



**Olavi Pärssinen**

**The wearing of  
spectacles and  
occurrence of myopia**

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**Olavi Pärssinen**    **The wearing of  
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**A study of wearing of spectacles and  
the prevalence and etiology of myopia  
in different age-groups in Central Finland**

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*To my family*





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## 1. INTRODUCTION

It is obvious that with increased education, with more televisions and visual display units, and with changes in occupations vision requirements in Finland have also changed during recent decades.

The wearing of spectacles can be said to be dependent on the following: 1) the optical and orthoptical status of the eyes, 2) vision requirements at school, at work, at home and at leisure, 3) the availability of optical services, 4) the economic situation of the population, and 5) one's own and others' attitudes to spectacles. It can be said that of this list at least points 2, 3 and 4 have changed during the last few decades in Finland, favouring a greater use of spectacles. Spectacles are so common nowadays that it can be supposed that opposition to spectacles, especially among school children, is less than before.

It is generally believed that the wearing spectacles has increased in Finland during recent decades, but there are not many statistics concerning it and, also, we do not know how far the above-mentioned factors and possible other factors have influenced the wearing of spectacles.

The main ophthalmic reasons for wearing spectacles are different refractive errors. Most spectacles among school children and before presbyopic age are used for myopia (NCHS 1974, NCHS 1978, Bear & Ricler 1982). The wearing of spectacles indirectly reflects the prevalence of myopia at these ages. In some epidemiological studies great changes in the prevalence of myopia have been seen. Alsbirk (1979) for example has observed that the prevalence of a myopic refraction of between -1 and -5 D. was 24 % among 15-19-year-old eskimos and only 11 % among 40-49-year-



olds. It is not clear whether changes of the same kind have happened in Finland or if the obvious increase in wearing of spectacles is caused by other factors than by changes in refraction.

Some authors regard accommodation in reading and close work as having at least a partial effect on the development of myopia (Angle & Wissmann 1978, Bear et al. 1981). If this hypothesis proves to be true there might be a connection between the amount of daily reading and close work with the prevalence of myopia and also with wearing of spectacles. On the other hand there are authors who think that refraction errors and myopia are based on heredity without any significant influence by environmental factors (Waardenburg 1932, Sorsby & Benjamin 1973, Rubin & Milder 1976). So there exist two main theories on the etiology of myopia, the so-called "biological-hereditary" theory, which says that hereditary factors are the main cause of ocular refraction and the so-called "use-abuse" theory, which says that myopia is mainly caused by the use of eyes for reading and close work. In any case, there is no general agreement on which has the greater effect on refraction, heredity or environment, and even if given that environment does influence refraction, the precise nature of that influence.

In this work I have studied the connections of different factors with the wearing of spectacles and myopia and tried to determine what external factors have some connection with myopia.

## 2. REVIEW OF THE LITERATURE

The main topics of the review of the literature are the following:

2.1.) Eye-strain and its connections with close work. The use of the eyes for reading and close work as adult is greatly dependent on studying and everyday employment and therefore recent changes in education and occupations are reviewed. 2.2.) Wearing of spectacles. This is closely connected with different refractive errors and is therefore briefly reviewed. 2.3.) Refraction and myopia.

2.1. Eye-strain, changes in vision requirements and availability of optical and ophthalmological services.

2.1.1. Eye-strain among school-children

Eye-strain may be defined as the symptoms experienced in the conscious striving of the visual apparatus to clarify vision by ineffectual adjustments (Duke-Elder & Abrams 1970; V: 559). The ocular symptoms of eye-strain are, mostly, a feeling of tiredness, hot and uncomfortable eyes, and pain in the eyes and spreading around the eyes. It may be caused by ocular factors such as uncorrected ametropia, accommodative difficulties, convergence difficulties, heterophoria, fusional inadequacy and aniseikonia and/or environmental factors such as the size, movement or contrast effect of the object of vision, or by constitutional factors (Duke-Elder & Abrams 1970; V: 559-77).

In Finland Viikari (1978, 1985) has studied the different symptoms of eye-strain. Her observations are mostly based on single cases and not on representative epidemiological samples.

In all cases, she has stressed the generality and diversity of symptoms of eye-strain and the importance of accommodation in the development of these symptoms and myopia. Hyvärinen (1985) on the other hand supposed that head-ache among school-children is seldom explained by ocular reasons.

