# Prevalence of myopia in a sample of Greek students

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**ABSTRACT.**

***Purpose:*** **An epidemiological study, concerning the prevalence of myopia among the student population (15–18 years old) of Northern Greece, was carried out.**

***Methods:*** **Specific questionnaires were used in order to collect data on the refractive condition of students.**

***Results:*** **Myopia prevalence was 36.8% and was found to be more common in females (46.0%) than in males (29.7%). The prevalence increased in students with myopic parents and myopic siblings. It was also found that myopia correlates strongly with nearwork and school performance.**

***Conclusion:*** **The study results suggest that myopia is a rather common refractive error in Greek students. Findings also indicate that myopia is probably hereditary and correlates with educational level, intelligence and excessive nearwork.**

**Key words:** myopia in students – epidemiology – heredity and myopia – nearwork – education.

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Myopia, as well as the other refractive errors, is a very common feature of the student population. According to extensive studies in various populations and in different countries, the distribution of myopia among students is variable. Several studies have shown that the prevalence of myopia increases with the level of education (Sperduto et al. 1983; Teasdale et al. 1988). It has also been supported that myopia is partly hereditary (Teikari et al. 1991; Zadnik et al. 1994). This study's aim is to examine the major epidemiological characteristics of myopia in the Greek student population and to identify the specific factors that cause myopia incidence.

## Material and Methods

In 1998, there were about 220,000 students aged between 15 and 18 years attending High School in Greece. In order to collect the material, 12 high schools in four cities of Northern Greece (Thessaloniki, Larissa, Alexandroupoli and Nigrita) were chosen. These cities were selected as they represent the urban (Thessaloniki), the semi-urban (Larissa, Alexandroupoli) and the rural (Nigrita) population of Northern Greece. It is therefore assumed that the selected population represents a sufficient range of the socio-economic spectrum. A total number of 1852 questionnaires were distributed to students in order to collect data on their refractive condition. We consider the questionnaire method to be of sufficient validity, taking into account that certain other studies were based on this method (Teikari et al. 1991; Zadnik et al. 1994).

Students were asked to quote their refractive situation using their ophthalmologist's prescription. They were also asked to determine their parents' and siblings' refractive situation, their performance at school, the hours they studied daily, the potential use of glasses or contact lenses and their habits. The questionnaires were anonymous and confidential.

Students who complained of poor vision but had not had their visual acuity examined were excluded. On the other hand, we assumed that students with no visual acuity test and no subjective visual problems were emmetropes, and as such they were included in the study. Foreigners and immigrants of the last eight years were also excluded so as to have a homogenous sample. The total number of excluded questionnaires from non-immigrant students was only 51, which corresponds to 2.754% of the sample (51 out of 1852). The total number of valid questionnaires was 1738 which accounts for 0.785% of the total High School student population. The epidemiological characteristics of the refractive errors were extracted from this sample.

Myopia was defined as the spherical error more than −0.25 D, emmetropia between –0.25 D and +0.25 D and hyperopia as the spherical error more than +0.25 D. Astigmatism was defined as more than 0.25 D of cylinder. Anisometropia was defined as a difference of more than 1.0 D of spherical equivalence between the two eyes.

In order to correlate myopia prevalence with several factors, such as heredity, sex, nearwork, performance at school, a different sample was chosen. It consisted of the 1431 students (554 myopes and 877 emmetropes) who had their visual acuity tested and reported the refractive status of their parents and siblings, as well as their school performance. Students with astigmatism (non-myopic) or hypermetropia were excluded from this sample, because our intention was to find the specific characteristics of the myopic students only, regarding the impact

