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ORIGINAL ARTICLE

Prevalence of Refractive Errors in Children in Equatorial Guinea

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ABSTRACT

Purpose. The aim of this work is to evaluate the epidemiological aspects of the refractive errors in school-aged children in Malabo (Island of Bioko), Equatorial Guinea (western-central Africa).

Methods. A total of 425 schoolchildren (209 male subjects and 216 female subjects, aged between 6 and 16 years) were examined to evaluate their refraction errors in Malabo, Equatorial Guinea (western-central Africa). The examination included autorefraction with cycloplegia, measurement of visual acuity (VA) for far vision, and the curvature radii of the main meridians of the anterior surface of the cornea.

Results. A low prevalence of myopia was found (≤ -0.50 diopters [D] spherical equivalent), with unilateral and bilateral myopia being 10.4 and 5.2%, respectively. The prevalence of unilateral and bilateral hypermetropia (≥ 2.0 D spherical equivalent) was 3.1 and 1.6%, respectively. Astigmatism (≤ -0.75 D) was found in unilateral form in 32.5% of these children, whereas bilateral astigmatism was found in 11.8%. After excluding children having any ocular pathology, the low prevalence of high refractive errors signified good VA in these children. Significant differences were found in the distribution of the refractive errors by age and type of schooling (public or private) but not by sex. In general, the radii of the anterior of the cornea did not vary significantly with age.

Conclusions. The mean refractive errors found were low and therefore VA was high in these children. There was a low prevalence of myopia, with significantly higher values in those who attended private schools (educationally and socio-economically more demanding). Astigmatism was the most frequent refractive error.

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Key Words: refractive errors, myopia, visual acuity, curvature radius, African schoolchildren, socioeconomic development

Uncorrected refractive errors are the leading cause of visual deficiency and the second highest cause of avoidable blindness in the world, being responsible for disability for 153 million people.[1] Prevalence is known to vary among societies, and these differences have been attributed to both genetic and environmental factors. A great number of studies have shown that the prevalence of myopia has increased in recent decades[2,3] and has become a worldwide problem. There is growing consensus concerning the exogenous factors involved in the prevalence of myopia, the most important being the increase in the level of education,[4–6] place of residence,[7,8] and socioeconomic and developmental level.[9] Other studies explore factors that may prevent or protect the appearance or progression of this disorder.[10,11]

Many studies have examined the prevalence of refractive errors in different countries in relation to variables such as age, educational level, ethnic background, and developmental level.[12–17] Even so, some areas of the world continue to have unknown levels of refractive errors, such as Africa, because few epidemiological studies of refractive errors have been performed in this continent,[17–24] although some of these studies administered optometric examinations only when visual acuity (VA) was not good and therefore the prevalence of refractive errors could be underestimated.[25]

The aim of the present study is to gather information on the prevalence of refractive errors in school-aged children in Malabo (Island of Bioko), the capital of Equatorial Guinea (western-central Africa). To date, no scientific studies that provide information on this subject have been conducted in this country.

METHODS

The field study was made during February 2012 in two public schools on the outskirts of the city and in one private school in the city center. In Malabo, enrolment in public schools is based generally on the residence zone, whereas in private schools, the socioeconomic level is the determinant factor, although a very small percentage can attend on scholarships, as the private schools

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are academically more demanding than the public ones. Three schools were chosen as representative, following the recommendations of the directors of Health and Education of Equatorial Guinea, for being in the capital and for having children from all the areas of the city. The net rate of schooling in Equatorial Guinea is 67%. In this country, the predominant ethnic group is the Fang (81.5%), followed by the Bubi (9.6%), and the rest are grouped as minorities, such as the Ndowé, Annabonesa, Pigmy, and Bisio, which we pooled as "Others." On the island of Bioko, the Bubi ethnic group represents 42% of the population, with the rest being primarily Fang. In total, 425 children participated in the study (209 male and 216 female subjects). The mean (±SD) age of the children was 10.77 (±3.10) years, with an age range of 6 to 16 years. All parents gave their informed consent. The present study adhered to the tenets of the Declaration of Helsinki. The permits necessary to perform this study were granted by health and educational authorities of Equatorial Guinea. Ethics approval for the protocol was granted by the Ministry of Health of Equatorial Guinea. Fifty percent of the children were examined at random (all the children were assigned a number and chosen for the study in multiples of 2). The distribution of the patients by age, sex, ethnic group, and type of school (public or private) is shown in Table 1.

