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REFRACTION ANOMALIES IN TANGANYIKAN CHILDREN*†

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THE present study was undertaken as an extension of work previously reported in which a high incidence of refractive errors was found in Gogo school children at Mvumi (McLaren, 1960).

Areas Surveyed

During 1961, school children aged 8 to 14 years were examined in six different areas of the Central, Lake, and West Lake Provinces of Tanganyika. Those in the neighbourhood of Mwanza (Lake Province) and Mvumi (Central Province) formed part of the group previously reported.

Mvumi has suffered from famine intermittently for many years. The latest famine occurred in 1953–54, so that children aged 8 to 14 had passed through the famine, some of them during their infancy. This is of interest because of the possible influence of nutritional status upon the incidence and degree of refractive errors in a community.

It was difficult to find another area comparable to Mvumi, but two schools (Sepuka and Munangana) in the Singida district (Central Province) were found to have a similar background in that there is intermittent famine and the economy is based mainly upon cattle raising; the diet is largely cereal (maize, millet, and sorghum) with very little meat or fish, cattle being regarded as wealth and seldom slaughtered. During the time of this study, Sepuka and Munangana (referred to below as "Singida II") were undergoing partial famine due to drought. Children at two other schools surveyed in the Singida district (Kiomboi and Kinambeu) had a much more varied diet; they are referred to below as "Singida I".

A single school was surveyed near Shinyanga (Lake Province); here the climate is hot and dry but the diet is more varied than in Mvumi. It is not in a famine area and cattle raising is common.

Four schools were surveyed near Bukoba (West Lake Province); here the climate is considerably wetter than in Mwanza (mean annual rainfall 35″) and the diet consists mainly of bananas.

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Examination

With the exception of those in Singida I and II, all the children were examined under 0·1 per cent. hyoscine cycloplegia (Sorsby, Sheridan, Moores, and Haythorne, 1955). Although mydriasis aided the study of the lens, it tended to hinder retinoscopy by uncovering peripheral lens aberrations. Sorsby and others recommend the instillation of one drop 0·05 per cent. hyoscine hydrobromide for good cycloplegia, but with these African children it was necessary to use 2 or 3 drops 0·1 per cent. hyoscine to obtain adequate cycloplegia and mydriasis. It was noted that, whether 0·05 or 0·1 per cent. hyoscine was used, mydriasis persisted for one week and in some instances for 2 weeks in these children, whereas Sorsby observed that the hyoscine effect cleared in 1 or 2 days. This prolonged cycloplegia interfered with school work and was a source of consternation to the children's families. For these reasons, we conducted the Singida surveys without cycloplegia. Refractions were done with a Hamblin battery-powered streak retinoscope and recordings were made so that astigmatism was always expressed as a plus cylinder measurement, the astigmatic axis being recorded in each instance. Visual acuity tests were attempted, but were found to be impracticable in these children examined under field conditions. The corneae were examined by the Zeiss 2× operating loupe and a hand-held, narrow-beam light source.

Observations

Refractive data previously reported from the Mwanza and Mvumi areas (McLaren, 1960) were verified and enlarged upon by this more detailed study.

It was thought advisable to record the refractive data both by "eyes" and by "patients", as this is the only way in which the truly wide range of observed refractive errors could be illustrated. Tables I to VI show the findings by eyes in each of the six areas studied. Both spherical and cylindrical errors were recorded for each eye, the astigmatism always being recorded as a plus cylinder. A usual method of recording refraction data from astigmatic eyes is to select the spherical equivalent of each eye and to record the resultant data in chart or graph form. That method is acceptable if one is satisfied to study spherical equivalent data. If one desires to analyse both spherical and astigmatic errors in large numbers of eyes, one must devise a method of illustrating these errors separately in their proper relationship and without distortion of the actual numerical value of the corrections involved. Tables I to VI accomplish this. A glance will show the spread of both astigmatic and spherical errors in the group illustrated. Furthermore, the astigmatic and spherical errors are seen in exactly the same relationship to one another as they occurred in the individual eyes.

