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Original Research Paper

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PATTERN OF REFRACTIVE ERRORS IN STUDENTS ATTENDING PUBLIC HIGH SCHOOLS IN NAIROBI

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ABSTRACT

Background: There is a global epidemic of refractive error with myopia being the most prevalent cause of correctable visual impairment. However there is little data on refractive error in sub-Saharan Africa. This study assesses the prevalence and pattern of refractive errors (RE) in urban public high school students in Nairobi County, Kenya.

Methods: This was a cross-section based survey of among1376 teenage high school students in Nairobi County, Kenya. Eleven out of 80 schools were selected and all the students in selected schools were invited to participate. All the students had their visual acuity taken using logMAR charts and those with a visual acuity of 6/12 or less in the better eye were invited for objective then subjective refraction. The data was analysed using SPSS 20.0. Chi-square test was used compare means and proportions.

Results: The total participation rate was 84.8% (1376/1622). Of the 1376 students who participated 751 (54%) were boys and 639 (46%) were girls. The prevalence of refractive error was 15.5% (209/1348) with a preponderance of myopia at 14.4% [194/1348, OR= 0.7(95% CI= 0.4-0.9)], followed by astigmatism at 7.6% [103/1348, OR= 0.9, (95% CI= 0.6-1.3)] and lastly at 0.7% [10/1348, OR= 0.6 (95% CI=0.2-2.0)] hyperopia. Boys were less likely than girls to have both refractive error (OR= 0.7, 95% CI= 0.5-0.9) and myopia (O.R= 0.7, 95% C.I= 0.4-0.9).Congruous low myopia, i.e. occurring in both eyes (75.4%, 153/209) was the commonest form of refractive error among students with refractive error.

Conclusions: There was a high prevalence of refractive error among teenagers attending high school in Nairobi Kenya with a predominance of myopia especially amongst girls.

KEYWORDS : Refractive error, myopia, hyperopia, astigmatism, congruous and incongruous

BACKGROUND

Visual impairment, a global priority eye disease, is defined as having visual acuity less than 6/18 or worse in the better eye.[1] The commonest cause of low vision is refractive error. Although refractive error is easy to diagnose and treat, uncorrected refractive error remains the main cause of moderate to severe visual impairment especially in developing countries[2]. A previous study in Kenya found that, 77.3% of children who required correction for a disabling refractive error did not have or wear spectacles.[3] Uncorrected refractive error hinders economic activities and has been shown to have a detrimental effect on the gross domestic product of a country. [4]

Refractive errors occur when there is a mismatch in the axial length of the eyeball and its refractive power. Normally, the refractive elements in the eye, cornea and lens, project an image on the fovea where the sharpest perception is achieved. Aberrations of the refractive elements, or abnormal intra-axial length, project the image either in front or behind the fovea in simple myopia and simple hyperopia respectively.

In astigmatism, the third type of refractive error, differential curvatures in the lens or cornea create two focal points instead of one. One classification of astigmatism considers the position of the focal point in relation to the fovea. In simple myopic astigmatism, one focal point lies on the fovea while the other lies in front of the fovea while in simple hyperopic astigmatism, one focal point lies on the fovea and the other behind the retina. In compound myopic astigmatism, both focal points lie in front of the fovea but in compound hyperopic astigmatism both focal points lie behind the fovea. Mixed astigmatism occurs where the focal points lie on either side of the fovea.

The other classification of astigmatism considers the meridians of the abnormal curvature in relation to the pupil. In 'regular astigmatism' the irregularities on the refractive elements have a constant orientation in relation to the pupil, while in 'irregular astigmatism' the orientation of irregularities at any one point on the cornea cannot be predicted in relation to the pupil. Regular astigmatism is further characterised as either 'with the rule' if the vertical meridian is the steepest or 'against the rule' when the horizontal meridian is steepest.[5]

Data are limited on the prevalence of refractive error among Kenyan teenagers and no studies categorise the patterns of refractive error. The objective of our study was to describe the prevalence and outline the patterns of refractive error in 16-17 year olds.

