Prevalence of refractive errors in school-going children of Taif region of Saudi Arabia

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Abstract:

PURPOSE: To determine the prevalence of refractive errors in the pediatric population in Taif, Saudi Arabia.

METHODS: This cross-sectional study included 7356 eyes of 3678 primary and secondary school children (males = 1837; females = 1841) with a mean age of 11.8 ± 2.2 years (range: 7–18) (males = 11.4 ± 2.0 [range: 8–16]; females = 12.2 ± 2.3 [range: 7–18]). All participants were selected from the school registers. The participants underwent noncycloplegic refraction to determine refractive errors. Students who refused visual acuity assessment or eye examination and were inconsistent in visual acuity assessment were excluded.

RESULTS: The manifest refraction spherical equivalent of the study population was 0.37 ± 1.52 D (range from −18.4 to 8.8 D) (males = −0.32 ± 1.4 D [range −15.88–8.8 D]; females = −0.42 ± 1.6 D [range −18.38–8.0 D]). The overall prevalence of uncorrected refractive errors among school children in this study was 50.91%. The overall distribution of astigmatism (cylinder error of ≥0.50 D) in the current study population was found to be 50.14% (3688/7356 eyes).

CONCLUSION: Nearly half of the study population in this area was affected with at least one type of refractive error. The findings reveal the necessity for implementing timely and sensitive screening programs/methods to identify and correct refractive errors in this age group.

Keywords:

Astigmatism, hyperopia, myopia, pediatric refractive error, refractive error

Introduction

Refractive errors are common vision defects, caused by the incongruity between the axial length and refractive power of the optical elements of the eye, as a result of which the optical system fails to focus the parallel rays of light sharply on the retina.[1] According to World Health Organization, visual disability due to uncorrected refractive errors represents a significant public health concern, accounting for 43% of visual impairment.[2,3] It has been reported that in 2010, about 101 million people worldwide were visually impaired due to uncorrected refractive errors.[2,4,5]

Refractive error in school-going children is an important concern because it constitutes a highly vulnerable age group where such optical defects if left uncorrected, may have negative impact on their learning capabilities, academic performance, job opportunities, and upcoming quality of life.[1,6] These errors usually remain uncorrected among children mainly due to lack of screening and the unavailability of refractive correction.[1,6] Most of the children with uncorrected refractive error remain asymptomatic, so periodic vision screening is recommended for early detection and timely intervention.[7]

Over the last two decades, the distribution of refractive errors in school children has been an issue of interest and a large number of studies have assessed the distribution of refractive errors in this age group, worldwide. Several investigators have studied the prevalence of refractive errors among different age groups of school children in Saudi Arabia.[1,8-11] However, most of the previous studies have been conducted

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in hot and dry regions of Saudi Arabia. To the best of our knowledge, this is the first study to estimate the pattern of refractive errors in a pediatric population (718 years) in Taif province.

Methods

Study design

The study was designed as cross-sectional, school-based survey of refractive errors in children aged 7–18 years from the Taif region of Saudi Arabia. Schools were selected by the Ministry of education in the region according to area and number of students. This study included 7356 eyes of 3678 primary and secondary school children (males = 1837; females = 1841) with a mean age of 11.8 ± 2.2 years (range: 7–18) (males = 11.4 ± 2.0 [range: 8–16]; females = 12.2 ± 2.3 [range: 7–18]).

All study participants were selected from the school registers. The study followed the tenets of the Declaration of Helsinki and was approved by the institutional review board with the waiver of consent because the data were collected as a part of normal practice care/screening provision. Students who refused visual acuity assessment or eye examination and were inconsistent in visual acuity assessment after 3 attempts were excluded.

Data collection

Examinations were performed by 1 ophthalmologist, 2 optometrists, 1 orthoptist, and 2 ophthalmic nurses all experienced with childhood vision testing and refraction. As a part of the standard ophthalmic examination, all subjects underwent noncycloplegic refraction to determine refractive errors. The data thus collected were analyzed to find out the pattern of the relative distribution of different types of refractive errors.

