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Changes in refraction between the ages of 1 and 3½ years

R. M. INGRAM AND A. BARR

From the Kettering and District General Hospital, Kettering

SUMMARY A study has been made of the changes in refraction as a sample of 148 children grew between the ages of 1 and 3½ years. There was no decrease in hypermetropia, but there was a significant decrease in the incidence of astigmatism. Study of the changes in the refraction in the horizontal and vertical meridia of individual eyes gave clear evidence of a trend towards emmetropia if the initial refraction in either meridian was myopic or less than +2·50 D. Above that level the refraction became more or less hypermetropic.

A knowledge of the changes that take place in the refraction of children during and after the sensitive period is required if we are to understand any connection between refractive errors and squint and amblyopia. Lagleyze (in Lyle, 1950) believed that there was a steady decrease in hypermetropia after birth, but Fabian (1966) has suggested that a process of 'emmetropisation' occurred. So far the only study of the changes of refractions occurring in a sample of children as they grow was confined to children over the age of 3 years (Sorsby *et al.*, 1961).

The old-established view, attributed to Lagleyze (in Lyle, 1950) is that all babies are born hypermetropic and as they grow they become less long-sighted. This view has been criticised by Cook and Glasscock (1951) and Ruskell (1967). Recent observations show that newborn babies are not predominantly hypermetropic (Cook and Glasscock, 1951; Graham and Gray, 1963; Grignolo and Rivara, 1968; Gotch and Kitazawa, 1968; Goldschmidt, 1969; Patel *et al.*, 1970; Lledo, 1976). Such a hypothesis would be confirmed if there was a decreasing incidence of a given level of hypermetropia or if the mean of the range of refractions shifted towards myopia. On the other hand Fabian (1966), relating his own observations in children during the second year of life to other workers' reports of refractions of children at different ages, observed that a curve drawn to represent the refractions of newborn children had a very wide spread and that this variation decreased as the age of the children increased. This suggests that there is a tendency for those children born either myopic or hypermetropic to become emmetropic. So far Fabian's hypothesis has not been challenged.

Address for reprints: Dr R. M. Ingram, Kettering and District General Hospital, Rothwell Road, Kettering, Northamptonshire NN16 8UZ

Materials and methods

Details of the 148 children and their refractions at ages 1 and 3½ years have been reported in an earlier paper (Ingram *et al.*, 1979, Tables 2 and 3).

Results

The association between anisometropia and astigmatism was first noticed among our children who were refracted after atropinisation (Ingram, 1979) (Table 5). For future reference attention is drawn

Table 1 *Refractions of individual eyes*

	Age 1 year	*Age 3½ years*	*Difference*
Incidence of hypermetropia +2·00 or more DS	33/296 = 11·0%	36/296 = 12·2%	Not significant
Incidence of astigmatism +1·50 or more D	35/296 = 11·8%	15/296 = 5·1%	P<0·01
Incidence of astigmatism +1·00 or more D	88/296 = 29·7%	23/296 = 7·8%	P<0·001

Table 2 *Refractions of children*

	Age 1 year	*Age 3½ years*	*Difference*
Incidence of bilateral hypermetropia +2·00 or more DS	16/148 = 10·8%	17/148 = 11·5%	Not significant
Incidence of astigmatism of +1·50 or more D in either or both eyes	23/148 = 15·5%	10/148 = 6·7%	P=2·68%
Incidence of anisometropia	12/148 = 8·1%	13/148 = 8·8%	Not significant

to a similar association at ages 1 year and $3\frac{1}{2}$ years (Table 3). This association is highly significant at both ages in spite of the fact that 7 children were anisometropic at 1 year but not at age $3\frac{1}{2}$, their places being taken at age $3\frac{1}{2}$ by 8 children who were not anisometropic at age 1 year.

It is also true to say that at both ages an anisometropic eye was significantly more likely to have +1·50 or more D of astigmatism (irrespective of whether the fellow eye is also astigmatic). At age 1 year $P \ll 0{\cdot}001$; at age $3\frac{1}{2}$ years $P \ll 0{\cdot}001$.

