Clinical Genetics 1975: **8**: 314–318

Influence of the myopia gene on brain development

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Evaluation of the performance of 17–18-year-old high school students on standard intelligence tests confirms previous reports that nearsighted persons consistently achieve scores approximately eight I.Q. points higher than non-myopes. Comparison of tests administered to the same students 10 years earlier suggests that the intellectual gain precedes the development of nearsightedness. Since there is convincing evidence from genetic studies that myopia is an inherited condition, probably transmitted as a recessive characteristic, it is concluded that the myopia gene has a stimulant action on the brain in addition to its effect on the eye. The high frequency of myopia in urbanized societies is explained in terms of an evolutionary adjustment, myopes probably having a survival advantage under conditions of industrialization.

Received 17 February, accepted for publication 24 March 1975

The observation was originally reported in northern Europe a century ago that the frequency of nearsightedness is increased among persons characterized by intellectual achievement (Cohn 1883). The reason for this association has been a subject of considerable debate, mainly among eye specialists. One popular opinion is that myopia may be produced by excessive "near" work, a concept sometimes referred to as "school myopia". However, more precise studies of families with nearsightedness have indicated that heredity is a principal cause (Dunphy 1970), although this interpretation is not universally accepted. It is firmly established that with rare exceptions monozygotic twins with myopia are concordant for the disorder (Karlsson 1974a). Ophthalmologists have also concluded that in most cases two severely myopic parents produce only myopic offspring (Waardenburg 1963). Family studies have led to the conclusion that the empiric risk in sibs of myopic index cases is in the order of 25, 50, or 100 %, depending on whether neither, one, or both parents are affected (Karlsson 1973). Several authors have made systematic population studies leading to the conclusion that the common type of myopia follows a recessive inheritance pattern (cf. Karlsson 1975).

The high frequency of myopia in the developed countries, approximately 25 % in certain Oriental, Jewish and West-European nations, also demands some explanation. These rates are exceedingly high for a recessive disorder, requiring gene frequencies of about 50 %. If one postulates that there is a myopia gene which has a primary effect on the brain, the eye condition being a secondary complication, the high frequency in some populations is easily explained, as it has been demonstrated that in competitive societies families of higher in-

telligence are able to successfully raise an increased number of children (Osborn 1968). In some West European countries it has also been shown that in the last century starting with the industrial revolution one-fourth of the initial population reproduced almost all those persons existing at the end of the period (Sutter 1963). One can conjecture that myopes and myopia carriers may have been among those who competed successfully.

The purpose of this paper is to present more detailed evidence on the association of myopia with increased intelligence and to evaluate further the underlying principles.

Materials and Methods

The present data deal with the pupils at the high school in Napa, California, located 30 miles north of San Francisco. This school has served the town of Napa, population 40,000, and the surrounding community, the number of students in each graduating class being approximately 800. Most of the inhabitants can be described as middle class Caucasians, with a small Mexican-American element, and it is a relatively stable population. Students attend this school from age 15 to 18 years, records from previous school attendance being on file.

All pupils have been screened for eye problems by the student health service, but correctional lenses, if needed, are prescribed by the students' own eye doctors. The individual cumulative records list the results of visual acuity tests, usually specifying the nature of any problem. They also contain annual photographs of the students, taken for the school year-book, which are helpful by indicating those pupils wearing glasses. In some cases, when the record gives only the distance visual acuity, it is possible to tell from the photographs whether the student wears concave lenses. Up-dated eye measurements are not available on all the pupils, and these would in any case change frequently in this age group.

By use of these materials, in some cases supplemented by information from the students or their families, it has been possible to identify 15 % of the senior classes as myopes, most of these individuals probably requiring corrections in excess of one diopter. While this method of selection is not as precise as visual screening procedures employed by some investigators, the present approach has the advantage of producing a large volume of data. One can in reality argue that the eye information does not need to be more precise than other aspects of the investigation, as all that is necessary for the present study is to ascertain whether or not definite myopia is present. It has been estimated that the rate of myopia in the area of study is approximately 15–20 %, so that it seems that most cases have indeed been identified.

Since school attendance is required by law up to age 17 years and most of the pupils actually stay on to graduate, the students in essence represent the whole population, rather than being a select group. Even a fair number of mentally retarded individuals, who attend special classes, are included in the data. The entire student body has been given standard intelligence tests at different times in their school careers. The present study deals with two group I. Q. tests; the California Mental Maturity test, administered to all students at age approximately 8 years, and the Lorge-Thorndike test, taken at age 17–18 years. These tests have been in general use in California public schools, uniform throughout the state.

