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Refractive Errors in School-age Children in Qazvin, Iran

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Background: Refractive error remains one of the primary causes of visual impairment among school children all over the world, and its prevalence varies widely.

Objectives: The present study was aimed to determine the prevalence of refractive errors in school children aged 7 to 18 years in Qazvin, Iran.

Patients and Methods: In this cross-sectional study, 11821 students (aged 7 to 18 years) were recruited from different schools. Emmetropia was defined as refractive status between +0.25 and -0.25 D sphere. A -0.50 D or greater spherical considered as myopia, -6.00 D or more as high myopia, and +0.50 D or more as hyperopia, and a cylinder refraction greater than 0.75 D was defined as astigmatism. Visual acuity and refraction of all students were tested. Anterior and posterior segment examination and ocular motility evaluation were also performed to rule out the pathological causes of visual impairments.

Results: The study was performed on 5641 (47.72%) male and 6180 (52.28%) female students. The prevalence of myopia (from 32.96% at the age of 7 to 79.02% at the age of 18 years) significantly increased ($P < 0.001$), and hyperopia significantly decreased (from 47.07% in 7-year- old individuals to 8.32% in 18-year- old subjects) with age ($P < 0.001$). There were significant differences in refractive errors between males and females. Hyperopia and myopia was more common among female in comparison to males ($P < 0.001$). Astigmatism greater than 0.75 D in one or both eyes was found in 990 children (8.37%). Astigmatism increased from 6.04% in 7-year-old students to 9.86% in 15-year-old-students e and then no more difference was found in age group ranged from 15 to 18 years.

Conclusions: Based on our study, the prevalence of myopia is more than other types of refractive error, which is similar to that reported in previous studies on other school-age populations in some Asian countries. The high prevalence of refractive error among school-age children indicated that untreated refractive error is one of the most common public health problems.

Keywords: Refractive Error; Myopia, Hyperopia; School children; Age; Sex

1. Background

The prevalence of refractive error in different age groups has been reported by a number of previous studies. It has been believed that uncorrected refractive error is one of the main causes of treatable visual impairments, and is one of the most common eye disorders in children around world (1). Under corrected refractive errors among school-age children, particularly myopia, is a critical public health problem and is the second leading cause of treatable blindness (2, 3). As refractive errors are the major causes of mild to moderate visual impairment in patients, knowledge about the prevalence of refractive error would be of great help in planning public health strategies (4). Some studies indicated that in children the prevalence of hyperopia decreased and that of myopia significantly increased ($P < 0.001$) by getting older (5-10). In contrast with the increment of myopia with age, some studies reported that the reduction of myopia and increment of hyperopia with aging (11, 12). Among refractive errors, myopia is the most common type of refractive errors among 6 to 12-year-old children (13). Several epidemiologic studies on the prevalence of refractive errors have been conducted in Asia- pacific regions and many other countries.

The prevalence of this disorder in Asian countries varies from 50% in China to 84% in Taiwan and Hong Kong (14-19). The comparison of the prevalence of refractive errors in Malay, Chinese, and Indian children in Malaysia and Singapore indicated that the prevalence of myopia was higher in children in Singapore from all the ethnic groups. Ethnic-specific hyperopia rates did not differ in Singapore and Malaysia (20). The highest prevalence of myopia was found among urban Chinese populations such as Hong Kong, Taiwan, Singapore and Southern China, and the lowest was reported in non-Chinese rural populations such as Nepali and Indians (21-26). In Taiwan, two studies involving school children aged 6 to 18 years

old showed a prevalence of more than 80% by the age of 18 (22), another study in a Japanese student population showed that an overall prevalence of approximately 50% (27). The age-adjusted overall prevalence rates of myopia, hyperopia, astigmatism, and anisometropia (SE difference of +1.0 D) in Indonesia were 26.1%, 9.2%, 18.5%, and 15.1% (95% CI: 12.9-17.4), respectively (1). Anisometropia > 1.00 D was found in 4.6% of primary school children in South Limburg, the Netherlands. The high prevalence of myopia in Chinese and Japanese students was reported (27, 28). Furthermore, 9.8% of children aged 2-6 years, 6.4% of children aged 7-11 years, 3.7% of adolescents, and 2.9% of adults were hyperopic (P = 0.380). The prevalence of myopia in female students (23.6%) was significantly higher in comparison with male ones (14.6%, P = 0.018). The mean prevalence of myopia among 7-year-old individuals increased from 5.8% in 1983 to 21% in 2000 in Taiwan (5). The high prevalence of myopia in Chinese and Japanese population was reported (27, 28). Furthermore, the prevalence of myopia has also increased among young Asian adult populations, as reported in a longitudinal 13-year- study on students aged between 3 and 17 years by Matsumura et al. (29). The progression of myopia was also noted to be more prevalent in older children, and was much higher than those reported in Western countries. In Sumatra, Indonesia, the prevalence of moderate hyperopia was 13.2% among children aged 6 years, and this amount decreased to 5% in 12-year–old individuals; this was more frequent in children with Caucasian ethnicity (15.7% and 6.8%, respectively) than those from ethnic groups (30).