A single example will suffice. Table I (opposite) shows that, in the Mvumi district, out of 1,015 eyes examined, 318 had less than +1 D spherical error

combined with less than +0·2 D cylindrical error. Similarly, there were three eyes with less than +1 D spherical error combined with a cylindrical error of between +3·1 and +4 D. Sorsby, Sheridan, Leary, and Benjamin (1960) used a similar chart which will be referred to in relation to astigmatic errors.

TABLE 1

DATA FOR 519 MVUMI SCHOOL CHILDREN, BY EYES

Sphere (Dioptres)		Plus Cylinder (Dioptres)									Totals
		0·0 to 0·19	0·2 to 0·3	0·4 to 0·5	0·6 to 1·0	1·1 to 2·0	2·1 to 3·0	3·1 to 4·0	4·1 to 5·0	5·1 to 6·0	
Plus	+9·0 to +9·9										
	+8·0 to +8·9	2									2
	+7·0 to +7·9										
	+6·0 to +6·9					1					1
	+5·0 to +5·9			1	1		1				3
	+4·0 to +4·9	1		1	2			1			5
	+3·0 to +3·9	2		2	1	2	2				9
	+2·0 to +2·9	8	2	3	2	3	2				20
	+1·0 to +1·9	69	15	11	10	5	2	2			114
	+0·0 to +0·9	318	119	96	47	13	2	3			598
Minus	−0·1 to −1·0	81	38	32	16	6	3				176
	−1·1 to −2·0	2	4	3	5	11	6	1			32
	−2·1 to −3·0	3	1	2	1	5	4	1			17
	−3·1 to −4·0	2				3	3	1			9
	−4·1 to −5·0	1				1	1	1			4
	−5·1 to −6·0		1	1				2	1		5
	−6·1 to −7·0	2		1			1				4
	−7·1 to −8·0					2			1	1	4
	−8·1 to −9·0							1			1
	−9·1 to −10·0	1						3		1	5
	−10·1 to −11·0				1				1		2
	−11·1 to −12·0									1	1
	−12·1 to −13·0					1	1	1			3
Totals		492	180	153	86	53	28	17	3	3	1,015

TABLE II

DATA FOR 507 MWANZA SCHOOL CHILDREN

Sphere (Dioptres)		Plus Cylinder (Dioptres)									Totals
		0·0 to 0·19	0·2 to 0·3	0·4 to 0·5	0·6 to 1·0	1·1 to 2·0	2·1 to 3·0	3·1 to 4·0	4·1 to 5·0	5·1 to 6·0	
Plus	+9·0 to +9·9										
	+8·0 to +8·9										
	+7·0 to +7·9										
	+6·0 to +6·9										
	+5·0 to +5·9										
	+4·0 to +4·9										
	+3·0 to +3·9										
	+2·0 to +2·9	1		1							2
	+1·0 to +1·9	32	3	6	2						43
	+0·0 to +0·9	485	127	55	14	1					682
Minus	−0·1 to −1·0	143	46	45	16	2		1			253
	−1·1 to −2·0	6	3	2	6	2					19
	−2·1 to −3·0	1	1	1	1	1					5
	−3·1 to −4·0	1		1		1					3
	−4·1 to −5·0										
	−5·1 to −6·0	1		1			1				3
	−6·1 to −7·0							1			1
	−7·1 to −8·0										
	−8·1 to −9·0										
	−9·1 to −10·0										
	−10·1 to −11·0										
	−11·1 to −12·0										
	−12·1 to −13·0										
Totals		670	180	112	39	7	1	2			1,011

