The prevalence and predictors of refractive error among school children in Riyadh, Saudi Arabia

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Abstract:

PURPOSE: Refractive error (RE) is one of the most common ocular disorders among children worldwide. This study aimed to investigate the prevalence of RE and possible risk factors among school children in Riyadh.

METHODS: This is a cross-sectional study using data collected at various schools. To achieve the aim of the study, we selected a random sample of 850 school children aged 6–15 years. The examination was based on the RESC protocol and included full visual assessment. Furthermore, a questionnaire was sent to the parents of the participants to ascertain information about lifestyle factors. We constructed a logistic regression model to evaluate the predictors of RE.

RESULTS: Close to a third of the children had a RE. Of those identified as having the condition, 60% did not wear glasses (newly diagnosed). Nearly all the children (95.4%) in our sample reported using electronic devices, according to parents. No association was found between using electronic devices and having a RE ($P = 0.26$). Doing outdoor activities was associated with 52% lower odds of a RE (odds ratio = 1.52).

CONCLUSION: We found a higher prevalence of uncorrected RE than previously reported in other Saudi studies. About 60% of children who had RE were not wearing glasses, highlighting the need for a standardized school screening program for early detection and management. Outdoor activities were associated with a lower likelihood of having a RE. These findings might support initiatives to encourage outdoor activities among school children.

Keywords:

Refractive Error, Prevalence, Near work, Electronic devices, Myopia, Hyperopia, Astigmatism, School children, Saudi Arabia

Introduction

Refractive errors (RE), which include myopia, hyperopia, and astigmatism, are optical defects of the visual system. They remain one of the primary causes of visual impairment among school children and one of the most common ocular disorders worldwide.[1] Uncorrected RE can affect the academic performance of children, their learning ability, and may impact their quality of life.[1,2] There is a dramatic increase in the prevalence of RE worldwide, particularly myopia over the past few decades, which suggests that RE in human is sensitive to environmental factors across a wide range of physical settings, communities, and lifestyles.[3]

Furthermore, a higher prevalence of myopia was associated with higher levels of education.[4,5]

Many of the international studies that explored this topic focused on the prevalence of myopia and myopia progression.[6-9] The prevalence of myopia is relatively high in the young generation of China.[10,11] Other countries such as Singapore and Taiwan also stated a high prevalence of myopia in the younger generation.[4,12,13]

Various factors may influence the underlying cause of RE. Several studies investigated whether educational style, school-associated lifestyle, and near work activity, in general, were potential risk factors for developing myopia.[5,10] Some studies showed that more near work activities were associated with an increased prevalence of myopia in children 6–18 years old.[14-17] They also

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suggested that near-work activities are a risk factor for myopic progression,[18,19] but other studies did not support these findings.[20-23]

The prevalence of RE in Saudi Arabia varied widely from 4.5% to 34.9% as many studies reported in deferent children's age groups.[24-26] All of these studies have focused only on the prevalence of RE. Nevertheless, the effect of environmental factors on children's visual state is still unexplored. Moreover, the lifestyle has changed significantly over the past few decades in Saudi Arabia. Children have better access to education and living in the new era of electronic devices. In the current study, we aimed to investigate the prevalence of RE and the possible risk factors among children.

Methods

This is a multischool cross-sectional study that was conducted in Riyadh, the country's capital. Schools were selected through a random cluster sampling. A random sample of 850 school children aged 6–15 years were selected. The study team screened children from 1st grade up to 9th grade, and 849 children were included in the final analysis. Children who attended the selected school were subjected to 10 min of eye assessment based on RESC protocol[27] (vision assessment, binocular motor function, auto-refractometer, and dry retinoscopy). Children with eye disorders (strabismus, nystagmus, ptosis, and others) or abnormal ocular movement were referred to a complete ophthalmic examination with cycloplegic refraction. Before the eye assessment, a consent form and a questionnaire were sent to parents and asking about the time their children spend doing near work activities and using electronic devices.

Outcome measure

This study defined RE as the presence of one or more of the following: hyperopia, myopia, or astigmatism. Hyperopia was defined as more than or equal to +2.00 D. Myopia also was defined as more than or equal to −0.75 D and astigmatism as more than or equal to −1.50 D.

Vision assessment

Distance visual acuity (VA) was measured with a LogMAR chart at 4 m distance. Acuity is measured first with spectacles "if the child wears them," followed by measurement of uncorrected (unaided) vision along with auto-refractometer and dry retinoscopy to verify the VA.