Definition of refractive errors

Refractive errors were classified as myopia, hyperopia, and astigmatism. Manifest refraction spherical equivalent (MRSE) was applied to define refractive errors in this study and was calculated mathematically by adding sphere power and half of the cylinder power.

Myopia was defined as a spherical equivalent of ≤ −0.50 diopters (D) (mathematically); which was further categorized as low (≤ −0.50 D and > −3.00 D), moderate (≤ −3.00 D and > −6.00 D), and high (≤ −6.00 D). Hyperopia was defined as a spherical equivalent of ≥ +0.50 D; which was further categorized as low to moderate (≥ +0.50 D and < +3.00 D) and high (≥ +3.0 D) hyperopia. Emmetropia was defined as spherical equivalent between > −0.5 D and < +0.5 D.

Astigmatism was defined as cylinder error of ≥0.50 D (absolute value) in any axis. Low to moderate astigmatism was defined as cylinder error of ≥0.50 D and <3.00 D and high astigmatism as ≥3.00 D. Distribution of astigmatism was also analyzed based on axis of the principal meridians. Astigmatism was classified as with the rule (WTR) if the axis of positive cylinder lied within 30°(°) on either side of the vertical meridian (60° to120°), against the rule (ATR) if the axis of positive cylinder lied within 30° on either side of the horizontal meridian (0° to 30°; 150° to 180°) and oblique if the axis lied between 120° to 150° and 30° to 60°.

Based on the focus of the principal meridians, astigmatism was classified into simple (myopic/hyperopic), compound (myopic/hyperopic), and mixed astigmatism. Simple myopic astigmatism was defined as plano sphere (> −0.5 D to < +0.5 D) and cylinder of ≤ −0.50 D, simple hyperopic astigmatism was defined as plano sphere (> −0.5 D to < +0.5 D) and cylinder of ≥ +0.50 D); compound myopic astigmatism was defined (mathematically) as sphere of ≤ −0.5 D and cylinder of ≤ −0.50 D, compound hyperopic astigmatism was defined as sphere of ≥ +0.5 D and cylinder of ≥ +0.50 D. Astigmatism was defined as mixed if the sphere was positive (> +0.5 D) and cylinder value was negative (≤ −0.75 D) or vice versa and the cylinder value was greater than sphere. Data were analyzed with Microsoft Excel 2016 (Microsoft, Redmond, WA).

Results

The mean spherical equivalent of the study population was-0.37 ± 1.52 D, ranging from − 18.4 to 8.8 D (males = −0.32 ± 1.4 D [range − 15.88–8.8 D]; females = −0.42 ± 1.6 D [range-18.38–8.0 D]). The overall prevalence of refractive errors among school children in this study was 50.91%. The proportion of myopia, hyperopia, and emmetropia for the overall and gender-wise population are presented in Table 1 and age-wise distribution in Table 2.

The overall distribution of astigmatism (cylinder error of ≥0.50 D) in the present study population was found to be 50.14% (3688/7356 eyes). Overall and gender-based distributions of different types of astigmatism are presented in Table 3 and age-based distribution in Table 4.

Discussion

This study describes the prevalence of refractive errors in the pediatric population of the age group 7–18 years in Taif, Saudi Arabia and compared it to the prevalence rate reported in other parts of the world. It is important to acknowledge that refractive error is a complex and multifactorial condition that varies widely in prevalence across populations with different genetics, demographics (age, race, ethnicity, and geographic region), ocular and extrinsic factors (education pressure, lifestyle changes, prolonged indoor and near activities). Several studies have evaluated the prevalence of different types of refractive errors among schoolchildren. However, to allow meaningful comparison, we restricted the comparison to studies that were published in the year 2010 and onwards.