METHODS

In October 2014, we conducted a cross-sectional school based survey, to assess the prevalence and patterns of refractive error among High school students in Nairobi County. The schools were sampled using multistage random sampling, where out of 80, 11 schools were selected to achieve a minimum student sample of 1290 students. The multistage stratification was based on the Ministry of Education's data to ensure proportional inclusion of gender-exclusive and mixed schools.[6] Form 3 students were chosen as they were 16 years and above (range 14-23yrs).

In accordance to the world medical association (WMA) declaration of Helsinki, ethical approval was obtained from University of Nairobi - Kenyatta National Hospital Research and Ethics committee and study approval was also granted by the Ministry of Education. The approvals were followed by a familiarization visit to each school. During the visit, permission to carry out the study from individual school head teachers was obtained. The goals of the study were explained to the students and individual students gave consent before examination. Students under the age of 16yrs in boarding schools, 46 in number, had consent given by the headmaster.

Basic demographic data was collected in a self-administered questionnaire. The students were then screened using

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logMAR charts. Students with visual acuity less than 6/12 in the better eye were invited for a non-cycloplegic objective refraction using a streak retinoscope. This was followed by a subjective refraction. Students who did not improve by at least two lines on logMAR were referred to the nearest eye facility. Examinations were carried out by the principal investigator (resident ophthalmologist), an ophthalmologist and a refractionist.

Data management and data analysis

The data collected was recorded in case report forms, and a data set created on Google docs. Analysed using SPSS Ver.20.0. Chi-square test was used compare means and proportions. In this study Students with visual acuity less than 6/12 in the better eye were classified as having impaired visual acuity. Students who had Refractive error were classified as per the following definitions.

Myopia: -0.50 Dioptres Sphere
Hyperopia: +1.00 Dioptre Sphere
Astigmatism: -0.5 Dioptre cylinder
'With the Rule' astigmatism: 0°-30°/150°-180°
'Against the Rule' Astigmatism: 61°-120°
Oblique astigmatism: 31°-60°/121°-149°
RESULTS

Flow of Study participants

At the time this study was carried out there were 41857 students attending Public High schools in Nairobi, among then 9400 in the third year of high school, the target class for this study. Figure 1, shows the study flow chart. In the 11 schools selected for this study, 1390 (85.7%) of 1622 students identified from the class register as eligible for the study were recruited, and included 751 (54%) males and 639 (46%) females. Excluded from the study were 131 students who were absent and 101 who declined study participation.

Visual acuity

The 1390 students were offered screening for visual acuity using logMAR charts and 1376 (99%) accepted while 14 declined (12 boys and 2 girls). Overall 1084 students had normal eye sight in both eyes, while another 45 (3.3%) had reduced vision, (23 and 22 in the left and right eye respectively) as shown in figure 2. According to current guidelines 1129 (82.0%) students were classified having normal visual acuity and their further participation in the study ended at this point. A visual acuity of 6/12 and worse in the better eye was found in 247 of the 1376 screened. The overall prevalence of impaired visual acuity among these 3rd form students was 18% (95%, Confidence interval (CI) = 15.92% to 19.98%).

Refractive error

Students with impaired visual acuity were invited for refraction, 28 declined participation, 16 boys and 12 girls and were then excluded from the denominator. Ten students were found to have other visual problems while 209 had a refractive error. The overall prevalence of refractive error among these High School students was 15.5% (CI= 13.6% to 17.4%), 209/1348. Among the 247 students with impaired visual acuity, 84.6% had a refractive error making it the most common cause. (Table 1)

Demographic characteristics of Students with refractive error

The mean age of the 209 students with refractive error was 17 years (SD = ± 1.04, range 14-23 years). This included 95(45.5%) males and 114(54.5 %%) females giving a male: female ratio of 1:1.2. The 28 students who declined refraction were 16 boys and 12 girls. Twenty eight boys and 14 girls out of 1390, opted out of both visual acuity testing as well as refraction but the difference was statistically insignificant (p= 0.1). Boys were 30% less likely to have refractive error than girls [Odd ratio, (OR) =0.7, 95% C.I= 0.5- 0.9] and this was statistically significant (p= 0.009). (Table 1)

Patterns of Refractive error in Students

All three types of refractive errors were found among this study population including 194 of 1348 (14.4%) with myopia, (103 (7.5%) with astigmatism and 10 (0.7%) hyperopia.