The prevalence of myopia in Europe seems to be slightly lower than in Asian countries (19). That was reported to be 36.8% among Greek students aged 15 to 18 years old (31). In Germany, similar to other countries, the prevalence of myopia increased with age, it was 0% in children aged 2-6 years, 5.5% in children aged 7-11 years, 21.0% in adolescents (aged 12-17 years) and 41.3% in adults aged 18-35 years (32). Among US population, aged 12 to 54 years this was estimated to be significantly higher in 1999-2004 than those reported in 1971-1972 (41.6% and 25.0%, respectively; P < 0.001) (33). Among the students in Northeast Brazil, hyperopia was the most common refractive errors with 71%, followed by astigmatism (34%) and myopia (13.3%) (34).

2. Objectives

The aim of our study was to determine the prevalence of refractive errors among school-age children in Qazvin province, Iran.

3. Patients and Methods

In this cross-sectional study, school children aged 7 to 18 years old recruited from 20 primary schools and 10 high schools using random cluster-sampling method, from September 2003 and May 2010. Students were invited by school authority to refer to Eye Clinic of Bouali Hospital in Qazvin city. There are two big educational areas in Qazvin province (area 1 and 2) with 2209 primary, secondary and high schools with 222713 students. We selected mentioned schools with no consideration on the students' social and economic position. Only schools with mentally disabled children were excluded from the selection. In this study, 1329 out of 13150 eligible students were excluded from the study because of various reasons such as refusing to participate in the eye examinations, pathological conditions and, inability to continue the examination (10). Therefore, 11821 students were entered to this study. Parents and children were asked to fill out a questionnaire about the history of their refractive errors and spectacle uses (24). Children who were unwilling to undergo the examination due to fear, sickness or those who were under medication for some other reasons; having ocular effect were excluded from this study (35). All subjects underwent a complete ophthalmic examination. Parents or legal guardians signed an informed consent, and expressed that they did not have no history of systematic cardiovascular or nervous diseases, such as congenital heart diseases, hypoxic-ischemic encephalopathy, and learning difficulties (10).

Distance visual aquity (VA) was assessed for each eye separately using a log minimum angle of resolution 9 (MAR) chart with and without any spectacle correction, if worn. In the cases of poor vision or failure in measuring the visual acuity with the normal chart, the following tests were used sequentially: counting fingers, hand movements, and light perception (36). Dry refraction and cycloplegic auto refraction were tested on all children less than 15 years of age. The cycloplegia induced by administering, one drop of 1% Cyclopentolate eye drop instilled twice at a 5-minute intervals, and at least 35 minutes after the last drop, the cycloplegic refraction was tested using streak retinoscopy, and one of two auto refractors (Canon, Nidek) (37), because this method of examination provides more reliable measurements in young children (35).

Then subjective refraction was performed to achieve best corrected visual acuities, along with refractive error under cycloplegia (38) for students when best corrected visual acuity was not achieved to 20/20 (39).

Also to rule out the pathological causes of visual impairment, anterior and posterior segment examinations, identification of amblyopia, and ocular motility evaluation, were measured. A cover test was performed to detect the strabismus (40). The data collectors were medical students and an experienced, qualified optometrist from the Department of Qazvin Medical Sciences (41). Parents were asked for permission to use their child's hospital records if needed. Other data, including sociodemographic information (ethnicity, parental education, employment, and home ownership) and the time that the child devotes to near work and outdoor activities were also obtained in parent questionnaires. The 12-year-old and older children completed a separate questionnaire, in which similar questions about time spent in near-work and outdoor

Table 1. Distribution of Refractive Error [a]

