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THE GROWTH OF THE EYE AND THE DEVELOPMENT OF MYOPIA: A STUDY IN THE CHANGES OF REFRACTION DURING THE SCHOOL PERIOD*

BY

A. SOURASKY

LONDON

THE material used for this investigation consists of the "follow up" records of the school clinic of the Tottenham Urban District Council; they therefore concern school children between the ages of five to fourteen; some of these records date back to 1915, and as all the refractions were done by one individual, the material forms an entity where the personal element is reduced to a minimum. Practically all the retinoscopies were done under hyoscine (oily solution 0.25 per cent.) Cases where the refractions were done at one time under hyoscine and at another under atropine were rejected from this series, as were also those in which the refractions did not lend themselves to analysis owing to some doubtful element in the records (irregular refractions, incomplete cycloplegia, etc.)

The selected material came to 621 cases (1,242 eyes); these fell into two groups, one containing 395 cases of hypermetropia including hypermetropic astigmatism, and the other 226 cases of myopia including myopic astigmatism, mixed astigmatism, and other cases not readily classified but containing a myopic element. Some

* This investigation was carried out under the auspices of the Jewish Health Organisation of Great Britain.

of these cases had been followed up for only one year, but others for seven, eight and even ten years.

In tracing the alterations in the refractive errors during the years they were followed up, it would have been of interest to see whether any of the changes observed were most active at some particular period of childhood. Unfortunately there were too few cases to establish the comparison of age groups which this implies. It was therefore necessary to ignore altogether the question of the age of the subject and confine oneself to the number of years he had been followed up; thus in recording a case followed up for four years the tables do not show whether these four years were between, say five and nine or ten and fourteen.

I. NORMAL DEVELOPMENT

A. The Development of the Hypermetropic Eye

An analysis of the 395 cases of hypermetropia (790 eyes) revealed a certain number that had only been followed up for one or two years, and 36 cases where the changes recorded are of irregular nature. Ignoring both these groups a series of 277 cases is obtained, which was followed up for a period varying from three to eight years. Of these 231 had been followed up for three, four or five years, and 46 for six, seven or eight years.

It is necessary to explain the system of classification adopted in tracing the modifications observed in these cases as they were followed up. Under "no change" were included all the cases that showed absolutely no change in the refraction or where the refractions were substantially the same, namely, a ± 0.5 variation. Spherical refraction offered no difficulty and astigmatic cases where both axes changed to the same extent were likewise easy. In cases of astigmatism where the two axes developed at unequal rates, any difference up to and including ± 0.5 was ignored and from 0.5 to 1 the difference was divided and added to each axis. When the difference was greater than 1D. the cases were considered as irregular. For some few cases an increase of hypermetropia is recorded; whether these are cases of genuine increase of hypermetropia or errors of observation is an interesting problem, but irrelevant to our present purpose.

An analysis of the 231 cases followed up for three to five years reveals an apparent increase of the hypermetropia in 15.5 cases; no change in 135.5 cases; and a reduction of hypermetropia in the remaining 80 cases. Of these 80 cases showing a reduction of hypermetropia, in 56 the reduction is between 0.5D.-1.0D.; a more extensive reduction occurs in the comparatively few remaining cases: in 19 the reduction ranged between 1.25D. and 2.0D.; in 45 between 2.25D. and 3.0D.; in 0.5 case the reduction was between 3.25D.-4.0D. and in none more than 4.0D. In terms of percentages the analysis can be stated as showing 65.4 per cent. no reduction of hypermetropia and 34.6 per cent. reduction to a varying degree.

A very similar result is obtained in an analysis of the 46 cases followed up for the longer period of six, seven and eight years. Here the percentages of no reduction and reduction are 60.8 and 39.2 respectively, thus differing but little from those obtained for the larger series followed up for a shorter period. The actual distribution of the cases is as follows: apparent increase of hypermetropia 4.5 cases; no change 23.5; and in the different groups of reduction of hypermetropia enumerated before the numbers are 8, 65, 25, 0 and 1 respectively.