#### 2.1.2. Eye-strain in everyday employment

The most important element of eye-strain is obviously accommodative asthenopia due to over-taxing of the ciliary muscle (Duke-Elder & Abrams 1970; V: 561). Even individuals with excellent visual acuity and eye muscle balance and depth perception are seen to experience eye fatigue and headache in close work (Dickerson 1976). Visual display unit workers have stated more subjective complaints than their controls (Knave et al. 1984). The same authors found also that women had more subjective symptoms than men. A part of these symptoms may be due to a gradual and progressive increase in tonic accommodation and tonic convergence induced by close work (Wolf et al. 1986).

#### 2.1.3. Changes in education, occupation and availability of optical and ophthalmological services

All except the seriously handicapped nowadays attend school in Finland. The minimum required attendance is nine years which is the equivalent of lower secondary school. 30 years ago all children of school age attended elementary school; but only 20 % of the age group attended lower secondary or more (Palmgren 1964). In 1985 all children attended at least lower secondary school and about 45 % of them would continue to higher secondary school (Repo 1983).

In 1960 about 40 percent of the people in Central Finland were engaged in agriculture and forestry, whereas in 1980 the proportion employed in this sector of the economy in the same area of the country was only 17 % (Palmgren 1964, Central Statistical Office of Finland 1981). During the same period the proportion of those engaged in service industries increased from 26 % to 52 %.

The number of ophthalmologists and opticians has also increased. In 1955 in Finland there was one ophthalmologist for every 78.000 inhabitants (Central Statistical Office of Finland 1957). 1983 the ratio was about 1/18.500 inhabitants (Central Statistical Office of Finland 1984). In 1961 there was one optician for every 11.000 inhabitants whereas now there is one optician for every 6.700 inhabitants (Central Statistical Office of Finland 1964 and 1984). At the same time the standard of living has also risen.

## 2.2. Wearing of spectacles

In Finland there are some earlier studies concerning the wearing of spectacles at different ages. In 1963-64 1,5 % of schoolchildren in the first grade of school wore spectacles (Hultin & Paavilainen 1967). Aine (1979) found that in 1977 20,4 % of 12-13-year-old children in two districts of Finland wore spectacles. The wearing of spectacles was more common among girls. Recently Aine (1984, (b)) has studied the wearing of spectacles in a rural area of Finland. In that area about 23 % of persons aged 6-20 years, 43 % aged 21-40 years, and 46 % aged 41-60 years wore spectacles for other than presbyopic correction. He also found that persons who had studied at college or university more often had spectacles and that they had received them earlier than others. The sample was fairly representative for a rural population but gave no information about a town population. Krause et al. (1982) compared the wearing of spectacles in different social classes among 14-year-old children. They

found that the wearing of spectacles was most common in the higher social classes and also among girls. 40 % of girls in socio-economic class I + II had lenses whereas the same percentage in class IV was 33 %. The lowest figure was for boys among agricultural workers and farmers viz. 15 % in contrast to 22 % in class III.

In the United States 51,8 % of the population wore either spectacles or contact lenses in 1980 (NHS 1984). When the age factor was adjusted to make the population similar with respect to the proportion of persons in each age group there was an increase of only 1 % in the wearing of spectacles during the last 15 years . Among children aged 3-16 years the proportion wearing corrective lenses was about the same in 1980 as it had been in 1965-66. However, for persons aged 17-24 years, the proportion wearing corrective lenses had declined from 41,6 % in 1965-66 to 36,5 % in 1980. The proportions of persons aged 25-44 and 45 years and over wearing corrective lenses had increased (NHS 1984). In the same large and representative study it was also found that the wearing of spectacles was related to age, sex, race, hispanic origin, education of the head of the family, education of the individual, geographical region, family income, and occupational status.

## 2.3. Refraction and myopia

### 2.3.1. Refractive changes with age

The main reason for the wearing of spectacles is the correcting of refractive errors. Refraction has been shown to change with age (Slataper 1950). In Finland Laatikainen and Erkkilä (1980) found that the percentage of moderate to high hyperopia (+ 2.0 D or more) decreased from 19,1 % in 7-8-year-olds to 3,6 % in 14-15-

year-olds. Similar results have obtained in many other studies (Hirsch 1961, Aoki 1982, Mäntyjärvi 1983). Significant growth of the eye proceeds only until early puberty; thereafter in the majority of subjects the axial length of the globe remains practically unaltered. Sorsby et al. (1961) found the average increase in the axial length of the eye between the ages of 3 and 13 or 14 to be only about 1 mm. At the same time the cornea and lens became flatter and their refractive power was reduced. Larsen (1971, IV) in his ultrasonic measurements found that the axial length of that globe shows fast growth until 2 years of age. Thereafter growth slows until the age of 5 years. From then to the of 13 years growth is about the same as between 2 and 5 years. At the same time lens becomes thinner and the anterior chamber deeper (Larsen 1971, II). The increase in axial length during ocular growth was explained as the major cause of refractive changes in childhood.

