THE PATTERN OF MYOPIA IN YOUNG SINGAPOREAN MEN

S J Chew, S C Chia, L K H Lee

SYNOPSIS

Vision defects due to myopia typically appear during the school years and are almost fully developed by the age of twenty. The comprehensive surveillance system of vision impairments in the 15 to 25 year-old men in Singapore (population 2.5 million) offers an opportunity to study the prevalence of myopia in this select group. The study population of 320,409 equals in size the entire male population of Singapore of that age group. It was found that 9% of subjects with no education or only primary education required spectacle correction in contrast to 50 - 60% of those with A-levels and above. Not only was there a greater incidence of myopia among the higher educated but the degree of myopia was also greater (4.5% of the latter having myopia of more than -7 D compared with 0.8% of the former). Having established the link between education and myopia, a closer look at its pathogenesis is warranted with the view to myopia prevention by the avoidance of excessive nearwork.

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INTRODUCTION

The clinical as well as social and economic importance of myopia is great, as nearly 90% of glasses worn between the ages of 12-27 are prescribed for this type of refraction (Bear & Richler 1982). More than eighty percent of those reporting to school eye clinics have myopia. The figures for the incidence of myopia vary. Harman (1936) gives a figure of 27% for Britain, Jackson (1932) 19.6% in the USA and Angle & Wissman (1980) 28.4% in males and 36.5% in females in the USA. Rasmussen reported a 70% incidence in young Chinese adults.

Myopia is not a single entity, but represents several different types each with its own type of heredity (Waardenburg 1963). Myopia can be classified as simple or school myopia and degenerative (Duke-Elder 1970). The school myopia commonly seen in children is uncomplicated and of low grade and develops toward puberty. Degenerative myopia represents 8 - 32% of the myopia population (Duke-Elder 1970). High myopia is usually pathological, rather than an extension of normal variation in refraction (Francois 1961; Duke-Elder 1970).

Many factors such as sex (Goldschmidt 1968; Aine 1979; Richler & Bear 1980; Angle & Wissman 1980), close work/educational level (Tscherning 1883; Yog 1975; Richler & Bear 1980), hormones (Balacco-Gabrielli & Tundo 1981) and dietary aspects (Gardiner 1958; Lane 1981) have been suggested as forming part of the myopising process.

From the multitude of factors listed above, it is evident that the growth and development of the refractive elements of the eye must be under elaborate genetic control; emmetropia, which occurs more often than expected were refraction normally distributed, results from correlated growth of cornea and lens, adjusting for elongation of the optic axis (Sorsby et al 1961). Resemblances between relatives suggest a substantial genetic component in population variation in ocular refraction (Sorsby et al 1962, 1966). On the other hand, the morphological variations underlying substantial refraction differences is very small (an uncompensated excess of 1mm or 4% in the length of the adult optic axis of 24mm, implies a myopia of -3 D). Subtle environmental disturbance of ocular development can therefore markedly influence refraction.

Van Alphen in 1961 has shown that accomodation increases the tension on the choroid with the consequent rise in intraocular pressure causing the eye to elongate and hence become myopic (Young 1975). Thus it is reasonable to postulate that variation in nearwork levels among the young could contribute to the prevalence of myopia via the influence of accomodative effort on axial length.

There is relatively little information relating myopia and nearwork in representative, unselected populations. Because of this paucity of direct observations in this area and because of its potential importance, a study was undertaken relating the refractive status and education level of young Singaporean males.

SUBJECTS & METHODS

The study population was restricted to men of the age group 15 to 25 for the following reasons:

(1) AGE SELECTION

Ocular refraction in man is a continuously distributed attribute. Its distribution at birth is roughly normal but leptokurtotic with a mean and mode in low values of hyperopia, and a deficiency in the low myopic range (Goldschmidt 1969). In adults, the distribution is markedly leptokurtotic, still exhibiting a mean and mode in mild hyperopia, but also a pronounced skew to myopia values (Betsch 1929).

Eye Section
Medical Classification Centre
Central Manpower Base
Dempsey Road
Tanglin
Singapore 1024

S J Chew, MBBS, Medical Officer

Department of Ophthalmology
Singapore General Hospital
Outram Road
Singapore 0316

S C Chia, MBBS, FRCS, Registrar

SAF Physical Performance Centre
SAF Medical Services
Tanglin Road
Singapore 1024

L K H Lee, MBBS, M Sc (Spts Med USA), Head

Thus myopia of clinical degree usually becomes manifest in late childhood, increasing slowly in degree for some years thereafter (Duke-Elder 1970). It is therefore for the reasons of stability of refraction and the absence of age-related visual problems (cataract and maculopathy) that early adulthood was chosen for study.

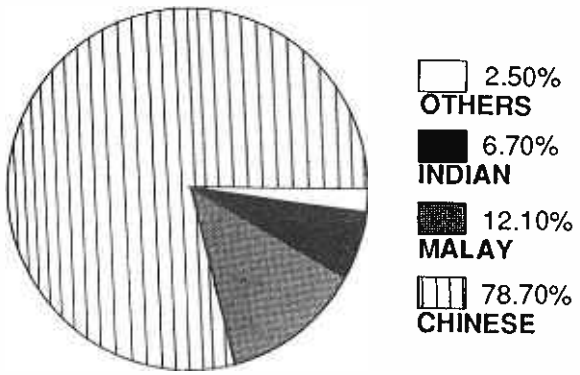
(2) CHOICE OF SEX

More girls than boys are myopic (Goldschmidt 1968; Roberts 1975; Aine 1979). Generally, girls mature earlier and myopia is related to puberty. However, from the age of 25 up to 80, myopia stays equal in women and men. Thus, having chosen the age group of young adults, it was necessary to restrict the study to a single gender in order to reduce the number of confounding factors in the analysis of myopia aetiology.

Since it has been established that the percentage of refraction anomalies is increased in urban environments (D. Velkovic), it is fortunate that Singapore, being a wholly urbanised country without a countryside, ensures homogeneity of the study population in this respect.

