

RANDALL (B. A.)

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B. ALEX. RANDALL, M.D.,

PHILADELPHIA, PA.

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CAN HYPERMETROPIA BE HEALTHFULLY
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In the study of refraction and its anomalies, it might be claimed that little advance has been made, in spite of the immense amount of work that has been done in this direction, since the era inaugurated by the treatise of Donders. That treatise marks a stage to which some of the ophthalmologists of to-day have not yet attained; and while progress, real and considerable, has been achieved at many points, there is a large part of the profession which seems to close the eyes to this, and persists in holding views no longer sustained by the facts. One of the views thus adhered to is that of the general prevalence of emmetropia, an assumption that has its comfortable side, and its long list of authoritative upholders, yet is surely in conflict with the experience of every careful student. We have outlived Jaeger's teaching, that infants are born myopic; and have quite generally accepted the showing of all later investigators, that they are, almost without exception, hypermetropic. Yet the investigations which show hypermetropia in the majority of school-children have met less acceptance; and studies which even *define* emmetropia as "having normal vision" are offered as competent to prove the contrary; while the known preval-



ence of H. after loss of the accommodation is explained by a theory of "hypermetropia acquisita," backed by the great name of Donders.

Much as we have received from that master which seems destined to remain an enduring monument of his labor and insight, there is danger that admiration may go much too far in upholding hypotheses which he framed to fill the wonderfully few gaps in his knowledge of this difficult subject. Surely his pupils have ill-learned the lessons which he taught, if they insist upon the points which he himself held only tentatively, and try to maintain his unsupported dicta in the face of strong evidence. It is as a most admiring follower of Donders that I wish to call in question some of the views which to-day pass current largely upon the authority of his name; for I believe them to be erroneous, and would wish that his sanctioning of them should be forgotten. In a previous paper (read before the Ophthalmic Section, American Medical Association, May, 1890) I have endeavored to show that he did not hold the view generally adduced from his much misused paragraph as to "tone of accommodation," which undermines his formal definition of emmetropia; and in the present instance I would call attention to another misunderstood passage of his treatise—that on the frequency of the occurrence of myopia, page 341. He here gives a diagram, based principally on his case-books, to indicate the relative frequency of the various degrees of refraction-error in the Dutch population—a diagram which might be understood to indicate that Em. is about as common as the lowest grades of M. or H., were it not expressly stated that the lines representing these are only 1/10 of their proper length. In fact, then, he distinctly states that Em. constitutes less than 2.5% of the population, although he had made outside observations in order to correct the possibly erroneous indications obtained from eye-cases only. M.=1/96 or less, he reckons at 37.5%—the corresponding grade of H. at 45%; and it is only by counting these as practically emmetropic that the percentage 85% Em. is obtained. Donders is far from teaching, therefore, that Em. predominates; and although he indicates a larger proportion of myopes than of hypermetropes in his experience,

and that the medium grades of H. are not very common, his results are not extremely different from those which I would urge as correct.

In previous publications ("American Journal Medical Sciences," July, 1885; Transactions VII, International Ophthalmological Congress, 1888) I have brought together as completely as possible all the investigations, to date, of the refraction of the eyes of school-children and others, in the endeavor to learn what is the prevailing refraction of the human eye; with the result of showing a decided preponderance of H., a small percentage of Em., and a varying proportion of M., depending upon the age, class, and education of those examined. Divergent as were the results which had been obtained by various investigators, the consensus of them all gave distinct pointings; and critical study of the methods used in each examination rarely failed to give full explanation for the deviations from the average result.

Such results have hardly received wide acceptance, reiterated though they have been by many of the best students of the subject; and they have been given little of their due weight in practice. Theoretically it is generally conceded that all children, as well as the new-born, are usually hypermetropic; yet it is constantly being rediscovered as a new fact, peculiar to some special group of individuals, and is employed as a positive proof of any theory that needs support. The importance of refraction-errors in many cases is incontestible, and will be little weakened by such misuse of the facts; yet it does not speak well for the judgment of the profession that they are so prone to ignore or try to explain away these teachings, except when they have special employment to make of them.