In some persons, however, changes in refraction continue to occur (Goldschmidt 1968), and these changes mainly constitute an increase in myopia. Tokoro and Suzuki (1968) studied the refractive components of 7 to 21 year-olds and found elongation of the axial length occurring even after 13-14 years age. Their study showed that the increase in the grade of myopia was mainly due to the elongation of the axial length even after the age of 13 or 14. The refractive power of the cornea and lens changed only slightly during the same time. In later ages the development of hypermetropia is generally encountered in the elderly (Hirsch 1958). Alsbirk (1979) found a significant trend towards hypermetropia with age in women but not in men among an Eskimo population. In older persons again gradually, an incipient cataract often shifts refraction in the direction of myopia (Slataper 1950).

Astigmatism is common during the first year of life and it decreases during the second year (Hyvärinen & Lindstedt 1981).

Aine (1984, (a)) found no differences in amount of astigmatism with regard to age among 7-85-year-olds. According to Hirsch (1959) a change in the direction of astigmatism against the rule happens during later ages. Duke-Elder and Abrams (1970, V: 278-9) cited that from early adult life onwards there is a general tendency for the direct astigmatism to decrease or even to be converted into inverse astigmatism. Forsius et al. (1964) found evidence that the change in the corneal refraction with age is less marked or slower in women than men.

### 2.3.2. Heredity of refractive errors and myopia

In many contexts racial variations in refraction are observed. These variations are believed to be evidence for hereditary variation in refraction. Myopia is said to be more common among Japanese and Thais (Nakajima 1968), Chinese (Duke-Elder & Abrams 1970; V: 238), and Europeans (Taylor 1981) than among primitive populations. The mean refraction of Australian aborigines aged 20-30 years, was + 0,54 D. and that for Europeans was + 0,15 D. (Taylor 1981). The aborigines had less myopia than Europeans. Differences are already seen in children. The mean refraction of Sioux Indian children in grades I to V in school was + 0,72 D. and that for Caucasians was + 0,33 D. (Wick & Crane 1976). In New Zealand Polynesian children had less hyperopia and myopia than European children (Grosvenor 1970).

In Finland Forsius et al. (1968) studied Scolt Lapps and found that myopia was very rare among them. The same was also true with people on Kökar island (Forsius & Eriksson 1961). Heinonen (1923) found that the prevalence of myopia and astigmatism was higher among Swedish speaking population of Finland than among the Finnish speaking population. In another study of Heinonen (1934) myopia was more common among children from educated

families. In most of these studies it has been difficult to separate the possible environmental effects from hereditary effects.

One theory has been that the higher prevalence of visual defects in the more advanced societies is not a racial difference at all but is due to a relaxation of the pressure of natural selection (Post 1962, Taylor 1981).

Especially with regard to school-children, myopic refraction seems to be more common among girls than among boys (Gardiner & Loud 1954, Aine 1979, Krause et al. 1982). Sperduto et al. (1983) found significant lower rates of myopia among men than among women. A greater prevalence of high myopia is found among women than among men (Steiger 1913, Stenström 1946). On the other hand Duke-Elder and Abrams (1970; V: 238) believed that in adults there is no correlation between sex and refraction.

The hereditary characteristics of refraction are suggested to be both autosomal dominant and autosomal recessive (Sorsby & Benjamin 1973, Karlsson 1975, Avetissow 1980). Sex-linked inheritance of high myopia has also been reported. (Worth 1906). Refractive errors are also associated with a variety of hereditary ocular or systemic disorders. In these cases the heredity of refraction obviously follows the mode of inheritance of the accompanying disease. As the heredity of refraction seems to be mainly multifactorial (Steiger 1913, Sorsby & Benjamin 1973, Sorsby et al. 1981) the ultimate result may be difficult to predict. There is also considerable evidence, however, that the higher degrees of myopia and hypermetropia especially are inherited in a monofactorial manner (Sorsby & Benjamin 1973). Many studies of the heredity of refraction are based on refraction in twins. In these studies concordance to a high degree is generally found in monozygotic twins. (Danning 1981). Dizygotic twins, on the other hand, show less concordance and



refractive differences may be very marked (Danning 1981). In cases of high myopia the intrapair concordance of refraction decreases, although even here it shows a significantly higher level than in binovular twins (Curtin 1970).