The survey consists of 320,409 men who had undergone compulsory full physical examination over a decade 1974 to 1984. Their ages ranged from 15 to 25 with a mean of 17.?5. The racial distribution is illustrated in Fig 1.

Fig 1 Singapore Ethnic Distribution



Ocular refraction was determined in the course of a standard optometric examination. Subjects with impaired vision uncorrected by refraction were excluded from the study. This amounted to 1.38% of the study population.

For analysis, any cylindrical correction was converted to spherical powering the vertical meridian, and because right and left eye refractions are highly correlated, only right eye refractions are analysed.

Educational attainment was carefully documented and the subjects classified into 8 levels:

(1) NFE - No formal education.

(2) PRI - Having begun but not completed primary school.

(3) PSLE/PR6 - Completed successfully 6 years of primary school.

(4) SEC - Having begun but not completed secondary school.

(5) O-level/GCE - Successful completion of 4 years of sec. school.

(6) A-level/HSC - Completion of 2 years of pre-university.

(7) TECH - Attained a diploma in technical skills.

(8) TERT/UNV - Completed 3-5 years of tertiary education.

Each education level represents approximately 2 years of completed schooling more than the lower level (i.e. PSLE represents 6 years, GCE 10 years, HSC 12 years, TECH 14 years and TERT 18 years).

RESULTS AND OBSERVATION

(1) Prevalence of myopia

Little is known about the distribution of myopia in the population of Singapore. Most surveys of refractive error have dealt with select populations, such as students, army conscripts, and eye clinic patients. As a result, knowledge of the prevalence of myopia in the overall population is incomplete.

Such prevalence data could be helpful in health care planning. In recent years, there has been growing interest in radial keratotomy. To evaluate the potential medical and economic importance of this procedure, better prevalence data are required.

Fig 2, 2a, 2b detail the incidence of refractive error. For this study, Snellen acuity of 6/9 to 6/12 was considered adequate without need for spectacle correction. This gives a 26.3% incidence of ametropia, which would rise to 45.5% if the 6/9 - 6/12 acuity group was included. From previous local studies, myopia has been found to have such an overwhelming preponderance over hyperopia in this age group that effectively a quarter of our male population are myopic.

Fig 2
Results of Visual Acuity Tests By Snellen's charting of 320,409 Males

Unaided Visual Acuity results (right eye)	Number of Persons	%
6/6	174,716	54.5
6/9 to 6/12	61,395	19.2
6/18 to 6/24	14,957	4.7
6/36 to 6/50	31,920	10.0
less than 6/60	37,423	11.6
Total	320,409	100.0

Fig 2a Results of Snellen Acuity Testing of Study Population (expressed as percentage of total study population)

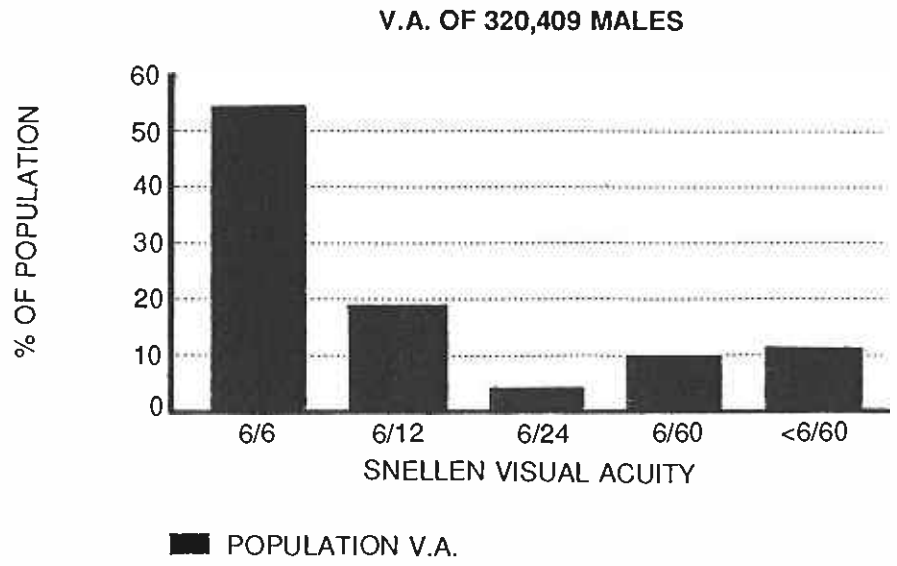


Fig 2b Results of Snellen Acuity Testing (expressed in no. of men)

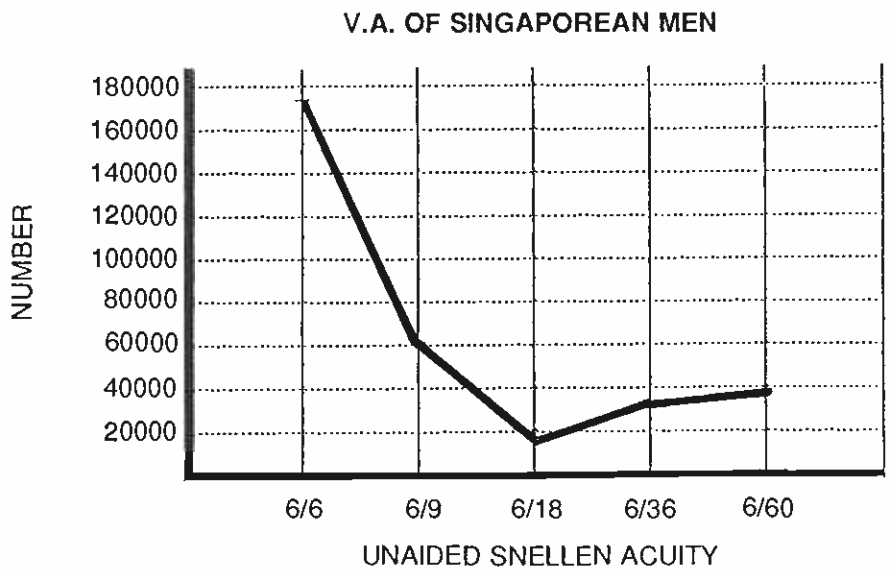


Fig3 a – g Visual Acuity of Differing Education Groups (% of Pop. in each educational group)