These figures would suggest that the majority of hypermetropic children show no reduction during the school period, and in those that do, it is confined in a large proportion to a reduction that is slight in extent, as is brought about by the following summary table:—

Cases followed up for	No reduction and reduction of not more than 1.0D	Reduction between 1.0D and 2.0D	Reduction over 2.0D
3, 4 and 5 years ...	207	19	5
6, 7 and 8 years ...	36	6.5	3.5

Cases that show a substantial reduction of hypermetropia are therefore by no means common, and it is clear that the tendency towards decrease in the amount of hypermetropia does not seem to be marked during the school period.

Before leaving this subject it will be of interest to see whether the modifications observed apply equally to cases of hypermetropia of a high degree as to cases nearer the emmetropic margin.

For this purpose the cases have been divided into four arbitrary groups, according to the degree of hypermetropia present, conforming to the following definitions:—

- Borderline Hypermetropia :** Cases of simple hypermetropia below 1.25D., and cases of hypermetropic astigmatism where the lesser axis is below 1.25D.
- Low Hypermetropia :** Simple hypermetropia (or the lesser axis of hypermetropic astigmatism) ranging between 1.25 and 3.0D.
- Medium Hypermetropia :** Cases on a similar basis ranging between 3.25D. and 6.0D.
- High Hypermetropia :** Over 6.0D.

Of the 231 cases followed for three to five years 62.5 fell in the group of borderline hypermetropia, 96.5 in that of low hypermetropia, 55 in that of medium, and 17 in that of high hypermetropia. Regarding apparent increase of hypermetropia and no change as one entity (no reduction) the following summary table shows to what extent the different groups of hypermetropia vary in the relative percentages they show of no reduction and reduction.

CASES FOLLOWED UP FOR 3, 4, AND 5 YEARS.

	No reduction	Reduction of hypermetropia
Hypermetropia of less than 1.25D.	67.2%	32.8%
„ „ 1.25D. to 3.0D.	65.3%	34.7%
„ „ 3.25D. to 6.0D.	59.1%	40.9%
„ „ over 6.0D.	79.4%	20.6%

From these figures it would appear that cases up to 1D. and from 1D. to 3D. develop on parallel lines, while above 3D. the hypermetropia seems to develop differently from the foregoing, and from each other when the two subdivisions of the cases above 3D. are considered. However, in these two sub-divisions we are dealing with rather small figures; but if these two groups are added together, that is, all cases above 3D. are considered as one entity, we get 72 cases of which 46 show no reduction of hypermetropia as against 26 which do, *i.e.*, 63.9 per cent. and 36.1 per cent. respectively. These percentages agree remarkably with those for the other groups of hypermetropia, *i.e.*, below 3D., and whilst one would have liked to have had more cases of hypermetropia above 6D. (because of the suggestion in the small number under the consideration that they are relatively stationary in development), it seems safe to conclude that cases of varying degrees of hypermetropia develop at the same pace, there being no greater percentage of cases showing changes in refraction amongst the cases of low hypermetropia as compared to the cases of medium and higher degrees of hypermetropia—in fact about 66 per cent. of all cases of hypermetropia show no tangible reduction when followed up for a period of three, four and five years.

No percentages have been worked out for the 46 cases followed up for six to eight years, as the numbers in each sub-division are so small. The number of cases showing reduction of hypermetropia is rather greater in those cases that have been followed up for the longer period of six to eight years, but there is nothing in the figures to contradict the conclusions reached above. The actual figures of cases showing reduction and no reduction in this group are seen in the following summary table:—

CASES FOLLOWED UP FOR 6, 7 AND 8 YEARS.

	No reduction	Reduction of hypermetropia
Hypermetropia of less than 1.25D.	5	4.5
„ „ 1.25D. to 3.0D.	11.5	9
„ „ 3.25D. to 6.0D.	9.5	4.5
„ „ over 6.0D.	2	—

B. The Development of the Myopic Eye

Of the 226 cases with a myopic element, 84 were followed up for only one or two years, and 12 for over five years, leaving 130 cases that were followed up for three, four or five years. The method of classifying the modifications these cases had undergone is very similar to the one used for the hypermetropic cases, and the results obtained with these three groups of cases of myopia are best considered separately.

(1) The 12 cases followed up for more than five years.