Myopia & Hyperopia Myopia was more prevalent among girls, 17% (106/625), compared to boys, 12.2% (88/723) and this was statistically significant [p= 0.01, OR= 0.7(CI= 0.4-0.9)] (Table 1). Table 2 shows the pattern, degree and type of refractive error among students with refractive error of right and left eye. Among students with refractive error (n=209), low myopia was the most prevalent form 78.3% (159/209) of right eye and 79.3% (161/209) of left eye. One hundred and eighty-five (88.5%) of 209 students had congruous myopia refractive error; that is the refractive error on the right eye matched the one on the left eye. Congruous low myopia accounted for 75.4 % (153/209) of students, congruous medium myopia at 10.3% (21/209), while all other congruous and incongruous forms of refractive error including hyperopia had proportions of less than 5%. None of the students had high hyperopia (>+5.00D).
Astigmatism: Overall in the left eye 103 (49.3%) of the 209 students had astigmatism. Nine (9%) of the 103 students had pure astigmatism while the other 94 (91%) had coexisting myopia or hyperopia. The most predominant type was 'with the rule' astigmatism, in 27.3% (57/209) in the right eye and 24.9% (52/209) in the left eye. The least common form was oblique astigmatism in 10.5% (22/209) of right eye and 12.9% (27/209) of left eye. Incongruous astigmatism (32%, 67/209) occurred more often than congruous astigmatism (29.7%, 62/209). (Table 3)

DISCUSSION

The first key findings in this study is that 18% of public high school students in Nairobi have impaired visual activity and 84.6% of it was attributable to refractive error. Our study recorded a prevalence of 15.5%, the prevalence of refractive error varies according to region, with the highest in Asia and the lowest in Africa. The prevalence in this study is in the range of other published work.[7-11] Our study shows higher prevalence of refractive error compared to other East African studies.[12] Some studies in Africa have shown an even higher prevalence.[10]

The heterogeneity of prevalence can be partly explained by differences in assessment methods and definitions of refractive error. Auto refraction is more sensitive than manual refraction and therefore studies using this method may find a higher prevalence of refractive error.[13] In published studies there is variability in the definition of abnormal visual acuity with some using a cut-off point of 6/9 while others used 6/12, 6/18 or worse vision in the better eye. The differences in the definition of impaired visual acuity partly reflect the changing policy environment as better understanding of the problem is achieved. The 2002 International Council of ophthalmology guidelines defined impaired vision on screening as 6/18. Since then a new global standard was adopted and current WHO recommendation is visual acuity of 6/12 or worse in the better eye is the cut-off in screening for refractive error.[14, 15] Other factors that have been attributed to the difference in refractive error prevalence are genetics, racial differences, geographic distribution and outdoor exposure.[16, 17]

In a resource constrained environment we were unable to refract the entire population. Therefore 'low vision' was dependent on the vision of the best performing eye when screening, overlooking students who had 'low vision' in one eye. Our study shows that 3.3% (45/1376) of students had normal vision in one eye while the other had poor vision. The 3.3% present a vulnerable group that requires follow-up as the vision in the normal eye could deteriorate. These students also qualify for protective eye-care if the vision in the fellow eye is disproportionately worse. They also may have difficulty in performing tasks that require stereopsis, such as hammering a nail or threading a needle which reduces their employability in some industries.