TABLE III

DATA FOR 53 SHINYANGA SCHOOL CHILDREN

Sphere (Dioptres)		Plus Cylinder (Dioptres)									Totals
		0·0 to 0·19	0·2 to 0·3	0·4 to 0·5	0·6 to 1·0	1·1 to 2·0	2·1 to 3·0	3·1 to 4·0	4·1 to 5·0	5·1 to 6·0	
Plus	+9·0 to +9·9										
	+8·0 to +8·9										
	+7·0 to +7·9										
	+6·0 to +6·9										
	+5·0 to +5·9										
	+4·0 to +4·9										
	+3·0 to +3·9										
	+2·0 to +2·9										
	+1·0 to +1·9	10	1		2						13
	+0·0 to +0·9	65	11	2	1		1				80
Minus	−0·1 to −1·0	4	2	4							10
	−1·1 to −2·0	1									1
	−2·1 to −3·0									1	1
	−3·1 to −4·0										
	−4·1 to −5·0										
	−5·1 to −6·0										
	−6·1 to −7·0										
	−7·1 to −8·0										
	−8·1 to −9·0										
	−9·1 to −10·0										
	−10·1 to −11·0										
	−11·1 to −12·0										
	−12·1 to −13·0										
Totals		80	14	6	3		1			1	105

TABLE IV

DATA FOR 280 BUKOBA SCHOOL CHILDREN

Sphere (Dioptres)		Plus Cylinder (Dioptres)									Totals
		0·0 to 0·19	0·2 to 0·3	0·4 to 0·5	0·6 to 1·0	1·1 to 2·0	2·1 to 3·0	3·1 to 4·0	4·1 to 5·0	5·1 to 6·0	
Plus	+9·0 to +9·9										
	+8·0 to +8·9										
	+7·0 to +7·9								1		1
	+6·0 to +6·9										
	+5·0 to +5·9										
	+4·0 to +4·9										
	+3·0 to +3·9										
	+2·0 to +2·9										
	+1·0 to +1·9	27	5	4							36
	+0·0 to +0·9	294	76	49	4						423
Minus	−0·1 to −1·0	43	11	21	7	1					83
	−1·1 to −2·0	3	4		2		1				10
	−2·1 to −3·0	1		1		1					3
	−3·1 to −4·0	1						1			2
	−4·1 to −5·0										
	−5·1 to −6·0			1							1
	−6·1 to −7·0										
	−7·0 to −8·0										
	−8·1 to −9·0										
	−9·1 to −10·0										
	−10·1 to −11·0										
	−11·1 to −12·0										
	−12·1 to −13·0										
Totals		369	96	76	13	2	1	1	1		559

TABLE V

DATA FOR 222 SINGIDA I SCHOOL CHILDREN

Sphere (Dioptres)		Plus Cylinder (Dioptres)									Totals
		0·0 to 0·19	0·2 to 0·3	0·4 to 0·5	0·6 to 1·0	1·1 to 2·0	2·1 to 3·0	3·1 to 4·0	4·1 to 5·0	5·1 to 6·0	
Plus	+9·0 to +9·9										
	+8·0 to +8·9										
	+7·0 to +7·9										
	+6·0 to +6·9										
	+5·0 to +5·9										
	+4·0 to +4·9										
	+3·0 to +3·9	1									1
	+2·0 to +2·9										
	+1·0 to +1·9	5									5
	+0·0 to +0·9	227	39	39	17	3					325
Minus	−0·1 to −1·0	20	14	29	31	2					96
	−1·1 to −2·0			3	5	8					16
	−2·1 to −3·0										
	−3·1 to −4·0										
	−4·1 to −5·0										
	−5·1 to −6·0										
	−6·1 to −7·0										
	−7·1 to −8·0										
	−8·1 to −9·0	1									1
	−9·1 to −10·0										
	−10·1 to −11·0										
	−11·1 to −12·0										
	−12·1 to −13·0										
Totals		254	53	71	53	13					444