Age, y	Myopia	Hyperopia	Astig	Amblyopia	Total
7	180 (32.96)	257 (47.07)	33 (6.04)	76 (13.92)	546
8	220 (40.5)	240 (44.2)	35 (6.45)	48 (8.84)	543
9	380 (51.98)	226 (30.92)	58 (7.93)	67 (9.17)	731
10	430 (58.74)	192 (26.23)	60 (8.2)	50 (6.83)	732
11	640 (64.2)	200 (20.01)	84 (8.43)	73 (7.32)	997
12	560 (62.57)	210 (23.46)	86 (9.61)	39 (4.36)	895
13	584 (63.83)	217 (23.72)	69 (7.54)	45 (4.92)	915
14	753 (67.9)	169 (15.23)	106 (9.58)	81 (7.3)	1109
15	834 (71.53)	152 (13.04)	115 (9.86)	65 (5.57)	1166
16	1006 (75.19)	142 (10.61)	118 (8.82)	72 (5.38)	1338
17	1090 (78.14)	130 (9.32)	110 (7.89)	65 (4.66)	1395
18	1149 (79.02)	121 (8.32)	116 (7.98)	68 (4.68)	1454
Total	7826 (66.2)	2256 (19.8)	990 (8.37)	749 (6.34)	11821

[a] Data are presented as No. (%).

Table 2. Distribution of Visual Impairment For Age Groups of 7 to 18 Aged and Gender [a]

Refractive Errors	Male	Female	Total
Myopia	3733 (47.7)	4093 (52.3)	7826 (66.2)
Hyperopia	1093 (48.45)	1163 (51.55)	2256 (19.08)
Astig	480 (48.48)	510 (51.52)	990 (8.37)
Amblyopia	335 (44.73)	414 (55.27)	749 (6.34)
Anisometropia	355 (55)	289 (45)	644 (5.45)

[a] Data are presented as No. (%).

activity were included (25). Activities included outdoor leisure activities, watching television/videos, near-work activity such as reading for pleasure, using a computer, and playing console games were recorded.

Analysis was performed using the Statistical Package for Social Science (SPSS Inc. Chicago, USA). Spherical equivalent refraction (SER) was calculated as the numerical sum of the sphere and half of the cylinder. Emmetropia was defined as refractive status between +0.25 D and -0.25 D Sphere. 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 $\geq$ 0.50 D and astigmatism was considered to be significant if it was $\geq$ 0.75 D. The chosen cut off values for myopia (0.50 D or less) is similar in the literature (42-44). Anisometropia was defined as difference of SER of 1.00 D or more between the two eyes.

4. Results

From total of 13150 eligible school children, 11821 (89.9%) cases responded to the study. The age group ranged from 7 to 18 years, with the mean age of 12.5 ± 3.61 years including 6180 (52.28%) females and 5641 (47.72%) males. The prevalence of myopia differed significantly in all age groups (32.96% in children aged 7 years, 58.74% in children aged $\leq$ 10 years, 67.9% in children aged $\leq$ 14 years and 79.02% in children aged $\leq$ 18 years) (Pearson's Chi-square, P $\leq$ 0.0001). Furthermore, the prevalence of hyperopia differed in all groups: 47.07% of children aged 7 years, 26.23% of children aged 10 years, 15.23% in children aged 14 years, and 8.23% in children aged 18 years were hyperopia (Table 1).

The prevalence of myopia in females (52.28%) was significantly higher than in males 47.72%, (P = 0.018). The reduced visual acuity was observed because of refractive errors. In a total of 11821 subjects, myopia was detected in 7826 cases (66.2%), hypermetropia in 2256 (19.08%), astigmatism in 990 (8.37%), and amblyopia in 749 cases (6.34%). Out of total myopia, high myopia (-6.00 D or more) was in 550 (4.65%), of all refractive errors, anisometropia was in 644 (5.45%), (Table 2)