In the current study, almost half of the study population (51%) had at least some refractive error [Table 1], which is relatively

Table 1: Types of refractive error in the study population (gender-based distribution)

Types of refractive error	Overall distribution (*n*=7356)		Gender-based distribution			
			Males (*n*=3674)		Females (*n*=3682)	
	Total, *n* (%)	*n* (%)	Total, *n* (%)	*n* (%)	Total, *n* (%)	*n* (%)
Myopia (MRSE ≤−0.50 D)						
Low myopia (≤−0.50 D and >−3.00 D)	2443 (33.2)	2106 (28.6)	1150 (31.3)	1015 (27.6)	1293 (35.1)	1091 (29.6)
Moderate myopia (≤−3.00 D and >−6.00 D)		271 (3.7)		103 (2.8)		168 (4.6)
High myopia (≤−6.00 D)		66 (0.9)		32 (0.9)		34 (0.9)
Hyperopia (MRSE ≥+0.50 D)						
Low to moderate hyperopia (≥+0.50 D and <+3.00 D)	1297 (17.6)	1198 (16.3)	633 (17.2)	581 (15.8)	664 (18)	617 (16.8)
High hyperopia (≥+3.0 D)		99 (1.3)		52 (1.4)		47 (1.3)
Emmetropia						
MRSE >−0.5 D to <+0.5 D	3611 (49.1	-	1891 (51.5)	-	1720 (46.7)	-

MRSE: Manifest spherical equivalent refraction

Table 2: Types of refractive error in the study population (age-wise distribution)

Types of refractive error	Age-based distribution							
	7-9 years (*n*=1324)		10-12 years (*n*=2798)		13-15 years (*n*=3138)		16-18 years (*n*=96)	
	Total, *n* (%)	*n* (%)	Total, *n* (%)	*n* (%)	Total, *n* (%)	*n* (%)	Total, *n* (%)	*n* (%)
Myopia (MRSE ≤−0.50 D)								
Low myopia (≤−0.50 D and >−3.00 D)	355 (26.8)	309 (23.3)	895 (32.0)	776 (27.7)	1156 (36.8)	986 (31.4)	42 (43.8)	35 (36.5)
Moderate myopia (≤−3.00 D and >−6.00 D)		33 (2.5)		96 (3.4)		135 (4.3)		7 (7.3)
High myopia (≤−6.00 D)		13 (1.0)		23 (0.8)		30 (1.0)		0
Hyperopia (MRSE ≥+0.50 D)								
Low to moderate hyperopia (≥+0.50 D and <+3.00 D)	273 (20.6)	255 (19.3)	509 (18.2)	476 (17.0)	501 (16.0)	458 (14.6)	14 (14.6)	9 (9.4)
High hyperopia (≥+3.0 D)		18 (1.4)		33 (1.2)		43 (1.4)		5 (5.2)
Emmetropia								
MRSE >−0.5 D to <+0.5 D	696 (52.6)	-	1394 (49.8)	-	1481 (47.2)	-	40 (41.7)	-

MRSE: Manifest spherical equivalent refraction

Table 3: Gender-based distribution of different astigmatism categories in the study population

Types of astigmatism	Overall distribution (*n*=7356)		Gender-based distribution			
			Males (*n*=3674)		Females (*n*=3682)	
	Total, *n* (%)	*n* (%)	Total, *n* (%)	*n* (%)	Total, *n* (%)	*n* (%)
Low to moderate astigmatism[a] (≥0.50 DC and <3.00 DC)	3688 (50.1)	3460 (47.0)	1752 (47.7)	1655 (45.0)	1936 (52.6)	1805 (49.0)
High Astigmatism[a] (≥3.00 DC)		228 (3.1)		97 (2.6)		131 (3.6)
WTR[a] (±30° on 90°; cylinder ≥0.50 DC)	3688 (50.1)	3004 (40.8)	1752 (47.7)	1329 (36.2)	1936 (52.6)	1675 (45.5)
ATR[a] (±30° on 180°); cylinder ≥0.50 DC)		450 (6.1)		306 (8.3)		144 (3.9)
OBL[a] (120°-150° and 30°-60; cylinder ≥0.50 DC)		234 (3.2)		117 (3.2)		117 (3.2)
Simple myopicb (plano sphere (>−0.5 D to <+0.5 D) and cylinder (negative) ≤−0.5 D)	3688 (50.1)	1219 (16.6)	1752 (47.7)	621 (16.9)	1936 (52.6)	598 (16.2)
Simple hyperopic[b] (plano sphere (>−0.5 D-<+0.5 D) and cylinder (positive) ≥0.5 D)		761 (10.3)		367 (10.0)		394 (10.7)
Compound myopic[b] (sphere ≤−0.5 D and cylinder ≤−0.50 D)		993 (13.5)		479 (13.0)		514 (14.0)
Compound hyperopic[b] (sphere of ≥+0.5 D and cylinder ≥+0.50 DC)		434 (5.9)		170 (4.6)		264 (7.2)
Mixed astigmatism[b] (if sphere (positive) (>0.5 D) and cylinder (negative) (<cylinder−0.5 D) or vice versa and cylinder >sphere)		281 (3.8)		115 (3.1)		166 (4.5)

