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Original Article

High Prevalence of Refractive Errors in 7 Year Old Children in Iran

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Abstract

Background: The latest WHO report indicates that refractive errors are the leading cause of visual impairment throughout the world. The aim of this study was to determine the prevalence of myopia, hyperopia, and astigmatism in 7 yr old children in Iran.

Methods: In a cross-sectional study in 2013 with multistage cluster sampling, first graders were randomly selected from 8 cities in Iran. All children were tested by an optometrist for uncorrected and corrected vision, and non-cycloplegic and cycloplegic refraction. Refractive errors in this study were determined based on spherical equivalent (SE) cyloplegic refraction.

Results: From 4614 selected children, 89.0% participated in the study, and 4072 were eligible. The prevalence rates of myopia, hyperopia and astigmatism were 3.04% (95% CI: 2.30-3.78), 6.20% (95% CI: 5.27-7.14), and 17.43% (95% CI: 15.39-19.46), respectively. Prevalence of myopia (P=0.925) and astigmatism (P=0.056) were not statistically significantly different between the two genders, but the odds of hyperopia were 1.11 (95% CI: 1.01-2.05) times higher in girls (P=0.011). The prevalence of with-the-rule astigmatism was 12.59%, against-the-rule was 2.07%, and oblique 2.65%. Overall, 22.8% (95% CI: 19.7-24.9) of the schoolchildren in this study had at least one type of refractive error.

Conclusion: One out of every 5 schoolchildren had some refractive error. Conducting multicenter studies throughout the Middle East can be very helpful in understanding the current distribution patterns and etiology of refractive errors compared to the previous decade.

Keyword: Refractive errors, Cross-sectional study, Iran

Introduction

The latest WHO report indicates that refractive errors are the leading cause of visual impairment throughout the world (1). In children, refractive errors are the leading cause of amblyopia (2,3). Although these errors are easily correctable with eyeglasses, various studies in children and adults report a considerable lack of correction. Since the yr 2000 when Negrel et al. (4) presented a protocol for studying refractive errors in children, many studies around the world have studied 5-15 yr olds using cycloplegic refraction (5-11).

Myopia prevalence rates vary more widely than hyperopia and range from 0.3% in Nepal(6) to 38% in China (12) as opposed to 1.1% (6) to 18%(11)

for hyperopia. Prevalence rates of astigmatism are noteworthy as well, because in most studies, they are higher than rates of myopia and hyperopia (6,12-15). These studies demonstrate that racial, genetic, and geographic differences are one of the most important reasons for different rates of refractive errors around the world, such that today, eastern Asian countries are hot spots of myopia. Nonetheless, there is no consensus in terms of hyperopia or astigmatism. Results regarding the relation between refractive errors and age are also conflicting which makes it difficult to determine their age-related trend. For example, in the 5-15 yr age group, there are more reports concerning age-related changes for myopia than hyperopia (5-8,12,15). Iran is the second most populous country in the Middle East, and many prevalence studies of refractive errors in children and adults have been reported from this country in the past 10 yr, perhaps more than many other countries (8-10,16-21). Most of these studies concerned childhood ages (8-10,17, 21) and results regarding the prevalence of refractive errors are conflicting. During childhood, refractive errors interfere with many different aspects including education. In Iran, children first enter elementary school at the age of 7 yr. In this age group, refractive errors can affect a child's academic performance, lack of their correction can lead to permanent visual impairment, and thus, they must be given high importance. The prevalence of refractive errors in 7-yr-olds in Iran has been reported (8-10, 17). These studies were conducted at different times, and their samples of 7-yr-olds were limited. Thus, generalizing results to all of Iran can be difficult and would have methodological issues.

In light of the issues stated above, and the importance of refractive errors in early school ages, we examined 7-yr-old students in the first grade of urban area elementary school in through a cross-sectional study in 2013 to investigate the prevalence of refractive errors in Iran.

Materials and Methods

The present study was conducted cross-sectionally in 2013. In this study, the target population was 7-yr-old children in urban areas of Iran, so first graders were considered. The sampling method of this study has been previously reported. However, we present the details of the sampling in the following.