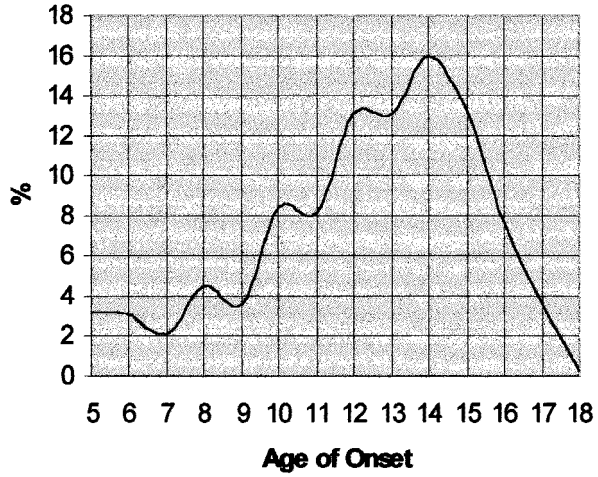


**Fig. 1.** The relationship between the percentage of myopes among Greek students and the age at which myopia was initially diagnosed.

of certain factors on myopia's prevalence. The statistical calculations were carried out by means of $\chi^2$ test with Yates' correction. The $\chi^2$ test with Yates' correction was used as in other similar studies conducted before (Jensen & Goldschmidt 1986; Katsougiannopoulos 1993).

# Results

Out of 1738 valid questionnaires, there were 505 students with myopia (29.0%), 136 students with myopia and astigmatism (7.8%), 974 emmetropes (56.1%) and 123 students with other refractive errors (7.1%). The degree of the students' myopia varies. Therefore, 53.4% of the myopes were found to be below the level of −2.0 D sph, 35.9% were between −2.0 and −4.0 D sph, whereas only 10.7% of all were found to be above the level of −4.0 D sph. Also, 10.3% of students had anisometropia of 1 D or more.

Myopia initially appeared at different ages, as shown by the Fig. 1. It is obvious that 79.6% of the refractive errors appear between 10 and 16 years of age. It is also remarkable that 16.0% of the cases make their appearance at the age of 14.

It was also checked whether myopia prevalence is greater in males (M) or females (F). Table 1 shows that 29.7% of males and 46.1% of females have myopia. This is a significant difference ($\chi^2=39.26$, $p<0.001$). Therefore, myopia is more prevalent in females than males.

It was also checked whether myopia is affected by heredity. For this purpose, students were divided into two groups: A (at least one of the parents had myopia) and B (both parents were emmetropes). It is easily observed (see Table 2) that 50.6% of children with at least one parent with myopia also have myopia, whereas only 31.0% of children with emmetropic parents are myopic. This is also a significant difference ($\chi^2=54.64$, $p<0.001$). Therefore, myopia is more common if parents are myopes.

Regarding myopia's distribution among siblings, students were also divided into two groups: C (at least one brother or sister has myopia), D (all siblings are emmetropes). It is clear (Table 3) that myopia is more common in group C (55.3%) than in D (31.5%). This difference is significant ($\chi^2=71.49$, $p<0.001$). Therefore, if either a brother or a sister has myopia it is more probable that the other siblings are myopes, too.

It was also examined whether myopia correlates with school performance (Table 4). The average of myopes is 17.048 (out of 20), whereas the average of emmetropes is 16.295. It is also remarkable that 20.40% of myopic students scored over 18.5 (out of 20) in comparison to 12.43% of emmetropic students. This difference at school performance is significant ($\chi^2=36.6$, $p<0.001$). Therefore, myopes probably have better school performance than emmetropes.

Finally, students were asked to quote the average hours they studied daily (Table 5). Myopes study 4.3 hours per day, whereas emmetropes study 3.6 hours per day. It is impressive that 43.14% of myopes study 5 or more hours per day, in comparison to only

**Table 1.** The number and percentage of myopes and emmetropes among male (M) and female (F) students.

| | M | F | Total |
|---|---|---|---|
| Myopes | 191 (29.7%) | 363 (46.1%) | 554 |
| Emmetropes | 452 (70.3%) | 425 (53.9%) | 877 |
| Total | 643 | 788 | 1431 |

**Table 2.** The number and percentage of myopes and emmetropes among students with at least one myopic parent (A) and among students with emmetropic parents (B).

| | A | B | Total |
|---|---|---|---|
| Myopes | 285 (50.6%) | 269 (31.0%) | 554 |
| Emmetropes | 278 (49.4%) | 599 (69.0%) | 877 |
| Total | 563 | 868 | 1431 |