The refractions of these children have been recorded in 4 different ways so that the range of refractions at age 1 year could be compared with those at $3\frac{1}{2}$ years (Table 4): (1) The basic spherical refraction of the more emmetropic of a pair of eyes, thus recording 1 figure for each child, but completely ignoring astigmatism and anisometropia (Fig. 1). (2) The mean of the spherical equivalents of each of a pair of eyes, which makes some allowance for astigmatism and anisometropia when present, but again records 1 single figure for each child. (3) The basic spherical refraction of individual eyes, recording 2 figures for each child, thus making some allowance for anisometropia but none for astigmatism (Fig. 2). (4) The spherical equivalents of individual eyes, again recording 2 figures for each child, but reflecting to some extent both astigmatism and anisometropia. The variances were calculated for all 8 sets of refractions. No significant differences were found when any pair within any of the 4 groups were compared.

The changes in refraction of the horizontal and vertical meridia are summarised in Tables 5 and 6. The difference between each group of both meridia

Table 3 *Anisometropia and astigmatism*

	Not aniso.	*Aniso.*	*Total*
Age 1 year:			
< +1·50 D cyl. in both eyes	124	2	126
+1·50 or more D cyl. in either or both eyes	12	10	22
Total	136	12	148
	P=0·000 003%		
Age $3\frac{1}{2}$ years:			
< +1·50 D cyl. in both eyes	131	6	137
+1·50 or more D cyl. in either or both eyes	4	7	11
Total	135	13	148

P=0·000 178%

Table 4 *Range of refractions at age 1 and $3\frac{1}{2}$*

Group	*Age*	*Mean*	*Standard deviation*	*Significance of difference*
(1)	1	+0·61	1·06	5%
	$3\frac{1}{2}$	+0·89	1·00	
(2)	1	+0·95	1·09	NS
	$3\frac{1}{2}$	+1·10	1·07	
(3)	1	+0·62	1·11	1%
	$3\frac{1}{2}$	+0·95	1·11	
(4)	1	+0·97	1·10	NS
	$3\frac{1}{2}$	+1·12	1·07	

NS = Not significant

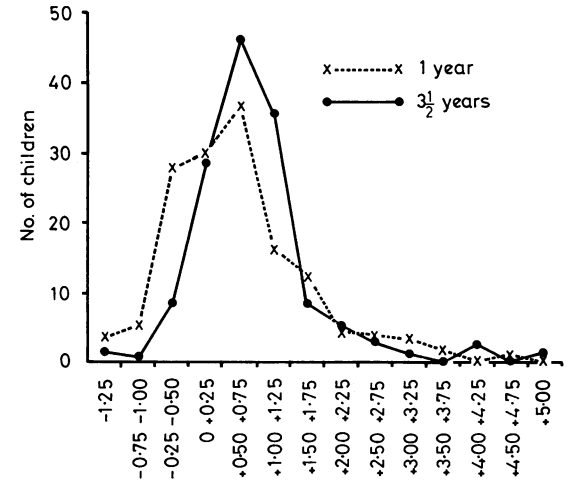

Fig. 1 *Distribution curve: basic spherical refraction of better eye*

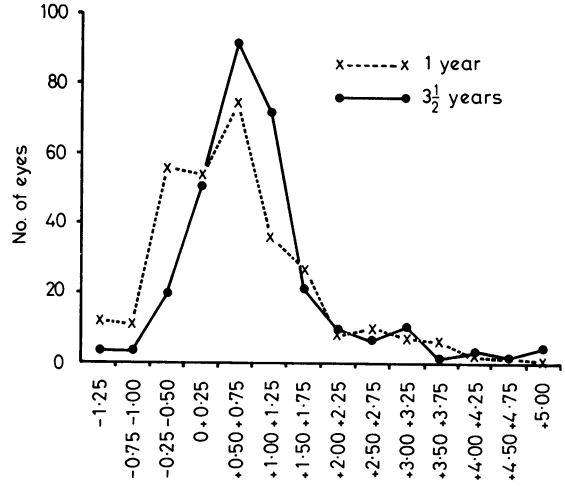

Fig. 2 *Distribution curve: basic spherical refraction of individual eyes*

Table 5 *Changes in refraction of horizontal and vertical meridia of individual eyes*