Sampling Method

Sampling was performed using multistage cluster sampling. After geographical classification of the different parts of Iran based on the population density, one city from each part was randomly selected. In total, as seen in Fig. 1, 8 cities of Iran were sampled**.** The selected cities were Sari, Birjand, Ardabil, Mashhad, Bandar Abbas, Dezful, Arak and Yazd.

After selecting the cities, the number of grade 1 students in each city was determined using the list of the Ministry of Education. Then, with the aim of selecting 500 students from each city, 250 female and 250 male samples were considered. Accordingly, the number of grade 1 classes in boys and girls primary schools was decided.

After determining the participating schools and making arrangements with the divisional office of education, consent forms were given to schools so that parents would sign them.

Study optometrists selected a space with proper lighting and dimensions in each school where they could conduct the examinations. To maintain order and avoid missing the students, the schoolchildren were enrolled in an alphabetical order of their last names in each school. First, we recorded demographics, and then schoolchildren entered the examination phase.

Vision Tests

First, schoolchildren had non-cycloplegic auto-refraction by a skilled technician using TOPCON RM8800 autorefractometer (Topcon Corporation, Tokyo, Japan). For children with glasses, we then measured visual acuity with presenting glasses using a Snellen chart with E optotypes from a distance of 6 meters, checked their glasses with Topcon LM 800 lensometer (Topcon Corporation, Tokyo, Japan), and recorded the prescription of the glasses and their prescription date. In the next stage, uncorrected visual acuity was

measured in all children. Then, autorefraction results were refined using HEINE BETA 200 ophthalmoscope (HEINE Optotechnic Germany) and MSD trial lenses (MSD Meniscus Trial Lenses, Italy). In all children, first the right eye and then the left eye was tested. For those with uncorrected visual acuity less than 20/25, a subjective test was done, and results with best correction were recorded. Eventually, cycloplegic refraction was done for all children.

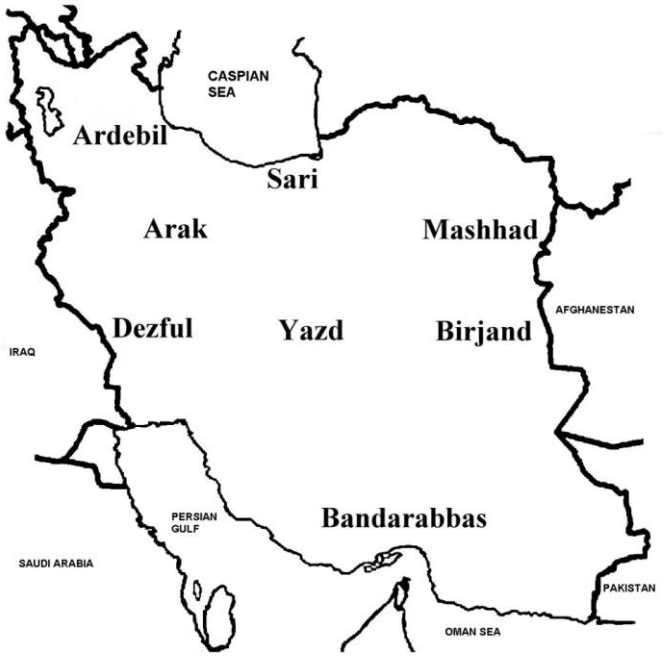

Fig. 1: The location of 8 cities selected in this study in map of Iran

We used cyclopentolate 1% eye drops 3 times at 0, 5, and 15 min intervals, and refraction was tested 35 min after the last drop using the autorefractometer and ophthalmoscope.