Of the different components of refraction vertical corneal power is the component most likely to be influenced by heredity (Young & Leary 1972). Significant correlations in other refractive components of the eye between parents and siblings have also been seen (Sorsby et al. 1962, Nakajima 1966, Nakajima 1968, Nakajima et al. 1968).

On the basis of these hereditary correlations many authors think that heredity is the only or main cause of refraction. It has even been claimed that external factors have no influence at all on myopia (Francois 1961). Rubin and Milder (1976) concluded that myopia is not a disease but simply a biological variant with hereditary implications, which is in many ways like physical size. Shapiro et al. (1982) supposed that most probably the degree of myopia is not influenced by sex, ethnic origin, or environmental conditions alone.

### 2.3.3. Reading, close work, and myopia

Epidemiological observations and studies have shown correlations between refraction and different environmental characteristics.

Kepler (1611) suggested as long ago as 1611 that excessive close work might be a determining factor in the etiology of myopia. This theory retained general acceptance until the nineteenth century. Cohn (1864) for example presented strong evidence that myopia developed in many youngsters only after they had begun attending school. Tscherning (1883) recorded that myopia

was quite rare among farmers and fishermen as opposed to educated persons and students. Reading and especially convergence were regarded as etiological factors also for example by Graefe (1857) and Donders (1864).

In a recent study in the United States the prevalence of myopia was seen to rise with family income and educational level (Sperduto et al. 1983). The investigators suggested that the importance of educational and income levels in cases of myopia may result from their associations with near work. Paritsis et al. (1983) found that length of studies and urban residence are factors that strongly influence the prevalence of myopia. On the basis of these variables discriminant factor analysis correctly classified 81 % of the subjects into the myopic or non-myopic group.

Connections with refraction and environmental factors have been seen already in childhood. Pecham et al. (1977), in their English material found that myopia was more common in children from non-manual families than in those from manual families. Myopic children were more likely to come from small families and to be of higher birth order than children with normal vision, and these associations held within each social class. At 11 years of age myopic children showed striking advantages in educational performance over their normal-sighted peers, as judged by tests of reading, arithmetic and general ability. Findings obtained at 7 years of age showed that superior educational attainments were already apparent before the onset of myopia. Children with myopia spent more of their leisure time reading than the normally-sighted children, but, despite the visual impairment, participated in outdoor sports as often as other children (Pecham et al. 1977 ).

In Finland Krause et al. (1982) also found that children with myopia were better at school than those with hyperopia.

These and other epidemiological studies have led many investigators to think that accommodation and convergence in reading and close work is an important cause of myopia (Goldschmidt 1968, Morgan et al. 1975, Viikari 1978, Angle & Wissmann 1978, Bear et al. 1981, etc.).

#### 2.3.4. Correlations between physiological and psychological characteristics and refraction

Many correlations between myopia and other human physiological and psychological characteristics have been indicated during recent decades (for a review of these studies see Baldwin 1981). It has been seen that myopic schoolboys are taller than non-myopic (Johansen 1950). The growth rate of the myopic has shown to be faster than that of the nonmyopic (Gardiner 1955). As adults myopic men are seen to be taller than non-myopic, but not taller than non-myopic men belonging to the same social or occupational group (Goldschmidt 1966). It has been thought that these findings show that myopia is only a growth anomaly (Johansen 1950, Rubin & Milder 1976). Metabolic (Awetissow 1980, Lane 1980) and hormonal disturbances (De Vreis 1950, Balacco-Gabrieli & Tundo 1981) and dietary deficiencies (Lane 1980) are also said to be associated with different forms of myopia.

With regard to psychological characteristics the myopic are said to have more tolerance of anxiety, greater passivity towards stress, and to be more cautious, doubting, more compliant and more likely to avoid hostile situations (Rosanes 1967). Hirsch (1959) concluded on the basis of intelligence tests of 6-17-year-olds and that the average IQ of myopic was considerably above

that of the hyperopic. Young (1963) could not find any significant correlation between refraction and IQ.

