autorefraction tests were done using the Topcon 8000. High school students had manifest refraction and elementary and middle school students had cycloplegic refraction (45 minutes after instilling 2 drops of 1% cyclopentolate, 5 minutes apart). This was because our pilot study showed that there were no differences between manifest and cyclopedia refraction in high school students.

Definitions

Spherical equivalent (SE) was used for calculations of refractive error. The SE is derived by adding the spherical component of refraction to half of the cylindrical component. Myopia was defined as an SE of at least -0.50

diopter (D) and hyperopia as an SE of +0.50 D or more. Emmetropia was defined as an SE between +0.5 D and -0.5 D. We categorized myopia as mild (-0.5 D to -3.0 D), moderate (-3.1 D to -6.0 D), and severe (more than -6.0 D). Hyperopia was categorized as mild (+0.5 D to +2.0 D), moderate (+2.1 D to +4.0D) and severe (more than +4.0D). Astigmatic students were those with a cylinder refraction of 0.75 D or more in at least one eye, which was recorded with a negative sign. Anisometropia was defined as a difference in SE of at least 1.0 D between right and left eyes. SEs in the right and left eyes were highly correlated (Pearson's correlation: r=0.89, P<0.001) and therefore, we present the data for only the right eye.

Ethical issues
Written informed consent was obtained from the students and their parents or guardians for all steps of the study, including use of eye drops before examinations. The research and ethics committee of vice chancellor for research of Mashhad university of medical sciences approved the study.

Statistical analysis
The prevalence of myopia, hyperopia, astigmatism, and anisometropia were calculated in this population. The 95% CI were calculated with clustering effects associated with the sampling design. Distribution of refractive errors were computed through separate analyses for first to eighth graders and high school students, using objective cycloplegic and objective non-cycloplegic refractions, respectively. Multivariate logistic regression was applied to assess the association between refractive errors and other factors, using a backward hierarchical elimination approach to create the model.

All analyses were done using STATA statistical software, version 8.0. P-value less than 0.05 were considered significant.

Results
During the study period, 2150 students of the 2450 selected ones participated in the study, accounting for 87.7% response rate. There were 1208 boys (56.2%) and 942 girls (43.8%); boys constituted 37.7% of first to 8th graders and 51% of high school students. The mean age was 11.2±2.6 years for elementary and middle school children, and 16.2±1.1 years for high school students.

Refraction was tested in 2137 students; cycloplegic refraction in 1163 elementary and middle school students, and manifest refraction in 974 high school students. The mean SE was 0.24 D (95% CI: 0.20 to 0.29) in elementary and middle school students and -0.29 D (95% CI: -0.35 to -0.23) in high school students. Across all ages and grades the mean SE refractive error was greater in females (P<0.001 CV=0.28) (Figure 1).
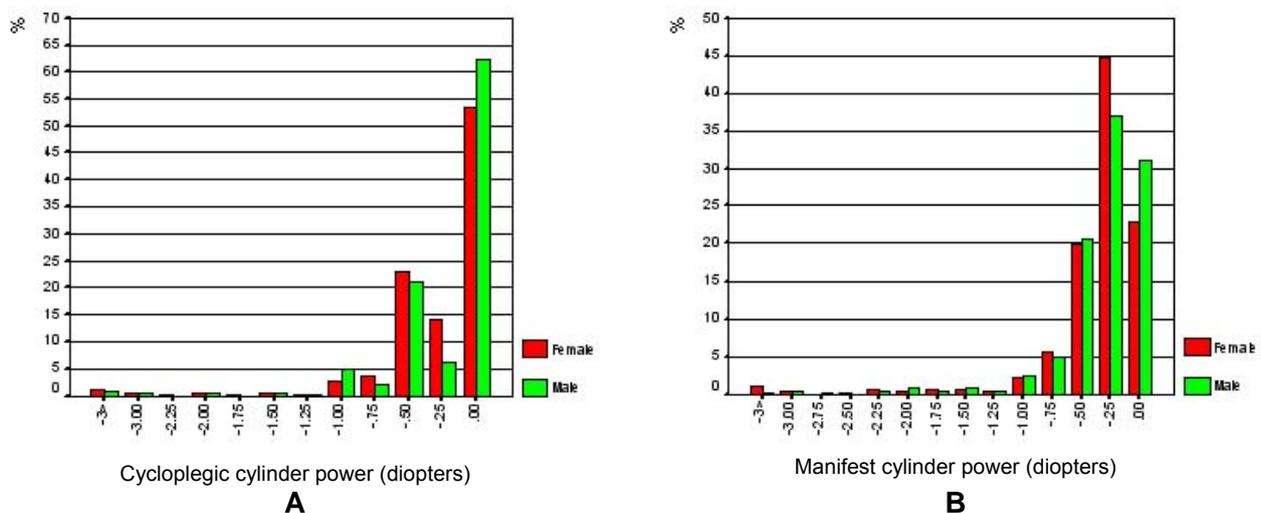
Figure 1. Prevalence (%) of astigmatism in elementary and middle school students (A) (cycloplegic refraction) and high school students (B) (manifest refraction)