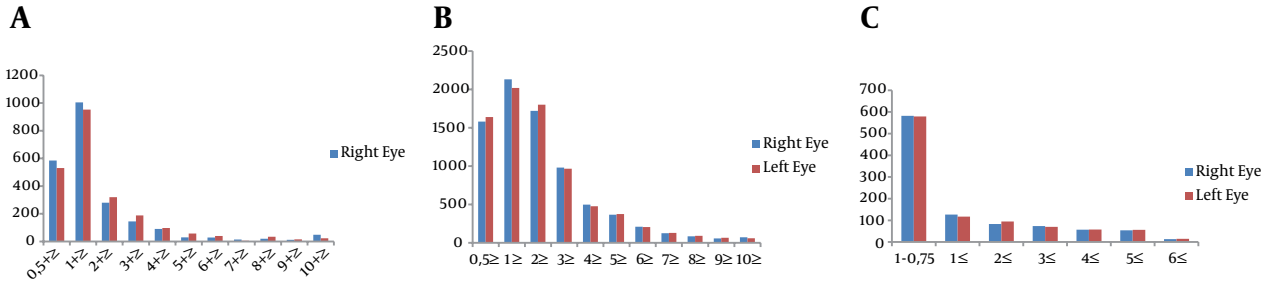
The prevalence of emmetropia and hyperopia significantly decreased with age (P < 0.001), and the prevalence of myopia and high myopia significantly increased with age (P < 0.001). In 7- year-old group, hyperopia had the most prevalence (47.07%), followed by myopia (32.96%), and astigmatism (6.04%). This distribution was changed in the 18- year-old age group, myopia (79.02%), followed by hyperopia (8.32%), and astigmatism (7.98%). Among all the participants with astigmatism (cylindrical error greater than 0.75 DC), 290 subjects (29.29%) had with-the-rule (WTR), 530 (53.54%) against-the-rule (ATR) astigmatism, and 170 (17.17%) oblique astigmatism. The prevalence of WTR and ATR astigmatism significantly increased with age (P < 0.001). Astigmatism increased from 6.04% in children aged 7 years to 9.86% in those 15 years of age and then no more difference was found in age group ranged from 15 to 18 years. Refractive error was detected in 11821 students and myopia was the most common type of refractive detected in 7826 students, contributing more than 66.2% of the refractive errors. Hyperopia was detected in 2256 students (19.8%), followed by astigmatism (cylinder power of 0.75 D or worse) in 990 (8.37%) of students (Table 3). Table 3 shows the distribution of hyperopia and myopia between 0.50 D and 10.00 D or greater, and astigmatism between 0.75 D and 6.00 D or greater in students aged 7 to 18 years. In hyperopia, myopia and astigmatism of right and left eyes, distribution of ± 2.00 D or less was more prevalent in those categorized in Table 3.

Table 3. Distribution of Types of Refractive Errors in School-Age Children in Qazvin, Iran [a,b]

Hyperopia (Spherical ≥ +0.5 D)			Myopia (Spherical ≤ 0.5 D)			Astigmatism (Cylindrical ≥ 0.75)		
Diopter	**RE**	**LE**	**Diopter**	**RE**	**LE**	**Diopter**	**RE**	**LE**
≥ +0.5	585 (25.93)	530 (23.49)	≤ 0.5	1580 (20.19)	1640 (20.96)	0.75-1	582 (58.79)	579 (58.48)
≥ +1	1004 (44.5)	952 (42.2)	≤ 1	2130 (27.22)	2019 (25.8)	≥ 1	127 (12.83)	117 (11.82)
≥ +2	280 (12.41)	320 (14.18)	≤ 2	1720 (21.98)	1800 (23)	≥ 2	83 (8.38)	95 (9.6)
≥ +3	145 (6.41)	188 (8.33)	≤ 3	981 (1255)	965 (12.33)	≥ 3	74 (7.47)	70 (7.07)
≥ +4	90 (3.99)	97 (4.3)	≤ 4	498 (6.36)	477 (6.09)	≥ 4	57 (5.75)	58 (5.86)
≥ +5	30 (1.33)	57 (2.53)	≤ 5	366 (4.68)	375 (4.79)	≥ 5	54 (5.45)	56 (5.66)
≥ +6	28 (1.24)	39 (1.73)	≤ 6	210 (2.68)	205 (2.62)	≥ 6	13 (1.31)	15 (1.52)
≥ +7	14 (0.62)	5 (0.22)	≤ 7	125 (1.6)	130 (1.66)	-	-	-
≥ +8	20 (0.89)	34 (1.51)	≤ 8	85 (1.09)	90 (1.15)	-	-	-
≥ +9	12 (0.53)	15 (0.66)	≤ 9	58 (0.74)	65 (0.83)	-	-	-
≥ +10	48 (2.13)	23 (1.02)	≤ 10	72 (0.92)	60 (0.77)	-	-	-
Total	2256 (100)	2256 (100)	total	7826 (100)	7826 (100)	total	990 (100)	990 (100)

[a] Abbreviations: LE, left eye; RE, right eye.
[b] Data are presented as No. (%).

Figure 1. Distribution of Refractive Error Types



Hypermetropia A, myopia; B, astigmatism; C, in school-age children of Qazvin Iran.