The differences found between the myopic and non-myopic are frequently explained as demonstrating the common genetic origin of myopia and the human characteristic studied.

### 2.3.5. Prevalence of refractive errors

As earlier shown there are reports of variation in refraction with regard to race, age, sex, education etc. factors. Therefore it is difficult to compare the prevalence figures. Factors which are still making comparisons difficult are differences in study methods and differences in definitions of myopia, emmetropia, hyperopia and astigmatism. Cycloplegics have been used in some studies and not in others.

In Finland, in the study of Laatikainen and Erkkilä (1980) the frequency of myopic eyes ( $-0,5$  or more) was 1,9 % among 7-8 year olds and 21,8 % among 14-15-year-olds. The percentage of children with a visual acuity of less than 0,8 in one or both eyes was 3,7 % among 7-8, 10,8 % among 11-12 and 29,1 % among 14-15-year-olds. The percentage of moderate to high hyperopia ( $+2,0$  D. or more) decreased from 19,1 % in the 7-8 year-old group to 3,6 % in the 11-15 year-old group.

In another study in Kuopio 2,6 % of children aged 7-15 years was seen to become myopic annually and 23 % of school-children would expect to be myopic by the age of 15 years (Mäntyjärvi 1983). Her material was based on cases referred for eye examination after screening of school nurses. The children with vision 0,8 or better were not referred. That may partly bias the results. Aine (1979) found that the 12-13-year-olds needed refraction correction in 18,4 - 21,9 % of cases, and almost all (97,3-98,8 %) of 69-70-year-olds needed spectacles, mostly for reading.

In the United States 25 % of persons between the ages of 12 and 54 years were estimated to be myopic (sfe. negative) in 1971-1972 (Sperduto et al. 1983 ). Significantly lower prevalence rates were found for male subjects than for female subjects and for blacks than for whites. The prevalence of myopia also rose with family income and educational level.

The prevalence of refractive errors among Japanese school children was 4,4 % in age group of 6-year-olds and 27 % in 11-year-olds (Aoki 1982). 70 % of refractive errors among 11-year-olds were myopic (myopia more than 0,5 D. and astigmatism less than 1,0 D.). These were higher figures than those of Laatikainen and Erkkilä (1980) in Finland.

#### 2.3.6. Changes in the prevalence of refractive errors with time

In his Finnish material Heinonen (1929) found no changes in the prevalence of myopia from 1910 to 1927 among school children. When comparing their own results with those of Heinonen, Laatikainen and Erkkilä (1979) proposed that the prevalence of myopia among school children seemed to have increased during recent decades in Finland. A Danish investigation indicated no major change in the prevalence of myopia during last century (Goldschmidt 1968). Sveinsson's (1982) study of 21939 Icelanders showed the prevalence of myopia (> 0,5 D. and astigmatism less than 1,0 D.) to be 3,6 % in 1935 and 20,5 % in 1975. The difference was marked but the study was based on subjects coming to him for spectacles. That may at least partly bias his results.

Among Inuit eskimoes less than 30 years old the prevalence of myopia (visual acuity 20/40 or worse, with improvement by pinhole correction) was far in excess of that of their elders (Morgan et al. 1975). This was especially true for females. The age and sex

distribution indicated the likelihood of an environmental effect, probably cultural, as responsible for the changes.

In the study from India the incidence of high myopia had not changed from 1966-1972 to 1980 but the earlier male dominance had declined (Jain et al. 1983).

### 2.3.7. Myopia in general

Myopia is the state of refraction in which parallel rays of light entering the eye at rest are brought to focus in front of the retina. In practice it is caused by "increased" corneal and/or lens power, or axial length.

A part of the confusion surrounding myopia may be due to the fact that there can be different types of myopia, and from difficulties in defining the type of myopia in question.

Goldschmidt (1968) believed that there are at least three different types of myopia each of which has a different etiology.

1) a "schoolmyopia" which is principally genetically determined  
2) a "late myopia" which arises after bodily growth has stopped and would be environmentally determined and 3) a "high myopia" which may have both a genetic and an environmental etiology.

Myopia is often divided into two main groups; a) simple myopia, or physiological and b) pathological myopia. Myopia is defined as pathological if some optical element of the eye lies outside the limits of normal biological variation (Duke-Elder & Abrams 1970; V: 297).