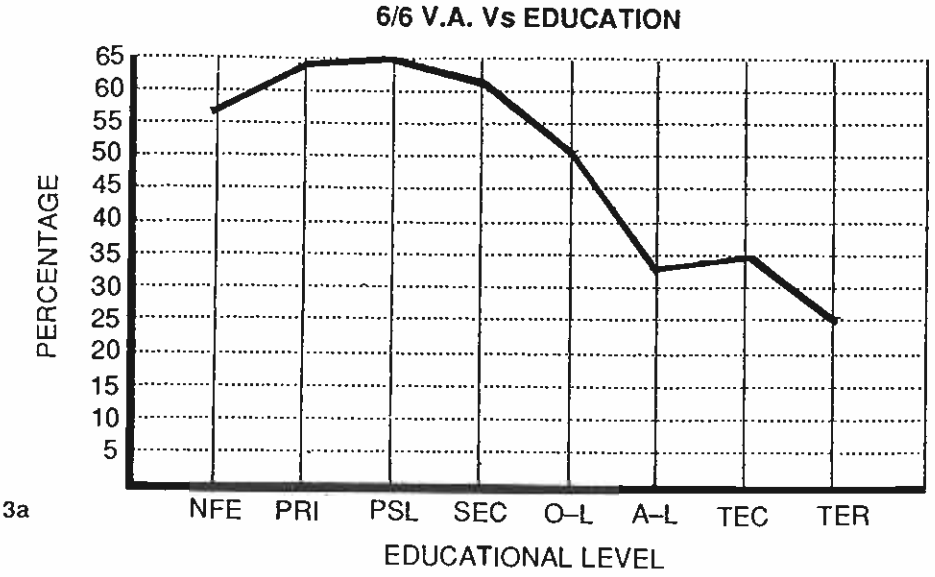


Fig 3a

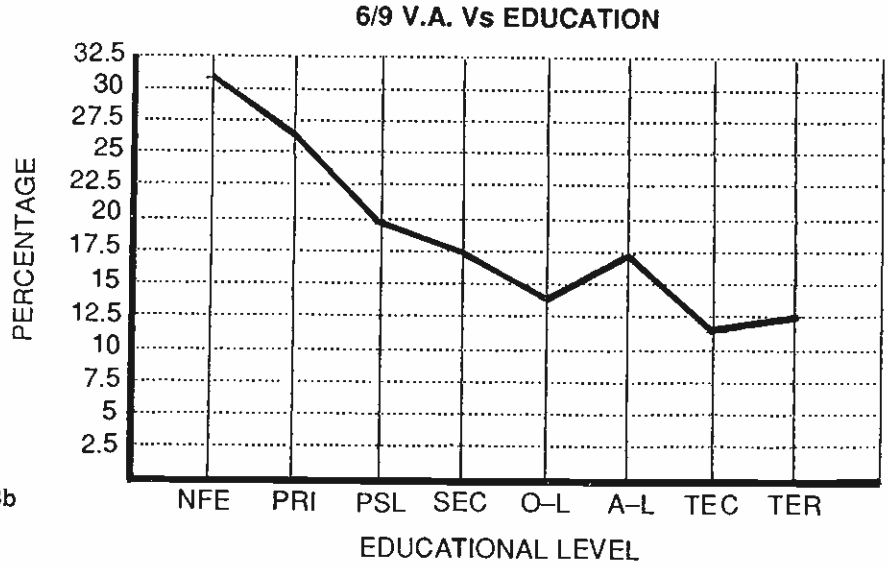


Fig 3b

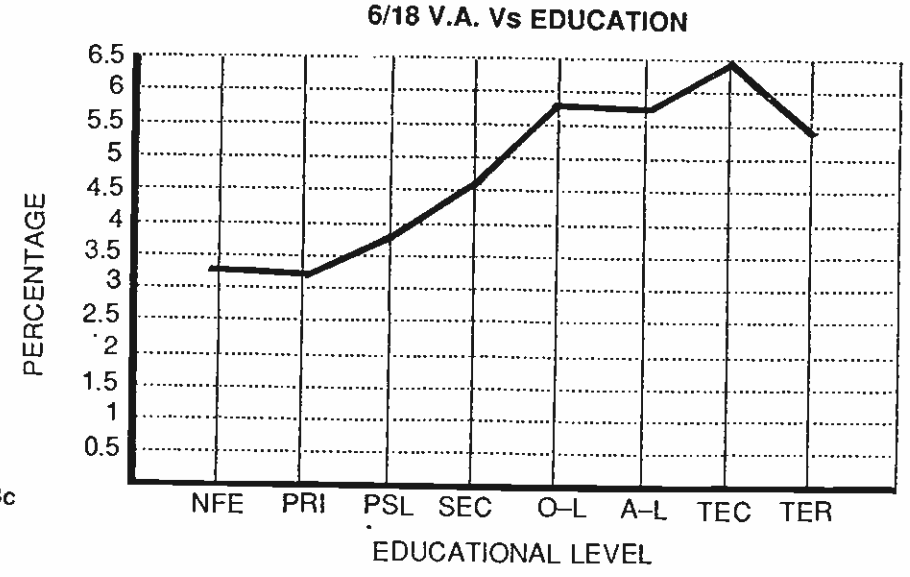


Fig 3c

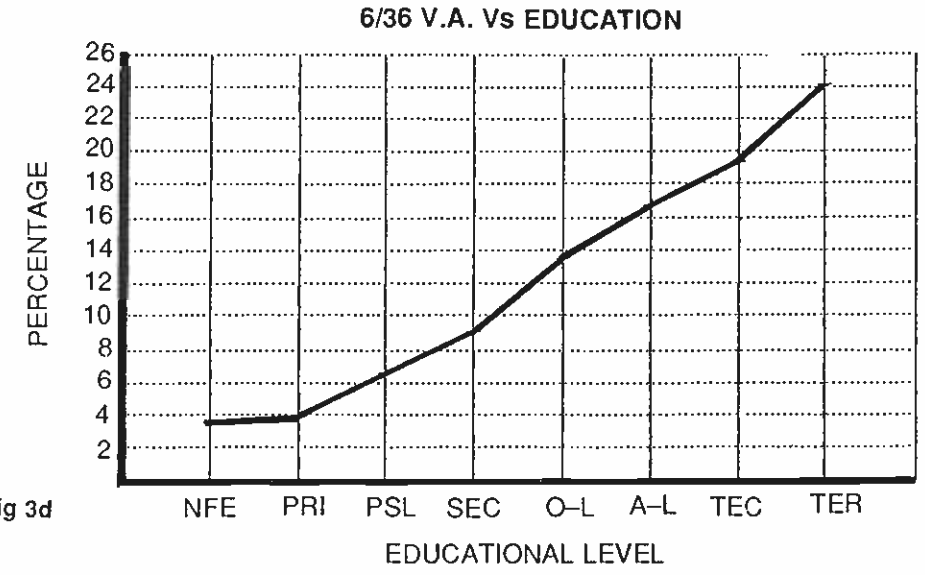


Fig 3d

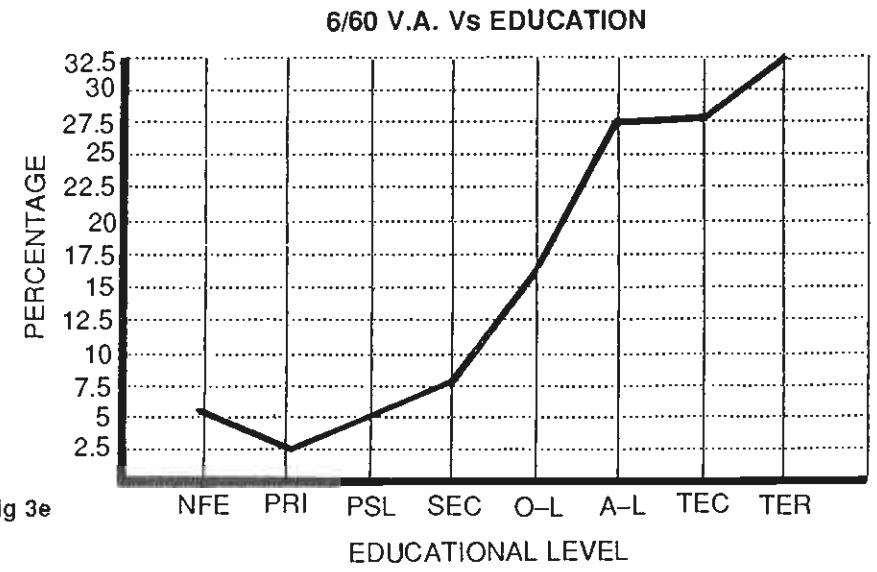


Fig 3e

Fig 3f Good Unaided Vision Vs Education Class