Most of the investigations referred to were undertaken in order to throw light upon the etiology of myopia. They showed a disquieting rise in the percentage of this defect from the lower to the higher classes in the schools, and of course there were enthusiasts to raise a hue and cry, thunder at the overburdening of the scholars, and draw all sorts of wide-reaching conclusions from ill-determined and insufficient data. Reaction was inevitable; and Donders, whose dictum, "a myopic eye is a diseased eye," had been the war-cry of the crusade against myopia, led the recoil toward the view that myopia is a mere

evolutionary adjustment of the eye to its environment, and wrote, "Were it in my power to eradicate all myopia, I would not do it." To-day Cohn and others are contending that myopia is a curse of civilization, to be fought by the "school-physician" and his hygienic dictatorship; while Stilling and others regard all except the high grades with equanimity—rather proud of its prevalence in Germany, as a proof of the national evolution into special fitness for the highest civilization. Hypermetropia, it is held, is a condition of under-development common to the brute, the infant, the savage, and the idiot—it is put off with other childish things when the full stature of manhood is attained.

This view, with various modifications and corollaries, is quite widely held, having gained ground since it was advanced, especially by Landolt and Dor, some twelve years ago, and it is to it particularly that I wish to draw attention on this occasion.

The short hypermetropic eyeball has always been regarded as in a condition of under-development; yet it is a newer and less prevalent view, that hypermetropia is merely a *stage* of incompleteness. It is quite natural that further growth toward the emmetropic standard should be expected of this, as of other infantile organs; and this *a priori* view gains strength from the fact that, as Jaeger has shown, the infantile eye lacks some six mm. of its adult axial length. Add that infants are almost invariably H., often in considerable degree—while adults are assumed to be Em.—and the position seems hardly open to attack. Further, it has been claimed by some investigators that they have demonstrated this progressive decrease of the juvenile H.—as when Germann found the average H. to be 5.3 D. in the first month of life, only 3.3 in the second month, and 2.3 in the earlier years. Hansen also found an average H.=1.75 in the tenth year, declining to 0.75 D. at the fifteenth.

Increase in the refraction of eyes, especially of children and young adults, has been frequently observed, not only in cases of progressive myopia, but in a considerable series of hypermetropic eyes, as has been recorded by Drs. Risley and Norris. Yet I fail to find in any of the instances any reason to believe that such a change has been brought about by a physiological growth; all have presented clear evidences of pathological pro-

cesses; and the combatting of these by the usual therapeutic measures for reducing intra-ocular inflammation has been followed by a relief of the distressing symptoms usually present, and by a cessation of the change in the refraction. Many of the cases alluded to I have had the privilege of studying, and I have had others in my own practice, so that I have some experience of the pathological form of change. But of an increase which could be regarded as healthy, I have met no single instance among many thousand cases.

In a lecture recently published, MacNamara urges that young hypermetropes, even those with absolute H., should not be given their correcting glasses, or even under-correcting lenses, for more than absolutely necessary use at near work, much less for constant wear; claiming that the normal development of the eye, whereby the H. would be outgrown, might thus be interfered with, and the defect rendered permanent. The same idea had previously occurred to me and led me to give under-correcting glasses to cases of high H.; for I had seen enough cases of this kind in which five years had brought no change in the refraction to feel confident that *under the full-correcting glasses* hypermetropia did not tend to decrease. I have since found occasion in some of these instances to increase the convex lenses, because the patient gave evidence of requiring fuller correction. In no case have I observed decrease in the hypermetropia; and I am now wholly skeptical as to it, and shall rarely repeat the experiment.

Inclining to reject this view, then, as unsupported by any facts derived from my own experience, and conflicting with much that I have observed, it remains to be seen if it is tenable in the light of the studies of the eyes of the children in the schools. Some supporting results have been already cited. Are they corroborated by the general result, or by other reliable investigations? My answer must be in the negative, since the small decline in the H. observed seems quite fully accounted for by the causes of pathological distension, which are known to be at work during childhood.

The study of the average refraction of children will be best begun by examining the findings as to the eyes of new-born infants, as to which five investigations are wholly available:

TABLE I. — REFRACTION GRADES OF NEW-BORN INFANTS.