In practice myopia is usually defined as pathological if some complications are associated with an excessive axial elongation of the eye. Other terms frequently used are: high myopia,

degenerative myopia, myopia magna and myopia maligna. The ocular refractions -6 D. or -8 D. are mostly used as the practical level of demarcation between simple and pathological myopia.

Occasionally a congenital myopia occurs - sometimes of high degree - and may not increase materially thereafter (Duke-Elder & Abrams 1970; V: 267).

In addition to that, myopia may be a part of a different syndromes (Roy 1975: 516). It may be transient caused by various drugs or toxic substances. (Roy 1975: 516) or diseases like diabetes (Duke-Elder 1970; V: 368) or a dark environment (night myopia) (Epstein 1983), and other more rare factors.

The recently published textbook about myopia includes an extensive review of basic science information and the clinical management of myopia (Curtin 1985: 1-495).

#### 2.4. Conclusions from the review of the literature

The education of the population in Finland has much increased during recent decades. At same time the number of people engaged in agriculture and industry has decreased as the proportion of those engaged in the service industries has increased.

Connections between education and occupation and the wearing of spectacles and myopia have been seen in many studies. It is not known how much influence these and other changes have had in Finland in the wearing of spectacles. There is also no general agreement about whether reading, education and close work have any effect, and, if so the degree of that effect in ocular refraction.

### 3. THE PURPOSE OF THE STUDY

The first figure shows the theoretical framework and the main relationships studied.

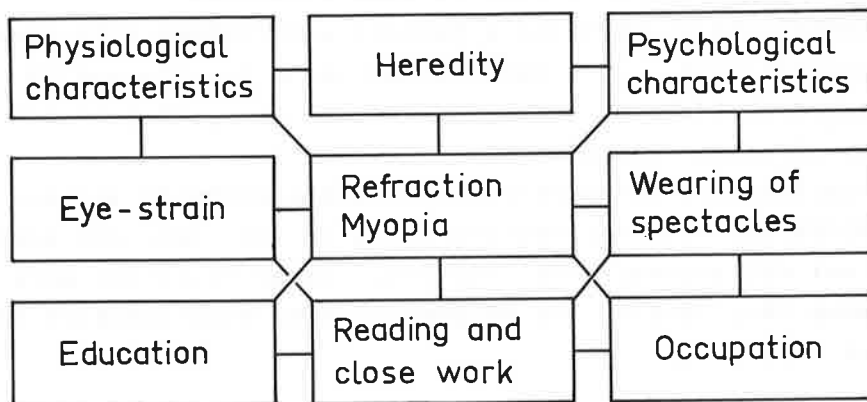


Fig. 1. The theoretical framework and the main relationships studied.

The main goal of this study has been to study the kinds of connections myopia has with external factors and especially with reading and close work. This was studied both by questionnaire and by clinical examination.

In particular, the following questions have been addressed:

- 1) The extent to which school children have symptoms of eye-strain and the connection these symptoms have with habits of reading, distant vision and wearing of spectacles. This study was conducted among 7-, 11-, and 15-year-old school-children by questionnaire.
- 2) The extent to which 26- and 46-year-olds need near vision in their everyday employment and the connection of these vision requirements at work on symptoms of eye-strain, the wearing of spectacles, and myopia. These questions were studied by questionnaire and by clinical examination.



- 3) The kinds of changes that have occurred in the wearing of spectacles during recent decades in Finland and the factors that could explain them. This study was conducted by questionnaire. A prognosis as to what changes will occur in the wearing of spectacles in the decades to come is also attempted.
- 4) The connections of hereditary factors and reading with myopia among school-children. This was studied among 7-, 11- and 15-year-old schoolchildren by questionnaire and among 12-year-old children by clinical examination.
- 5) The relationships which refraction, and especially myopia, has with different external factors and with age, sex, and some physiological and psychological factors. These relations were studied among 26-, 33-37-, and 46-year-olds by questionnaire and by clinical examination.

#### 4. MATERIAL AND METHODS

##### 4.1. Locality of study

The locality of the study was the town of Jyväskylä with about 65 000 inhabitants and six rural parishes around it, i.e. Hankasalmi, Jyväskylä Rural District, Laukaa, Petäjävesi, Toivakka, Uurainen. The total population living in this area was 118 758 people at the end of 1982. (Central Statistical Office of Finland 1984).