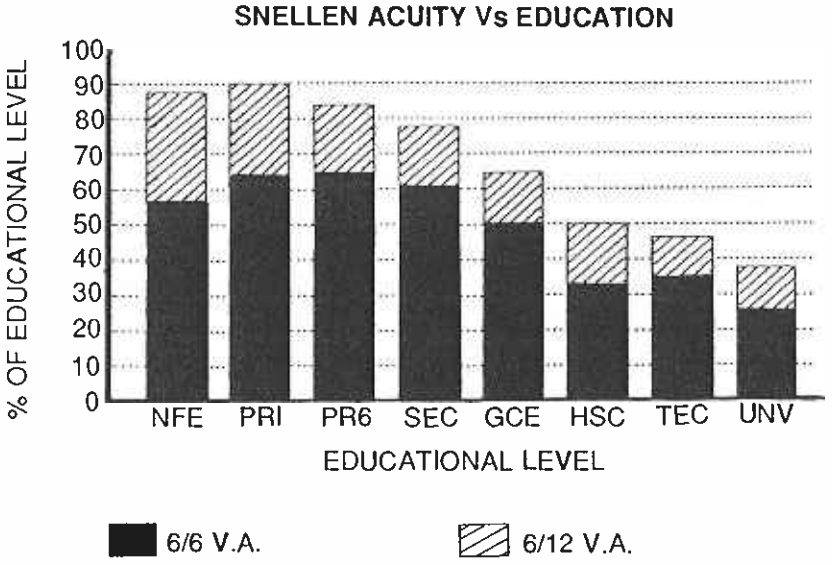


Fig 3g Poor unaided Vision Vs Education Class

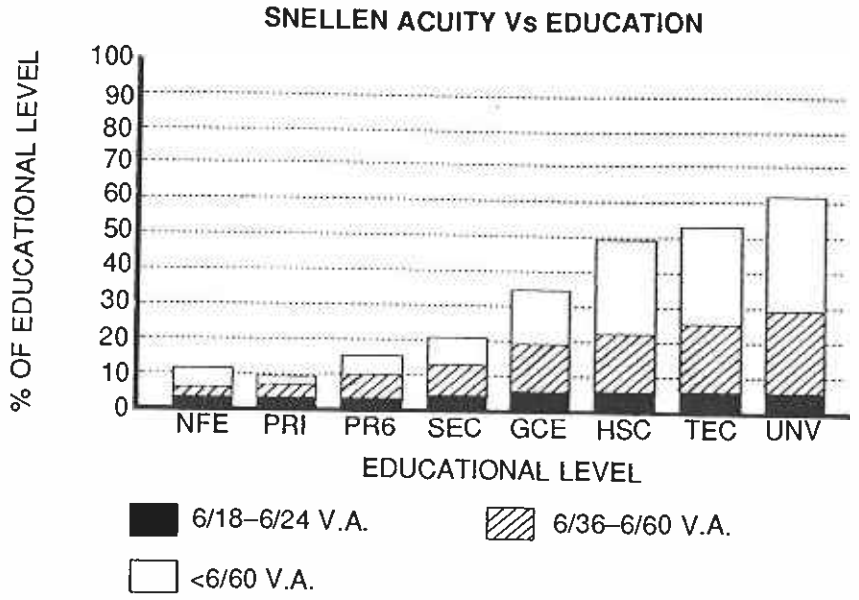


Fig 4

RESULTS OF VISUAL ACUITY TESTS BY SNELLEN'S CHARTS OF 320,409 MALES SUBDIVIDED ACCORDING TO EDUCATIONAL LEVELS

(RESULTS EXPRESSED AS A PERCENTAGE OF THE TOTAL IN EACH OF THOSE EDUCATIONAL LEVELS)

