

## Original Article

# Importance of Including Refractive Error Tests in School Children's Vision Screening

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## Abstract

**Background:** This study determined the importance of including tests for refractive errors in vision screening.

**Methods:** In this cross-sectional study, we performed a random cluster sampling of schoolchildren in the city of Dezful, Iran. After sampling and obtaining informed written consents from their parents, children underwent examinations at the school sites. Students underwent tests of visual acuity, cover tests and cycloplegic refractions. Elementary and middle school students who had a visual acuity of 20/20 or better in both eyes were included in the study.

**Results:** From 3673 elementary and middle school students, 2957 (80.5%) had 20/20 vision or better. Of these, 16.1% [95% confidence interval (CI): 14.8 – 17.4] were ametropic, 0.4% had myopia and 10.1% had hyperopia. Mean sphere in those with hyperopia was +2.6±0.7 (range: +2.0 to +7.28) diopter (D). Astigmatism was detected in 6.6% and the mean cylinder was -0.9 (range: -0.75 to -3.25) D. The rate of anisometropia was 1.5% (95% CI: 0.8 – 2.0).

**Conclusion:** Screening results of 20/20 vision for schoolchildren does not necessarily indicate normal eye status because hyperopia and astigmatism may still be sources of visual discomfort. To identify these cases and increase the sensitivity of screening tests, measurement of refractive errors by cycloplegic refraction tests might be included in vision screening.

**Keywords:** refractive error, schoolchildren, vision screening

## Introduction

The importance of normal vision in children has led to vision screening initiatives worldwide with governmental support. Amblyopia is one of the most common visual problems in children and an important target in vision screening programs.<sup>1-3</sup> Amblyopia, as one of the most important causes of unilateral visual impairment, is seen in the elderly worldwide.<sup>4,5</sup> After amblyopia, strabismus is the second most important focus of attention in screening programs.<sup>6</sup> Objective and subjective tests are performed to diagnose these two conditions in kindergartens and primary schools. Testing visual acuity by E charts and subjective tests such as the cover test are among the most common tests of vision screening.<sup>7,8</sup> A review of the relevant literature shows that these tests are of different sensitivity and specificity rates.<sup>3, 9-12</sup> In Iran, a study on Dezful, Khuzestan Province<sup>13</sup> schoolchildren showed a sensitivity of 25% for these screening tests while some studies have reported sensitivity rates up to 100%.<sup>12,14</sup> Statistics in children show that amblyopia and strabismus are less prevalent in comparison to refractive errors.<sup>15-17</sup> Vision screening of students from Baltimore (USA) and South Korea have revealed that refractive errors were more prevalent than amblyopia and strabismus.<sup>2,18</sup> The importance of childhood amblyopia,<sup>19</sup> because of early treat-

ability,<sup>20</sup> should not be underestimated; nonetheless, refractive errors in children can affect their educational performance as well as psychological health.<sup>21,22</sup> As a result it is expected that refractive errors, as one of the most common cause of visual disorders in children, should be tested in all screening programs. Nevertheless, there are reports that in some countries, screening is still done in its traditional form through Snellen charts and alignment tests.<sup>12,23</sup> The aim of the current report is to demonstrate and emphasize the necessity of including tests of refractive error measurement in vision screening.

## Materials and Methods

The current study is part of the refractive errors study on Dezful schoolchildren, reports of which have already been published.<sup>24</sup> This cross-sectional study was undertaken on Dezful schoolchildren between February 2004 and March 2005. Samples were selected through random cluster sampling among 83250 Dezful schoolchildren during the 2004 – 2005 academic year. Among 460 Dezful schools, 39 schools (clusters) were randomly selected after receiving necessary permits from the Dezful Department of Education.

### Examinations

For all students, visual acuity without correction, with correction, and with their glasses (if applicable), as well as objective refraction with an autorefractometer (Topcon KR 8000) were performed. Ocular movements were tested through the cover test. Additionally, the cycloplegic refraction test was also performed in elementary and middle school students after the administration of 3 drops of cyclopentolate. Subjective refraction and best corrected visual acuity (BCVA) tests were done for all students whose uncorrected visual acuity (UCVA) was worse than 20/20.