MRSE: Manifest spherical equivalent refraction, *n*: Number of eyes, WTR: With the rule, ATR: Against the rule, OBL: Oblique; a based on absolute cylinder; b based on criteria of least defocus equivalent

greater than that reported in previous studies from Saudi Arabia (4.5%–18.6%).[8-11] As evident, the prevalence of refractive error varies widely among different parts of the world ranging from 3.3% in Pakistan to 64.4% in Iran.[12-17] This wide variation in the overall prevalence of refractive error even among the studies conducted in the same geographical region could be attributed to differences in the operational definition, cut-off values used to determine different types refractive errors and methods of measurement (cycloplegic/noncycloplegic refraction).[1]

The prevalence of myopia varies from 0.85 to 46.5% in similar school-based studies from different parts of the world.

Table 4: Age-based distribution of different astigmatism categories in the study population

Types of astigmatism	Age-based distribution							
	7-9 years (*n*=1324)		10-12 years (*n*=2798)		13-15 years (*n*=3138)		16-18 years (*n*=96)	
	Total, *n* (%)	*n* (%)	Total, *n* (%)	*n* (%)	Total, *n* (%)	*n* (%)	Total, *n* (%)	*n* (%)
Low to moderate astigmatism[a] (≥0.50 DC and <3.00 DC)	656 (49.5)	615 (46.5)	1378 (49.2)	1289 (46.1)	1598 (50.9)	1503 (47.9)	56 (58.3)	53 (55.2)
High astigmatism[a] (≥3.00 DC)		41 (3.1)		89 (3.2)		95 (3.0)		3 (3.1)
WTR[a] (±30° on 90°; cylinder ≥0.50 DC)	656 (49.5)	565 (42.7)	1378 (49.2)	1113 (39.8)	1598 (50.9)	1281 (40.8)	56 (58.3)	45 (46.9)
ATR[a] (±30° on 180°); cylinder ≥0.50 DC)		58 (4.4)		174 (6.2)		210 (6.7)		8 (8.3)
OBL[a] (120°-150° and 30°-60; cylinder ≥0.50 DC)		33 (2.5)		91 (3.3)		107 (3.4)		3 (3.1)
Simple myopic[b] (plano sphere (>−0.5 D-<+0.5 D) and cylinder (negative) ≤−0.5 D)	656 (49.5)	214 (16.2)	1378 (49.2)	460 (16.4)	1598 (50.9)	526 (16.8)	56 (58.3)	19 (19.1)
Simple hyperopic[b] (plano sphere (>−0.5 D–<+0.5 D) and cylinder (positive) ≥0.5 D)		163 (12.3)		292 (10.4)		298 (9.5)		8 (8.3)
Compound myopic[b] (sphere ≤−0.5 D and cylinder ≤−0.50 D)		131 (9.9)		370 (13.2)		475 (15.1)		17 (17.7)
Compound hyperopic[b] (sphere of ≥+0.5 D and cylinder ≥+0.50 DC)		91 (6.9)		157 (5.6)		178 (5.7)		8 (8.3)
Mixed astigmatism[b] (if sphere (positive) (>0.5 D) and cylinder (negative) (<−0.5 D) or vice versa and cylinder >sphere)		57 (4.3)		99 (3.5)		121 (3.9)		4 (4.2)