Unaided Visual Acuity by Snellen's chart (right eye)	EDUCATIONAL LEVEL							
	No formal education	Primary school	PSLE	Secon-dary school	O Level	A Level	Technical	Tertiary education
6/6	56.9	64.1	64.9	61.1	50.7	32.9	35.0	25.7
6/9 to 6/12	30.8	26.4	19.6	17.3	14.0	17.3	11.4	12.6
6/18 to 6/24	3.3	4.2	3.8	4.6	5.8	5.7	6.4	5.4
6/36 to 6/60	3.5	3.8	6.7	9.0	13.5	16.7	19.3	24.2
less than 6/60	5.5	2.5	5.0	7.9	16.0	27.4	27.8	32.1
Total	100%	100%	100%	100%	100%	100%	100%	100%

Fig 5a Percentage of Emmetropia In The Various Educational Classes

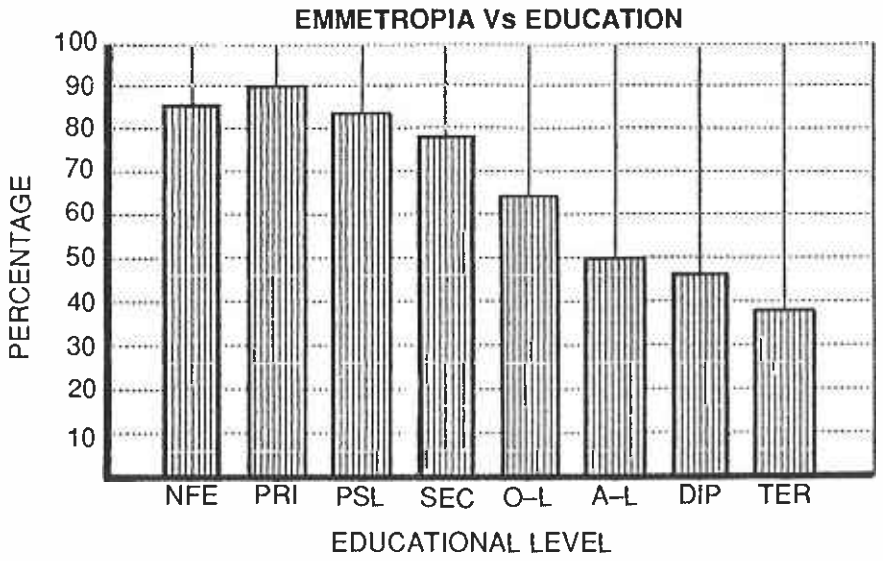
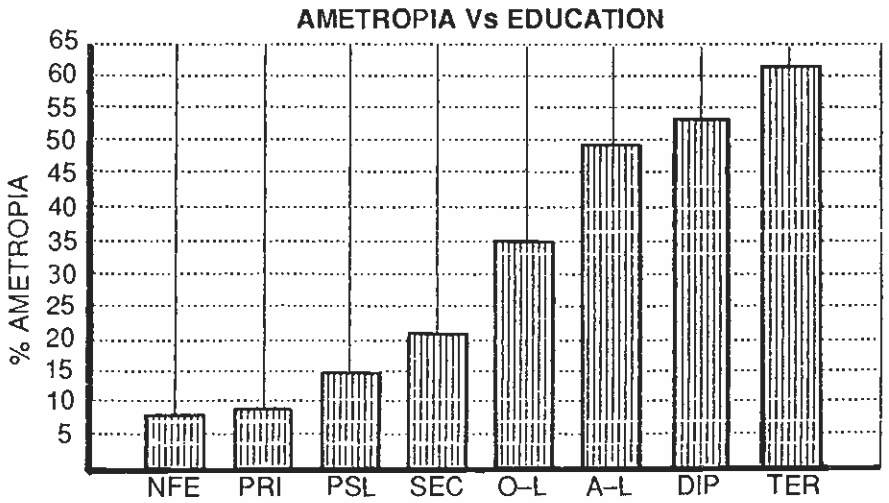


