

MYOPIA IN TEN YEAR OLD CHILDREN — A CASE CONTROL STUDY

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SYNOPSIS

8082 ten year old children in 35 schools had visual acuity testing using Snellen's Chart. Those with defective vision but no organic eye lesion were further tested using an autorefractometer. The prevalence rate of myopia was 24.9%, hypermetropia 3.3%, astigmatism 2.2% and amblyopia 3.8%. The case control study comprised 1834 myopes and 1972 normal controls. Statistically significant associations were found between the occurrence of myopia and a family history of myopia, close proximity of viewing television, and reading in a supine position. The two environmental factors are probably related to excessive and prolonged accommodation. A person genetically prone to develop myopia is more likely to be susceptible to environmental factors.

INTRODUCTION

Controversy over the relative importance of heredity and environment in the aetiology of myopia has persisted over the years. Earlier reports were of the opinion that biological factors are the principal determinant of myopia, stressing that environmental factors do not cause any permanent physical or pathological changes to the eyes (1). Recent studies however indicated that environmental factors are responsible for myopia, either solely (2) or in conjunction with some underlying genetic mechanism (4). In particular, increasing exposure to reading and other types of close work associated with higher education has been implicated in several studies, as increasing the prevalence of myopia (5,6,7). Local studies, done by the School Health Services (8) and the Ministry of Defence (9), also found an association between education and prevalence of myopia. An understanding of these factors will have important practical implications that could lead to the prevention of myopia and a consequent reduction in visual impairment.

This paper reports on the prevalence of refractive errors among 10 year old children and the results of a case control study on myopes.

This case-control study was conducted bearing in mind the genes vs environment aetiological hypothesis. The object is to determine the relative contribution of genetic and the various environment factors towards myopia.

METHODOLOGY

8082 ten year old children in the 4th year of primary school in 35 schools were studied during the period April 1984 — July 1985. Altogether there were 4189 boys and 3893 girls. Their ethnic distribution was 69.1% Chinese, 16.3% Malay and 14.1% Indian. The children were screened by school nurses for visual acuity using Shellen's charts. Those with defective vision (visual acuity 6/9 or worse) but no organic eye lesion were further tested at the Institute of Health Eye Clinic using an autorefractometer without cycloplegics. Children detected as myopic by the autorefractometer ie vision equal to or worse than -0.5 dioptre in one or both eyes formed the study group. The control group consisted of children of similar age, sex and ethnicity as the "study group" and from the same schools, but who do not suffer from myopia. Information on the family history of myopia, birth history and reading habits were obtained through interviews with students or their parents. Incomplete questionnaires were completed using telephone contacts.

In this study, a child was considered as having myopia when his visual acuity was equal to or worse than -0.5 dioptre in one or both eyes; hypermetropia when visual acuity was equal to or worse than +0.5 dioptre sphere in one or both eyes; and astigmatism as visual acuity equal to or worse than ± 0.5 dioptre cylinder. Amblyopia was diagnosed when visual acuity after full correction of both eyes indicated a difference of one or two lines on the Shellen's chart; and/or visual acuity in both eyes after full correction cannot be improved to 6/6 on the Shellen's chart. Children falling into one of the above criteria should also have demonstrable refractive types of amblyogenic factors eg. ametropia — more than ± 5.0 dioptres sphere; anisometropia — a different of 3.0 dioptres sphere or more in each eye; or meridional amblyopia — astigmatism of more than 1.5 dioptres in the oblique axis.

RESULTS

Prevalence of Refractive Errors

Out of 8082 children screened at school, 3100 (38.4%) were found to have a visual acuity of 6/9 or worse. As 31 were found to have organic eye lesion other than refractive error, only 3069 children were called up for autorefractometer testing. In total 2829 children were autorefracted, giving a non response rate of 7.8%. The results of the auto-refractometer testing are shown in table 1.

TABLE 1: DISTRIBUTION OF REFRACTIVE ERRORS

	Number	Percent
Myopia	1834	64.8
Hypermetropia	277	8.0
Astigmatism	169	6.0
Amblyopia	293	10.4
Emmetropia	306	10.8
Total	2829	100.0

The results showed that 65% were myopic, 8% hypermetropic and 6% had pure astigmatism. In addition, 10% had amblyopia and 11% were false positives. Many of the children who had myopia or hypermetropia had some degree of astigmatism as well.

The prevalence of myopia in this group of primary four children was 24.9%, hypermetropia 3.3%, astigmatism 2.2% and amblyopia 3.8%. The prevalence rate of myopia among Chinese children was significantly higher, 28.9%, compared to the Malays and Indians which was 15.1% respectively ($p \ll 0.001$). Ethnic differentials were less marked in the other types of visual defects (table 2).