TABLE VI

DATA FOR 236 SINGIDA II SCHOOL CHILDREN

Sphere (Dioptres)		Plus Cylinder (Dioptres)									Totals
		0·0 to 0·19	0·2 to 0·3	0·4 to 0·5	0·6 to 1·0	1·1 to 2·0	2·1 to 3·0	3·1 to 4·0	4·1 to 5·0	5·1 to 6·9	
Plus	+9·0 to +9·9										
	+8·0 to +8·9										
	+7·0 to +7·9										
	+6·0 to +6·9										
	+5·0 to +5·9										
	+4·0 to +4·9						1				1
	+3·0 to +3·9	1				1					2
	+2·0 to +2·9	1		1							2
	+1·0 to +1·9	7	1	2	1	1	1				13
	+0·0 to +0·9	220	42	70	16	5	1	1			355
Minus	−0·1 to −1·0	11	3	14	13	15	3				52
	−1·1 to −2·0				1	7	3	1			12
	−2·1 to −3·0				2	1	6				9
	−3·1 to −4·0						1	1			2
	−4·1 to −5·0										
	−5·1 to −6·0										
	−6·1 to −7·0										
	−7·1 to −8·0					1					1
	−8·1 to −9·0										
	−9·1 to −10·0										
	−10·1 to −11·0										
	−11·1 to −12·0										
	−11·1 to −13·0										
Totals		240	46	87	33	31	16	3			456

Sorsby, Benjamin, Davey, Sheridan, and Tanner (1957a) chose 4 D as the outer limit of myopia or hyperopia which can be included in the "aberrations of emmetropia". In this study, ametropia is taken to comprise those spherical errors which are greater than +3·5 D or −1 D. It is felt that errors of this magnitude are sufficiently large to be clinically significant.

Table VII, composed of data extracted from Tables I to VI, shows the relative incidence, by eyes, of spherical ametropia as well as that of cylindrical errors greater than +1 D. It is at once evident that spherical as well as astigmatic errors were much more prevalent in Mvumi than elsewhere. Most of the refractive errors in all areas tended to myopia, and 8·6 per cent. of the eyes refracted in Mvumi area had more than − 1 D spherical error, compared with an average of 2·9 per cent. for the Mwanza, Bukoba, Shinyanga, and Singida I areas combined. The Singida II area eyes had 5·5 per cent. of their spherical refractive error in this range.

The occurrence of astigmatic errors greater than +1 D averaged 10·6 per cent. of eyes in Mvumi and Singida II, but only 1·7 per cent. for the remaining areas. In all areas the majority of eyes had refractions lying within the limits defined by Sorsby and others (1957a). Of 3,590 eyes refracted, only 190 had spherical errors greater than +3·5 or −1 D, and 184 had cylindrical errors greater than +1 D. As noted by Sorsby and others (1960) in examining young British national servicemen, the astigmatic errors in the Tanganyikan children tended to cluster about the smaller spherical errors.

TABLE VII

SPHERICAL AND CYLINDRICAL ERRORS IN 374 OUT OF 3,590 EYES EXAMINED

Type of Error		Mwanza	Bukoba	Shinyanga	Singida I	Singida II	Mvumi	Total Errors
Sphere	> +3·5 D	0 (0·0%)	1 (0·2%)	0 (0·0%)	0 (0·0%)	1 (0·2%)	11 (1·1%)	13
	> −1 D	31 (3·1%)	16 (2·9%)	2 (1·9%)	17 (3·8%)	24 (5·3%)	87 (8·6%)	177
	Total	31 (3·1%)	17 (3·0%)	2 (1·9%)	17 (3·8%)	25 (5·5%)	98 (9·7%)	190
Cylinder	> +1 D	10 (1·0%)	5 (0·9%)	2 (1·9%)	13 (2·9%)	50 (11·0%)	104 (10·3%)	184
Total Eyes Examined		1,011	559	105	444	456	1,015	3,590

Table VIII (overleaf) shows the incidence of bilateral spherical ametropia in 1,817 children. They average less than 2 per cent. for all areas, except Mvumi with 5 per cent. ametropia, of which 4·4 per cent. was due to myopia. The ametropia in all other areas was exclusively due to myopia.