##### 4.2. Recipients and dates of questionnaire

A questionnaire was sent to all subjects living in the area described and belonging to the following groups:

a) all the 3337 person who were resident at the beginning of 1983 in the locality and were born in the years 1937 and 1957. Their names and addresses were obtained from the population register. The questionnaires were sent out in May-July 1983. If a subject did not respond to the first questionnaire, the second questionnaire was mailed after about a month. Those who had moved to another locality or had died by the end of July (2 men) were not removed from the sample,

b) a random sample of 183 men born between 1946-1950 and living in Jyväskylä participated in a questionnaire study between September 1981 and January 1982 as a part of study on health and functional capacity (Heikkinen et al. 1984),

c) all the 4961 children who were in the 1st and 5th grades of primary school in autumn 1983 and in the 8th grade of lower secondary school in spring 1983 and attended school in the area. Those in the 1st and 5th grades received the questionnaire in autumn 1983 and those in the 8th grade in April-May 1983.

In what follows these groups are regarded as 7-, 11-, 15-, 26-, 33 - 37- and 46-year-olds.

The study design and percentage of responses and participation is shown in table 1.

Table 1. The study populations

Age (yrs.)	<u>Questionnaire study</u>			<u>Ophthalmological study</u>		
	<u>Received</u>	<u>Replied</u>		<u>Invited</u>	<u>Participated</u>	
	n	n	%	n	n	%
7	1716	1589	83			
11	1494	1384	93			
12				156	141	90
15	1751	1379	79			
26	2007	1503	75	249	210	84
33-37	183	152	83	68	65	96
46	1330	1040	78	274	256	93
Together	8481	7047	83	747	672	90

On the basis of information on occupations in the population register it could be seen that the distribution of occupations of 26- and 46-year-olds did not differ significantly from that of the population in general (Appendix 1.).

Of those 26- and 46-year-olds who participated in the clinical examination 27 % had been born in the same town or parish in which they were now living. 40 % of the total number of subjects were born inside the locality studied. All except one Canadian man were Finnish.

It can thus be supposed that the sample was not greatly biased from the point of view of heredity.

The 33-37-year-olds who did not participate in the study did not essentially differ from those who participated in terms of education, occupation and perceived health. This information was gathered by interviewing them at home or by telephone.

#### 4.3. Participants and dates of clinical examination

The clinical examination was directed at four age-groups:

a) Of those born in 1937 and 1957 the subjects for clinical examination were selected from those who answered the questionnaire. All farmers (95 subjects), about one third randomly selected unskilled or semi-skilled workers (224 subjects), and all those in managerial positions (122 subjects) plus 76 randomly selected subjects who had or who were undertaking university education were called for a clinical examination. The group consisted of 276 men and 247 women, 523 subjects altogether. The examination was made between December 1983 and March 1984.

b) In the study of health and functional capacity (Heikkinen et al. 1984) the physiological and psychological characteristics of the men born between 1946-1950 were collected between September 1981 and January 1982. 33 men out of 131 reported themselves to be myopic. All these with the addition of 35 randomly selected men from the remaining 98 subjects were invited to have their eyes examined between December 1983 and February 1984. The refraction value was established for 32 of those who reported themselves to be myopic and for 33 of the control subjects.

c) Of those who were in 5th grade in autumn 1983 156 children were called for clinical examination in autumn 1984. The selection was made so that of those who had no spectacles equal numbers of boys and girls were randomly selected. A further criterion for selection was the respondent's own or parents' opinion that the time the child spent indoors was either a) more than that of his/her age fellows or b) less than that of his/her age fellows. Other children were excluded before selection of the sample.

#### 4.4. Methods of the questionnaire study

The questionnaires used in the study are available from the author. Appendixes 2-5 show the list of variables used in the questionnaires. Most of these questions and a large number of more detailed questions were put to those who participated in the study of health and functional capacity (Heikkinen et al. 1984).

Parents' wearing of spectacles was taken into account when calculating the wearing of spectacles in different age cohorts at different ages.

#### 4.5. Classification of the material

For occupational classification Finnish Gallup's five grade classification was used modified so that students and housewives were classified in their own groups. Occupational group I consisted of higher managerials or others in leading positions, group II, lower managerials, group III, skilled industrial workers or persons engaged in the service trades, group IV, semi-skilled or non-skilled workers or persons engaged in the service trades, group V, farmers or agricultural workers, group VI, students and group VII, housewives.

Comparison was also made with regard to different close work categories among 26- and 46-year-olds. Close work was classified with regard to main type of daily close work. If a subject had to use a visual display unit, if only for short periods, he/she was classified as a visual display unit worker.