Before the optometric examination, the ocular health of the subject was confirmed by indirect ophthalmoscopy. Of all the children assigned at random to participate in the study, 6 were excluded for having eye pathology (1 ptosis, 1 conjunctivitis, 2 cataracts, and 2 leukomas) and sent to the ophthalmology service of Loeri Comba Hospital of Malabo. The optometric examinations were made by two optometrists of the Optics Department of the University of Granada and an ophthalmologist from the Loeri Comba Hospital of Malabo. Visual acuity without correction was measured using the logarithmic tumbling E chart test (CSV-1000TumbE, Promoción Optométrica, Spain) at a distance of 6 m. The refractive error and the keratometric measurements were determined with an autorefractometer-keratometer (ARK-30, Nidek Co, Ltd, Tokyo, Japan) under cycloplegia. Two drops of 1% sodium cyclopentolate were instilled at 5-minute intervals. The cycloplegia was evaluated after 20 minutes and it was considered complete when the diameter of the pupil was 6 mm or greater and the photomotor reflex was absent,[19] whereas if not, a third drop was instilled. We performed cycloplegic autorefraction 30 minutes after the last instillation. For the autorefractometer-keratometer records, five readings from each eye were made during each measurement and averaged. The autorefractometer was calibrated daily before use.

The definition of the refractive errors followed the RESC (Refractive Error Study in Children) guideline[26]: a diagnosis of myopia is made when the spherical equivalent (SE) is more than −0.50 diopters (D) in at least one eye; hyperopia, when the SE is more than 2 D in at least one eye; astigmatism, having more than −0.75 D of cylindrical error in at least one eye; anisometropia, when the difference in SE between the right and left eye is more than 1 D; and bilateral emmetropia, when neither eye is myopic or hypermetropic. The RESC guideline, widely used in these types of epidemiological work, arose from the need of epidemiological studies to have unifying evaluation criteria. The World Health Organization supported a protocol to carry out refractive-error studies for different cultural and ethnic settings.[12,13,15,23,27–31] Because we also sought to quantify the prevalence of myopia, hyperopia, astigmatism (both monocular and binocular), and anisometropia, it is necessary to know the refractive error in each eye; hence, both eyes were examined in all children, as described in the literature.[9,17–20,29,32]

The statistical analysis was performed with the statistical package SPSS 15.0 (SPSS, Chicago, IL). The statistical tests used were as follows: analysis of variance (ANOVA) to compare the mean values between groups, at a significance level of $p < 0.05$. If the difference proved significant, it would be useful to identify the samples corresponding to this significance. For this, we performed a multiple comparison (Bonferroni *post hoc* test) of the mean of the variables for the different age groups and ethnic groups. To compare the prevalence values between groups, the χ^2 test was used, at a significance level of $p < 0.05$.

RESULTS

Visual Acuity Analysis

Children of this African region presented with good VA as would be suggested by the low prevalence of large refractive errors

TABLE 1.
Mean values of the logMAR VA, monocular and binocular, by sex and age groups and by school and ethnic groups

logMAR VA by sex and age groups (mean ± SD)

	All	Sex: Male	Sex: Female	p	Age groups, y: 6–8	9–11	12–16	p
n	425	209	216		123	129	173	
Monocular	−0.015 ± 0.154	−0.006 ± 0.111	0.035 ± 0.185	0.045	0.072 ± 0.153	−0.009 ± 0.105	−0.009 ± 0.175	<0.001
Binocular	−0.022 ± 0.149	−0.037 ± 0.113	−0.007 ± 0.176	0.039	0.049 ± 0.152	−0.045 ± 0.097	−0.055 ± 0.162	<0.001

logMAR VA by school and ethnic groups (mean ± SD)

	School: Public	Private	p	Ethnic groups: Fang	Bubi	Others	p
n	231	194		248	136	41	
Monocular	−0.006 ± 0.134	0.040 ± 0.172	<0.001	0.019 ± 0.149	−0.004 ± 0.138	0.049 ± 0.220	0.012
Binocular	−0.042 ± 0.137	0.003 ± 0.160	0.002	−0.171 ± 0.150	−0.339 ± 0.124	−0.008 ± 0.209	0.480

Standard deviation and p values are included.