This group is too small to be considered to any extent. It is, however, interesting to note that fully 5 out of the 12 cases showed no change in the refraction. Of the remaining 7 cases 1 showed an increase of myopia less than 1.0D.; 5 an increase between 1.25D.-2.0D., and 1 an increase of over 4.0D.

(2) The cases followed up for only one and two years.

This group can be dismissed briefly—of the 84 cases 49.5 showed no change; of the remaining 34.5 cases which showed an increase in myopia, 20.5 recorded an increase of 0.75D.-1.0D.; 13 an increase of 1.25D.-2.0D., and only 1 case gave an increase of 2.25D.-3.0D.

(3) The cases followed up for three to five years.

This group of 130 cases is of considerable interest. The result of the analysis can be tabulated as follows:—

34.6%	show no change	
17.7%	show an increase by	0.75D. - 1.0D.
23.9%	„ „	1.25D. - 2.0D.
12.3%	„ „	2.25D. - 3.0D.
3.5%	„ „	3.25D. - 4.0D.
6.5%	„ „	over 4.0D.
1.5%	„ „	that is irregular
100%		

The interesting feature of this analysis is the high proportion of cases (34.6 per cent.) that show no change when followed up for a period of from three to five years. These cases taken together with those that show but little progression (0.75 and 1.0D.) make up over 50 per cent. of all the cases, which is a distinctly lower percentage than that for the corresponding groups among the hyper-

metropes. It is an everyday experience to find the myopic eye developing to a greater and more rapid extent than the hypermetropic eye, and in this respect this table brings out nothing new. But what is worthy of note is that fully 50 per cent. of myopes do not show the steady, creeping progress that one associates mentally with every case of myopia. In hypermetropia it has been seen that the tendency is towards the refractive conditions remaining stationary rather than become greatly reduced; in myopia the tendency towards progression is decidedly more marked, but there is, nevertheless, a large class that remains stationary or develops but little.

An analysis of the cases of myopia according to the degree and type of myopia is of interest; the groups considered are:—

- Low Myopia: Myopia up to 3.0D. and myopic astigmatism, where the higher axis is no more than - 3.0D.
- Medium Myopia: Similar cases within the range of - 3.25D. to - 6.0D.
- High Myopia: Over - 6.0D.
- Mixed Astigmatism:—
- Unclassified: Cases with a myopic element that do not fall in the above groups, *i.e.*, anisometropia, and cases of astigmatism in which contrary signs (*i.e.*, + and -) are present in only one eye.

Ignoring the cases followed up for only one and two years, and those few followed for more than five years, a table is obtained of which the following is a summary:—

CASES FOLLOWED UP FOR 3, 4 AND 5 YEARS.

	No change and a progression of 0.75D. - 1.0D.	Progression of 1.25D. - 2.0D.	Progression of over 2.25D.
Low myopia	12	19	19
Med. „	14	4.5	5.5
High „	5	2	—
Mixed astigmatism	19.5	4.5	2
Unclassified	17.5	1	2.5

It is not safe to draw any final conclusions from these figures as they are not extensive, but it appears that the cases of low myopia show the greatest tendency towards progression. In this connection it is of interest to note that of 7 cases of high myopia, 5 are for practical purposes stationary, and though a stationary type of high myopia in children is a recognised clinical condition, it

would be interesting to know whether a larger series would substantiate the suggestion of this small series: that among high myopes the stationary type is more common than the progressive.

II. ABNORMAL DEVELOPMENT

A. Abnormal Development of the Hypermetropic Eye

It has been seen earlier on that out of 98 cases of hypermetropia that show a reduction, 64 reveal a reduction of less than 1.25D. and that in 25.5 of the remaining 34 the reduction is between 1.25D. and 2.25D. The remaining $8\frac{1}{2}$ cases (17 eyes) deserve a few remarks. Do these cases represent a special type of hypermetropia which tends to diminish more rapidly than the usual variety, or are they explicable in some other way? It will be best to consider each case separately.

Case No. 1.—The child (a boy) was first seen at the age of eight. The refraction changed within one year from R.: Emm.; L.: + 0.5D. to -1D.B.E.* At 14 the refraction was -5.25D. We are, therefore, dealing with a case of progressive myopia rather than of hypermetropia. The interest here lies in the fact that the hypermetropia did not remain stationary, as it does in most cases, but passed over to myopia. It is unfortunate that no earlier refraction than the one at eight is available. Anyhow, this large diminution is not so much a diminution of hypermetropia as an increase of myopia.

