Refractive error of Saudi children enrolled in primary school and kindergarten measured with a spot screener

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Abstract:
AIMS: To evaluate the refractive status of young Saudi schoolchildren with a “Spot Screener.”

SUBJECTS AND METHODS: This cross-sectional study was conducted from January to July 2016 in Riyadh, Saudi Arabia. Children of kindergarten (3–5 years) and grades 1 and 2 (6–7 years) were screened for refractive error (RE) using the handheld Spot Screener (Welch Allyn, Skaneateles Falls, NY, USA). Data were collected on age, gender, and spectacle use. The pass/fail notation from the Spot Screener and the RE were documented. Children with a “fail” were re-tested with an autorefractor (AR). The rate of agreement was evaluated for the spherical equivalent (SE) from the Spot Screener and AR.

RESULTS: We examined 300 schoolchildren and 114 preschool children. The prevalence of RE was 22% in schoolchildren and 25% in preschoolers. There were 183 (61%) hyperopes, 110 (36.7%) myopes, 6 (2%) emmetropes, and 29 (9.7%) astigmats (>2 D cylinder) in grade 1 and 2. There were 85 (74.6%) hyperopes, 22 (19.3%) myopes, 7 (6.1%) emmetropes, and 10 (8.8%) astigmats among preschoolers. The SE differed between the AR and the Spot Screener in 17 (28%) children of 61 failed Spot Screener tests. Accommodation (9, 53%) and high astigmatism (8, 47%) were the main underlying causes of the difference. The Spot Screener could identify RE for the first time in 51 (17%) schoolchildren and 26 (22%) preschoolers. End-users suggested that Spot Screener was child-friendly and quick to test RE.

CONCLUSIONS: The Spot Screener could be a good initial screening tool for RE in young schoolchildren.

Keywords: Childhood blindness, eye screening, myopia, refractive error

Introduction

Vision and eye screening in children is important for early diagnosis and timely treatment of disorders leading to visual disabilities. Refractive error (RE) is one of the leading causes of visual impairment and amblyopia in children. Poor academic performance, learning abilities, and personality disorders have all been partially attributed to the defective vision. Early vision defects are often asymptomatic and are therefore often ignored by children and parents. Hence, proactive screening of preschool and schoolchildren is recommended. Amblyopia should be treated as early as possible since the age at which amblyopia becomes irreversible still remains debatable. The current methods of vision assessment and RE are not very child-friendly. For young children,

How to cite this article: Yasir ZH, Almadhi N, Tarabzouni S, Alhommadi A, Khandekar R. Refractive error of Saudi children enrolled in primary school and kindergarten measured with a spot screener. Oman J Ophthalmol 2019;12:114-8.
automated vision screeners are recommended.[10-13] The Spot Screener (Welch Allyn, Skaneateles Falls, NY, USA) is one such automated vision screener [Figure 1].[14] It is a handheld, portable device designed to quickly screen for RE, anisometropia, and anisocoria even in children as young as 6 months of age.[15,16] The Spot Screener is also reliable in preverbal children.[17-21]

To the best of our knowledge, an assessment of RE in Saudi children using the Spot Screener has not been previously published. In this study, we evaluated the utility of the Spot Screener for RE screening by nonophthalmic personnel and also compared the results of failed screenings to the outcomes of an autorefractor (AR).

**Subjects and Methods**

In this cross-sectional study, we included young schoolchildren of two primary schools and two kindergartens in Riyadh, Saudi Arabia. The institutional research and ethics board approved this study (1633-P). Written informed consent was obtained from the principals at the four schools. The study was conducted between September 2016 and February 2017. Children of kindergarten or grades 1 and 2 primary schools were included. Students who were absent on the day of screening were excluded.

We assumed that the rate of failed test for RE screening with the Spot Screener would be 15% among a population of 5000 primary students. To achieve a 95% confidence interval (CI) with 5% acceptable margin of error and a design effect of 1.5, at least 283 children were required. The final sample was 300 children. We assumed the rate of failed test among kindergarten students was 25%. Hence, at least 100 kindergarten students were required.

Two medical students trained in using the Spot Screener were the field staff for the study. An ophthalmologist supervised the field activities. The school records were used to collect demographic data such as birth date and gender. Information on spectacle wear on the day of screening was also noted.