Definitions

In accordance with previous studies,(8,9) the spherical equivalent (SE) was used to define refractive errors, and diagnoses were based on cycloplegic refractions. An SE equal to or worse than -0.5D was classified as myopia, and to classify individuals' degree of myopia, people with an SE between 0.5 and 3.0D were categorized as mild myopia, -3.1 to -6.0D as moderate myopia, and worse than -6.0D as high myopia. Hyperopia was defined as an SE of +2.0D and worse, and astigmatism was defined as a cylinder error worse than -0.5D. To categorize astigmatism axis, definitions were 0 to 30 and 150 to 180 degrees for with-the-rule astigmatism, 60-120 degrees for against-the-rule astigmatism, and all others as oblique astigmatism. Cylinder errors were recorded with a minus sign.

Statistical Analysis

To determine the prevalence rates, those with refractive error in at least one eye were defined as a case with refractive error, and they are given with 95% confidence intervals. The design effect of a cluster sampling approach was taken into consideration and adjusted for in the calculation of 95% CIs. In addition, since the number of students in each city was not proportionate to the total number of students in the city, we applied weighting in the analyses. Logistic regression analyses and chi-square tests were used to examine associations between refractive errors and related factors.

Ethical Issues

The Ethics Committee of Arak University of Medical Sciences approved the study protocol, conducted in accord with the tenets of the Helsinki Declaration. All participants signed a written informed consent.

Results

Seventy schools were selected by multistage cluster sampling, of 4614 selected schoolchildren, 4106 participated in the study (response rate=89.0%) and 52.2% (n=2127) of the participants were male. Cycloplegic refraction was not done for 34 children due to lack of cooperation or having a contraindication, and eventually, we used data from 4072 children.

Mean SE was 0.81D (95% CI: 0.72-0.90), and mean cylinder error was 0.51D (95% CI: 0.44-0.56). Mean SE was 0.77D (95% CI: 0.66-0.87) in boys and 0.85D (95% CI: 0.70-1.01) in girls (*P*=0.366). Analysis of variance revealed signifi-

cant differences in SE among different cities (P<0.001).

Table 1 shows the prevalence of different types of refractive errors throughout Iran. As demonstrated, the prevalence of myopia was 3.04 (95%CI: 2.30-3.78), hyperopia was 6.20 (95%CI: 5.27-7.14), and astigmatism was 17.43 (95%CI: 15.39-19.46). Based on logistic regression results, the inter-sex differences were not significant in terms of myopia (P=0.925) and astigmatism (P=0.056) after adjusted cities, but the odds of hyperopia in girls was 1.11 (95% CI: 1.01-2.05) times higher than boys after adjusted cities (P=0.011).

Table 1 shows the prevalence of different types of refractive errors in each of the 8 cities of this study. The prevalence of myopia was lowest in Sari and highest in Bandar Abbas, but there were no significant differences among cities (P=0.284). The prevalence of hyperopia ranged from 2.54% in Birjand to 9.61% in Mashhad; this difference was statistically significant (P<0.001). The prevalence of astigmatism also differed significantly among cities (P<0.001); the highest rate was observed in Arak and the lowest rate was in Sari.

The prevalence of with-the-rule astigmatism was 12.59% (95% CI: 10.43-14.75), against-the-rule was 2.07% (95% CI: 1.51-2.63), and oblique astigmatism was seen in 2.65% (95% CI: 1.44-3.87).

Table 1: The prevalence of refractive errors in 7 yr old children in Iran by gender and city

		Myopia % (95%CI)	Hyperopia % (95% CI)	Astigmatism % (95% CI)
	Total	3.04 (2.30-3.78)	6.20 (5.27-7.14)	17.43 (15.39-19.46)
Gender	Male	3.07 (2.26-3.89)	5.06 (3.96-6.16)	15.46 (13 -17.92)
	Female	3.00 (1.75-4.26)	7.43 (5.98-8.88)	19.54 (16.32 -22.76)
City	Dezful	2.05 (0.91-3.19)	7.19 (4.85-9.53)	14.58 (10.83-18.33)
	Bandar Abbas	4.84 (1.83-7.85)	7.46 (5.68-9.24)	24.8 (20.52-29.08)
	Ardebill	2.63 (1.33-3.93)	6.20 (4.55-7.86)	20.49 (18.49-22.48)
	Birjand	3.09 (1.99-4.19)	2.54 (0.96-4.12)	16.70 (14.12-19.27)
	Sari	1.20 (0.18-2.23)	3.37 (1.17-5.58)	11.57 (9.02-14.12)
	Arak	3.44 (1.98-4.9)	7.07 (5.86-8.29)	25.24 (19.55-30.93)
	Mashhad	3.57 (0.87-6.26)	9.61 (6.37-12.86)	12.56 (7.78-17.33)
	Yazd	3.02 (0.48-5.56)	4.78 (2.14-7.60)	12.76 (4.74-20.78)