5. Discussion

To our best of knowledge, this is one of the largest cross-sectional studies examining the prevalence of refractive errors in primary and high school students in Iran. Students with a mean age of 12.5 ± 3.61 years were randomly cluster selected from all over Qazvin province from different academic and socioeconomic backgrounds. In our study, myopia was the most common type of refractive errors among children aged 7 to 18 years, comprised 66.2% of all the errors, followed by hypermetropia (19.8%), astigmatism (8.37%) and amblyopia in 749 subjects (6.34%). This observation was similar to the study on Swedish children age of 12-13 years in which the prevalence of myopia was 49%.These values are consistently lower than our findings (45). The distributions of refractive frequency in various age groups displayed a clear change, the prevalence of hyperopia significantly decreased and the prevalence of myopia increased (10). It has been reported a prevalence of myopia of 11.6% for children aged 5 to 17 years and 20% for children aged 12 years and increased to 33% for those aged ≥ 20 years (46-48), and in study on 2353 Austeralian students aged 11-15-years old, the prevalence of myopia was 4.6% and this amount was 6.1% among European Caucasian and Middle Eastern children respectively, whereas prevalence of myopia was 31.5% among South Asian children (49). Similar to our findings, the increasing prevalence of myopia with age was observed in the population-based studies in some countries such as Taiwan (5), Australia (6), Singapore (7), Malaysia (13), and Indonesia (50). The prevalence of myopia and high myopia in our study was 66.2% and 4.65%, respectively, which significantly increased with age (from 32.96% in 7-year-old children to 79.02 in 18-year-old ones). These findings are in contrast with other population-based studies from different parts of the world that reported a decreasing trend of myopia with age, in countries such as India, hypermetropia was the commonest refractive error among children, that is accounted for 23% of all errors followed by astigmatism with myopia (12), and in primary schools in Kampala, Astigmatism was the most frequent refractive error, accounting for 52% of all the errors, followed by hyperopia, and myopia, respectively (36). In Northeast Brazil hyperopia was the most common type of refractive errors with a prevalence of 71%, followed by astigmatism (34%) and myopia (13.3%) (30). These results are in con-

trast with previous publications, mainly from the orient, where myopia is always considered as the most common refractive error among students (30).

In Asia the prevalence of myopia has the highest rate in comparison to the other countries of the world. For example Hong Kong has one of the highest incidence of myopia in the world, and it is likely that both the rate and severity of myopia will increase over the time (21). Similar trends are observed among Iran's East Asian neighbors, which causes important medical, social, and public health concerns (21-26). Several factors could interfere with the prevalence of myopia. In addition to heredity that influences the prevalence of myopia, which is believed as the most important associated factor to juvenile myopia, several other environmental factors could also be responsible for the increasing myopia among school-age children (especially among those with family history of myopia) such as; sleeping on night lighting (51), computer vision syndrome (52), and UV exposure (53).

The prevalence rates of amblyopia in this study were slightly different from the results of epidemiological studies from other countries. In studies on Singaporean 30 to 72-month old children, 7-year- old children in the United Kingdom and Australian children aged 6 years; the prevalence of amblyopia was 1.19%, 3.6% and 0.7%, respectively (54-56). The reported prevalence of amblyopia in a questionnaire-based study on Japanese children aged between 1.5 and 12 years was between 0% to 0.2% and this amount in Korean children aged 3 to 5 years was 0.4% of the 43% who responded (57-59). Amblyopias was detected in Taiwan in approximately 5% of 625 preschool children and in 3% of 4368 Guangzhou children, aged 5 to 15 years (24, 60). It was concluded that the high prevalence of ocular blindness among primary and high school children was observed in school children and refractive errors are the most common ocular disorders. Finally, the aim of all programs for controlling the blindness should be to publicizethe public awareness about eye care and to teach the essentials of eye healthcare (61).

In this study the overall prevalence of refractive errors and progression of myopia among school-age children were 66.2% for myopia, 19.8% for hyperopia, and 8.37% for astigmatism. The prevalence of myopia in this study was slightly higher than previous studies in other countries. The large increase in prevalence of myopia reported in all studies may be affected by several factors including the environmental factors and also the genetic features.

The results of the present study represents that patients in adolescent age group are at high risk for visual impairment especially myopia. Therefore, visual screening at the pre-school and school ages should be performed periodically. This could be useful in detecting the correctable causes of decreased vision especially refractive errors and eventually leading to improvement level of students, education. In addition, children at these ages and their parents should be educated about the signs and symptoms of refractive errors, ocular hygiene and also the risk factors involved in the development of these errors and other ocular pathological problems. Uncorrected refractive errors are the potential causes of learning difficulties and may limit the choices children make in their daily activities. New policies are needed to be developed to address this public health problem (46). Suggesting that we should develop preventive strategies and also develop approaches towards early treatments of these sorts of visual disabilities.