Myopia and hyperopia

Based on these tests, the prevalence rates of myopia and hyperopia were 2.4% and 87.9%, respectively in elementary and middle school students, and 24.1% and 8.4% in high school students.

In the myopic population of students, there were 24 cases (2.1%) of mild myopia, 2 cases (0.2%) of moderate myopia, and 1 cases (0.1%) of severe myopia among elementary and middle school students, and respectively 214 (21.9%), 20 (2.1%), and 1 (0.1%) cases of each category among high school students.

In the hyperopic population of students, cycloplegic refraction tests for elementary and middle school student found 994 cases (85.8%) with mild hyperopia, 24 cases (2.1%) with moderate hyperopia, and 5 cases (0.4%) with severe hyperopia. In high school students, there were 76 students (7.8%) with mild hyperopia and 5 (0.5%) with moderate hyperopia.

The prevalence rates of myopia and hyperopia in high school students were not significantly different among different age groups, but inter-gender differences were statistically significant (P<0.001) (Table 1). The prevalence of myopia was higher in high school girls than boys (P<0.001). After eliminating the age effect in the gender groups, this difference still existed in the 15,

16, and 17 year old age groups. The prevalence of hyperopia was significantly different between genders; it was higher in high school boys (P<0.001). This difference continued to exist after eliminating the age effect.

The prevalence rates of myopia and hyperopia in elementary and middle school students did not differ between genders (Table 2). The prevalence of myopia in these students significantly correlated with age (P<0.001). After eliminating the gender effect, the prevalence of myopia still showed an increase with age in both gender groups (OR=1.3 95% CI: 1.03 to 1.7 and P=0.013).

As shown in table 2, the prevalence rates of hyperopia in elementary and middle school students, which were based on cycloplegic refraction, were not significantly different among different age groups. The prevalence of hyperopia in these students was significantly higher in 11-year old age group, even after eliminating the gender effect. The prevalence of hyperopia based on cycloplegic refraction was significantly lower in 13-year old girls group (P<0.001). The prevalence rates of hyperopia in elementary and middle school boys were not significantly different among age groups.

Table 1. Prevalence (%) of myopia and hyperopia in high school students by age and gender (manifest refraction)