TABLE 2.
Mean values of SRE and astigmatism by sex, school, ethnic groups, and age groups (mean ± SD); p values are included

		SRE, D	p	Astigmatism, D	p			SRE, D	p	Astigmatism, D	p
Sex	Male	+0.54 ± 0.68	0.194	−0.45 ± 0.45	0.001	School	Public	+0.58 ± 1.02	0.001	−0.48 ± 0.49	0.305
	Female	+0.42 ± 1.332		−0.56 ± 0.57			Private	+0.36 ± 1.11		−0.52 ± 0.55	
Ethnic group	Fang	+0.44 ± 1.21	0.396	−0.51 ± 0.49	0.125	Age, y	6–8	+0.65 ± 0.88	0.004	−0.49 ± 0.55	0.343
	Bubi	+0.51± 0.69		−0.51 ± 0.62			9–11	+0.55 ± 0.57		−0.47 ± 0.51	
	Others	+0.62 ± 1.16		−0.39 ± 0.32			12–16	+0.31 ± 1.40		−0.53 ± 0.50	
	All	+0.48 ± 1.07		−0.50 ± 0.52							

and exclusion of those with pathology. Table 1 shows the mean values of monocular logMAR (logarithm of the minimum angle of resolution) VA according to age, sex, school, and ethnic group. The mean (±SD) monocular logMAR VA was −0.015 (±0.154). The differences between age groups proved significant for the 6- to 8-year-old group with worse logMAR VA than the other two groups (ANOVA, $p < 0.001$; Bonferroni, $p < 0.001$ in both cases). Also, the differences were significant between sexes ($p = 0.045$), with the male group having better logMAR VA (−0.006 ± 0.111) than the female group (0.035 ± 0.185). With respect to the ethnic group, the Bubi presented a better VA than did the other ethnic groups, although differences were significant only with respect to Others (ANOVA, $p = 0.012$; Bonferroni test, $p = 0.021$).

Children from public schools had better monocular logMAR VA (−0.006 ± 0.134) than those from private schools (0.040 ± 0.172; ANOVA, $p < 0.001$). The binocular logMAR VA was 0.049 ± 0.152 in the 6- to 8-year-old group and was significantly better in the two other groups (ANOVA, $p < 0.001$; Bonferroni, $p < 0.001$ and $p < 0.001$). Significant differences were found in binocular logMAR VA by sex ($p = 0.039$), but not by ethnic group (ANOVA, $p = 0.480$). The binocular VA of the children from public schools (−0.042 ± 0.137) was significantly better (ANOVA, $p = 0.002$) than that from children from private schools (0.003 ± 0.160). These differences in VA, though statistically significant, are very small and not clinically meaningful.

Analysis of Refractive Error

Table 2 shows the mean values of spherical refractive error (SRE) and astigmatism for all the eyes studied, according to sex, age, ethnic group, and school. The mean (±SD) value of SRE for all the children studied was +0.48 (±1.07) D. No significant differences were found according to sex or ethnic group (ANOVA, $p = 0.194$ and $p = 0.396$, respectively). In terms of age groups, significant differences were found between the two youngest groups versus the 12- to 16-year-old group, which presented the lowest SE value (ANOVA, $p = 0.004$; Bonferroni, $p < 0.001$ and $p = 0.019$, respectively). We also found significant differences by schools: private ones presented a lower SRE value (ANOVA, $p = 0.001$). The mean (±SD) value for astigmatism was −0.50 (±0.52) D, without significant differences between age groups (ANOVA, $p = 0.343$), ethnic group (ANOVA, $p = 0.125$), or school (ANOVA, $p = 0.305$). Significant differences were found between sexes, with the highest values in the female group (ANOVA, $p = 0.001$). It is important to point out that the finding of statistically significant differences does not always imply that these differences are clinically significant (e.g., differences less than 0.25 D in SRE).