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References

1. Saw SM, Gazzard G, Koh D, Farook M, Widjaja D, Lee J, et al. Prevalence rates of refractive errors in Sumatra, Indonesia. *Invest Ophthalmol Vis Sci.* 2002;**43**(10):3174–80.
2. Alam H, Siddiqui MI, Jafri SI, Khan AS, Ahmed SI, Jafar M. Prevalence of refractive error in school children of Karachi. *J Pak Med Assoc.* 2008;**58**(6):322–5.
3. AL-Nuaim A. Elsayed Salama. R, Eldeen Eljack.I. Study of Refractive Errors among School Children in Doha. *Fam Pract.* 2010;**8**(7):22–44.
4. Raju P, Ramesh SV, Arvind H, George R, Baskaran M, Paul PG, et al. Prevalence of refractive errors in a rural South Indian population. *Invest Ophthalmol Vis Sci.* 2004;**45**(12):4268–72.
5. Lin LL, Shih YF, Hsiao CK, Chen CJ. Prevalence of myopia in Taiwanese schoolchildren: 1983 to 2000. *Ann Acad Med Singapore.* 2004;**33**(1):27–33.
6. Rose K, Smith W, Morgan I, Mitchell P. The increasing prevalence of myopia: implications for Australia. *Clin Experiment Ophthalmol.* 2001;**29**(3):116–20.
7. Saw SM, Tong L, Chua WH, Chia KS, Koh D, Tan DT, et al. Incidence and progression of myopia in Singaporean school children. *Invest Ophthalmol Vis Sci.* 2005;**46**(1):51–7.
8. 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**(3):242–8.
9. Goh PP, Abqariyah Y, Pokharel GP, Ellwein LB. Refractive error and visual impairment in school-age children in Gombak District, Malaysia. *Ophthalmology.* 2005;**112**(4):678–85.
10. Pi LH, Chen L, Liu Q, Ke N, Fang J, Zhang S, et al. Refractive status and prevalence of refractive errors in suburban school-age children. *Int J Med Sci.* 2010;**7**(6):342–53.
11. Montes-Mico R, Ferrer-Blasco T. Distribution of refractive errors in Spain. *Doc Ophthalmol.* 2000;**101**(1):25–33.
12. Kalikivayi V, Naduvilath TJ, Bansal AK, Dandona L. Visual impairment in school children in southern India. *Indian J Ophthalmol.* 1997;**45**(2):129–34.
13. Hashim SE, Tan HK, Wan-Hazabbah WH, Ibrahim M. Prevalence of refractive error in malay primary school children in suburban area of Kota Bharu, Kelantan, Malaysia. *Ann Acad Med Singapore.* 2008;**37**(11):940–6.
14. Lin LL, Shih YF, Lee YC, Hung PT, Hou PK. Changes in ocular refraction and its components among medical students--a 5-year longitudinal study. *Optom Vis Sci.* 1996;**73**(7):495–8.
15. Lam CS, Goldschmidt E, Edwards MH. Prevalence of myopia in local and international schools in Hong Kong. *Optom Vis Sci.* 2004;**81**(5):317–22.
16. Khalaj M, Gasemi MR, Mohammadi ZI. Prevalence of Refractive Errors in Primary School Children [7-15 Years] of Qazvin City. *Eur J Sci Res.* 2009;**28**:174–85.
17. Zhan MZ, Saw SM, Hong RZ, Fu ZF, Yang H, Shui YB, et al. Refractive errors in Singapore and Xiamen, China--a comparative study in school children aged 6 to 7 years. *Optom Vis Sci.* 2000;**77**(6):302–8.