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## Definitions

We used the spherical equivalent to assess and compare the amount of refractive errors. Myopia was defined as a spherical equivalent of  $-0.5$  diopter (D) or less, hyperopia was defined as a spherical equivalent of  $+2.0$  D or more and astigmatism was defined as a cylinder error of  $0.75$  D or more recorded with a minus sign. Anisometropia was defined as a spherical equivalent difference of  $1.0$  D or more between the two eyes. Ametropia was defined as a person who had at least one eye with refractive error. In the present study, findings were presented in participants with normal vision (visual acuity of 20/20 in both eyes without tropia) and those with impaired vision.

## Statistical analysis

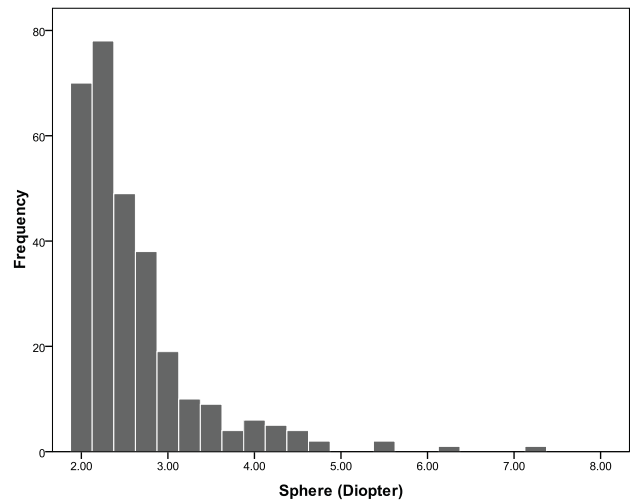
Prevalence rates of refractive errors were determined as percentages with their 95% confidence intervals (CI). Normal distribution was used to calculate 95% CI. In cases of low proportion that did not follow the normal distribution, binominal distribution was used. All values were directly standardized according to the population structure of Dezfoul schoolchildren in terms of gender and grade. Logistic regression was used to evaluate the association of the variables.

## Results

Out of 3673 elementary and middle school students, 9 were excluded because their visual acuity was not measured. Also excluded were another 183 students who missed the cycloplegic refraction tests. Included in this study were the remaining 3481 individuals from the original study. Of these, 1598 (45.9%) were boys and 1883 (54.1%) were girls. The mean age of the students was  $10.7 \pm 2.3$  years (6 to 17).

Of these, 682 (19.6%) students had refractive errors, out of which 433 students had normal vision. Of students with refractive errors and normal vision, 411 (94.9%), 22 (5.1%), and 11 (2.5%) students had hyperopia, myopia and astigmatism, respectively. Glasses were prescribed for 16.6% ( $n=557$ ) of the students.

Of the participants, 2957 students had a visual acuity of 20/20 in both eyes without tropia. The study findings showed that 16.1% (95% CI: 14.8 – 17.4) of these students were ametropic. Table 1 shows the prevalence of ametropia and other refractive errors in the students based on age. Ametropia tends to decrease with age ( $P=0.002$ ).



**Figure 1.** The distribution of spherical error in schoolchildren with 20/20 vision and hyperopia  $\geq 2$  diopter.

Myopia was diagnosed in 0.4% of the students and the mean SE in myopic students was  $-0.8$  ( $-0.5$  to  $-1.9$ ). No significant correlation was found between myopia and age ( $P=0.293$ ). As Table 1 shows, the prevalence of hyperopia was 10.1%, which decreased in a non-linear fashion with age ( $P=0.043$ ). Mean spherical error of the subjects with hyperopia was  $2.60.7 \pm$  (range: 2.0 – 7.25) D. Figure 1 demonstrates the sphere distribution in subjects with hyperopia.

Astigmatism was seen in 6.6% of subjects with a slight difference among different age groups ( $P=0.055$ ). The mean cylinder of the subjects was  $-0.9$  (range:  $-0.75$  to  $-3.25$ ) D. The prevalence of anisometropia was 1.5% (95% CI: 0.8 – 2.0).