Examiner.	H. Eyes	0.5	1.0	1.25	1.5	2.0	2.5	3.0	3.25	3.5	3.75	4.0	4.5	5.0	5.5	6.0	6.25	7.0	8.0	9.0	10.0	11.0	12.0	?	Ag. H.	Av. H.
Ger mann, .	220	4	4	6	..	14	14	10	8	4	7	34	16	..	25	10	11	34	..	12	2	2	3	..	1073.	4.87
Ulrich, .	204	..	30	..	..	132	..	8	..	..	..	16	2	..	..	2	..	..	..	..	..	..	..	14	406.	2.14
Bjerrum, .	122	..	..	..	..	34	..	..	..	..	..	88	..	..	..	..	..	..	..	..	..	..	..	..	420.	3.44
Schleich, .	300	..	6	..	..	27	..	41	..	..	..	68	..	68	..	58	..	31	1	..	..	..	..	..	1368.	4.56
Horstmann,	88	..	16	..	..	16	..	36	..	..	..	14	..	4	..	2	..	..	..	..	..	..	..	..	244.	2.79
Total, .	934	4	56	6	..	223	14	95	8	4	7	220	18	72	25	72	11	65	1	12	2	2	3	14	3511.	3.80

TABLE II. — REFRACTION GRADES OF UNSCHOOLED CHILDREN.

Examiner.	H. Eyes.	0.5	.75	1.0	1.25	1.5	2.0	2.5	2.75	3.0	3.25	3.5	4.0	4.5	5.0	5.5	6.0	7.0	8.0	9.0	Ag. H.	Av. H.
Koppe, . . .	61	..	1	15	..	20	3	7	..	7	..	2	6	..	..	..	..	..	..	..	128.7	2.19
Horstmann, .	74	18	..	21	..	14	13	..	..	5	..	..	2	..	1	..	1	..	..	..	111.0	1.37
Horstmann, .	84	..	..	24	..	..	32	..	..	18	..	..	6	..	4	..	..	..	..	..	194.0	2.31
Ger mann, . .	119	10	..	22	3	16	17	22	2	1	2	2	8	7	..	2	2	1	1	1	276.2	2.32
Total, . . .	338	28	1	82	3	50	65	29	2	31	2	4	22	7	5	2	3	1	1	1	710.0	2.10

Some caution is probably necessary in accepting as general the results of several of the investigations, even though they give evidence of rather special accuracy. Their discordance with others, presumably as well done, brings their weight somewhat into question, and indicates that they may, though perfectly accurate, be accidental. Thus Germann found 19=11% of infants to have H.=9—12, and 50%, H.=4.5—8 in the first month; while later there were none over 8, and only 14=24% over 4 D. In his young children he found three eyes with H.=7, 8, and 9 D. respectively, 2=6, 2=5.5, and 7=4.5—only 14=12% over 4 D. Yet Schleich found but 1 in 300 as high as 8, and 31=7 D.; and none of the other investigators met any such grades. The high average hypermetropia shown by the table rests, therefore, upon the work of these two upon 520 eyes; while among 414 eyes examined by others the average was only 2.6 D.; and among 756 eyes as to which the grade is not specifically noted, the lower grades seem to have predominated—*e. g.*, 2—2.5 among Koenigstein's 562. Horstmann's very careful work was done after the first week of life, and it is highly probable that just as he saw practically nothing of the retinal extravasations frequently met in the first week, so too he did not see the accompanying swollen discs, the temporary prominence of which was probably measured by the others. Thus only can we understand the remarkable decrease of 2 D. in the average H. from the first to the second month of life (from 5.37 to 3.30) found by Germann. It seems probable that the average hypermetropia about birth is rather below than above 3 D.

Passing on to the results in young children not yet of school age (Germann's were from 1½ to 10, but unschooled), the few available records will be found in table No. 2, page 6.

Only Horstmann's earlier study differs from the rather remarkable coincidence of the other figures, with which a further study of his seems to have been in close accord. We may, therefore, accept this average as a little above 2 D. as shown.

Turning now to the results in the schools, and using as before every group of figures which affords the requisite data as to age and grade of refraction, we obtain from the studies of Callan, Dennett (Hyde Park and Nantucket), Howe, Emmert, Risley, Collard, Van Anrooy, Hansen, and Randall:—

TABLE III.—REFRACTION GRADES IN THE SCHOOLS.