Binocular motor function and external eye examination

The alignment assessments were performed by the cover/uncover test and extraocular motility test.

Complete ophthalmic examination included subjective refraction, fundus examination, and cycloplegic refraction. If a child had unaided VA 20/40 or worse in either eye, pupillary dilation and cycloplegia (in both eyes) were attained using two drops of 1% cyclopentolate. Refraction was performed with autorefractor and retinoscope.

The study excluded any child with reduced visual function due to pathological causes such as corneal defect, cataract, lens subluxation, fundus abnormality, and optic nerve defect or abnormality. In addition, we excluded any child with high RE associated with a syndrome, such as Marfan syndrome, Down syndrome, and Stickler syndrome. Children who have RE and any mental or developmental delay were also excluded.

Statistical analysis

The data were collected using Microsoft Excel. All the analyses were performed using STATA 15 for Mac Stata is a statistical software. The frequencies and percentages were used to express categorical variables. The presence of RE and its subtypes were assessed and analyzed using the Chi-squared test. Furthermore, the distribution and association of RE, along with wearing glasses, near work activities, electronic devices, and outdoor activities were assessed and analyzed using Chi-squared tests. A logistic regression model was constructed to evaluate the predictors of RE. A cutoff value of 0.05 was declared to be statistically significant.

Results

Prevalence of refractive error

This study included 850 school children. 55.94% (475) were boys, and the remaining were girls. All children were included except one girl who was absent on the screening day. Of the overall sample, 244 (28.73%) were diagnosed with RE. Of those, only 39.34% (96) were wearing glasses, while the majority of children 60.66% (148) did not have glasses (newly diagnosed). 1.82% (11) of children who were wearing glasses did not fit into our RE criteria [Table 1]. Primary school students accounted for 69.26% of children who had RE. No association was found between grade and RE ($P = 0.159$) [Table 2].

Myopia was the most common type of RE, representing 14.13% and followed by hyperopia 6.12% and astigmatism

Table 1: Distribution of refractive error and wearing glasses

Glasses	No RE, *n* (%)	Have RE, *n* (%)	Total, *n* (%)
No glasses	594 (98.18)	148 (60.66)	742 (87.40)
Has glasses	11 (1.82)	96 (39.34)	107 (12.60)
Total	605 (100)	244 (100)	849 (100)

RE=Refractive error

Table 2: Distribution and association between refractive error and grade

Grade	No RE, *n* (%)	Have RE, *n* (%)	Total, *n* (%)
1	69 (11.40)	27 (11.07)	96 (11.31)
2	79 (13.06)	17 (6.97)	96 (11.31)
3	96 (15.87)	36 (14.75)	132 (15.55)
4	70 (11.57)	35 (14.34)	105 (12.37)
5	72 (11.90)	31 (12.70)	103 (12.13)
6	61 (10.08)	23 (9.43)	84 (9.89)
7	44 (7.27)	24 (9.84)	68 (8.01)
8	63 (10.41)	21 (8.61)	84 (9.89)
9	51 (8.43)	30 (12.30)	81 (9.54)
Total	100 (605)	100 (244)	100 (849)

RE=Refractive error

16.13%. Children who had only myopia accounted for 10.48% and 2.12% had only hyperopia. Astigmatism alone was present in 8.48% of children, 3.65% had myopia with astigmatism, and 4% had hyperopia with astigmatism [Table 3].

Time spent on homework

The majority of children (95.02%) were doing their homework on a daily basis. 43.78% (359) of children were spending 2–3 h on their homework. No association was found between how often children did their homework and having a RE ($P = 0.17$). Similarly, no association was found between how many hours spent on homework and having a RE [$P = 0.75$; Table 4].

Using electronic devices

The majority of children in our sample were using electronic devices (95.47%). No association was found between using electronic devices and RE [$P = 0.26$; Table 4].

After school activities (outdoor activities)

We found that 69.21% of children were doing outdoor activities. Doing outdoor activities was associated with RE ($P < 0.01$). Of those, 72.16% of children who did outdoor activities had no RE. 38.14% of children who had RE did not do outdoor activities [Table 4].

A logistic regression model was constructed to evaluate the predictors of RE. Variables included gender, grade, and outdoor activity. Our results suggest that children who did outdoor activities had 52% lower odds of having a RE than the ones who did not do any outdoor activities adjusting for grade and gender [Table 5].