Spherical anisometropia is a term not easily defined because of the many possible types of anisometropia. For the purposes of this study, anisometropia is defined

TABLE VIII
BILATERAL AMETROPIA IN 48 OUT OF 1,817 CHILDREN EXAMINED

Area	Mwanza	Bukoba	Shinyanga	Singida I	Singida II	Mvumi	Totals
No. of Ametropic Children (Myopia)	9 (1·8%)	5 (1·8%)	0 (0·0%)	4 (1·8%)	4 (1·7%)	26 (5·0%) 23 myopes (4·4%) 3 hyperopes (6·6%)	48 45 myopes 3 hyperopes
Total Children Examined	507	280	53	222	236	519	1,817

as that condition in which one eye has less than 0·75 D spherical error while the other has more than +3·5 or −1 D, and there is at least 1 D difference in the spherical refractive error of the two eyes. The majority of patients classified as anisometropic had much more than 1 D difference between the two eyes. Table IX shows the incidence of this type of anisometropia in each of the areas examined. The incidence is greatest in Mvumi with 7·3 per cent. and Singida II with 5·5 per cent. compared with an average of 1·4 per cent. in the remaining four areas.

TABLE IX
SPHERICAL ANISOMETROPIA IN 65 OUT OF 1,817 CHILDREN EXAMINED

Area	Mwanza	Bukoba	Shinyanga	Singida I	Singida II	Mvumi	Total
No. of Anisometropic Children	7 (1·4%)	4 (1·4%)	1 (1·9%)	2 (1·0%)	13 (5·5%)	38 (7·3%)	65
Total Children Examined	507	280	53	222	236	519	1,817

It will be seen that in Tables VII, VIII, and IX, the numbers of eyes do not tally with the numbers of patients. For example, in Table VII, there are 98 eyes at Mvumi with spherical refractive errors greater than +3·5 or −1 D; in Table VIII there are 26 Mvumi children (52 eyes) with bilateral spherical errors of the same order, and in Table IX there are 38 Mvumi children with spherical anisometropia. By our definition of anisometropia, only one eye in each of the last 38 children had an error greater than +3·5 or −1 D. As calculated from Tables VIII and IX, the total number of Mvumi children's eyes with errors greater than +3·5 or −1 D is 90, while Table VII lists 98 such eyes. This discrepancy is caused by borderline cases which did not fit into our defined boundaries of bilateral ametropia and anisometropia. Each of these borderline cases had one ametropic eye, but the fellow eye was either not sufficiently ametropic to classify the patient as a bilateral ametrope or not sufficiently emmetropic to classify the patient as an anisometrope. In the whole series there were 29 of these borderline cases, of which 25 were on the myopic side. In other words, had it been possible to include them with the overall data, they would have added their weight to the preponderance of myopia in all areas. They were distributed over the six centres in such a way that their inclusion or deletion did not materially affect the relative incidence of refractive errors in the six areas.

1,757 children were examined for evidence of trachoma (Table X), the diagnosis in individual cases being based upon the presence of Herbert's pits and/or active pannus at the superior limbus (Thygeson, 1960).