18. Arnold RW, Ruben J, Donahue SP. Korean kindergarten vision screen programme. *Br J Ophthalmol.* 2005;**89**(3):392–3.
19. Saw SM, Gazzard G, Shih-Yen EC, Chua WH. Myopia and associated pathological complications. *Ophthalmic Physiol Opt.* 2005;**25**(5):381–91.
20. Saw SM, Goh PP, Cheng A, Shankar A, Tan DT, Ellwein LB. Ethnicity-specific prevalences of refractive errors vary in Asian children in neighbouring Malaysia and Singapore. *Br J Ophthalmol.* 2006;**90**(10):1230–5.
21. Fan DS, Lam DS, Lam RF, Lau JT, Chong KS, Cheung EY, et al. Prevalence, incidence, and progression of myopia of school children in Hong Kong. *Invest Ophthalmol Vis Sci.* 2004;**45**(4):1071–5.
22. Lin LL, Shih YF, Tsai CB, Chen CJ, Lee LA, Hung PT, et al. Epidemiologic study of ocular refraction among schoolchildren in Taiwan in 1995. *Optom Vis Sci.* 1999;**76**(5):275–81.
23. Wu HM, Seet B, Yap EP, Saw SM, Lim TH, Chia KS. Does education explain ethnic differences in myopia prevalence? A population-based study of young adult males in Singapore. *Optom Vis Sci.* 2001;**78**(4):234–9.
24. 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**(3):793–9.
25. Pokharel GP, Negrel AD, Munoz SR, Ellwein LB. Refractive Error Study in Children: results from Mechi Zone, Nepal. *Am J Ophthalmol.* 2000;**129**(4):436–44.
26. Dandona R, Dandona L, Srinivas M, Sahare P, Narsaiah S, Munoz SR, et al. Refractive error in children in a rural population in India. *Invest Ophthalmol Vis Sci.* 2002;**43**(3):615–22.
27. Hosaka A. Population studies--myopia experience in Japan Acta Ophthalmol 1988,Prevalence Rates of Refractive Errors in Sumatra, Indonesia. *Invest Ophthalmol Vis Sci.* 2002;**43**:3174–80.
28. Saw SM, Katz J, Schein OD, Chew SJ, Chan TK. Epidemiology of myopia. *Epidemiol Rev.* 1996;**18**(2):175–87.
29. Matsumura H, Hirai H. Prevalence of myopia and refractive changes in students from 3 to 17 years of age. *Surv Ophthalmol.* 1999;**44 Suppl 1**:S109–15.
30. Ip JM, Robaei D, Kifley A, Wang JJ, Rose KA, Mitchell P. Prevalence of hyperopia and associations with eye findings in 6- and 12-year-olds. *Ophthalmology.* 2008;**115**(4):678–685 e1.
31. Mavracanas TA, Mandalos A, Peios D, Golias V, Megalou K, Gregoriadou A, et al. Prevalence of myopia in a sample of Greek students. *Acta Ophthalmol Scand.* 2000;**78**(6):656–9.
32. Jobke S, Kasten E, Vorwerk C. The prevalence rates of refractive errors among children, adolescents, and adults in Germany. *Clin Ophthalmol.* 2008;**2**(3):601–7.
33. Vitale S, Sperduto RD, Ferris FL, 3rd. Increased prevalence of myopia in the United States between 1971-1972 and 1999-2004. *Arch Ophthalmol.* 2009;**127**(12):1632–9.
34. Garcia CA, Orefice F, Nobre GF, Souza Dde B, Rocha ML, Vianna RN. [Prevalence of refractive errors in students in Northeastern Brazil]. *Arq Bras Oftalmol.* 2005;**68**(3):321–5.
35. Kawuma M, Mayeku R. A survey of the prevalence of refractive errors among children in lower primary schools in Kampala district. *Afr Health Sci.* 2002;**2**(2):69–72.
36. Vijaya L, George R, Arvind H, Baskaran M, Raju P, Ramesh SV, et al. Prevalence and causes of blindness in the rural population of the Chennai Glaucoma Study. *Br J Ophthalmol.* 2006;**90**(4):407–10.
37. 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**(4):364–9.
38. Negrel AD, Maul E, Pokharel GP, Zhao J, Ellwein LB. Refractive Error Study in Children: sampling and measurement methods for a multi-country survey. *Am J Ophthalmol.* 2000;**129**(4):421–6.
39. Bataineh HA, Khatatbeh AE. Prevalence of Refractive Errors in School Children (12-17 Years) of Tafila City. *Rawal Med J.* 2008;**33**:85–7.
40. Ojaimi E, Rose KA, Smith W, Morgan IG, Martin FJ, Mitchell P. Methods for a population-based study of myopia and other eye conditions in school children: the Sydney Myopia Study. *Ophthalmic Epidemiol.* 2005;**12**(1):59–69.