	Myopia			Hyperopia		
	n	%	95%CI	n	%	95%CI
Girl						
14	27	30.7	13.8-47.6	3	11.5	3.2-16.2
15	125	29.6	25.8-33.3	7	5.6	5.3-5.8
16	186	33.8	27.2-40.4	10	5.3	1.6-9.0
17	139	32.3	24.9-39.8	7	5.0	1.6-8.4
Boy						
14	9	11.1	3.3-17.5	0	0	0
15	120	21.6	13.5-29.7	14	11.6	10.3-12.9
16	130	10.0	4.4-15.5	19	14.6	7.5-21.7
17	236	17.7	11.6-23.7	22	9.2	4.3-14.1
Boy and Girl						
14	36	25.7	6.1-45.2	3	8.5	1.2-16.3
15	245	25.7	23.4-28.0	21	8.5	5.2-11.9
16	316	24.0	14.4-33.6	29	9.1	6.1-12.1
17	375	23.1	19.8-26.4	29	7.7	3.2-12.1
All age						
Girl	477	16.4	13.8-19.1	55	11.0	8.7-13.3
Boy	495	32.0	28.5-35.6	27	5.6	2.9-8.3
Total	972	24.1	20.5-27.7	82	8.4	5.6-11.2

Table 2. Prevalence (%) of myopia and hyperopia in elementary and middle school students by age and gender

	Myopia			Hyperopia		
	n	%	95%CI	n	%	95%CI
Girl						
7	0	0		0	0	0
8	65	0		62	95.3	92.1-98.6
9	41	0		40	97.5	89.2-99.3
10	65	1.5	0.5-4.6	56	86.1	80.4-91.8
11	122	1.6	0.3-8.2	111	91.7	88.4-95.0
12	99	2	0.4-2.3	84	85.7	82.8-88.6
13	126	7	3.1-16.0	103	81.7	75.3-88.1
14	207	1.9	0.3-9.8	186	89.8	89.4-90.2
Boy						
7	117	1.7	1.1-2.3	102	87.1	84.3-90.4
8	75	2.6	0.09-78.0	62	82.6	80.6-84.6
9	50	2	0.03-3.7	43	86.0	83.7-88.2
10	23		0	17	73.9	66.8-80.9
11	7		0	5	71.4	46.1-96.7
12	17	5.8	0.06-11.4	15	88.2	74.6-97.3
13	57	0	0	53	94.6	90.3-89.9
14	92	3.2	0.9-11.7	81	88.0	81.7-94.3
Boy and Girl						
7	117	1.7	1.1-2.3	102	87.2	84.3-90.4
8	140	1.4	0.11-2.7	124	88.6	86.2-90.8
9	91	1	0.12-6.2	83	91.2	85.1-97.2
10	88	1.1	0.22-5.7	73	82.9	78.5-87.4
11	129	1.5	0.4-5.7	116	90.6	86.7-94.4
12	116	2.6	0.11-6.0	99	86.8	81.9-90.2
13	183	4.9	1.7-8.1	156	85.7	79.9-91.5
14	299	2.3	0.7-7.0	267	89.2	86.7-91.9
All age						
Girl	725	2.0	0.7-3.3	379	86.5	83.3-89.7
Boy	438	2.5	0.02-4.9	644	88.9	85.9-91.7
Total	1,163	2.4	0.7-3.8	1023	87.9	86.8-89.0

Astigmatism

Astigmatism or cylinder refraction equal to or more than 0.75 D was detected in 11.8% (95% CI: 8.3 to 15.2) of high school students. Based on cycloplegic refraction, this figure was 9.8% (95% CI: 7.6 to 12.1) in elementary and middle school students. Severe astigmatism of equal to or greater than 1.50 D was seen in 3.7% (95% CI: 2.6 to 4.9) of high school students and 3% (95% CI: 1.8 to 4.1) of elementary and middle school students. The prevalence rates of with-the-rule, against-the-rule, and oblique astigmatism in elementary and middle school students were 56.5% (n=65), 23.4% (n=27), and 20% (n=23), respectively. In high school students, these figures were 31.3% (n=36), 37.3% (n=43), and 31.3% (n=36), respectively, based on manifest refraction. The prevalence of with-the-rule astigmatism in elementary and middle school students was significantly higher in younger age groups, and the prevalence of oblique astigmatism significantly increased with age (P<0.001) (Figure 1).