Prevalence of Refractive Errors

Table 3A shows the total prevalence of refractive errors and the distribution of prevalence by age groups and sex. Unilateral myopia was found in 44 children (10.4%), whereas bilateral myopia was diagnosed in 22 children (5.2%). Hyperopia in at least one eye was found in 13 children (3.1%), whereas binocularly 7 children were affected (1.6%). It is important to emphasize here that the numbers in both the unilateral and bilateral hyperopia groups are very small (13 and 7, respectively), and therefore the results in these two groups should be viewed with caution. Unilateral astigmatism was found in 138 children (32.5%) and bilateral astigmatism was viewed in 50 (11.8%). Anisometropia was present in 4.2% of the children. Only bilateral hyperopia (χ^2, $p = 0.005$) was greater in the 6- to 8-year-old group whereas unilateral astigmatism (χ^2, $p = 0.001$), which was lower in the 9- to 11-year-old group, presented significant differences. The rest of the refractive errors did not present significant differences according to age (χ^2, $p > 0.05$). With respect to bilateral emmetropia, the 9- to 11-year-old group presented significant differences with respect to the other two groups (χ^2, $p = 0.002$). In no type of ametropia did significant differences appear in the prevalence values according to sex (χ^2, $p > 0.05$).

The prevalence of the different refractive errors as a function of ethnic group and school and the significance values are listed in Table 3B. Only unilateral myopia (χ^2, $p = 0.004$) and bilateral myopia (χ^2, $p = 0.009$) presented significant differences according to school, with prevalence being greater in private schools. In the rest, no significant differences regarding school or ethnic group were found (χ^2, $p > 0.05$).

Analysis of the Curvature Radii of the Anterior Surface of the Cornea

Table 4 presents the mean values found according to sex, school, ethnic group, and age of the children. As can be seen, neither the flattest meridian (R1) nor the steepest one (R2) presented any significant differences according to age, ethnic group, or school. By sex, the differences between the two groups were significant for R1 ($p = 0.007$) and R2 ($p = 0.005$), with male subjects presenting the highest values (7.89 ± 0.46 mm in male subjects compared with 7.82 ± 0.30 mm in female subjects for the flattest meridian; 7.74 ± 0.49 mm in male subjects compared with 7.67 ± 0.30 mm in female subjects for the steepest meridian). Fig. 1 represents the orientation of R1 according to its frequency.

DISCUSSION

The prevalence of myopia (10.4%) found in this group of children from equatorial Africa is low and quite similar to that found in

TABLE 3.
Refractive-error prevalence by (A) age groups and sex and (B) ethnic groups and school

(A) Refractive-error prevalence by age groups and sex

Refractive groups	Age 6–8 y, % (n/N)	Age 9–11 y, % (n/N)	Age 12–16 y, % (n/N)	p	Male, % (n/N)	Female, % (n/N)	p	Total % (n/N)
Unilateral myopia	9.8 (12/123)	7.0 (9/129)	13.3 (23/173)	0.197	7.7 (16/209)	13.0 (28/216)	0.730	10.4 (44/425)
Bilateral myopia	4.1 (5/123)	3.9 (5/129)	6.9 (12/173)	0.397	4.3 (9/209)	6.0 (13/216)	0.426	5.2 (22/425)
Unilateral hyperopia	5.7 (7/123)	2.3 (3/129)	1.7 (3/173)	0.157	3.3 (7/209)	2.8 (6/216)	0.732	3.1 (13/425)
Bilateral hyperopia	4.9 (6/123)	0.0 (0/129)	0.6 (1/173)	0.005	1.9 (4/209)	1.4 (3/216)	0.671	1.6 (7/425)
Unilateral astigmatism	35.0 (43/123)	20.2 (26/129)	39.9 (69/173)	0.001	28.2 (59/209)	36.6 (79/216)	0.660	32.5 (138/425)
Bilateral astigmatism	8.9 (11/123)	8.5 (11/129)	16.2 (28/173)	0.064	9.6 (20/209)	13.9 (30/216)	0.167	11.8 (50/425)
Bilateral emmetropia	58.5 (72/123)	74.4 (96/129)	55.5 (96/173)	0.002	65.6 (137/209)	58.8 (127/216)	0.162	62.1 (264/425)
Anisometropia	4.1 (5/123)	3.9 (5/129)	4.6 (8/173)	0.944	2.9 (6/209)	5.6 (12/216)	0.169	4.2 (18/425)