41. Kassa T, Alene GD. Prevalence of refractive errors in pre-school and school children of Debark and Kola Diba towns, North-western Ethiopia. Ethiop. *Health Dev.* 2002;**17**(2):117–24.
42. Midelfart A, Kinge B, Midelfart S, Lydersen S. Prevalence of refractive errors in young and middle-aged adults in Norway. *Acta Ophthalmol Scand.* 2002;**80**(5):501–5.
43. Guggenheim JA, Hill C, Yam TF. Myopia, genetics, and ambient lighting at night in a UK sample. *Br J Ophthalmol.* 2003;**87**(5):580–2.
44. Fledelius HC. Is myopia getting more frequent? A cross-sectional study of 1416 Danes aged 16 years+. *Acta Ophthalmol (Copenh).* 1983;**61**(4):545–59.
45. Villarreal MG, Ohlsson J, Abrahamsson M, Sjostrom A, Sjostrand J. Myopisation: the refractive tendency in teenagers. Prevalence of myopia among young teenagers in Sweden. *Acta Ophthalmol Scand.* 2000;**78**(2):177–81.
46. Kleinstein RN, Jones LA, Hullett S, Kwon S, Lee RJ, Friedman NE, et al. Refractive error and ethnicity in children. *Arch Ophthalmol.* 2003;**121**(8):1141–7.
47. Zadnik K. The Glenn A. Fry Award Lecture (1995). Myopia development in childhood. *Optom Vis Sci.* 1997;**74**(8):603–8.
48. Vitale S, Ellwein L, Cotch MF, Ferris FL, 3rd, Sperduto R. Prevalence of refractive error in the United States, 1999-2004. *Arch Ophthalmol.* 2008;**126**(8):1111–9.
49. Ip JM, Huynh SC, Robaei D, Kifley A, Rose KA, Morgan IG, et al. Ethnic differences in refraction and ocular biometry in a population-based sample of 11-15-year-old Australian children. *Eye (Lond).* 2008;**22**(5):649–56.
50. Hendricks TJ, de Brabander J, Vankan-Hendricks MH, van der Horst FG, Hendrikse F, Knottnerus JA. Prevalence of habitual refractive errors and anisometropia among Dutch schoolchildren and hospital employees. *Acta Ophthalmol.* 2009;**87**(5):538–43.
51. Tonks A. Children who sleep with light on may damage their sight. *BMJ.* 1999;**318**(7195):1369A.
52. Barar A, Apatachioaie ID, Apatachioaie C, Marceanu-Brasov L. [Ophthalmologist and "computer vision syndrome"]. *Oftalmologia.* 2007;**51**(3):104–9.
53. Spierer A, Rosner M, Belkin M. Pterygium, solar ultraviolet radiation and myopia. *Metab Pediatr Syst Ophthalmol.* 1985;**8**(2-3):47–8.
54. Chia A, Dirani M, Chan YH, Gazzard G, Au Eong KG, Selvaraj P, et al. Prevalence of amblyopia and strabismus in young singaporean chinese children. *Invest Ophthalmol Vis Sci.* 2010;**51**(7):3411–7.
55. Williams C, Northstone K, Howard M, Harvey I, Harrad RA, Sparrow JM. Prevalence and risk factors for common vision problems in children: data from the ALSPAC study. *Br J Ophthalmol.* 2008;**92**(7):959–64.
56. Robaei D, Rose KA, Ojaimi E, Kifley A, Martin FJ, Mitchell P. Causes and associations of amblyopia in a population-based sample of 6-year-old Australian children. *Arch Ophthalmol.* 2006;**124**(6):878–84.
57. Matsuo T, Matsuo C. Comparison of prevalence rates of strabismus and amblyopia in Japanese elementary school children between the years 2003 and 2005. *Acta Med Okayama.* 2007;**61**(6):329–34.
58. Matsuo T, Matsuo C, Matsuoka H, Kio K. Detection of strabismus and amblyopia in 1.5- and 3-year-old children by a preschool vision-screening program in Japan. *Acta Med Okayama.* 2007;**61**(1):9–16.
59. Lim HT, Yu YS, Park SH, Ahn H, Kim S, Lee M, et al. The Seoul Metropolitan Preschool Vision Screening Programme: results from South Korea. *Br J Ophthalmol.* 2004;**88**(7):929–33.
60. Lai YH, Hsu HT, Wang HZ, Chang SJ, Wu WC. The visual status of children ages 3 to 6 years in the vision screening program in Taiwan. *J AAPOS.* 2009;**13**(1):58–62.
61. Gupta M, Gupta BP, Chauhan A, Bhardwaj A. Ocular morbidity prevalence among school children in Shimla, Himachal, North India. *Indian J Ophthalmol.* 2009;**57**(2):133–8.