Case No. 2.—This boy of nine showed a refraction of +0.5D., cyl. axis vertical. By 13 he was myopic to the extent of -2.5D. This case is therefore similar to No. 1, except that his myopia is not so progressive.

Case No. 3.—This boy first seen at six showed a hypermetropia of about 3D. By the age of ten it had dwindled to +0.5D. Here is a case of rapidly diminishing hypermetropia, that is hypermetropic eyes behaving like myopic. It is unfortunate that his refraction a few years later is not available. Is he a potential myope, through heredity or otherwise, and is his hypermetropic reserve of no avail in saving him from myopia? Can there be a hypermetropia of the potentially myopic eye, and does this hypermetropia diminish more rapidly than the normal type?

Case No. 4.—This girl showed a refraction of +5.5D. each eye at the age of eight. Four years later the hypermetropia had dwindled to 2.5D. This case, therefore, like the preceding, shows a development more akin to myopia than to hypermetropia.

Thus, whilst cases Nos. 1 and 2 are of interest as showing cases which instead of remaining stationary pass over to myopia, and

*In stating the findings of refractions "allowance for distance" has been made.

keep on progressing, Nos. 3 and 4 illustrate rather similar conditions, but the eyes are still hypermetropic, not so much because of a slighter progression, as on account of a larger hypermetropic reserve.

In the cases just considered both eyes have progressed to the same extent, but in the following the progress was mainly confined to one eye.

Case No. 5.—A boy first seen at five, with refraction

At 9 the refraction has changed rather unequally in the two eyes, being :—

But at 13, four years later the refraction was

Ignoring the change in the astigmatism in the left eye, there is no dramatic variation here, but the right eye has changed greatly towards emmetropia. Here we have a case of two almost symmetrical eyes developing along different lines, one developing rapidly and towards emmetropia, and the other remaining more or less stationary and hypermetropic.

Case No. 6.—Ignoring as in No. 5 the change in the degree of astigmatism, the essential feature is the very much greater development of the right eye.

At 8 the refraction was

at 10 a reduction of 1.0D. had occurred in each eye, but at 13, the following refraction was present

Case No. 7.—Beginning at the age of nine with almost symmetrical refractions, three years later one eye is practically unchanged, whilst the other is myopic.

L. + 0.5

The last three cases are rather striking, but the following cases illustrate the same condition, only the discrepancy between the two eyes is not so marked.

Case No. 8.

Case No. 9.

at 13 R. Hypermetropia reduced by + 0.75 D.
L. Hypermetropia reduced by + 2.5 D.

Case No. 10.

at 13 R. Hypermetropia reduced by 2.75D.
L. Hypermetropia reduced by 1.5D.

Case No. 11.

It will be seen that the right eye has passed on to mixed astigmatism, whilst the left, progressing at a slightly slower pace, has not yet done so.

There remains yet one more case where the hypermetropia has decreased by over 2.0D., but as this is a case of corneal nebulae, no useful purpose is served by giving details of the refraction here.

The very paucity of the number of cases of hypermetropia that develop to any large extent, emphasises the extent to which hypermetropia tends to remain stationary, but a consideration of these 11 cases tempts one—not so much on the evidence of cases Nos. 3 and 4, which show a diminution in hypermetropia more than most, but on the evidence of the unilateral development of cases like Nos. 5, 6 and 7—to suggest that there is a rapidly diminishing

form of hypermetropia in addition to the normal slowly diminishing or stationary type, and the bearing of such a condition on myopia is obvious. Furthermore, there is the probability that this type is not so uncommon as the evidence submitted here tends to suggest, owing to the fact that a rapidly diminishing hypermetropia is likely to escape observation in the stage before it passes over to myopia, unless there be a high hypermetropic reserve. Children subject to this rapidly diminishing type of hypermetropia would in all probability be first seen as myopes, as they are the very subjects who, on account of their low hypermetropia, would escape attention in a routine school examination for visual acuity until such time as their vision became defective owing to the development of myopia.