Results

Records have been obtained on all graduating seniors at the Napa High School for

Table 1

Summary of results on the Lorge-Thorndike group I. Q. test administered to the senior class at the Napa High School in 1970–1972

	N	Verbal score	Non-verbal score	Total score
Entire class	2527	103	109	106
All males	1272	103	110	107
All females	1255	102	108	105
Non-myopic males	1095	102	109	106
Myopic males	177	113	116	114
Non-myopic females	1055	101	107	104
Myopic females	200	109	113	111
All non-myopes	2150	101	108	105
All myopes	377	111	115	113

the years 1970, 1971, and 1972, a total of 2527 individuals, of whom 377 are identified as myopes. The overall I.Q. for the senior classes on the Lorge-Thorndike test is 106, the pattern of distribution being essentially identical for the 3 years. The mean figure may be somewhat higher than the result for the entire state of California. On this examination males generally score a little higher than females, presumably reflecting the composition of the test. The I.Q. data on different groups are summarized in Table 1. The two bottom lines show that the myope group scores 10 points above non-myopes on the verbal portion of the test, seven points higher on the non-verbal, with an overall increment of eight points. The results for the two sexes show similar differences.

To check whether the higher I.Q. measures for myopes correlate with anatomical changes which are known to occur in the eyes of myopes at certain stages of development, the scores have been compared for the same students at age approximately 8 years, that is, before nearsightedness generally appears. These data are shown in Fig. 1, based on the California Mental Maturity test. It appears that the I.Q. difference between the two groups is already present before the usual age of onset of nearsightedness. For comparison of the overall pattern, Fig. 2 shows the entire I.Q. distribution on the Lorge-Thorndike test at age 17–18 years, supplementing the data in Table 1 which are also from that test. At both age levels the I.Q. curve is shifted toward the higher scores in individuals homozygous for the presumed myopia gene.

Since it is likely that the majority of myopes among the students have been identified, it is also possible to estimate the rate of myopia in different I.Q. groups. The data in Table 2 show a successive rise in the myopia frequency as one ascends

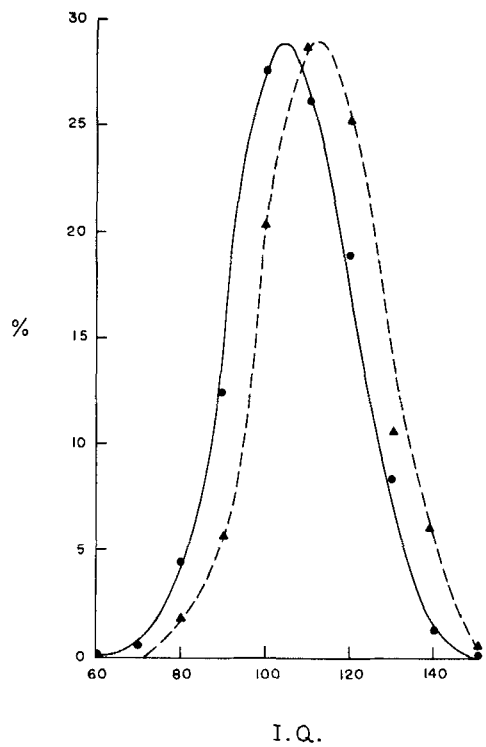

Fig. 1. Distribution of I. Q. scores for non-myopes (solid line) and pre-myopes (broken line) on the California Mental Maturity test at age 7–8 years.

Table 2

Frequency of myopia in relation to I. Q. scores among 17–18-year-old high school students in Napa, California

I. Q. range	N	% myopia
55–74	30	0.0
75–94	516	7.4
95–114	1317	12.5
115–134	619	24.9
135–	45	44.4

Chi square based on even distribution 114.5, $P < 0.001$.

the I.Q. scale, with almost one-half of the brightest students being myopes. Those with I.Q. scores in the mentally retarded range are completely free of myopia in the present material.

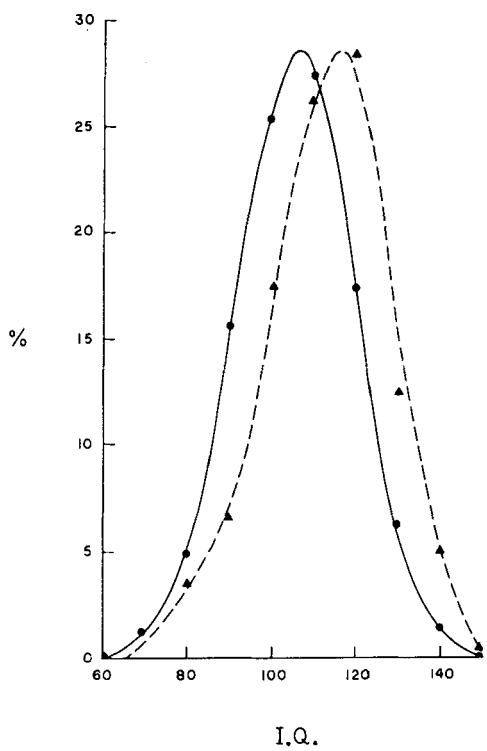

Fig. 2. Distribution of I. Q. scores for non-myopes (solid line) and myopes (broken line) on the Lorge-Thorndike group test at age 17–18 years.