The Spot Screener was calibrated daily to ensure the uniformity. The device was held at 1 m distance from the child. The distance was then adjusted based on the message displayed on the monitor. If the message was “too far,” the Spot Screener was moved closer to the child. If it was “too close,” the Spot Screener was slowly moved away from the child without losing focus from the child’s eyes. The device produces a bird chirping sound to attract the child’s attention and fixation. In approximately 5–10 s, a “Pass” or “Fail” message is displayed on the monitor. Both eyes are tested simultaneously. A “fail” test indicates that the eye has a visual defect. In addition to the test result, the refractive status of each eye is also displayed in sphere, cylinder and axis. Refraction by Spot Screener was done as first level screening. In addition, we assessed the visual acuity (VA) using the Lea symbol chart held at 3 m distance and recorded the acuity in LogMAR notation. If the findings of “failed test” were consistent with the impaired VA and RE was >±0.75 D, defective vision was suspected to be due to RE. These cases were retested for RE with an AR (NIDEK Co. Ltd., Gamagori, Japan) as the second level screening. Children with anisometropia, high myopia, amblyopia, high hyperopia, and strabismus were advised to consult an optometrist and/or an ophthalmologist for further eye care. A “pass” indicated that the participant had no defects or marginal RE. If a message indicated that the pupils were constricted, the ambient room lighting was reduced and the test was repeated.

If the cylinder was present, we calculated the spherical equivalent (SE) RE of each eye using the following equation: sph + (cyl/2), where sph = sphere and cyl = cylinder values. The eye with higher value of RE was considered as RE of the person. Anisometropia was considered a difference >2.5 D between two eyes. Mild myopia was defined as SE between ~0.5 D and <‑2 D. Moderate myopia was defined as SE between ≥‑2 D and ≤‑6 D. Severe myopia was defined as SE >‑6 D (Adler’s Physiology of Eye-PG 25). Hyperopes were further grouped as SE between ≤1 D and >1D. Emmetropia was defined as RE between <‑0.5D and <0.5D SE. A mismatch was defined as difference in SE >2D measured by spot screener and AR.

The data were collected on a pretested collection form and subsequently computed using Excel® (Microsoft Corp., Redmond, WA, USA). The data were reviewed for errors and then transferred to the Statistical Package.
for the Social Science (SPSS 22; IBM Corp., Armonk, NY, USA). For qualitative data, the frequencies and the percentage proportions were calculated. For quantitative data, normality was tested and the mean and standard deviations were calculated if the variable was distributed normally. To associate the outcome to the determinants, the odds ratio, and the 95% CI, a two-sided “P” value were calculated. A P < 0.05 was considered statistically significant.

Results

We examined 300 children in grades 1 and 2 (group 1) and 114 children of kindergarten (group 2). The demographic details for both groups are compared in Table 1. The rate of spectacle users between groups did not differ significantly (P = 0.13).

The outcomes of spot screening are presented in Table 2. The Spot Screener aided in the detection of RE for the first time in 51 (17%) children in group 1 and 26 (22%) children in group 2. Of the 172 boys, 31 (18%) failed the test. While among 242 girls, 64 (26.4%) failed the test. The failure rate was significantly higher among girls compared to boys (P = 0.04). Hyperopia was significantly more prevalent among preschool children than primary school students (P < 0.001).

Sixty-six (22%) children in group 1 failed the Spot Screener test and were retested with the AR. Only 61 of 66 (92%) children presented for retesting. The findings were compared of the Spot Screener and AR among 60 children in group 1 (in one child, Spot Screener test was inconclusive) [Table 3]. Autorefractometry detected more hyperopia and less myopia.

The comparison of RE measured with the Spot Screener and AR is presented in Table 4. A mismatch in refraction between the AR and Spot Screener was noted in 17 of 61 (27.9%) children.

No child had anisocoria based on the Spot Screener testing.

The feedback of field staff who used both devices indicated the Spot Screener required much less time for measurement compared to the AR. In addition, their impression was that children prefer the Spot Screener.

Discussion

The Spot Screener was easy to use for assessing RE (an amblyogenic factor) in both primary students and preschoolers. The study staff who used both units preferred the Spot Screener over the AR. Evaluation of RE by autorefraction resulted in more hyperopic values compared to the Spot Screener. This screening initiative enabled us to identify 18% new cases of RE in young schoolchildren.

To our knowledge, this is the first published study that uses the Spot Screener for screening Saudi children. The ability of the Spot Screener to detect new RE was

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Table 1: Demographics and spectacle wear of preschool and primary school Saudi children screened for refractive error

| Gender   | Primary school (n=300), n (%) | Kindergarten school (n=114), n (%) | Validation P value* |
|----------|-----------------------------|------------------------------------|---------------------|
| Male     | 118 (39.3)                  | 54 (47.4)                          | 0.14                |
| Female   | 182 (60.7)                  | 60 (52.6)                          |                     |

*P<0.05 is statistically significant difference between Primary school children and those in Kindergarten. SD: Standard deviation