TABLE X
TRACHOMA IN 470 OUT OF 1,757 CHILDREN EXAMINED

Area	Mwanza	Bukoba	Shinyanga	Singida I	Singida II	Mvumi	Total
No. of Children with Trachoma	50 (9·9%)	34 (12·2%)	22 (41·5%)	15 (6·8%)	83 (35·2%)	266 (58·0%)	470 (26·8%)
Total Children Examined	507	280	53	222	236	459	1,757

One corneal lesion commonly noted at Mvumi but seldom encountered in other areas was a hazy appearance of the epithelium. This haze did not appear to be an oedema but could rather be described as a faint whitening of the epithelial cells. The haze appeared in various patterns ranging from a diffuse involvement to a nummular and punctate scattering. Although eyes in which corneal haze complicated the classical signs of trachoma were too few to be considered significant, all these eyes were excluded in the study of the relationship between trachoma and astigmatism. The study of trachoma with astigmatism was limited to eyes showing only Herbert's pits and/or active pannus of the superior limbus, and are referred to in the following discussion. The aetiology of the corneal haze is obscure but may have resulted from relatively mild xerosis corneae in early infancy due to vitamin A deficiency (McLaren, 1960). Another possible explanation is suggested by the fact that the condition occurred mostly in those children living in a hot, dry, and dusty atmosphere, in intimate association with large herds of cattle.

Discussion

In a study such as this, it would have been impossible to conduct a complete genetic survey. In the Mvumi area, however, relatives of the 519 school children in the survey were refracted, and the incidence of bilateral ametropia and anisometropia in various related groups is shown in Table XI.

TABLE XI
INCIDENCE OF REFRACTIVE ERRORS IN RELATED GROUPS AT MVUMI

Group	Number Refracted	No. with Refractive Errors	
		Bilateral Ametropia	Anisometropia
(1) School Children	173	11 (6·3%)	24 (13·9%)
(2) Parents and Grandparents	191	22 (11·5%)	19 (9·9%)
(3) Non-school Siblings	139	13 (9·3%)	10 (7·1%)
(4) Related School Children	222 } 519	15 (6·7%)	21 (9·4%)
(5) Unrelated School Children	297 }	11 (3·7%)	17 (5·7%)

The groups comprise 173 school children (1), 191 of their parents and grandparents (2), and 139 of their siblings not at school (3). Of the total 519 school children examined at Mvumi, 222 were related to one another as siblings, cousins, aunts, uncles, nephews, or nieces (4) and the remaining 297 were not so related (5).

This high familial incidence would seem to bear out the generally held opinion that high refractive errors are usually genetically determined (Sorsby, 1951; Sorsby and others, 1957a,b). The fact that myopia so preponderated in the Mvumi famine area cannot be lightly passed over, but the present study has failed to establish any causal relationship between malnutrition and refractive error. The Singida II famine area had an incidence of bilateral myopia (Table VIII) resembling that in the non-famine areas, although the percentage incidence of anisometropia was almost identical with that in Mvumi. Duke-Elder (1949a) implies that anisometropia of the type described in this study is almost impossible to explain on the basis of nutritional changes. During the Mvumi studies, relatives were questioned as to deaths occurring during the famine of 1953–54 and, although most families reported the death of most of their cattle, human deaths did not greatly exceed the normal expectation. If malnutrition has played a part in the refractive errors of these children and their relatives, one possible factor to consider is a vitamin A deficiency during infancy. A deficiency severe enough to interfere with corneal metabolism but not sufficiently severe to produce keratomalacia and resultant gross corneal damage could conceivably alter the corneal curvature and the total ocular refraction.

It would seem that animal experimentation would be the only possible way of solving the problem of the effect of nutritional status on the total refraction of the eye. It has been stated (Duke-Elder, 1949b) that monkeys are often highly myopic. Long-term studies, involving a large series of pedigreed myopic and emmetropic monkeys subjected to various dietary deficiencies, could possibly provide valuable answers to these questions.

Of 1,817 school children examined, 45 had bilateral myopic ametropia while only three had bilateral hyperopic ametropia (Table VIII), and all the latter were seen at Mvumi. In view of previous reports of the preponderance of hyperopia and the practical non-existence of myopia among literate and illiterate Africans (Holm, 1937), this group with a high incidence of myopia and almost no hyperopia is of special interest. The incidence of myopia in Mwanza, Bukoba, Shinyanga, and Singida I and II averaged 1·3 per cent., which compares favourably with the 1·4 per cent. normal incidence of myopia in lower-grade school children in Germany as reported by Cohn (1949); in contrast, the incidence of myopia in Mvumi was 4·4 per cent.