Initial refraction	*Horizontal meridian*													
	−1·25	*−1·00*	*−0·50*	*0*	*+0·50*	*+1·00*	*+1·50*	*+2·00*	*+2·50*	*+3·00*	*+3·50*	*+4·00*	*+4·50*	*+5·00*
	More myopia	*−0·75*	*−0·25*	*+0·25*	*+0·75*	*+1·25*	*+1·75*	*+2·25*	*+2·75*	*+3·25*	*+3·75*	*+4·25*	*+4·75*	*More hyper-metropia*
Change in refraction														
+	6	8	24	32	33	15	4	4	6	3	4	1	2	0
0	0	0	5	11	25	8	6	3	1	3	0	0	0	0
−	2	2	1	3	13	25	24	12	6	5	1	2	0	0
	Vertical meridian													
+	6	3	35	33	38	8	9	7	3	1	4	3	0	2
0	0	0	11	10	22	9	4	4	2	4	0	0	0	0
−	2	2	2	4	10	25	18	9	5	1	2	2	0	0

+ = More hypermetropic or less myopic. 0 = No change. − = Less hypermetropic or more myopic

Table 6

Range of refraction at age 1 year		*Change*			*Change*		
		Horizontal meridian			*Vertical meridian*		
		+	*0*	*−*	*+*	*0*	*−*
Group 1	Myopia to +0·75 D	103	41	21	115	43	20
Group 2	+1·00 to +2·25 D	23	17	61	24	16	52
Group 3	+2·50 or more D	16	4	14	13	6	10

is statistically significant except for Group 2 versus Group 3 in the vertical meridian.

Discussion

There is no evidence to indicate that the incidence or amount of hypermetropia decreased between the ages of 1 and 3½ years. Of four possible methods used to record the range of refractions of these children the mean moved significantly towards the hypermetropic side in 2 instances. There was no significant difference when either of the other 2 methods were used.

If the concept of emmetropisation was correct, the spread of the curve representing the range of refractions at age 1 year should narrow by the age of 3½ years, but this did not occur.

There is quite clearly a highly significant decrease in the incidence of astigmatism both in individual eyes and in the number of children who have astigmatism of +1·50 or more D in either or both eyes. Possibly there may be a resurgence of interest in astigmatism and its effects on visual acuity, and it seems natural to study the changes that occurred in the refraction of the horizontal and vertical meridia of individual eyes. Astigmatism is not always in the 90° or 180° axis, but for simplicity the refraction of the meridian nearest to the horizontal and vertical axis has been recorded as that of the horizontal and vertical axis respectively. If at the age of 1 year the refraction in either meridian was myopic or less than +2·50 D, there was a definitely significant trend towards emmetropia (+0·50 to +1·25 D). Thus there is unequivocal evidence to support Fabian's (1966) theory of emmetropisation *if this is applied to the refraction of individual meridia between the ages of 1 and 3½ years.*

If the refraction in either meridian at age 1 year was +2·50 or more D, it seems that the change in refraction in that meridian is against the above trend, that is the refraction became either more or less hypermetropic by the age of 3½ years. This is, however, significant only in the case of the horizontal meridian, although the trend appears similar in the vertical meridian.

It has been suggested (Ingram, 1977) that the absence of a refractive error (by implication hypermetropia and/or anisometropia) at the time a child presents with squint and/or amblyopia might not preclude an abnormal refraction earlier in life. It would have been convenient if this analysis had shown an overall decrease in hypermetropia between the ages of 1 and 3½ years, but this does not occur. However, preliminary observations on the changes in refraction between the ages of 6 and 12 months do show a consistent decrease in hypermetropia in only those eyes, or meridia, which are hypermetropic at age 6 months. Thus it may be that between the

ages of 1 and $3\frac{1}{2}$ years there is a fine tuning in an overall process of emmetropisation with, in particular, a shift of the mildly myopic refractions towards hypermetropia. It will be necessary to trace the changes in refraction from the first few weeks of life through to $3\frac{1}{2}$ years and later in order to complete the picture.

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