Fig 5b Percentage of Ametropia In The Various Educational Classes



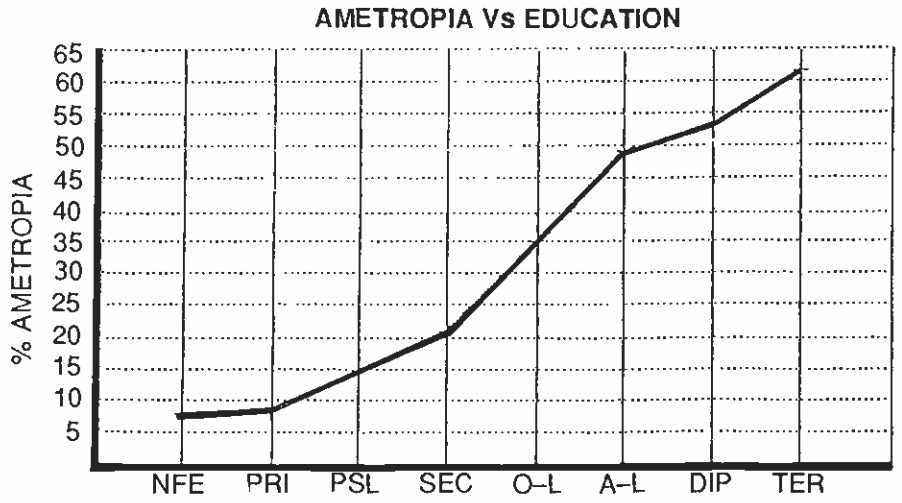


Fig 5c & 5d Ratios of Emmetropes and Ametropes In The Various Classes

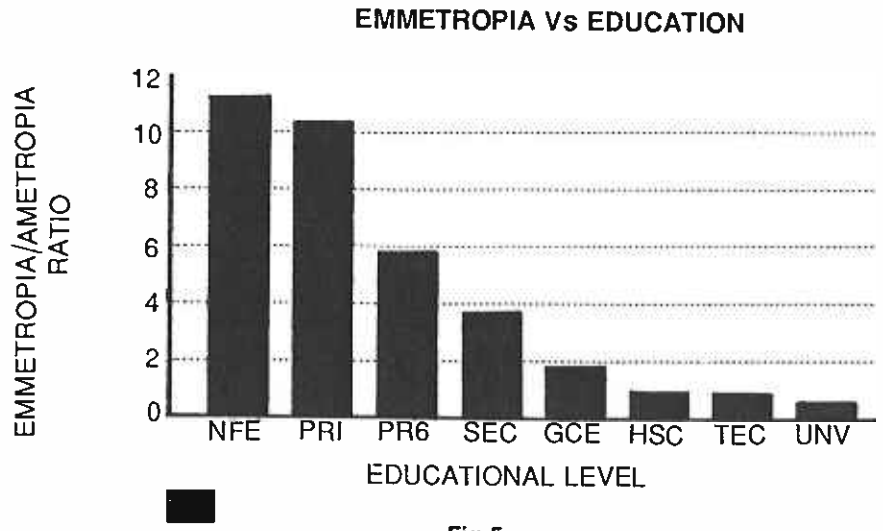


Fig 5c

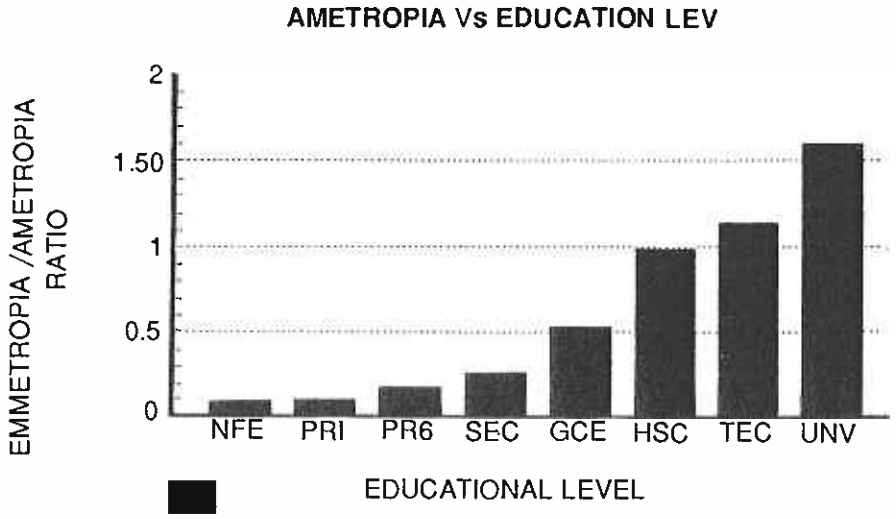


Fig 5d

(2) Education and myopia

Fig 3 a-e show a breakdown of the various degrees of metropia correlated with educational level. It is evident, especially from Fig 3d that the incidence of myopia is proportional to the number of years of education. These charts are summarised in Fig 3 f-g and tabulated in Fig 4. Although the incidence of low refractive errors causing an acuity of 6/18 to 6/24 remains relatively unchanged throughout the groups (probably due to a larger incidence of nearwork unaffected hyperopia at this level), the proportion of higher errors rises sixfold when the number of years of education are doubled (from PSLE to HSC).

Fig 5 a-d illustrate the data in simplified form with "emmetropia" including 6/6 to 6/12 acuity. Although this is 73.7% of the entire population, it falls from 90.5% of those with only primary education to only 38.3% of university graduates. Fig 5 c-d show that for every bespectacled man with no formal education, there are eleven of his peers who have no need for glasses. This is in contrast to the ratio of 1.6 myopes to emmetropes among university graduates. This progression follows closely the number of years of education completed.

(3) High myopia and education

Persons with refractions above -6D are usually not included in papers on nearwork and myopia because their refraction is said to be almost always pathological and assumed to be due to marked inherited anomalies. This group is predisposed to complications of fundus changes, retinal haemorrhages and retinal detachment as distinct from school myopia.

Our study showed an incidence of 1.59% of high myopia (defined here as greater than 7 D). The detailed correlation with education is tabulated in Fig 6 where 4 groups are compared.

That a difference in the incidence of high myopia exists is hinted at in Fig 7 where the left pie chart shows the level of education of young Singaporean men and the right the education standard of our high myopes. Tertiary educated men are over- represented in the latter. Fig 8b highlights this contrast.

Fig 8a clearly demonstrates the high proportion of high myopes among university graduates (4.51%) compared to primary school (0.79%) and the uneducated (1.11%). This is an apparent contradiction to the teaching

Fig 6

THE DISTRIBUTION OF HIGH MYOPIA IN THE DIFFERING EDUCATION CLASSES

Refractive Error (Diopters)	Total Study Population 320,409		No Formal Education 28,488l		Primary School 104,772		Secondary School 143,243		Pre-University/ above 43,906	
	No.	%	No.	%	No.	%	No.	%	No.	%
–7 to –10	2768	0.86	62	0.22	230	0.22	1060	0.74	1416	3.23
–10 to –14	1976	0.62	168	0.59	461	0.44	872	0.40	475	1.08
–14 & above	351	0.11	58	0.20	132	0.13	75	0.05	86	0.20
Total	5095	1.59	288	1.11	823	0.79	2007	1.39	1977	4.51

that degenerative or pathological myopia is not affected by education. The dilemma is resolved when one examines Fig 8 c-d where the various degrees of high myopia are detailed. The proportion of very high myopia of greater than -10D is almost unchanged among the different education levels while the -7 to -10 D myopes show a very marked corelation with the years of education. It thus indicates that in our population, school myopia can reach a 'pathological' level of severity.