**Table 3.** The number and percentage of myopes and emmetropes among students with at least one myopic brother/sister (C) and among students with emmetropic siblings (D).

| | C | D | Total |
|---|---|---|---|
| Myopes | 241 (55.3%) | 313 (31.5%) | 554 |
| Emmetropes | 195 (44.7%) | 682 (68.5%) | 877 |
| Total | 436 | 995 | 1431 |

**Table 4.** The distribution of myopic (M) and emmetropic (E) students according to their school performance.

| Score | M | E | Total |
|---|---|---|---|
| <12.5 | 8 (1.44%) | 25 (2.85%) | 33 |
| 12.5–15.5 | 114 (20.58%) | 287 (32.73%) | 401 |
| 15.5–18.5 | 319 (57.58%) | 456 (51.99%) | 775 |
| 18.5–20 | 113 (20.40%) | 109 (12.43%) | 222 |
| Total | 554 | 877 | 1431 |

**Table 5.** The distribution of myopic (M) and emmetropic (E) students according to the time of their daily study.

| Study time | M | E | Total |
|---|---|---|---|
| 0–2 h | 106 (19.13%) | 261 (29.76%) | 367 |
| 3–4 h | 209 (37.73%) | 365 (41.62%) | 574 |
| 5–6 h | 167 (30.14%) | 181 (20.64%) | 348 |
| > 6 h | 72 (13.00%) | 70 (7.98%) | 142 |
| Total | 554 | 877 | 1431 |

28.62% of emmetropes. This difference is also significant ($\chi^2=37.36$, $p<0.001$). Therefore, myopes seem to study more than emmetropes.

# Discussion

Myopia prevalence among Greek students (15–18 years old) is 36.8%. The distribution of myopia among students varies in different countries. In Scandinavia, myopia prevalence of 54.1% has been revealed among medical students in Norway (Midelfart et al. 1992), about 23.0% in students aged 15 in Finland (Mantyjarvi 1983) and about 11.8% in primary school children in Denmark (Jensen & Goldschmidt 1986). A percentage of 15.8% has been detected among males (17–19 years old) in Israel (Rosner & Belkin 1987), while in India a myopia prevalence of 19.7% has been reported in school children (Mohan et al. 1988). Regarding myopia prevalence in the general population, a rate of 25.0% is detected in the United States (Sperduto et al. 1983), while in Alaska a high frequency of 44.7% is reported (van Rens & Arkell 1991). On the other hand, myopia is very rare in India's general population where a rate of 6.9% is found (Mohan et al. 1988). It is also remarkable that myopia is really absent in certain populations, as in Vanuatu, where the frequency reported is about 0.8% (Garner et al. 1985).

Among Greek students, myopia initially appears between the ages of 10 and 16. According to Midelfart et al. (1992), myopia is initially diagnosed at the ages of 10, 13 and 21–22 years. Mantyjarvi (1983) reports that myopia's incidence is the highest in the age groups of 11–13 years. There is a negative relationship between the age myopia initially appeared and the current degree of myopia. If myopia appears in young adulthood, it rarely exceeds the level of −2.00 D sph. (Midelfart et al. 1992). On the other hand, Parssinen (1991) proved that if myopia has an early onset it shows a mean increase from −1.43 D sph. to −3.06 D sph., during the primary school years (6–12 years old). It is therefore obvious that persons with high degree of myopia acquired this refractive error at an early age. It is also clear that myopia increases steadily at least until adulthood.

In this study, it is found that myopia is more common among female students. A higher prevalence of myopia in females is also detected in Finnish students (Mantyjarvi 1983) and in the general population of the United States (Sperduto et al. 1983).

According to this study, children of myopic parents develop myopia at a greater rate in comparison to children of emmetropic parents. Proof for heritability of myopia is a study of monozygotic and dizygotic twin pairs in Finland (Teikari et al. 1991). A greater percentage of concordant pairs (both twins myopes or both emmetropes) among monozygotic twin pairs was found compared to dizygotic twin pairs. On the other hand, Young and colleagues (1969) found no correlation between the refractive situation of parents (myopia rate: 8.4%) and children (myopia rate: 58.6%), in the indigenous population of the Arctic zone. However, he observed a strong correlation of the refractive condition of siblings, a feature also present in the Greek student population.