Discussion

The basic results of the present study are in agreement with data previously published by several authors (Hirsch 1959, Grosvenor 1970, Scholz 1970, Karlsson 1973). Studies in this field have uniformly shown an association of myopia with school achievement or increased I.Q. scores, although most of the older investigations have involved relatively small numbers. It may be concluded that the validity of this association has been adequately demonstrated and that the present data give a fairly precise measure of the difference in terms of I.Q. points.

Since it can also be considered sufficiently documented that myopia is in general a hereditary condition, as was discussed in the introduction, one must try to decide whether the higher intellect of myopes is caused by direct effects of the myopia gene on the brain or whether myopes perform better for some other reason. In either case the measured difference must reflect a real functional gain, as otherwise there would be no explanation for myopia attaining high frequencies in industrialized populations.

The finding that pre-myopes already show an I.Q. advantage seems to eliminate the explanation that the myopic eye may in some manner enable a person to perform better on tasks requiring close work, as the eyes of pre-myopes are not known to function differently than other eyes. Studies of school children in California have established the rate of myopia at age 8 years as less than 1 % (Hirsch 1952), and similar results are reported from Japan (Furusho 1957). Since enhanced intelligence is thus the first sign of the presence of the mutant gene, the best hypothesis seems to be that the myopia gene in a homozygous state produces both brain stimulation and lengthening of the eye ball.

The relationships described in this paper may be an example of an evolutionary change in human populations, the higher intelligence of myopes apparently having a survival value under conditions of urbanization or industrialization. Although myopes as a group exhibit improved performance on scholastic types of tests, it should be pointed out that the I.Q. gain is not a very large one. It is of interest that mental deficiency as presently defined (I.Q. below 70) is almost absent in myopes. However, mongoloid defectives have been reported to show the same frequency of myopia as the general population (Lowe 1949). Although myopes perform well in learning situations, there is no evidence for increased creativity in their ranks, whereas there are indications that a major gene postulated to be important in schizophrenia is closely related to creativity (Karlsson 1974b). This may be the reason why it does not appear that famous scholars in various fields are necessarily myopic. Studies of I.Q. tests in twins, including pairs that were reared apart, have given strong support to the theory of a genetic contribution to intelligence (Erlenmeyer-Kimling & Jarvik 1963), and now it appears that the myopia and schizophrenia genes may be specific factors involved in mentality differences.

References

Cohn, H. (1883). *Die Hygiene des Auges in den Schulen.* Wien, Urban und Schwarzenberg.

Dunphy, E. B. (1970). The biology of myopia. *New Engl. J. Med.* **283**, 796–800.

Erlenmeyer-Kimling, L. & L. F. Jarvik (1963). Genetics and intelligence: a review. *Science* **142**, 1477–1479.

Furusho, T. (1957). Studies on the genetic mechanism of short-sightedness. *Jap. J. Ophthal.* **1**, 185–190.

Grosvenor, T. (1970). Refractive state, intelligence test scores, and academic ability. *Amer. J. Optom.* **47**, 355–361.

Hirsch, M. J. (1952). The change in refraction between the ages of 5 and 14. *Amer. J. Optom.* **29**, 445–459.

Hirsch, M. J. (1959). The relationship between refractive state of the eye and intelligence test scores. *Amer. J. Optom. 36*, 12–21.

Karlsson, J. L. (1973). Genetic relationship between giftedness and myopia. *Hereditas (Lund)* **73**, 85–88.

Karlsson, J. L. (1974a). Concordance rates for myopia in twins. *Clin. Genet.* **6**, 142–146.

Karlsson, J. L. (1974b). Inheritance of schizophrenia. *Acta psychiat. scand.* **50**, Suppl. 247, 1–116.

Karlsson, J. L. (1975). Evidence for recessive inheritance of myopia. *Clin. Genet.* **7**, 197–202.

Lowe, R. F. (1949). The eyes in mongolism. *Brit. J. Ophthal.* **33**, 131–174.

Osborn, F. (1968). *The Future of Human Heredity.* New York, Weybright and Talley.

Scholz, D. (1970). Die Beziehungen zwischen Myopie und Schulerfolg, Wachstum und sozialen Faktoren. *Öff. Gesundheitswes.* **32**, 530–535.

Sutter, J. (1963). The relationship between human population genetics and demography. *The Genetics of Migrant and Isolate Populations,* ed. Goldschmidt, E. Baltimore, Williams and Wilkins.

Waardenburg, P. J. (1963). *Genetics and Ophthalmology.* Assen, Van Gorcum.

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