The prevalence rates of with-the-rule astigmatism in boys and girls were respectively 11.28% and 14.00% (P=0.009), against-the-rule was 2.26% and 1.86% (P=0.384), and oblique astigmatism was 1.83% and 3.54% (P<0.001). With-the-rule astigmatism was significantly different among the 8 cities; the highest rate was seen in Arak and the lowest was observed in Sari (P<0.001). The prevalence rates of against-the-rule astigmatism (P=0.076) and oblique astigmatism (P=0.401) did not show a significant inter-city difference.

In terms of the severity of refractive errors, none of the study participants had more than 6.0 D of myopia; myopia was between 3.0 and 6.0D in 4 children, and 3% of the studied schoolchildren had myopia of 0.5 to 3.0D. In addition, 5.71% of the schoolchildren had 2.0-4.0D of hyperopia, and 0.51% had 4.0D of hyperopia or more. Overall, 22.8% (95% CI: 19.7-24.9) had at least one refractive error; the prevalence of ametropia was 20.7% (95% CI: 17.01-22.24) in boys and 25.1% (95% CI: 20.9-29.7) in girls (P<0.001).

Discussion

We demonstrated the prevalence of refractive errors in 7 yr old children throughout Iran. The sampling method of this study and the selection

of cities from different geographic regions in Iran make it better generalizable than previous studies, (8-10) and results can provide an estimate of the whole country. Since 98% of 7-yr-old children are in the first grade and enter elementary school, we believe the population of first graders well represents the population of 7-yr-old children. Few studies have been done exclusively on 7-yr-olds, so we used results concerning 7-yr-olds in studies of 5-15 yr olds to compare the results of this study (22, 23).

The prevalence of myopia in this study was 3.04%. Results of other myopia prevalence studies in 7-yr-old children throughout the world are summarized in Table 2. The prevalence rates of myopia vary widely, such that the lowest rates were reported previously from Iran (9) and Oman (24), and the highest was observed in Hong Kong (25) where it is significantly higher than other countries. Apart from Hong Kong (25) the prevalence of myopia in 7-yr-old children is less than 10% everywhere, and is most prevalent in Malaysia (15) and China (12). We already know from previous studies that the prevalence of myopia is higher in East Asian countries in all age groups (26-31), and studies in Hong Kong (25), Malaysia (15), and China (12) indicate that the same is true in case of 7-yr-olds. In our study, rates ranged from 1.2% to 4.84% in different cities. Although the overall prevalence is not as high as that in China (12) or Hong Kong (25) results in different cities show that myopia in this age group are not low. Myopia is the most common uncorrected refractive error (32). Lack of correction of refractive errors is the leading cause of visual impairment globally (1). Thus, addressing myopia in this age group and its correction should be a health priority. Furthermore, changes in lifestyle, especially increased near work will cause myopia to increase in the next yr, and this point must be noted as well.

The prevalence of hyperopia was 6.20% in this study. Results of other studies in Table 2 show that the prevalence of hyperopia in the 7 yr age group in other countries ranges between 0.2% in Oman (24) and 28.9% in a previous study in Dezful (8). The rate of hyperopia appears relatively high in this study, although a high prevalence of hyperopia in the 7 yr age group is expected. The rate of hyperopia is high in Iran (8,9,18, 33).

One of the interesting findings of our study concerns the city of Dezful. In 2007, the prevalence of hyperopia in Dezul in the 7 yr age group was 28.9%, but is 7.19% now.