It is also established that the axial length determines, in a meaningful way, the refractive situation (van Rens & Arkell 1991). Therefore, the myopia "epidemics" in the Arctic zone can be attributed to the action of exogenous factors (modern way of living) on families with a certain predisposition to myopia (increased axial length). This genetic predisposition is essential for myopia's development. It is still supported that this genetic predisposition affects anterior chamber depth, axial length and vitreous chamber depth, leading to increased rates of myopia (Zadnik et al. 1994).

The educational level strongly affects myopia's development. It has been found that the rate of myopia is correlated to the educational level in a linear way (Teasdale et al. 1988). It has also been deduced that myopia prevalence in different age groups is proportional to the duration of each age group's education (Sperduto et al. 1983). These conclusions account for the high rate of myopia in medical students in Norway (54.1%) and the low rate in an Indian rural population (2.8%) that is barely educated.

It is also supported that myopia rate is higher among persons with increased levels of intelligence (Rosner & Belkin 1987; Teasdale et al. 1988). The overall difference between myopes and emmetropes in intelligence test scores corresponds to approximately 7 IQ points (Teasdale et al. 1988). In this study of Greek student population, it is found that myopes have better school performance than emmetropes. The explanation of these results is not totally documented. It is possible that habitual visual exploration of the near environment at an early age (0–5 years old) may be associated with both higher intelligence levels and myopia later in life (Teasdale et al. 1988). It is also likely that persons of high intelligence tend to study more than less intelligent people and achieve higher educational levels, with the myopia being the result of excessive reading and nearwork (Peckham et al. 1977; Angle & Wissmann 1980).

It is supported that excessive nearwork

(reading, etc.) can produce a serious dysfunction of the accommodation mechanism and thereby induce myopia (Adams et al. 1989; Curtin 1985, 1988). This theory explains the increased myopia prevalence in highly educated groups such as medical students (Midelfart et al. 1992). Experiments in animals have shown that myopia incidence increased in the animals confined to small chambers. This demonstrates that the accommodative process is involved in the induction of myopia during development, at least in mammals (Shulkin & Bari 1986).

Therefore, myopia seems to be a frequent result of rearing in environments where distance vision is restricted (Young 1961; Wallman et al. 1978). The accommodative effort in the developing eye causes the optic axis to elongate and the eye to become myopic (Sperduto et al. 1983). This theory accounts for increasing degrees of myopia up to about −2.0 D. Perhaps genetic factors become decisive in determining whether myopia develops beyond the level of −2.0 D and the mechanism may lie in the nervous system (Teasdale et al. 1988).

Since some of the preceding factors like the educational level, intelligence, and nearwork are likely to be influenced by demographic and socioeconomic features of the population in study, and our samples do not precisely correspond to these features of the Northern Greece student population, a possible bias towards urban and higher socio-economic populations should be noted.

It is also noticeable that hyperopia's frequency is relatively low among Greek students. This fact is probably due to the long school training of Greek students, as nearwork has been proved to reduce hypermetropic errors towards emmetropia and myopia (Garner et al. 1985).

Two main theories attempt to explain the pathogenesis of myopia (Zadnik et al. 1994). According to the first, the eye destined to be myopic may be normal-sized and grow faster during the onset or progression of myopia that seldom exceeds the level of −2.0 D. This faster growth rate is probably correlated to the educational level, intelligence and excessive nearwork. The action of these factors accounts for the considerable increase in myopia's frequency that took place during the last twenty years in many countries (Katz et al. 1997; Johnson 1988). According to the second theory (Zadnik et al. 1994), the pre-myopic eye may be sized and shaped differently (increased axial length, flatter cornea or lens) but may undergo normal growth patterns. This theory explains myopia of early onset that exceeds the level of −2.0 D.

Similar studies of different ethnic groups will enable the scientific community to clarify myopia's pathogenesis and identify the specific risk factors. We hope that current and future results will provide the ophthalmologist with an answer to the question frequently asked by parents: "Will my child develop myopia?"

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