Table 3: Prevalence of refractive error

RE type	Frequency (%)	Cumulative frequency
No RE	605 (71.26)	71.26
Myopic	89 (10.48)	81.74
Hyperopic	18 (2.12)	83.86
Astigmatic	72 (8.48)	92.34
Myopic and astigmatic	31 (3.65)	96
Hyperopic and astigmatic	34 (4)	100
Total	849 (100)	

RE=Refractive error

Table 4: Distribution and association between refractive error with how often children did their homework, hours spent doing homework, using electronic devices, and outdoor activities

	No RE, *n* (%)	Have RE, *n* (%)	Total, *n* (%)
How often homework is done			
Daily	552 (94.36)	231 (96.65)	783 (95.02)
Weekly	33 (5.64)	8 (3.35)	41 (4.98)
Total	585 (100)	239 (100)	824 (100)
Time spent on homework			
1 h or less	140 (23.97)	53 (22.46)	193 (23.54)
2-3 h	252 (43.15)	107 (45.34)	359 (43.78)
4-5 h	113 (19.35)	40 (16.95)	153 (18.66)
6 h or more	79 (13.53)	36 (15.25)	115 (14.02)
Total	584 (100)	236 (100)	820 (100)
Electronic devices			
Not using electronic devices	24 (4.01)	14 (5.81)	38 (4.53)
Using electronic devices	574 (95.99)	227 (94.19)	801 (95.47)
Total	598 (100)	241 (100)	839 (100)
Outdoor activities			
Doing an outdoor activity	425 (72.16)	164 (61.86)	571 (69.21)
Not doing outdoor activity	164 (27.84)	90 (38.14)	246 (30.79)
Total	589 (100)	236 (100)	825 (100)

RE=Refractive error

Table 5: Relationship between refractive error with gender, age, and outdoor activity

RE	OR	SE	*Z*	*P*>|*Z*|	95% CI
Gender	1.35	0.24	1.89	0.06	0.99-1.84
Grade	1.06	0.03	1.84	0.07	1.00-1.13
Outdoor activities	1.53	0.25	2.58	0.01	1.11-2.11
Cons estimates baseline odds.	0.11	0.04	−6.02	0.00	0.05-0.23

OR=Odds ratio, SE=Standard error, CI=Confidence interval, RE=Refractive error

Discussion

We found that more than half of the children who have RE do not have the optical correction they need. We also found that outdoor activities were significantly associated with not having RE. The prevalence of RE in Saudi Arabia varied widely from 4.5% to 34.9% as many studies reported in different children's age groups and different geographical regions.[24-26,28] The prevalence reported here is higher than most of the studies that were conducted in other regions. The prevalence of RE in Jeddah was reported around 10%[26] while in Qassim 18.6%[29] and 23% in Abha [Table 6].[25] Other countries reported a lower prevalence of RE than in the current study. A study in Qatar reported a prevalence of 15.2%, Malaysia reported 17.1%, while in Iran the prevalence of RE was 14.9% [Table 7].[30-32]

On the other hand, the findings presented here are similar to a recent study conducted in the western region in Saudi Arabia.[28] Uncorrected RE accounted for 34.9%, which is considered high. We both relied on an auto-refractometer, and the VA was used to verify the result. Besides, in this study, we used dry retinoscopy along with the VA to verify the result of the auto-refractometer. Both studies found that the prevalence of RE is high in Saudi Arabia, even though each one of them was conducted in a different geographical region. In our study, we did not only look into the prevalence of uncorrected RE alone as in the western region study. We calculated the prevalence of RE to the total subjects' number. Then, we looked into the distribution of having RE and wearing glasses. The lowest prevalence reported among a similar cohort was 4.5% among patients in King Abdul Aziz Medical City (KAMC) in Riyadh.[24] However, the study followed a different protocol in screening. They depend on poor VA as referral criteria for full ophthalmic examination. This significantly low prevalence than other of most studies could be due to their method in screening. Depending on poor VA as referral criteria might not reflect the true prevalence of RE.