Table 2: Prevalence of childhood refractive errors in different studies

Country	Myopia (%)	Hyperopia (%)
Oman(24)	0.4	0.2
Hong Kong(25)	28.9	-
Morocco(11)	2.7	0.7
South Africa(14)	0.6	1.7
India (new Delhi)(45)	3.13	10.7
Malaysia(Gombak)(15)	9.8	3.8
Iran (Dezful)(8)	2.5	28.9
Iran (Shiraz)(10)	1.73	8.95
China(12)	6.8	7.1
Iran (Bojnourd)(9)	0	10.8
China(46)	1.92	7.67
Iran (Qazvin)(47)*	32.6	47.07

*Myopia was considered when the measured objective refraction was greater than or equal to -0.50 spherical diopters in one or both eyes, hyperopia as ≥0.50 D

While some of this difference may be due to the sampling method or even the method used for cycloplegic refraction, we believe lifestyle changes can be responsible for reduced rates of hyperopia, and increased prevalence of myopia. In recent years, the younger generation is commonly using computers, which causes them to accommodate more than before. This leads to increased axial length of the eye, decreased hyperopia, and a shift of refractive error towards myopia. Therefore, there is concern about the refractive changes in this age group in the coming yr, and we might be facing a myopia epidemic. In addition, we observed a significant difference in the prevalence of hyperopia among different cities in Iran, with rates ranging from 2.54% to 9.61%. There seems

to be two reasons for this: first, economic inequality among cities in Iran and differences in lifestyle, and sec, racial and genetic differences.

Myopia prevalence did not differ significantly between boys and girls in our study. Results of other studies in this age group are conflicting, although in adults; most studies have shown higher prevalence rates of myopia in males (5,6,8-11,34-36). In terms of hyperopia, females were more likely to be hyperopic in this study. This finding is in agreement with most other studies in children, older populations and even the elderly, while few reports contradict this finding (5-7, 18, 20). The main reason for the inter-sex difference in refractive errors seems to be the inter-sex difference in axial length. Females have shorter axial lengths, thus, a higher prevalence of hyperopia is not unexpected (37-39).

In this study, the prevalence of astigmatism was 17.43%, which is high compared to previous studies (9-11,40,41). Since cycloplegic refraction hardly (41) affects astigmatism, this observation cannot be attributed to differences in cycloplegic refraction in different parts of the world. In terms of definition, we followed other studies and used a cutoff point of 0.5 D. Although there is no evidence for this hypothesis, we reiterate that changes in lifestyle and use of computers in recent yr can be responsible. Use of computer devices can cause the corneal surface to dry, which can lead to eye rubbing, and consequently, increased astigmatism.

As demonstrated, the most common type of astigmatism in this study was with-the-rule astigmatism. We already know that astigmatism has an age-related trend such that newborns have against-the-rule astigmatism, and during the first yr of life, it changes to with-the-rule astigmatism, which is the prominent type until adolescence (42). At older ages, since eyelid muscles become weaker, eyelid pressure decreases and astigmatism axis shifts toward against-the-rule (43).

We found significant difference between the two sexes in terms of astigmatism type. Regarding with-the-rule astigmatism was 3% higher in girls, so the difference was statistically significant. Mandel (44) also demonstrated that with-the-rule astigmatism is more common in girls. One of the findings of our study was varied prevalence rates for different types of astigmatism among the studied cities. Possible roles of racial and genetic differences in the prevalence of astigmatism have been discussed. Some studies explain this through differences in the form of the eyelids in different races (42). Nonetheless; we believe diverse climates in Iran can also be an explanation for this finding.

Conclusion

Refractive errors in children seem to be increasing. In this study, one out of every 5 schoolchildren had some refractive error, and astigmatism was most common. In light of the effect of astigmatism on vision, it is very important to correct them in schoolchildren in a timely manner. Improving family awareness about the importance of correcting these errors and promoting screening programs can be effective in identifying these errors and preventing vision impairment. Conducting multicenter studies throughout the Middle East can be very helpful in understanding the current distribution patterns and etiology of refractive errors compared to the previous decade.

Ethical considerations

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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