The occurrence of trachoma among these children deserves special attention. The incidence was high in the Mvumi and Singida II areas, where it was also much more severe, the Herbert's pits being larger and more numerous and the pannus much heavier and more extensive.

Table XII contains data from 2,892 eyes from the six areas (1,078 had simple hyperopic astigmatism, and the remaining 1,814 were emmetropic), showing the relative incidence of simple hyperopic astigmatism and emmetropia in trachomatous and non-trachomatous eyes. Although there was a higher incidence of simple hyperopic astigmatism where the trachoma was more severe, this was even more evident in the non-trachomatous ($P < 0{\cdot}001$) than in the trachomatous ($P < 0{\cdot}01$) group. As Herbert's pits and trachomatous pannus comprise essentially a cicatrization of the upper limbus, it was thought wise to investigate the possible effect of this scarring upon the astigmatic axis. Table XIII shows that, in the two areas considered separately, the incidence of against-the-rule astigmatism is almost identical in the trachomatous and non-trachomatous groups. When the incidence of against-the-rule astigmatism in the groups is compared it is evident that, although it is higher in the severe trachoma group (Mvumi and Singida II) than in the mild trachoma group, it is higher still in the non-trachomatous group.

TABLE XII

INCIDENCE OF SIMPLE HYPEROPIC ASTIGMATISM AND EMMETROPIA WITH AND WITHOUT TRACHOMA IN 2,892 EYES

Area		Trachoma		No Trachoma	
		Simple Hyperopic Astigmatism	Emmetropia	Simple Hyperopic Astigmatism	Emmetropia
Mwanza, Bukoba, Shinyanga, Singida I	Mild	80 (37·5%)	133 (62·5%)	588 (33·0%)	1,195 (67·0%)
Mvumi, Singida II	Severe	196 (52·1%)	180 (47·9%)	214 (41·2%)	306 (58·8%)

TABLE XIII

WITH-THE-RULE AND AGAINST-THE-RULE ASTIGMATISM WITH AND WITHOUT TRACHOMA IN 1,078 EYES

Area		Trachoma		No Trachoma	
		Simple Hyperopic Astigmatism		Simple Hyperopic Astigmatism	
		With-the-rule	Against-the-rule	With-the-rule	Against-the-rule
Mwanza, Bukoba, Shinyanga, Singida I	Mild	61 (76·2%)	19 (23·8%)	442 (75·2%)	146 (24·8%)
Mvumi, Singida II	Severe	121 (61·3%)	75 (38·7%)	124 (57·9%)	90 (42·1%)

Data from Tables XII and XIII indicate that, while the incidence of trachoma is directly proportional to the incidence of astigmatism, and to that of against-the-rule astigmatism in particular, the latter can hardly be a causal relationship; there is obviously another factor which raises the incidence of against-the-rule astigmatism in non-trachomatous patients in areas where trachoma is more severe. We must assume that the trachomatous scarring of the upper limbus does not produce the same astigmatic changes as those commonly observed after such operations as cataract extraction with a superior limbal incision.

Summary

A study of the refraction of Tanganyikan school children in six areas of the country, comprising the results for 3,590 eyes, is reported. The high incidence of myopia in both school children and their relatives in a famine area of central Tanganyika is discussed and compared with the incidence of refractive errors in other areas. Evidence was found to support the classical view that myopia and anisometropia are genetically determined. If malnutrition played a role in the production of refractive errors, it was considered that distortion of the cornea from vitamin A deficiency was more likely to be responsible than interference with the growth of the eyeball by general inanition. Although trachoma and astigmatism were prevalent in the famine area studied, no causal relationship could be traced between them.

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