B. Abnormal Development of the Myopic Eye

In considering abnormal development in the hypermetropic eye, the point of interest that emerged was that all hypermetropic eyes do not develop at the same pace, and that even symmetrical eyes in the same individual may develop unequally, giving rise to asymmetry.

In discussing anomalies of development in the myopic eye, it will serve no useful purpose to show a slowly and a rapidly progressing type, as both of these are well known clinically, and the cases shown here are of interest in illustrating that unequal development occurs in the myopic eye as it has been shown to occur in the hypermetropic.

Cast No. 1.—The interest of this case lies in the fact that from the age of eight to thirteen, the left eye remained stationary, whilst the right, which was much less myopic, progressed rapidly, practically reaching the myopia of the left.

This type of case is distinctly rare—one individual exhibiting the two extremes of which myopia is capable—namely, remaining stationary and progressing rapidly.

The tendency towards unequal development is also illustrated by the three following cases of anisometropia.

Case No. 5.

Refraction at 7

$$\begin{array}{c} -0.25 \\ \text{R} \quad \text{---} \quad \text{---} \quad +3.25 \\ \text{---} \end{array}$$

$$\begin{array}{c} +0.5 \\ \text{L} \quad \text{---} \quad \text{---} \quad +3.75 \\ \text{---} \end{array}$$

Refraction at 12

$$\begin{array}{c} -3.5 \\ \text{R} \quad \text{---} \quad \text{---} \quad +0.5 \\ \text{---} \end{array}$$

$$\begin{array}{c} +0.5 \\ \text{L} \quad \text{---} \quad \text{---} \quad +3.5 \\ \text{---} \end{array}$$

Here it is seen that the left eye is stationary, whilst the right has progressed to the extent of about -3D .

Case No. 6.

Refraction at 9

$$\begin{array}{c} -3 \\ \text{R} \quad \text{---} \quad \text{---} \quad +2.5 \\ \text{---} \end{array}$$

$$\begin{array}{c} +2.25 \\ \text{L} \quad \text{---} \quad \text{---} \quad +1.5 \\ \text{---} \end{array}$$

Refraction at 13

R. No change

L. $+0.5\text{D}$.

Apart from bringing out the fact of asymmetrical development taking place in myopic cases as well as in hypermetropic, these few cases when taken in conjunction with the hypermetropic cases are of interest in suggesting that anisometropia must frequently be due to this asymmetrical development, and is not, as is generally believed, a congenital asymmetry from the very first.

This suggestion is further strengthened by the following cases derived from other sources than those considered up to now.

Case No. 7.—This patient was seen by Mr. A. H. Levy in November, 1915, at the age of ten. His vision was then R. 6/6; L. 6/60.

Refraction

R. $+3.0$ L. -1.0

With correction, vision was

R. 6/6

L. 6/9

Glasses ordered

R. $+2.0\text{D}$. sphereL. -2.0D . sphere

Sixteen months later vision with glasses in the right was 6/6, and in the left 6/36. But -4.0D. sphere for the left gave 6/6.

In March, 1927, vision without glasses was

R. 6/5	L. > 6/60
Refraction	
$\begin{array}{c} +1.25 \\ \\ \text{R} \text{---} +1.25 \\ \\ = 6/6 \end{array}$	$\begin{array}{c} -12.5 \\ \\ \text{L} \text{---} -11.0 \\ \\ = 6/36 \end{array}$

The marked progress of the myopia is most striking, especially in comparison with the relatively stationary hypermetropia. It is not at all unlikely that this anisometropia had its origin in perfectly symmetrical eyes.

Cases Nos. 8, 9, 10 and 11 illustrate the same condition, but not to such a dramatic extent.

Case No. 8.

Refraction at age of 9	R. - 1.5	L. +1.5
„ 3 years later	R. - 4.5	L. +1.0

Case No. 9.

Refraction at age of 11	R. +0.5	L. - 1.0
„ 3 years later	R. No change	L. - 4.0

Case No. 10.

Refraction at age of 7	R. - 2.5	L. Emm.
„ 3 years later	R. $\frac{-5.0}{-1.0 \downarrow}$	L. No change

Case No. 11.