Table 2: Outcomes of the Spot Screener testing of preschool and primary school Saudi children

| Validation | Primary school (n=300), n (%) | Kindergarten school (n=114), n (%) | OR=1.15 95% CI=0.7-1.9 P=0.6 |
|------------|------------------------------|------------------------------------|-------------------------------|
| Pass       | 233 (77.7)                   | 86 (75.4)                          |                               |
| Fail       | 66 (22)                      | 28 (24.6)                          |                               |
| Inconclusive | 1 (0.3)                      | 0 (0.0)                            |                               |
| Myopia     | 110 (36.7)                   | 22 (19.3)                          | P<0.001                       |
| Mild <2 D  | 78 (26.0)                    | 10 (8.8)                           |                               |
| Moderate   | 3 (1.0)                      | 1 (0.9)                            |                               |
| Severe (>6 D) | 1 (0.3)                   | 1 (0.9)                            |                               |
| Astigmatism (2 D cylinder) | 29 (9.7) | 10 (8.8) |                               |
| Hyperopia  | 183 (61.0)                   | 85 (74.6)                          |                               |
| ≤1D        | 175 (58.3)                   | 75 (65.8)                          |                               |
| >1 D       | 8 (2.7)                      | 10 (8.8)                           |                               |
| Emotropia  | 6 (2.0)                      | 7 (6.1)                            |                               |
| Missing    | 1 (0.3)                      | 0 (0.0)                            |                               |

*P<0.05 is statistically significant. OR: Odds ratio, CI: Confidence interval

Table 3: Comparison of refractive error status among primary school children in Saudi Arabia assessed by a Spot Screener and an Autorefractor

| Primary school | Auto refractometer |
|----------------|--------------------|
| Myopia         | Hyperopia          | Emetropia | Total |

Spot Screener failed test

| Myopia | Hyperopia | Emetropia | Total |
|--------|-----------|-----------|-------|
| 34     | 12        | 0         | 46    |
| 1      | 11        | 1         | 13    |
| 1      | 0         | 0         | 1     |
| Total  | 36        | 23        | 1     | 60    |
Hyperopia was more common than myopia in both preschoolers and primary schoolchildren. Accommodation seems to have less effect on Spot Screener results compared to an AR.

There are some limitations of this study. In this study, the Spot Screener findings were compared to another handheld RE screening tool – an AR. However, the gold standard is a manual refraction after cycloplegia, which was not used for comparison in our study.[22,23] Hence, a conclusion of the accuracy of either instrument could not be determined here. A comparison of all three methods for evaluating RE is recommended. The RE status of preschool-aged children was not evaluated with the AR. Hence, validity parameters could not be estimated.

The prevalence of RE in primary schoolchildren and preschoolers in our study was 22% and 25%, respectively. In contrast, the prevalence of RE in Dammam (located in an Eastern province of Saudi Arabia) and in Jeddah (located in a Western province) was 44.4% and 69%, respectively.[24,25] The study from Dammam was a clinic-based study; hence, it is likely to include children with signs and symptoms of asthenopia, resulting in higher rate of RE compared to our school-based study.

In our study, boys comprised 39% and 47% of primary students and preschool children, respectively. The proportion of boys in primary schools was different than the population proportion of Saudi male children of less than 10 years of age (51%).[25] We cannot explain this variation and needs further study.

In the current study, girls had significantly higher failed tests compared to the boys. Al Wadaani et al. performed a study in a different region of Saudi Arabia and also noted that girls had higher prevalence of RE compared to the boys.[26]

Hyperopia was more common than myopia in both preschoolers and primary schoolchildren in our study. This concurs with the findings of a previous study that reported that children assessed at a pediatric eye clinic in Dammam were predominantly hyperopic.[24] Both studies enrolled children of urban population, which explains the greater preponderance of hyperopia in these studies. Urban children have greater access to parks, malls, and outdoor activities reducing the risk for developing myopia.[26]

Astigmatism was greater in primary schoolchildren compared to preschoolers. Reading is known to cause RE.[27] Primary schoolchildren do more near work for studies compared to preschoolers. Overall, astigmatism in our study was higher compared to studies from Dammam.[24] Variation in definitions of astigmatism could explain this difference.

The mismatch in refractive status between the Spot Screener and AR among cases with failed test (with the Spot Screener) was noted in more than one-fourth of primary schoolchildren. Differential stimulation of accommodation by these testing devices and overall high rates of astigmatism in our study could be the reasons for the mismatch between devices.

In our study, we compared two handheld RE screening tools. Crescioni et al. used the plusoptiX vision screener (Plusoptix Inc., Atlanta, GA, USA) and Spot Screener for comparison of high astigmatism and found that Spot Screener had more valid results.[28]

This study indicates that the Spot Screener can be used as a screening tool for the initial evaluation of RE in children. However, further studies are recommended in other regions of Saudi Arabia to suggest its use for national school eye health screening program.

Conclusions

The Spot Screener is fast, accurate, and widely acceptable both by children and screener and therefore is a good first level screening tool for RE and related amblyogenic factors in young children. AR does not seem to be a preferred first level screening tool for vision/RE screening as it overestimates hyperopia. AR’s use as the second level screening has limited benefit. Children failing the test by Spot Screener are identified and can be referred to eye care professionals for further action.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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