Age.	H. Eyes.	+ 5	.65	.75	.90	1.0	1.25	1.50	1.75	2.0	2.25	2.5	2.75	3.0	3.25	3.5	3.75	4.0	4.5	5.0	6.0	?	Ag. H.	Av. H.
6 years, .	212	18	11	17	22	52	24	45	9	12	..	..	..	2	..	..	..	..	..	..	..	..	244 0	1.15
7 "	222	15	6	18	19	58	22	43	20	16	..	2	..	2	..	1	..	..	..	..	..	..	282.5	1.27
8 "	281	13	7	33	41	95	49	21	2	17	..	..	..	1	..	1	..	..	..	..	..	1	304.5	1.08
9 "	366	14	10	62	34	89	38	45	36	20	2	..	..	5	..	..	2	3	..	1	3	2	452.6	1.23
10 "	795	26	21	24	24	124	75	229	40	197	3	23	4	5	..	..	..	..	..	..	..	..	1180.7	1.48
11 "	955	37	96	73	47	189	83	296	29	79	..	17	..	6	..	..	..	3	..	..	..	..	1186.0	1.24
12 "	1044	54	26	69	57	300	92	288	60	52	2	14	3	10	2	5	..	4	5	..	1	..	1349.2	1.29
13 "	889	39	32	91	38	296	96	178	49	40	..	12	..	12	1	3	..	..	..	..	..	2	1156.7	1.30
14 "	849	183	32	93	44	218	64	115	51	31	..	4	..	9	..	3	..	1	..	1	..	..	922.4	1.09
15 "	454	25	27	48	14	131	60	70	26	20	3	9	..	8	1	1	1	3	5	..	..	2	579.4	1.27
16 "	381	23	21	41	23	113	40	61	23	18	4	1	..	3	2	..	..	4	..	1	1	2	481.3	1.26
17 "	400	57	10	51	23	143	35	40	7	19	2	3	..	4	..	2	..	3	..	..	..	1	434.0	1.08
18 "	338	61	18	54	6	99	21	41	4	18	..	2	2	2	..	1	..	5	..	1	1	..	369.3	1.09
19 "	143	22	1	30	7	39	7	20	2	12	..	2	..	1	..	..	..	..	..	..	..	..	143.0	1.00
20 "	50	13	..	6	..	17	5	5	..	..	..	4	..	..	..	..	..	..	..	..	..	..	51.3	1.03
21 or more,	151	31	2	30	..	39	4	6	1	4	..	3	1	15	..	2	..	10	3	..	..	..	217.0	1.43
Total, .	7530	631	320	740	399	2002	715	1503	359	555	16	96	10	85	6	19	3	36	13	4	6	10	9354 0	1.24

An almost unvarying grade of hypermetropia would seem to be the average during this period, for the utmost variation is less than .5 D., and even this may be regarded as perhaps accidental. Much of the variation is due to Hansen's figures—his 412 eyes, with an average H. = 1.75 at ten years and 242 eyes with only H. = 0.75 at fourteen, change the averages at those ages from 1.20 and 1.22 to 1.48 and 1.09 D. A very slight downward tendency appears when we sum up the results for each five years of life, the average grade being 1.31 for the second period, 1.24 for the third, and 1.13 for the fourth, that for the whole 7,530 eyes being 1.24 D.

Data are lacking from which to endeavor to compute the average H. in early adult life, Seggel's examination of recruits in the Munich garrison standing about alone. He found with the test glasses an average H. m. = .50 in over 3,000 eyes.

Such, then, is the evidence bearing upon our question which I am able to find in the literature—figures which, taken at their face-value, as all of equal weight, go but a short way toward proving any notable decline in the hypermetropia with the growth of the individual. Yet it requires no deep study of the investigations furnishing these results to convince one that that they are far from being all of equal value. Further, there are many studies which do not furnish their results in shape for our tabulation, yet are very distinct in their pointings, and probably more trustworthy than some of those used. The strongest case possible has been made for the view that H. is outgrown; and while I do not propose to undertake the invidious task of showing the flaws in the studies cited, I will point out some of the investigations which seem to me of much weight and offsetting more or less the results above given.

In his study at Schreiberhau under atropine, Cohn found the average H. of 299 eyes of children, 6 to 13 years of age, to be 1.20, with no relation of the grade to the age. Callan, among 346 eyes of negro pupils, found the average grade 1.23, present at all ages, from 6 to 19 years, with only accidental variations. Schadow, among the 240 H. eyes which he studied in Borchum, found an average of 1. at 7 to 8, 1.7 at 9 to 10, and intermediate grades at the other ages (6 to 14). Conrad found

an average H. about 1.26 among his youngest pupils (6 years), with rather higher grades in the next years. Emmert, among his 3,279 hypermetropic eyes, found an average of 1.16 in the 5 to 10 years, 1.38 in the 11 to 15, and 1.31 in the 16 to 20; the general average being 1.31 D.