(B) Refractive-error prevalence by ethnic groups and school

Refractive groups	Fang, % (n/N)	Bubi, % (n/N)	Others, % (n/N)	p	Public school, % (n/N)	Private school, % (n/N)	p
Unilateral myopia	11.3 (28/248)	8.8 (12/136)	9.8 (4/41)	0.743	6.5 (15/231)	14.9 (29/194)	0.004
Bilateral myopia	5.2 (13/248)	5.1 (7/136)	4.9 (2/41)	0.995	2.6 (6/231)	8.2 (16/194)	0.009
Unilateral hyperopia	2.8 (7/248)	2.2 (3/136)	7.3 (3/41)	0.254	3.9 (9/231)	2.1 (4/194)	0.274
Bilateral hyperopia	1.2 (3/248)	1.5 (2/136)	4.9 (2/41)	0.261	2.2 (5/231)	1.0 (2/194)	0.462
Unilateral astigmatism	33.9 (84/248)	31.6 (43/136)	26.8 (11/41)	0.650	32.0 (74/231)	33.0 (64/194)	0.834
Bilateral astigmatism	13.3 (33/248)	10.3 (14/136)	7.3 (3/41)	0.462	12.1 (28/231)	11.3 (22/194)	0.880
Bilateral emmetropia	60.1 (149/248)	64.7 (88/136)	65.9 (27/41)	0.586	63.6 (147/231)	60.3 (117/194)	0.481
Anisometropia	5.2 (13/248)	2.2 (3/136)	4.9 (2/41)	0.398	2.6 (6/231)	6.2 (12/194)	0.067

For each group, the values indicate percentages and children presenting each type of refractive error (and bilateral emmetropia) (n) over the total children examined (N); p values are included.

studies carried out in Morocco[19] (6.1%) and Tunisia[21] (9.1%), countries with a similar Human Development Index (HDI) and comparable average years of education.[26] It is not as low as that found in three other African studies: two in Burkina Faso[18,20] and one in Tanzania,[22] where only 0.5, 2.5, and 1.0%, respectively, of the children were reported to be myopic. These differences could be explained by the differences in development between the countries, which are reflected in educational and socioeconomic differences, in addition to ethnic factors. Other results considering a wider age range (from 15 to 50 years), where presbyopia was also included, showed a low prevalence of all refractive errors (6.4%) in Eritrea,[24] a country with a low HDI. The results of the present epidemiological study in general agree with other studies in populations with an urban lifestyle, as in Poland[7] (13.3%), Malaysia[9] (13.4%), India[12] (7.4%), and the United States[16] (9.2%), although these studies should be compared with caution because of the different methodology used, as well as differences in ethnic characteristics, population sizes, and ages, among others.

Among the most noteworthy results of this study are the significant differences found in the prevalence values of unilateral and bilateral myopia according to the type of school where the children studied. Our results agree with those found in Australia[28] and China,[6] where the prevalence values for unilateral and binocular myopia are reportedly greater in private schools in city centers that have greater academic demands (14.9 and 8.2%, respectively) than in public schools on the periphery of the city (6.5 and 2.6%, respectively). Our data suggest that these differences could also be explained by the socioeconomic differences in the country under study: Equatorial Guinea is the African country with the greatest inequality in gross national income per capita ($17,608) and its HDI rank is 136, giving a gross national income per capita rank minus HDI rank of −91, which reflects the inequalities of the population,[33] in such a way that the use of computers, video consoles, textbooks, and so on (activities requiring near vision, which can contribute to a higher prevalence of myopia[5]) is available only to those with a higher socioeconomic level. We found no

TABLE 4.
Corneal radius by sex, school, ethnic group, and age group (mean ± SD); p values are included

		R1, mm	p	R2, mm	p			R1, mm	p	R2, mm	p
Sex	Male	7.89 ± 0.46	0.007	7.74 ± 0.49	0.005	School	Public	7.88 ± 0.32	0.070	7.72 ± 0.30	0.059
	Female	7.82 ± 0.30		7.67 ± 0.30			Private	7.83 ± 0.46		7.67 ± 0.50	
Ethnic group	Fang	7.85 ± 0.45	0.820	7.69 ± 0.47	0.757	Age, y	6–8	7.88 ± 0.54	0.625	7.72 ± 0.60	0.619
	Bubi	7.87 ± 0.29		7.71 ± 0.29			9–11	7.85 ± 0.30		7.69 ± 0.29	
	Others	7.86 ± 0.31		7.73 ± 0.31			12–16	7.85 ± 0.31		7.69 ± 0.30	
	All	7.86 ± 0.39		7.70 ± 0.41							