Refraction at age of 14	R. +0.5	L. - 0.5
„ 1 year later	R. Emm.	L. - 1.25
„ 1 year later	R. +0.25	L. - 2.5
still		

It is, therefore, perhaps not unjustifiable to conclude that at least some cases of anisometropia have their origin in the unequal development of the two eyes. Or to put it differently: not only may there be a varying pace at which the eyes of different individuals develop, but also the two eyes in the same individual may develop at a different rate.

III. THE PROBLEM OF MYOPIA

The analysis of the hypermetropic cases has revealed the fact that on the whole the hypermetropic eye tends to remain stationary; reduction of more than 1.0D. during three to five years of school life is decidedly unusual. Still it cannot be denied that there are cases that do develop to some extent, and a few to over 2.0D.

That some development must take place is obvious by the appearance of low degrees of myopia in many children towards the end of school life. This is a well substantiated observation; in fact myopes constitute only about 10 per cent. of the visually defective among children between the ages of five and nine, whilst the percentage rises to about 25 in the case of children between ten and fourteen as was shown elsewhere (BRITISH JOURNAL OF OPHTHALMOLOGY, April, 1928). The existence of these cases therefore argues that in addition to the majority of cases where the hypermetropia is stationary there must exist a class of cases where it progresses on to myopia. The analysis has shown that this is the case, and indeed it is common experience.

But the question that arises is this: Do these cases of hypermetropia passing over to myopia represent a normal growth, *i.e.*, is the myopia the physiological result of a congenital absence of a high hypermetropic reserve? If the question be answered in the affirmative one must explain why about 66 per cent. of borderline hypermetropia, *i.e.*, hypermetropia below 1.25D. remain stationary, and do not become myopes. Admitting that we are dealing with a limited period of the child's life, and that we have in these statistics no evidence at all of what happens after the age of fourteen, it must still be recognised that the comparative value of these two groups remains. It remains a fact that for the period discussed here about 66 per cent. remain stationary, and the remainder progress—and that of this remainder some cases progress very rapidly indeed, as the consideration in the section on the abnormal development of the hypermetropic eye has shown (particularly in the case of development of one eye). Still it is also true that of the hypermetropic cases that do show development there are but few that show it extensively. But it must not be forgotten that the series considered here is composed of selected cases, cases that have found it necessary to maintain attendance; if a low hypermetrope have an extensive reduction of his hypermetropia he becomes a myope and thus remains under observation, and any further progress is regarded as the progression of the myopia; but if a medium or a high hypermetrope has his hypermetropia reduced extensively, he finds he can see better and quite comfortably without his glasses and simply discards these, and is no

longer seen in the treatment centre. It is, therefore, not surprising that in a "follow up series" there should be comparatively little direct evidence of a rapidly diminishing hypermetropia and that most of the evidence submitted here should come from the relatively few cases of development of this type confined to one eye, as these cases still find it necessary to maintain attendance.

One would have liked to have the more direct evidence, such as would be given by a large series of unselected cases followed up for many years, but it would seem warranted on the evidence considered to conclude that :

(1) The vast majority of hypermetropic cases are absolutely stationary—or almost so—during the school period.

(2) A certain proportion show some reduction say up to 1.5D.

(3) A much smaller proportion show a more marked reduction, even over 4D.

When the cases of myopia are analysed it is found that progression is the characteristic of about 66 per cent., *i.e.*, the position is reversed in comparison to hypermetropia. As myopic cases are more subject to supervision, they lend themselves much more to an accurate analysis, and it is not necessary to stress what is well known. Thus it is well established that :

(1) Some cases are stationary.

(2) Many progress slowly and constantly.

(3) Some few progress very rapidly (progressive myopia).

But what the analysis has brought out is the fact that the proportion of cases that are stationary during the school period, is quite considerable (about 33 per cent.) and furthermore that about 15 per cent. progress very slowly indeed (0.5D.-1.0D.)

Again making allowance for the limited period with which these figures deal, their comparative value must also be stressed. It is also worth recalling that the greatest tendency towards progression is exhibited by the cases of low myopia.

What has been said so far, may briefly be summarised thus :—

(1) that there is a progressive type of hypermetropia as well as of myopia, and (2) that there is also a stationary type of myopia as well as of hypermetropia. (It is, of course, unnecessary to point out that while progression implies the same process in both myopia and hypermetropia, it results in a decrease in the error of refraction in the case of hypermetropia, but an increase in the case of myopia).