Numerous other points could readily be cited in support of the conclusion which I have drawn from my study, that there is a very insignificant decline, if any, in the grade of hypermetropia during school life; and when the occurrence of quite frequent pathological progression toward myopia at this age is taken into consideration, the surprise must be that the decline is so little. Before the school period there is some evidence that higher averages of hypermetropia are to be found than later; but a number of considerations more or less completely explain away this apparent showing. All the reliable measurements of the refraction of the very young have been made under a mydriatic; and while very far from believing that this introduces any element of error, I must hold them as not strictly comparable with results obtained without mydriatics. The grades of hypermetropia met in such work have no need of being scaled down for the reason sometimes urged, that the mydriatic must be discounted because it gives a fictitious H. Properly used, the mydriatic can only have increased the accuracy of the results. But to make them really comparable, the averages found without a mydriatic most certainly need to be scaled up—increased by a considerable increment to represent the latent hypermetropia which escaped measurement. The use of the ophthalmoscope, which was all too rare in the investigations which have been above cited, can do something towards this end; but only an ultra-enthusiastic ophthalmoscopist could shut his eyes to its numerous shortcomings, and believe that its results could not be decidedly improved upon. One of the investigators quoted above (Koppe) suggests the discounting of his results on the ground that with the ophthalmoscope he was measuring hypermetropia of his own instead of that of the patient; yet a comparison of his objective and subjective results shows that while he uncovered H. in 35 eyes which had no manifest H., he failed to see the hypermetropia with the

ophthalmoscope in 105 eyes which had already revealed it to the test-glasses. Such results are common among the younger pupils; but my own study among medical students shows that the same holds among the elder. Not only did the ophthalmoscopic measurement raise the percentage of H. eyes from 26 to 67%, but it also increased the average grade from .57 to .85 D. So, too, Cohn found among his 299 atropinized eyes 98% H., and an average of 1.20, where without the mydriatic there had been but 82% H. m., with an average of .75 D. Reasons have already been given for the belief that the hypermetropia at birth is below 3 D.; and we here see that the 1.24 of school-life should be considered to represent a real average of about 2 D.; so I believe we shall not go far astray if we accept a dioptre and a half as representing the extreme limit of the real average decline in the refraction from birth to adult life.

Such a change in the refraction is far from unimportant, and would abundantly serve the purpose of those who claim that hypermetropia is outgrown, could they adduce any evidence that it is due to physiological growth. In the utter absence of any such evidence, so far as I am aware, and with the all too probable explanation that the pathological progress towards myopia is alone responsible for the change in the many, as it undoubtedly is in the few, the position of skepticism as to any normal decrease in hypermetropia seems fully justified. The burden of proof certainly rests upon those who wish to uphold such a view.

Two arguments deserve notice in closing. In twenty sections of the eyes of new-born infants V. Jaeger found the average axial length to be 17.5, as against 23.4 mm., in as many adult eyeballs. Yet these were by no means the shallow balls of high hypermetropia, for in almost every instance the axis was the greatest diameter of the globe, the vertical averaging but 16.4, and the horizontal 17.2 mm. While such an axial length in an adult eye might correspond with a hypermetropia of some 35 D., it must not be forgotten that the lens has its full adult thickness, although its diameter is only 6.3 instead of nearly 9 mm. Consequently its curvatures are such as probably, even in its comparatively homogeneous condition, to fully

compensate for the proximity of the retina. Whether it has a proportionately forward position, as indicated by the shallow anterior chamber, need not be discussed until some evidence is brought forward to show that the other compensation would not be complete. If it can nearly compensate, as we know it to do, for so huge a grade of axial shortening, it will be difficult to prove that it is not fully competent—however wonderful it may seem that the eyeball should undergo such changes in its dimensions without alteration of its refraction. It is quite probable that many of the cases of myopia found at birth, some of which have been observed to decrease greatly in the following months, have been due to a forward displacement or subluxation of the lens.

The other point that deserves a passing notice is the view that the tendency towards myopia is an evolutionary adjustment of the eyeball for the demands of near-work which environ it in modern civilized communities. Until the proof, yet lacking, is adduced to show that myopia is actually inherited, such a view has no claim to be treated as even a scientific hypothesis; and its demonstration is almost impossible. It has been repeatedly observed that scoliosis and myopia were developed together by the faulty positions of school-children, especially in writing; and whoever undertakes to champion the evolutionary value of myopia, may well be challenged to uphold the same view as to spinal curvature.