DISCUSSION

Our findings clearly indicate, in the population studied, an association between refraction and education. The question is however, whether this association indicates that nearwork actually influences refraction.

There are thus two theories which can relate myopia and education -

(1) The Biological Theory views myopia as the result of genetically determined characteristics of eye tissues. It predicts that either age from birth or age from puberty explains any tendency for myopia to appear and progress among children or adolescents. It implies that the myopia genes are inherited with those for intelligence, hence the correlation of myopia with education.

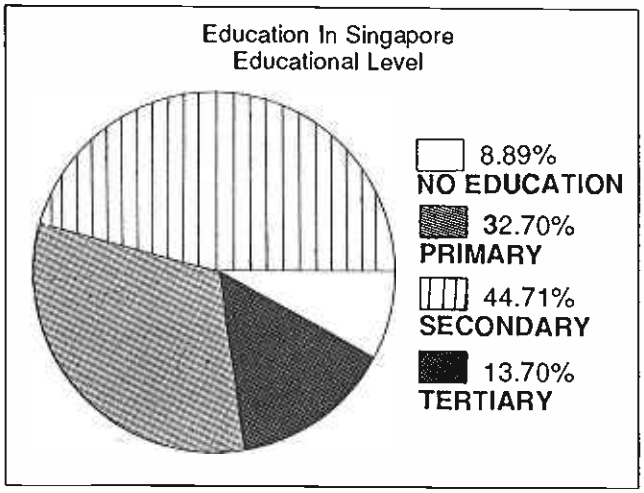
(2) The Use-Abuse Theory views myopia as the result of habitual use of the eye at a near focal length (nearwork). It predicts that current amount of reading and cumulative exposure to reading, as indicated by years of schooling, explain myopia.

The use-abuse theory implies that myopia is preventable whereas the biological theory does not. There are several studies to support both theories:

(1) Use-Abuse Theory

Bear, Richler and Burke found that refraction was consistently correlated with nearwork from ages 5 to 60 even after adjustments for age and sex (as was shown by our survey). A multiple regression coefficient of -0.43D/h for the ages of 5-14 years was even worked out in their

Fig 7



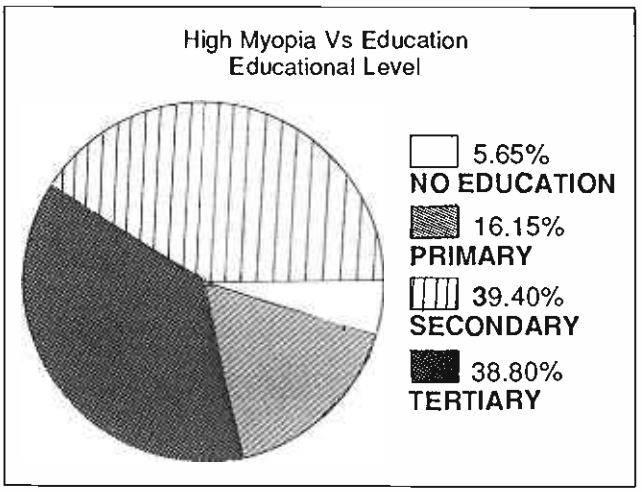


Fig 8a Percentage of High Myopes In The Education Groups

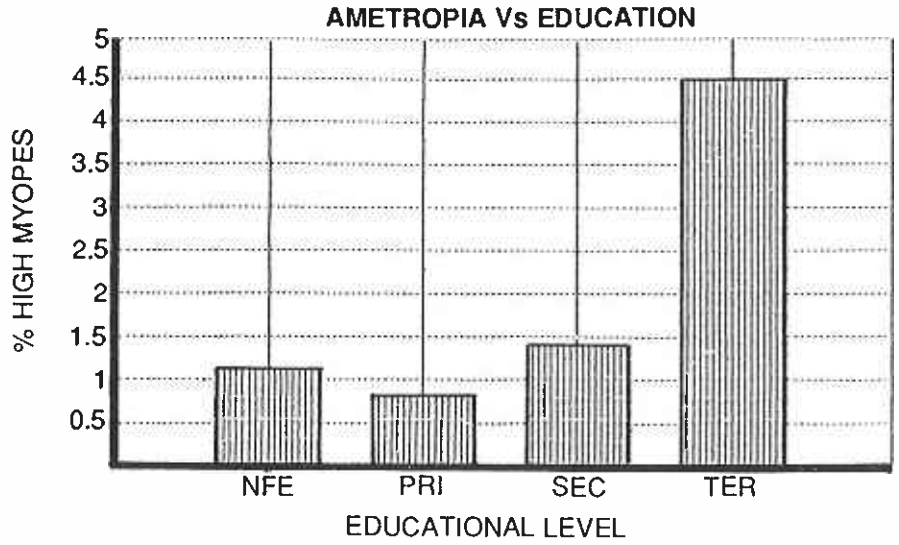


Fig 8b Comparison Of Distribution Of The VArious Education Groups In The Singapore Population With High Myopis Incidence In Education Groups