Gender differences in the rate of refractive error show that females are disproportionately affected, being 70% more likely to have refractive error compared to their male counterparts. Hormonal influence on growth spurts, and its relationship to the growth of ocular structures, has not being adequately investigated. However, there is evidence that later age at menarche is associated with decreased risk of moderate and high myopia.[11] As females generally experience therlache one year earlier than males experience adrenarche, the earlier exposure to pubertal hormones may explain the gender related differences in prevalence of refractive error.[18] Outdoor activity has also been shown to have a moderate effect on the progression of refractive error, in particular myopia.[19, 20] Whether girls have less outdoor activity in our population requires further investigation although increasing outdoor activities could be recommended amongst girl educationists as this has been shown to have a preventive effect on development and progression of refractive error.[20] [21]

Myopia in our population as well as internationally, is the commonest form of refractive error and this is affirmed in our study. [13, 17, 22-25] We found myopia more prevalent in girls, compared to boys. This was consistent with studies done in Europe but converse to studies done in Asia. [23, 26, 27] The prevalence of myopia increased from 9.5% in an earlier study done in the same location but in a younger age group (mean 14 years) to 14.1% in our study. [3]The prevalence in urban populations was higher than the prevalence of 1.7% found in a Kenyan rural population.[28]. There is undeniably an exponential increase in myopia, with higher prevalence in urban areas compared to rural areas. In our study, most of the students with refractive error had congruent low or medium myopia (85.7%).These studies show that the general trends of myopia are already established in a younger age group. Therefore, myopia progression and prevention interventions should commence early to be most effective.[29]

Pure astigmatism, without a spherical component, was rare in our population. Most students with astigmatism had a spherical component. In this study, the prevalence of astigmatism was higher than other regions in East Africa but lower than in other populations in the world.[30] [12] [17, 23, 26, 27] The most common pattern of astigmatism in students with refractive error was 'with the rule', occurring congruously in 17.2% and separately in 27.3% of right eye and 24.9% of left eye. In this regard, our study patterns matched other populations, where 'with the rule' often occurs in young populations.[27, 31]

The prevalence of hyperopia at 0.9% was remarkably low in our study, consistent with a study previously carried out in Nairobi.[3] Cycloplegic refraction was not feasible in our study and could partly have contributed to the low prevalence. In a study done in rural Kenya, hyperopia at 3.2% was the most prevalent form of refractive error.[28] In comparison with other populations, the prevalence of hyperopia was much lower than in other reported studies.[17, 27]

The multi-stage random sampling of the 11 participating schools enabled us to recruit a representative population of third form high school students in urban public schools. Just over four out of five eligible students were enrolled into the study. Over 96% of the enrolled students went through the 2-step screening process for refractive error, and therefore we are confident that the results of this study reflect the true prevalence and pattern of refractive error in this group of urban students. This study also illustrates some of the challenges that maybe faced if screening for visual acuity was to be carried out as public health campaign in schools. Nearly 20% of the students were unavailable on the day the screening was being conducted in their school, some absent while others declined maybe fearing the unknown. The city of Nairobi has many private schools and this population of students was not included in the study.

Our study among teenage high school students in Nairobi showed a high prevalence of refractive error, with a preponderance of myopia. The prevalence of myopia appears to have risen over the years, with a majority of students having low myopia. In addition, myopia is generally more prevalent in urban areas, while hyperopia is more predominant in rural Kenya. Our study also shows a higher prevalence of refractive error in girls compared to boys. In conclusion, comparative analysis of study hours and schooling habits in rural versus urban schools in Kenya might explain the difference in myopia and hyperopia prevalence compared with other parts of the world.These findings justify early childhood screening, prevention and intervention programs for refractive error.

Abbreviations

RE- refractive error

SPSS-20.0-Statistical Package for the Social Sciences version 20.0

LogMAr-Logarithm of the Minimum Angle of Resolution

Declarations

Ethics (and consent to participate)

Ethical approval was obtained from the from University of Nairobi - Kenyatta National Hospital Research and ethics committee(KNH-ERC/A/314)

Authority from the County Director for Education, Nairobi County was sought. Ministry of Education, Science and Technology. State Department of Education. Ref: (NC/GA/14/224)

Individual consent sought from the students.