Anisometropia

Based on manifest refraction, 5.6% (3.6-7.6) of high school students had anisometropia of 1.0 D or more. The prevalence of anisometropia was higher in hyperopic students than in myopic students (19.5% vs. 12.7%).

The prevalence of anisometropia of 1.0 D or more in elementary and middle school students was 4.8% (95% CI: 3.3 to 6.3). In elementary students, the prevalence of anisometropia significantly decreased with age in both genders (P<0.001). Based on cycloplegic refraction, the prevalence of anisometropia in myopic students was higher than hyperopic students (51.8% vs. 3%). In the total population of participants, the prevalence of anisometropia significantly increased with an increase in the prevalence of astigmatism (P<0.001).

Discussion

In this cross-sectional study, we assessed the prevalence of refractive errors among students of a district in Mashhad, and relevant associated factors such as age and gender.

The prevalence of myopia among high school students, which was determined through manifest refraction tests, was 24.1%. Considering different definitions and sample populations in other studies, and the age range of high school students, it would be difficult to make accurate comparisons. The prevalence of myopia in other studies, performed on populations in the same age range, varies from 33% in Dezful, Iran to 4.1% in south India; all indicating the difference in the extent of refractive errors between Iran and other countries.[8-13] Comparisons of studies in rural areas of India, China, Chili, and Nepal, which have been done with a similar methodology, with the study performed on school children in Dezful, demonstrate a higher prevalence of myopia among high school students in Iran.[8-14] In this study, no association was found between age and myopia for high school students, although other studies state otherwise; a difference that may be attributed to the 4 year age range.[8-12,14-17] Another finding in this study was the higher prevalence of myopia in girls compared to boys, which further confirms the role of gender shown by previous studies,[3,15,17] although some have shown an equal prevalence among the two genders.[12]

The prevalence of hyperopia among high school students, based on manifest refraction, was 8.4% and its difference from prevalence rates reported elsewhere is worthy of attention.[8-12,14] The prevalence of hyperopia showed a significant inter-gender difference which existed even after age adjustments. This has been stated in other reports as well, and further studies on the association between gender and hyperopia in high school students are recommended.[8-11]

The prevalence of myopia in elementary and middle school students was 2.3%; a result very similar to that of their peers in Dezful. However, the prevalence rates of myopia in the same age range have been reported very differently, probably because of differences in measurement techniques and definitions of refractive errors and their normal range.[8-14] Similar to other studies on elementary and middle school students, the prevalence of myopia based on cycloplegic refraction was not different between girls and boys, but this prevalence increased significantly with age; a finding which is supported by studies from other countries and also Dezful study.[9-13]

The prevalence of hyperopia based on cycloplegic refraction in elementary and middle school students was quite different from that of their peers in Dezful; this could be due to differences in definitions.[12,13] Comparison of these results with those concerning their peers in other countries (the 7 to 14 year age range) indicates major differences. In all these studies, gender and hyperopia correlated; this confirms the association between gender and hyperoia in this age range.[8-14]

The prevalence of astigmatism in the studied population, and that reported by other studies, demonstrates uniformity among the student population in Iran. Yet again, the prevalence of astigmatism in Iran differs from that of other countries. Similar to other studies, the prevalence of astigmatism did not change significantly with age, but with-the-rule astigmatism was more prevalent than against-the-rule or oblique astigmatism. The higher prevalence of with-the-rule astigmatism in younger ages and the higher prevalence of oblique astigmatism in older students agrees with results of other studies and further confirms the effect of age on astigmatism axis.[8-11]

Considering different definitions, it would be difficult to compare the prevalence of anisometropia in the present study with that reported elsewhere, although the association between anisometropia and astigmatism observed in this study is worthy of attention.

Conclusion

The present report provides valuable information regarding refractive errors among students in Mashhad and shows a higher prevalence of refractive errors compared to other countries. It is necessary to perform screening studies in other populations and age ranges, especially school children in other areas of Iran, so that the collected information can be used in planning and improving health care services.

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