The conclusions to which one is tempted by these observations are :

(1) That the normal tendency shown by the hypermetropic eye during school period is to remain stationary.

(2) If any noticeable reduction takes place this must be regarded as abnormal.

(3) It is this abnormality manifested by the hypermetropic eye which is the root cause of myopia.

(4) If this abnormality—undue development of the eye—is at all marked, myopia must supervene unless there be a high hypermetropic reserve.

(5) This abnormality may be of a feeble extent or quite strongly marked (just as there are mild and severe forms of other abnormal processes).

(6) It affects the hypermetropic and myopic eye equally, but it is most obvious in eyes that have become myopic owing to this affection.

(7) This process may become arrested at any stage and any period: hence the stationary type of myopia.

(8) Or it may continue unchecked for a considerable time (progressive myopia) even through adult life (malignant myopia).

(9) The greater frequency of the progressive type in low degrees of myopia is explained by the fact that low myopia is an early manifestation of this affection; whilst the increase of the stationary type in the medium and high degrees finds its explanation in the fact that the process is subsiding after running its course.

(10) Or to be put otherwise: this tendency is a disorder, which may affect any eye, irrespective of its being hypermetropic, emmetropic or myopic; its intensity is variable and its course is evolutionary, ending in subsidence, sometimes early in childhood (as these statistics show) usually at some period during adolescence (as is the common experience), more rarely not until late life (of which type most oculists have experience).

(11) This process is *not* myopia: indeed, myopia only stands in casual connection with it; it is most commonly seen in myopia as this is one of its results.

(12) A myopic eye elongates not because it is myopic, but because it is subject to this affection. Myopia *per se* is no more the cause of the progressive elongation of the globe, than a glaucomatous cup is the cause of increasing tension.

Apart from the evidence considered here in favour of this view the following clinical observations may be mentioned.

(1) Cases do occur in which "typical myopic crescents" are present in eyes with low hypermetropia and in eyes with very low myopia. These cases must be regarded—if the crescents are really due to stretching—to a rapid reduction of the hypermetropia from a high degree to a low, or to low myopia, *i.e.*, as manifestations of this affection in the hypermetropic eye.

(2) Very extensive myopic changes are sometimes found in relatively low degrees of myopia: these eyes were in all probability originally cases of high hypermetropia and their low myopia therefore represents a stretching of a considerable degree.

(3) There are also the somewhat rare cases of high myopia with but little degeneration. These may be either purely congenital errors (and they are generally believed to be such) or they may represent cases where the greater part of the high degree of the myopia is not due to this process which induces stretching, with its concomitant degeneration.

As an illustration of the onset of this alleged disorder in eyes that had been developing normally (*i.e.*, remaining practically stationary) for a period of years and then began to show rapid development (*i.e.*, behaving like myopic eyes) the following case can be given.

A girl, aged five, showed the following refraction

R. +4.5D.

L. +4.0D.

At eleven the refraction had changed to

R. +3.0D.

L. +3.5D.

but at thirteen both eyes showed a refraction +1.5D.

Thus for the whole of the first six years the mean reduction for each eye was 1.0D., as against a reduction of 1.75D. for a period of no more than two years later on. This later reduction is much more like the progression seen in myopia, and in fact should this tendency to a reduction of about 1D. per year persist till about 18, the child will become a myope of about -3.5D.

A somewhat similar condition is seen in the right eye in case No. 5, and in the left eye in case No. 8 of the hypermetropic series.

An attempt to define the nature of this affection which causes elongation of the eye opens an extensive problem, the discussion of which is not within the scope of this paper. But as a passing suggestion it is worth recalling that vitreous changes are a frequent association of myopia—and it may very well be that the relationship is more than casual, that stretching of the sclerotic is induced through its being relaxed or perhaps softened through a chronic inflammatory condition of the eye (manifested by the vitreous changes).*

Perhaps it is not superfluous to add that this article is offered not so much as a serious contribution to the problem of myopia, as a plea for the more intensive study of the changes undergone by the eye during the period of growth. It is only through an understanding of the physiological changes undergone by the eye, that one can hope to appreciate that abnormal development which results in myopia.