Table 6: Prevalence of refractive error reported in other similar Saudi studies

City	Years	Sample size	Age group	Prevalence of RE (%)
Riyadh[24]	2010	1319	4-8	4.5
Abha[25]	2010	975	6-12	23
Jeddah[26]	2002	102	Kindergartens	10.7
Medina[28]	2017	2121	3-10	34.9
Qassim[29]	2013	5176	6-13	18.6

RE=Refractive error

Table 7: Prevalence of refractive error reported in studies in other countries

Country	Years	Sample size	Age group	Prevalence of RE (%)
Qatar[30]	2010	670	Primary school children	15.2
Malaysia[31]	2005	4634	7-15	17.1
Iran[32]	2015	1151	6-15	14.9

RE=Refractive error

The overall prevalence of myopia, hyperopia, and astigmatism was 14.13%, 6.12%, and 16.13%, respectively. Worldwide, myopia is the most common type of RE, and its prevalence varied from 4.9% to 18.2%.[33] In the current study, the prevalence of myopia is considered high in comparison to other studies in Saudi Arabia. A study conducted in the western region reported 0.7%[28] while a Riyadh study 2.5%,[24] and Al-Qassim's study 5.8%.[29] Astigmatism was the most common type of RE in our study. A high prevalence of astigmatism was also reported by western region study as 25.3%.[28]

In contrast to these findings, the prevalence of astigmatism was reported by other studies 1.7%,[34] 2.5%,[24] and 6.5%.[35] There is a variation in the prevalence of astigmatism between studies in Saudi Arabia. This variation could be due to the difference between screening methods among studies. In addition, the prevalence of hyperopia in the present study was also higher than in other studies. The western region study reported 1.5%,[28] Riyadh's study 2.1%,[24] and Al-Qassim's study, 0.7%.[29] The variations in the prevalence of RE and its different types between studies could be due to differences in the definition of variables and cutoff points of RE, screening method, and environmental influences. Unifying the cutoff points of RE and screening methods may lead to a more comparable result, which could help in a better understanding of environmental influences and its impact.

Many studies have reported that daily habits such as near work and outdoor activities are associated with RE. In the current study, we have investigated the possible factors that might be related to RE in children. Many studies have reported the relationship between RE and outdoor activities.[36,37] Outdoor activities are considered a prophylactic measure of progression of myopia.[36,37] Furthermore, it has been reported that higher levels of total time spent outdoors were associated with less myopia.[38] Doing outdoor activities was also associated with having a more hyperopic refraction.[38-40] These findings could indicate that outdoor activities can lower the risk of developing RE, as our study suggest.

Contrary to our hypothesis, near work was not associated with RE or myopia. These findings are similar to other studies that have investigated the effect of near work activities on RE in children.[20-23] Most studies have focused only on the relationship between myopia and near work.[14,15,20-23,41] Meanwhile, in our study, we did not focus only on one type, we studied the association between all types of RE and near work, and no association was found.

On the other hand, some studies have found that near work activities were associated with myopia.[14-17] They found that myopia progression was associated with continuous reading (more than 45 min) and reading for pleasure.[41] It has been suggested that myopia is associated with the intensity of near work rather than the duration.[40] Furthermore, The strength of evidence regarding the association between near work activities and myopia was classified as level 2.[14] This means that the data provided substantial evidence in support of the recommendation. However, the evidence was lacking in some qualities. Furthermore, the recommendation regarding decreasing near work activities was considered Level B, which indicates that the recommendation is moderately important. Where Level A is critical to the clinical outcome, and Level C is relevant but not critical. The effect of near work and outdoor activities on RE is still widely studied and not fully understood yet. Many theories tried to explain this relationship.[36,38,42-44] Further work is needed in this area to provide more conclusive evidence of the presence or lack of this association.

Several limitations need to be acknowledged in our study. First, there was no face to face interviewing with parents. Part of the data was based on questionnaires sent to the parents of children, and we did not interview the children to validate the answers. Second, this study is a cross-sectional study, which does not guarantee temporality. Further longitudinal studies are warranted to be able to understand this relationship fully. Finally, the sample was not population based, which may affect the generalizability of the results to the country.

Nevertheless, to our knowledge, this is the first study in Saudi Arabia to study the association between RE and school children's daily habits in the Saudi population. Moreover, the study followed the RESC protocol, which is a recognized international screening protocol. Furthermore, it is the first study that investigated the impact of electronic devices on RE.

Conclusion

The prevalence of RE is considered relatively higher than previously reported. The majority of the children are not wearing the optical correction they need. These findings reflect the need for an adequate screening program for school children. Moreover, to have comparable results, we need a unified, standardized protocol for screening for school children in Saudi Arabia. Importantly, our study showed that doing outdoor activities lowered the chance of having RE. These findings might help parents, teachers, and policymakers to

create a more balanced daily routine between near work and outdoor activities for children.

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Conflicts of interest

There are no conflicts of interest.

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