Consent to Publish

Not applicable

Competing interests

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No other competing interests

Authors' contributions

Lily Nyamai- Conception and design, acquisition of data, analysis and interpretation of data, drafting the manuscript, approval, accountability

Daniel Kanyata- acquisition of data, drafting the manuscript, approval, accountability

Availability of data and materials

The dataset is available to individual researchers on request to lilynyamai@gmail.com and will uploaded on the University of Nairobi online repository once data mining for manuscripts is done and identifying information has been removed.

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Table 1: Demographic and Gender Characteristics of Students

		Students interviewed		Odds ratio (95% CI)	P- value
	Total N=1390	Male N=751	Female N=639		
Mean Age		Mean 17 yrs (14-23yrs) , S.D = ± 1.04)			
Impaired visual acuity§	247 (18%)	135/737 (18.3%)	116/637 (18.2%)	1.0 (0.7,1.3)	1.0
Opted- out of screening & refraction	42 (3%)	28 (3.7%)	14 (2.1%)	1.7 (0.9,3.3)	0.1
	N=1348	N=723	N=625		
Refractive errorα	209 (15.5%)	95 (13.1%)	114 (18.2%)	0.7 (0.5,0.9)	0.009
Myopia	194 (14.4%)	88 (12.0) (12.2%)	106 (17%)	0.7 (0.4-0.9)	0.01
Astigmatism	103 (7.6%)	57 (7.9%)	61 (9.8%)	0.9 (0.6-1.3)	0.8
Hyperopia	10 (0.7%)	4 (0.6%)	6 (1.0%)	0.6 (0.2-2.0)	0.6

§LogMar screening αsubjective/objective refraction

Table 2: Pattern, Degree and Type of Refractive Error in right eye and left eye

Pattern, Degree and Type of refractive error in right and left eyes									
N=209					Diagnosis of Left Eye				Population Prevalence Right eye (n=1376)
				MYOPIA			HYPEROPIA		
				High Myopia	Medium Myopia	Low Myopia	Low Hyperopia	Medium Hyperopia	
			TOTALS		23(11.3%)	161(79.3%)	8(3.9%)	2(1.0%)	
Diagnosis Right Eye	MYOPIA	High Myopia	9(4.4%)	7(3.4%)	1(0.5%)	1(0.5%)	-	-	Myopia 193(14.0%)
		Medium Myopia	25(12.3%)	1(0.5%)	21(10.3%)	3(1.5%)	-	-	
		Low Myopia	159(78.3%)	1(0.5%)	1(0.5%)	153(75.4%)	3(1.5%)	1(0.5%)	
	HYPEROPIA	Low Hyperopia	9(4.4%)	-	-	4(2.0%)	4(2.0%)	1(0.5%)	Hyperopia 10(0.7%)
		Medium Hyperopia	1(0.5%)	-	-	-	1(0.5%)	-	
	Population Prevalence left eye (n=1376)			Myopia			Hyperopia		
				193(14.0%)			10(0.7%)		

Low myopia (<-3.00 D)
Medium myopia -(3.25 D-6.00 D)
High myopia (<-6.25 D)
Low hyperopia <+2.00 Diopter
Moderate hyperopia +2.25 to +5.00 Diopter
High Hyperopia over +5.00 Diopter. (Skuta, Cantor, & Weiss, Clinical Optics, 2012-2013)

Table 3 Type of astigmatism in students with refractive error in Nairobi County

Types of Astigmatism*						
N=209			Left Eye Astigmatism			
			Against the Rule	No Astigmatism	Oblique	With the Rule
		TOTALS	24(11.5%)	106(50.7%)	27(12.9%)	52(24.9%)
Right Eye Astigmatism	Against the Rule	39(18.7%)	19(9.1%)	8(3.8%)	8(3.8%)	4(1.9%)
	No Astigmatism	91(43.5%)	5(2.4%)	80(38.3%)	4(1.9%)	2(1.0%)
	Oblique	22(10.5%)		5(2.4%)	7(3.3%)	10(4.8%)
	With the Rule	57(27.3%)		13(6.2%)	8(3.8%)	36(17.2%)

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