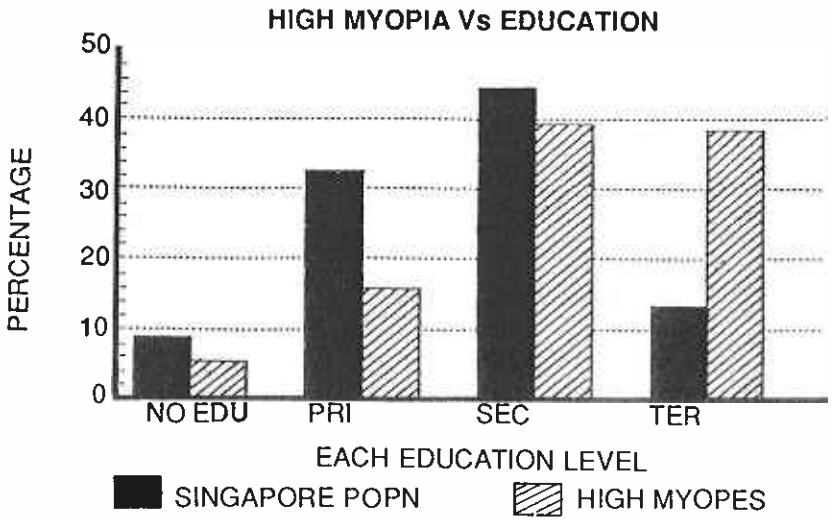


Fig 8c& 8d Distribution Of The Grades (Severity) Of High Myopes In The Education Groups

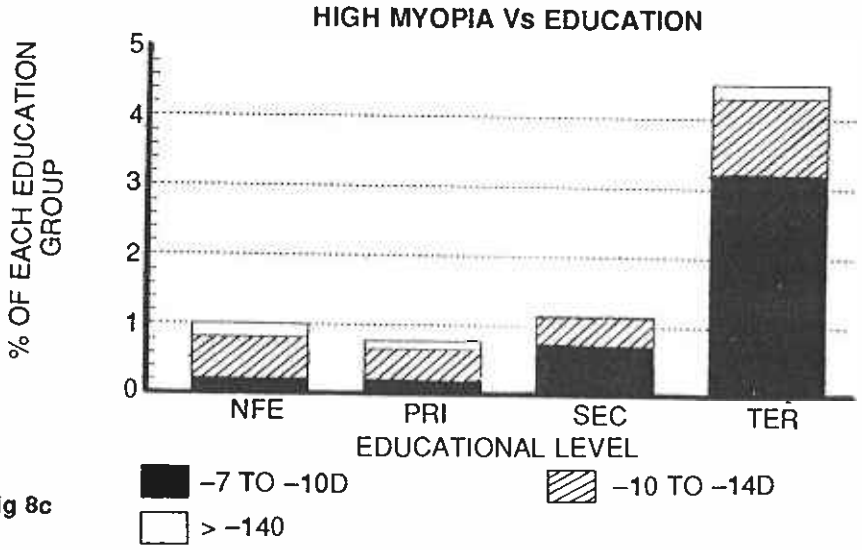


Fig 8c

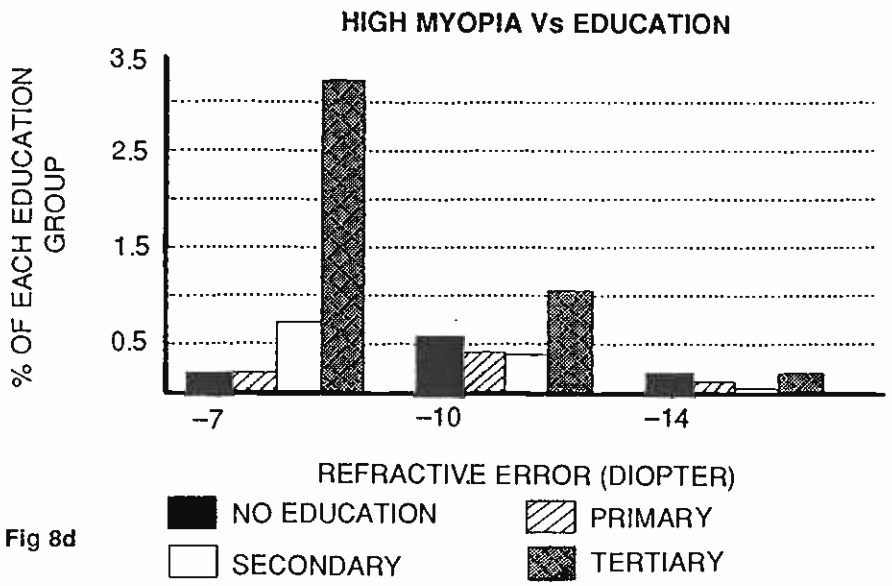


Fig 8d

study, suggesting that large amounts of nearwork in childhood contributes to the prevalence of clinical myopia.

Angle and Wissmann noted that when one controlled for education, age was not related to increased myopia.

Young et al (1969) and Woodruff & Somek (1977) found that the introduction of formal education in Eskimo and Amerind populations has dramatically increased the prevalence of myopia.

Experimental studies on adult and young animals, some of which are visually immature, show an alteration in the myopic direction if the animals are brought up in an environment with only near stimulation, as compared with a control group. An adolescent myope will decrease the progress of myopia if atropine and bifocals are given.

(2) Biological Theory

Sofaer and Emery's 1981 study of British members of Mensa showed real associations between high IQ and myopia and evaluation of scholastic achievement test scores by Heron and Zytkoskee confirmed that persons with poor visual acuity perform better on tests than individuals with normal or superior acuity.

In fact, Peckham et al found that superior educational attainments were already apparent before the onset of myopia as found in 7-year-olds.

It has been plausibly argued by Goldschmidt (1968) that the association of myopia with education and occupation in the relatively rigid class structure of Europe is the result of prolonged genetic selection and social stratification. This is untrue of the Singapore population where the population studied are the first or second order relatives of immigrants with a wide blend of genetic and social backgrounds.

Genetics and environment are thus both important factors affecting the relation of education and myopia, although controversy still exists about the relative influence of each on the development of refractive errors.

CONCLUSIONS

The large excesses of clinical myopia observed among advanced Singapore students compared with less educated members of their cohort suggests that levels of nearwork usual to Singaporean education may in fact alter the refractions of most young persons.

It is not possible in cross-sectional data to approach the question of whether nearwork levels decrease refraction in all young persons or only some. Limited longitudinal and family studies might clarify the generality or otherwise, of the nearwork-refraction association.

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