TABLE 2: PREVALENCE OF REFRACTIVE ERRORS IN DIFFERENT ETHNIC GROUPS

	Chinese	Malay	Indian	Total
Myopia	28.9%	15.1%	15.1%	24.9%
Hypermetropia	2.7%	4.6%	4.6%	3.3%
Astigmatism	2.3%	2.1%	1.8%	2.2%
Amblyopia	4.0%	2.7%	3.5%	3.8%

TABLE 3: PREVALENCE OF REFRACTIVE ERRORS BY SEX

	Male	Female	Total
Myopia	24.7%	25.1%	24.9%
Hypermetropia	3.2%	3.4%	3.3%
Astigmatism	1.6%	2.9%	2.2%
Amblyopia	3.2%	4.3%	3.8%

Although the rates for all the refractive errors appeared to be slightly higher among girls, the difference between the sexes is not significant for myopia and hypermetropia ($p > 0.05$) (table 3).

Myopia Case Control Study

The case-control study comprised 1834 myopes and 1972 normal controls. The age, sex and ethnic distributions of the myopes and controls were comparable.

All probable factors which may ease, precipitate or aggravate myopia were studied. These include family history of myopia, gestational length and birth weight, length of formal education, adequacy of lighting when studying or watching TV, amount of sleep, amount of time spent on close work such as homework, watching TV or computer screen, the TV viewing distance, habit of reading supine and the habit of practising eye accommodation after a period of close work.

Only three factors were found to be associated with myopia. They were:-

(1) Family history of myopia

A family history of myopia is strongly related to a child developing the same refractive error ($p \ll 0.001$) (table 4). The relative risk of developing myopia increases with increasing numbers of family members with myopia, but this increase was only marginal. For every 100 children with a family history of myopia and who also developed this refractive error, 46 of them, with one family member having myopia, could attribute the myopia to their genetic make-up. This figure increased to 52 when two family members were myopic, and to 60 when three or more family members had myopia. The risk of developing myopia was increased when just a single family member was

TABLE 4: RISK OF MYOPIA ASSOCIATED WITH FAMILY HISTORY OF MYOPIA

No. of family members with myopia	Myopia	Emmetropia	Relative Risk	Attributable Risk % Exposed	Population Attributable Risk %
3 or more	228	148	2.46	59.3	11.0
2	330	256	2.06	51.5	12.8
1	643	556	1.85	45.9	19.8
0	633	1012	1.00	—	—

X^2 (trend) = 97.76 $p \ll 0.001$

myopic, compared to no family history of myopia at all. If it were possible to select one's genetic make-up such that the "myopic gene" was absent, one would prevent 44 cases of myopia out of every three hundred or 147 out of every thousand cases. This shows that myopia is not solely due to the genetic constitution.

(2) distance of viewing television

Information on television viewing distance was ascertained from the questionnaire. The distance where the child was seated away from the TV screen was divided into 3 categories. There was a highly significant difference between the myopic group and the normal controls, as regards their television-viewing distance ($p \ll 0.001$) (Table 5). The risk was increased three fold when the child sat < 1 metre from the television screen, as compared to 3 metres away.

To avoid genetic make-up being solely responsible for this finding, a separate analysis of myopes and controls who had no family history of myopia, and the distance they maintained from the television screen, was made (Table 6). This showed that the difference in the distance from the television screen between myopes and normal controls was still very highly significant and a significantly greater proportion of myopic children watched television at close range, compared to children with normal eyesight.

Further analysis was made on 767 newly detected myopes (Table 7) so as to nullify the effect that myopia might have caused the child to sit further or nearer the screen. The findings confirmed that they tended to sit closer to the television screen than children with good eyesight ($p \ll 0.001$).

TABLE 5 — VISUAL ACUITY BY DISTANCE FROM TELEVISION SCREEN

Distance	Myopia	Emmetropia	Relative Risk	Attributable Risk % Exposed	Population Attributable Risk %
< 1 m	253	153	3.29	69.6	17.0
1 — 2 m	1252	1165	2.14	53.3	40.6
3 m or more	329	654	1.00	—	—

X^2 (trend) = 125.62 $p \ll 0.001$

TABLE 6: VISUAL ACUITY BY DISTANCE FROM TELEVISION SCREEN, FOR THOSE WITH NO FAMILY HISTORY OF MYOPIA

Distance	Myopia	Emmetropia	Relative Risk	Attributable Risk % Exposed	Population Attributable Risk %
1 m	86	77	3.12	67.9	12.3
1 — 2 m	425	594	2.00	50.0	32.1
3 m or more	122	341	1.00	—	—

X^2 (trend) = 46.66 $p \ll 0.001$

TABLE 7: VISUAL ACUITY AND RISK OF MYOPIA BY DISTANCE FROM TELEVISION SCREEN, FOR NEW CASES OF MYOPIA

Distance from TV screen	Myopia	Emmetropia	Relative Risk	Attributable Risk % Exposed	Population Attributable Risk %
1 m	100	153	2.69	62.8	9.7
1 — 2 m	508	1165	1.79	44.1	26.2
3 m or more	159	654	1.00	—	—

X^2 (trend) = 49.88 $p \ll 0.001$

There was a positive dose-response relationship, the relative risk being almost tripled when the distance from the television screen was reduced from 3 metres to less than 1 metre. Analysis also showed that the maximum effect of disallowing television viewing at closer range than 3 metres will be a reduction of 180 cases of myopia for every 1000 children.