Five hundred and twenty four students did not have a visual acuity of 20/20 in both eyes and their findings are presented in this report as a separate group. The prevalence of myopia and hyperopia was 16.9% (95% CI: 13.6 – 20.2) and 22.4% (95% CI: 18.8 – 26.1) in these students, respectively. The odds of myopia in individuals with normal vision was 58.8 times less than people with impaired vision although the chance of hyperopia was 2.6 times more in these individuals. In these students, the prevalence of astigmatism was 51.9% (95% CI: 47.5 – 56.3). Totally, 69.9% (95% CI: 65.9 – 73.9) of these students were ametropic and the odds of being ametropic was 12 times more in these students compared to individuals with normal vision.

**Table 1.** Prevalence of ametropia and refractive errors in schoolchildren with 20/20 vision expressed in percentages (95% CI).

Age	n	Myopia	Hyperopia	Astigmatism	Ametropia
$\leq 7$	323	0	15.8 (11.8–19.8)	6.8 (4.0–9.6)	21.1 (16.6–25.5)
8	345	0.6 (0.1–2.1)	14.5 (10.8–18.2)	7.5 (4.7–10.3)	20.9 (16.6–25.2)
9	298	0.3 (0–1.9)	11.1 (7.5–14.7)	9.1 (5.8–12.3)	17.8 (13.4–22.2)
10	382	0.8 (0.2–2.3)	6.5 (4.1–9.0)	7.9 (5.1–10.6)	14.7 (11.1–18.2)
11	425	0.5 (0.1–1.7)	6.4 (4.0–8.7.0)	8.5 (5.8–11.1)	14.8 (11.4–18.2)
12	396	0.3 (0.0–1.4)	11.9 (8.7–15.1)	6.1 (3.7–8.4)	17.4 (13.7–21.2)
13	415	0.5 (0.1–1.7)	9.2 (6.4–11.9)	3.4 (1.6–5.1)	13.0 (9.8–16.3)
$\geq 14$	373	0	7.2 (4.6–9.9)	4.0 (2.0–6.0)	11.0 (7.8–14.2)
Male	1371	0.3 (0.1–0.7)	9.4 (7.9–11.0)	7.0 (5.6–8.4)	16.2 (14.2–18.1)
Female	1586	0.4 (0.2–0.9)	10.7 (9.1–12.2)	6.2 (5.0–7.4)	16.0 (14.2–17.8)
Total	2957	0.4 (0.2–0.6)	10.1 (9.0–11.2)	6.6 (5.7–7.5)	16.1 (14.8–17.4)

## Discussion

According to our results, 16.1% of students were ametropic. Thus, it is important to know that 16.1% of the studied students had refractive errors despite being considered normal. Since we had excluded individuals with a visual acuity lower than 20/20 based on far vision, even the 0.4% prevalence of myopia is significant. As reports have shown that the prevalence of myopia in schoolchildren between 5 and 15 years of age ranges from 0.3% in Nepal<sup>29</sup> to 38% in southern China,<sup>30</sup> we expected to find a few individuals with myopia after being screened for visual acuity. Based on our definition of hyperopia, it can be concluded that 10.1% of students with a visual acuity of 20/20 or better in both eyes are hypermetropic. The mentioned finding can be discussed from two aspects. Firstly, regarding general health, these students are not regularly examined for their vision and although 10% of them are hyperopic, some are unaware of their condition. Secondly, hyperopia is of clinical importance. Those with hyperopia have more problems with near work than myopic patients, and they suffer symptoms such as asthenopia while reading and studying. Furthermore, those who present with hyperopia at younger ages are more susceptible to amblyopia. For this reason special attention should be paid to hyperopia at early ages.

Unfortunately, the application of Snellen charts in screening fails to identify hyperopic cases. In this study, 10.1% of students with hyperopia were missed in vision screenings and considered to have normal vision. Should such cases be identified appropriately in vision screening, prescription of suitable eyeglasses would reduce the symptoms they have while studying.