In the current study, myopia was reported in 33.28%, which is comparable to previous reports from China (36.9%),[18] Iran (29.3%)[19] and Nigeria (29.5%)[13] but higher than the previously reported estimates from Iran,[4,15,20-22] China,[23-25] Lao PDR,[12] Mexico,[26] Ethiopia,[16,27,28] Vietnam,[29] Nigeria,[30] Pakistan[17] and even Saudi Arabia[1,9-11] (2.5%–8.9%). Consistent with previous findings,[4,8,9,12,16,18-25,29-32] we found an increasing trend of myopia with age in this study (26.81% in 7–9 years to 43.75% in 16–18 years age group) [Table 1]. Furthermore, the distribution of myopia was found to be higher in females (31.30 vs 35.12% in males and females respectively), as reported in most of the previous studies.[8,9,17,18,29,30] On the other hand, some studies reported no significant difference in the distribution of myopia between the two sexes.[12,22,24,25]

Hyperopia has been found to vary widely in different populations ranging from 0.33% in Ethiopia to 69.8% in China.[24] The prevalence of hyperopia reported in the current study (17.63%) is found to be higher than that previously reported from Saudi Arabia (0.9%–2.5%),[8-11] Iran,[4,20-22] China,[23,25] South Korea,[31] Nigeria,[13,30] Mexico,[26] Pakistan,[17] Vietnam,[29] Ethopia;[27,28] whereas lower than that reported from China[18,24] and Iran.[4,15] Moreover, a decreasing trend of hyperopia prevalence with age was evident in the current study (20.62% in 7–9-14.58% in 16–18 years age group) which is in agreement with previous findings.[4,12,16-18,20-22,24,25,29,31,32] Of all the study participants identified with hyperopia, about 92% had low to moderate hyperopia. Similar to some previous reports, no difference in hyperopia prevalence was observed between males and females in this study.[12,22,24,25] In contrast, other studies reported higher hyperopia prevalence in males, compared to females.[9,18,29]

Astigmatism was the most common type of refractive error in this study population (50.14%), consistent with the studies conducted in various parts of the world.[10-13,20-22,24,30] The prevalence of astigmatism varies from 0.65% in Nepal[33] to 57.4% in Nigeria[13] in previous studies, and the rates (50.14%) we found in this study falls within this range [Table 2]. The estimates of astigmatism prevalence in the current study are comparatively higher than that reported in similar studies previously conducted in Saudi Arabia (2.5%–6.5%).[1,10,11] More than 93% of the total astigmatism cases had low to moderate astigmatism. In this study, astigmatism prevalence rates demonstrated no variation/significant trend from 7 to 15 years (~50%) but increased to 58.33% in the 16–18 years age group. The distribution of astigmatism was also found to be greater in females compared to males (47.69% vs. 52.58%). Based on the orientation of the astigmatism axis, WTR was found to be the most dominant type of astigmatism (81.45%), followed by ATR (12.20%) and opaque bubble layer (6.34%), which is similar to previous findings.[13,15,19,21,22]

There is a lack of uniformity among different studies regarding the definition criterion of refractive error; while most of the studies have used MRSE, others have not specified their definition criteria.[1,27,28,32-35] Furthermore, previous studies have used different methodologies for calculating refractive error, i.e., both eyes or only one eye (worse/right/left eye). In addition, a review of the literature showed discrepancy/inconsistency in the lower and upper cut-off points for the diagnosis of different types of refractive errors and their sub-categories (low, moderate and high). In the current study, we have used the definitions of refractive errors as recommended by the American Academy of Ophthalmology with a few modifications.[36] As such, there is a need to standardize the definitions for different types of refractive errors.

Conclusion

In conclusion, the present study presented the status of refractive errors in school-going children in the Taif region of

Saudi Arabia. Based on the findings of this study, nearly half of the study population in this area had at least some refractive error. These findings reveal the necessity for implementing timely and sensitive screening programs to identify and correct refractive errors in this age group.

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Conflicts of interest

There are no conflicts of interest.

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