* Since this paper has been written there has appeared the Annual Report for 1927 of the School Medical Officer of the London County Council, where there is a record of the work of Dr. Elizabeth M. McVail, who found that children subject to progressive myopia show a definitely heavier incidence of infected tonsils than the normal school population. (V. p. 664 of this number.)

Summary

I. When traced for a period of three to five years, about 65 per cent. of hypermetropes showed no reduction of their hypermetropia. Of the remaining cases, a reduction of more than 1.0D. was seen in only a few.

II. Rather similar proportions were obtained for the smaller number of cases followed up for six to eight years, as far as the percentage of cases showing no reduction is concerned; for those cases that do show reduction, the tendency is for the reduction to be rather heavier.

III. These considerations, in all probability, apply equally to all degrees of hypermetropia, whether near the emmetropic margin or over 6.0D.

IV. About 35 per cent. of cases of myopia appear to be stationary when followed up for between three to five years; and about 15 per cent. show an increase of not more than 1.0D.; it is only in the remaining 50 per cent. that the progression is seen that one associates with all myopes.

V. Unlike the conditions seen among hypermetropes, the different degrees of myopia appear to behave in a different manner. Thus low myopia seems to tend more towards progression than medium and high myopia, and mixed astigmatism.

VI. A consideration of cases of abnormal development reveals that some cases of hypermetropia developed more on the lines of the rapid progression seen in myopia than on the relatively stationary condition or slow progression usually obtained in hypermetropia. Much of the evidence brought forward is concerned with the unequal development seen in the two eyes of an individual.

VII. Similar unequal development is shown to exist among myopes.

VIII. It is concluded that not only may there be a varying rate at which the eyes of different individuals develop, but also that the two eyes in the same individual may develop at a different rate, and incidentally the congenital nature of most cases of anisometropia is questioned.

IX. Mainly in view of the fact that there are :

(1) Some cases of hypermetropia changing as rapidly as myopia.

(2) Some cases of myopia remaining as stationary as hypermetropia, and

(3) Symmetrical eyes progressing unequally,

it is argued that the refractive condition of an eye has nothing to do with the tendency to progression. This tendency is regarded as an abnormal state supervening as readily in the hypermetropic as in the myopic eye, and may affect one eye only. That this tendency should be most often seen in myopia is only to be

expected, as it induces a myopia where this has not existed before. Myopia is the result, not the cause of the progression.

X. Cases are quoted to illustrate how hypermetropia that has been stationary for years suddenly diminishes, without going on to myopia, because of the presence of a sufficient hypermetropic reserve.

XI. Of the behaviour of this disorder which induces elongation of the globe, it is pointed out that it has an evolutionary course, beginning at some period of childhood, and persisting through adolescence (progressive myopia), though it may become arrested at an earlier age (stationary myopia in children), or go on through adult life (malignant myopia). (The usual age for the onset of this disorder is probably somewhere about twelve to fourteen years).

XII. A passing suggestion as to the nature of this disorder is made.

XIII. During the school period the growth of the eye has but little effect on its refractive condition.

In conclusion, I wish to express my indebtedness to Mr. T. W. Letchworth. Apart from making this work possible through his permission to use the material discussed in this paper, he has helped the writer to get a clear perception of many of the ideas expressed, of which not a few represent what he has been teaching for some years.

To Mr. A. H. Levy I am obliged for permission to use case No. 7, in the series of myopic cases; and it is a pleasure to acknowledge appreciation of his ready help and sympathetic criticism.

ASEPTIC SEROUS MENINGITIS FOLLOWING INTRA-OCULAR FOREIGN BODY

BY

FRANK W. LAW, M.A., M.B.

SENIOR HOUSE SURGEON, ROYAL LONDON OPHTHALMIC HOSPITAL

I BELIEVE the case described below to be of a very rare type, and worthy of report.

E.W.H.N., male, aged 17 years, was admitted to this hospital on September 25, 1928, having been sent here from the Royal Free Hospital. At 11 a.m. on the morning of admission he had been struck in the right eye and face by some steel splinters while at work; no previous eye trouble was reported.

There was a skin abrasion of the right cheek. The right eye was slightly injected and watering; examination revealed a perforating