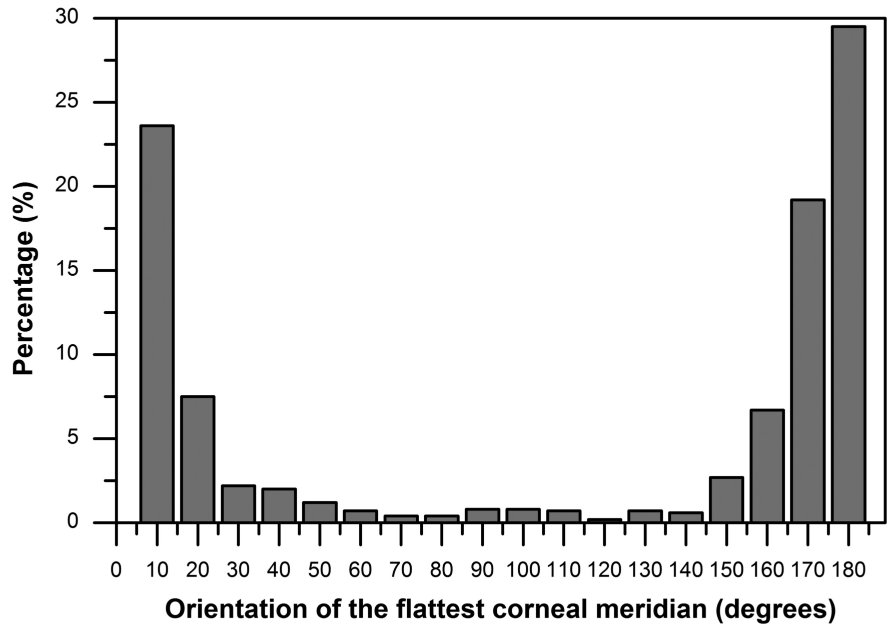

FIGURE 1.
Prevalence of orientations of the flattest corneal radius (R1).

significant differences in the distribution of myopia according to sex, age groups, or ethnic group.

The prevalence of unilateral hyperopia (3.1%) and bilateral hyperopia (1.6%) was very low and similar to values reported in other studies in the same continent: South Africa[17] (2.6%) and Burkina Faso[18] (4.9%). These values are also similar to those of countries in other continents, such as Malaysia[9] (2.9%), Australia[14] (6.1%), and Germany[15] (5.0%). We found significant differences only in bilateral hyperopia according to age.

Astigmatism, as in other studies, is the most prevalent refractive error,[19] with values (32.5% unilateral and 11.8% bilateral) far above those found in most African countries and only close to those found by Anera et al.[19] in Morocco in 2009 (23.5%). In relation to studies made in other zones, we found that they are similar to values reported in the United States by Kleinstein et al.[16] (28.4%).

The prevalence of anisometropia (4.2%) was very similar to that found in studies in Morocco[19] (2.9%), Burkina Faso[20] (3.5%), and Iran[13] (2.2%). None of the refractive errors presented differences according to the ethnic group, perhaps because all the ethnic groups except for the pigmies (included with the group Others) are of Bantu origin, implying similar genetic loads. Neither did we find differences according to sex.

The mean SE found was low, diminishing significantly with age, in agreement with a large number of studies[7,14,19,20] and significantly lower, as might be expected in private schools because of the greater prevalence of myopia. Therefore, the VA without correction (monocular and binocular) was good and significantly better with age but worse in private than in public schools.

In the analysis of the most frequent orientations of the main meridians of the anterior surface of the cornea (Fig. 1), it was found that the flattest meridian appeared most frequently with a horizontal orientation, whereas the most curved meridian had a vertical orientation, indicating that most corneal astigmatisms presented by these children are with the rule; this finding is consistent with the results shown in Morocco.[19] The female subjects presented a corneal power significantly greater in both meridians compared with the male subjects (these results coincide with those of Zadnik et al.[34] and Twelker et al.[35]).

CONCLUSIONS

The prevalence of myopia was very low in all the age groups and ethnic groups tested; it was higher in private schools. Astigmatism was the most frequent refractive error. There were no significant differences between the distributions of refractive errors according to sex. Children of this African region presented with good VA, as would be suggested by the low prevalence of large refractive errors. The results presented in this study agree with those of other studies on populations with low literacy and a nonurban lifestyle.

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