In addition to hyperopia, astigmatism is another refractive error assessed in this study. Approximately 6.6% of the students with 20/20 visual acuity had astigmatism of 0.75 D or more. As a type of refractive error, astigmatism can also trouble students while studying and during daily activities. Of note, if astigmatism is not diagnosed and treated during early childhood, it can lead to amblyopia.<sup>31</sup> Therefore, attention to hyperopia and astigmatism in screening programs, and their treatment and follow-up can lead to better vision, better education and even a better psychological profile.

Based on the findings of this study and the evaluation of screening programs worldwide, it can be stated that visual acuity worse than 20/20 is not a suitable criteria to label individuals for visual problems because test conditions and malingering may lead to false positive cases.<sup>11,12</sup> On the other hand, 20/20 visual acuity alone does not guarantee visual health because it does not identify individuals with hyperopia and astigmatism. Moreover, testing visual acuity has some false negatives in screening programs. According to Villegas,<sup>32</sup> vision is not only visual sharpness; the quality of vision in some individuals with normal or even excellent vision may not be satisfactory due to corneal aberrations or low contrast sensitivity.

Although various methods are used in screening programs worldwide with the aim to prevent blindness, the practical methods and procedures of screening are similar. In a study on screening tests in preschool children, Harmann<sup>25</sup> has reported that measurement of visual acuity and cover tests were important diagnostic tests for amblyopia and strabismus, as recommended by some organizations such as the American Academy of Ophthalmology, American Academy of Pediatrics, American Association of Pediatric Ophthalmology and Strabismus, American Optometric Association and Prevent Blindness America. Among these, only the American

Optometric Association has recommended the measurement of refractive errors in children. However, recent studies<sup>12,23</sup> on screening tests have shown that many countries do not include tests for measuring refractive errors in their screening programs. Here, we have demonstrated that screening tests without assessing refractive errors may yield false negative results. These false negative results in screening programs in preschool and primary school children include hyperopia and astigmatism.

The reason why these cases remain undiagnosed is that by the application of the Snellen chart; most hyperopic cases as well as some cases with astigmatism answer correctly during the far test. Based on the findings of this study, we suggest cycloplegic refractive tests be included in vision screening programs. In screening programs, although inexpensive tests in simple conditions are more common, their sensitivity and predictive value must also be taken into account.

In the current study, we evaluated refractive errors in schoolchildren who were examined by an optometrist and had visual acuities of 20/20 in both eyes. Hence, ideal considerations taken in this study must be noted: firstly, the examiners were optometrists and the visual measurements were performed under standard conditions and a visual acuity of 20/20 in both eyes was necessary for the subject to be included in the study. The mentioned points are important because in some countries vision screening tests are performed by teachers or school nurses.<sup>12</sup> Additionally in some countries, a visual acuity of 20/25 does not require further evaluation. In this study we expected minimal refraction errors because we considered ideal definitions and measurement conditions. Also, it is noteworthy that all screening tests carried out around the world have some false negative results.<sup>11</sup> We may claim here that our cases yielded the lowest rates of false negative or false positive results.

Few studies were conducted regarding the accuracy of preschool screening in Iran<sup>13</sup> and more studies are needed to confirm the consistency of this finding in other areas. However, huge numbers of students receive the preschool vision screening annually. Regarding the importance of refractive error in the quality of life and education progress of students,<sup>21</sup> thus inaccurate screening can be considered a major concern at the national level.

In the end, care must be taken to ensure that performing refraction examinations in addition to visual acuity measurements for students is feasible and cost-effective. Since evaluation of the students' refractive errors without cycloplegic refraction is not very reliable, it is prudent to assess refractive errors along with other pre-school screening tests in some parts of the country as a pilot project and then generalize it to the entire country if proven effective. Also, it has already been shown that hyperopia is more prevalent in our students. Therefore, detecting this problem through refraction tests can play an important role in students' health.

A 20/20 visual acuity in screening tests is not necessarily indicative of the person's visual health. Undiagnosed hyperopia and astigmatism in these individuals can lead to some visual disorders. To diagnose these cases, and to increase the sensitivity of screening tests, refractive errors might be accessed through cycloplegic refraction tests in vision screening programs.

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