(3) reading in supine position

The study had shown some association between the incidence of myopia and the frequency of reading when in the supine position ($p \ll 0.001$) (Table 8). There was also a positive dose-response relationship i.e. the relative risk of developing myopia increased with the frequency of reading in a supine position.

To exclude the effect of genetic susceptibility, a separate analysis of those with no family history of

myopia was done. There was again a highly significant difference in the frequency of reading lying on the back, between myopes and normals (Table 9).

To remove the effect of the "disease" affecting exposure, analysis of newly detected cases of myopia by whether reading is done in the supine position (Table 10), again showed that myopes have a highly statistically significant proportion ($p \ll 0.001$) who have bad visual hygiene of reading while in a supine posture, compared to normal controls. The risk of myopia is increased more than 2 fold for those who usually lie down to read compared to those who do not lie down to read. Should a preventive program be instituted, and no child indulge in this habit of reading in bed, the maximum effect it can have is the prevention of 61 out of every 1000 myopic children.

Although no association was found with all the

TABLE 8: VISUAL ACUITY AND RISK OF MYOPIA BY FREQUENCY OF READING WHEN SUPINE

Frequency of reading when supine	Myopia	Emmetropia	Relative Risk	Attributable Risk % Exposed	Population Attributable Risk %
Usually	215	94	3.26	69.3	12.4
Sometimes	1062	1085	1.39	28.1	17.5
Never	557	793	1.00	—	—

X^2 (trend) = 74.26 $p \ll 0.001$

TABLE 9: VISUAL ACUITY AND RISK OF MYOPIA BY FREQUENCY OF READING WHEN SUPINE, FOR THOSE WITH NO FAMILY HISTORY OF MYOPIA

Frequency of reading when supine	Myopia	Emmetropia	Relative Risk	Attributable Risk % Exposed	Population Attributable Risk %
Usually	66	39	3.41	70.7	8.1
Sometimes	338	511	1.33	24.8	11.7
Never	229	462	1.00	—	—

X^2 (trend) = 28.09 $p \ll 0.001$

TABLE 10: VISUAL ACUITY AND RISK OF MYOPIA BY LYING DOWN TO READ, FOR NEW CASES OF MYOPIA

Frequency of reading when supine	Myopia	Emmetropia	Relative Risk	Attributable Risk % Exposed	Population Attributable Risk %
Usually	80	94	2.55	60.8	6.0
Sometimes	422	1085	1.16	13.8	6.2
Never	265	793	1.00	—	—

X^2 (trend) = 20.5 $p \ll 0.001$

other factors studied, it does not altogether negate the influence which these variables might have on myopia. Other studies have implicated the quantum of close work and myopia (2), which commences in adult life (spatmyopia). There is a latent interval between exposure and "disease", and as the group of children studied are only aged 10 years, the latent interval or the intensity of exposure (such as close work or poor lighting) might not be of sufficient magnitude to have an effect on this group of children. Other factors, prematurity and low birth weight, were reported to be important factors in the causation of myopia in young children. However, because of the small number of children who had prematurity or low birth weight in the group studied no conclusion could be made between the association of prematurity and myopia.

DISCUSSION

The two popular theories on the aetiology of myopia are the Hereditary Theory and the Lenticular Theory. Most authorities believe that myopia is mainly transmitted by autosomal dominance; and in certain cases of high myopia, the inheritance is autosomal recessive. A genetically determined person, therefore, is more susceptible to be affected by environmental factors and will develop myopia during a certain period of life. The period of susceptibility has not been precisely determined, but it is believed to be in the school going age.

The most important environmental factor identified is excessive and prolonged accommodation of the eyes in near work (10). Myopia, according to the Lenticular Theory, is acquired through adaptive change in the refractive power of the crystalline lens and in the related system, caused by continual accommodation to near work. The tonus of the ciliary muscles, its hypertrophy and atrophy, the changes in the elasticity and the shape of the lens and the zonules may all be related to the adaptive change.

This study confirms the Hereditary and Lenticular Theories. Both genes and environment appear to play a role, various environmental factors in combination probably playing a larger role than genetic make-up alone. Although an association has been found between poor visual hygiene (ie. reading while supine and watching television at close proximity) and myopia, we cannot make a definitive deduction of causality. The

question of which comes first, myopia or poor visual hygiene, cannot be determined. Despite this, we should continue to exhort good visual habits, as environment factors do have a part to play in the aetiology of myopia.

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