Close work groups were: RV = reading and writing, VDU = visual display unit work, IQC = industrial quality control, OAW = other accurate close work, for example sewing, cutting etc. and NAW = no accurate close work. Another question asked the time spent daily on close work and it was divided into groups as follows: 0 = no accurate close work, 1 = close work occasionally during the working day, 2 = close work less than half of the working day, 3 = close work about half of the working day, 4 = close work most of the working day.

Formal education was classified according to three groups: 1 = primary school taking 6-9 years, 2 = lower secondary school taking 9-10 years, and 3 = higher secondary school, usually taking 11-12 years and in many cases leading to university studies.

On the basis of information from the questionnaire, children were regarded as myopic if their distant vision without spectacles was abnormal and their parents were regarded as myopic if they had

received their first spectacles for poor distant vision. In clinical examination the subjects were regarded as myopic if the spheric equivalent of the right eye was negative. Wearing contact lenses was regarded as the same as wearing spectacles.

Astigmatism was regarded as direct if the median of the positive cylinder made an angle of less than  $30^{\circ}$  with the horizontal plane. If it made such an angle with the vertical plane it was regarded as inverse astigmatism, other cases being regarded as oblique astigmatism.

#### 4.6. Clinical examination

In the clinical examination the right eye was refracted by cycloplegia, which was accomplished by two drops of 1 % cyclopentolate-hydrochloride and the refraction was determined about 40-60 minutes after the second drop.

In the group of 33-37-year-olds three men refused the drops. In the age-groups of 26- and 46-year-olds 0,5 % tropicamide x 2 was used in 7 cases (1,5 %) and information for 17 people (3,6 %) who did not come for examination was obtained from the health records of ophthalmologists and opticians. The left eye was refracted by the fogging method (Milder & Rubin 1978).

The refraction was determined at 0,25 D. intervals and the final amount of astigmatism was determined by 0,25 cross-cylinder. The highest plus or lowest minus in the trial frames which gave the best vision at five meters distance was regarded as the subjects refraction. As there is a high correlation for both spherical refraction and astigmatism in right and left eyes, the analysis which follows is for the right eyes only (Taylor 1981). In addition to refraction the usual ophthalmological status including biomicroscopy, applanation tonometry, measurement of phorias and ophthalmoscopy etc. was also determined.

The anthropometric, physiological and psychological data together with haematological assays for the 33-37-year-olds were obtained from the research project of health and functional capacity (Heikkinen et al. 1984). Isometric muscular force was measured for five muscle groups (grip strength, arm flexion, knee extension, body flexion, and body extension) by strain gauge dynamometers. A force factor allowing for the effect of weight was later constructed from three of these measurements (arm flexion, leg extension and body extension) as a general indicator of muscular force. Aerobic capacity was assessed by a maximal stepwise bicycle ergometer test and an index of physical fitness was calculated according to the decrease in the pulse rate after loading. (Heikkinen et al. 1984)

Among 12-year-old children the reading distance was measured by Clement Clarc's accommodometer. The angle of reading, the angle between the horizontal plane and the direction of reading, were subjectively estimated by Clement Clarc's accommodometer.

In the whole sample there was one pathological myopia in a 46-year-old man (-21 D) in the right eye. There was also two aphacias, one 26-year-old man and a woman of the same age. These pathological cases were excluded.

#### 4.7. Examination of the reliability of subjective opinion concerning distant vision.

The reliability of subjective information about distant vision was studied among 7-, 11-, 15-, 26- and 46-year-olds. This was done for the three youngest age-groups by comparing answers with the results of a vision test made by nurses at school. The comparison was made between randomly selected groups of



children which had answered as having either good or poor distant vision without spectacles. Vision results were gathered from different schools in the town of Jyväskylä. Nurses had tested vision at the same grades in schools. The maximal interval between questionnaire and vision test was about half a year among the 15-year-olds. The vision of all them had been tested before the questionnaire.

Comparison between the subjects' own opinions about distant vision and the results of vision tests at school among school-children is shown in table 2.

Table 2. Comparison of subjects own opinions about distant vision with results of vision tests made by school nurses among 7-, 11- and 15-year-olds. Good = distant vision regarded as good. Poor = distant vision regarded as poor. (n) = number of subjects. Vodx = result of vision test made by nurses at school (vision of right eye). The children were divided into two groups, those whose vision was 1,0 or more without spectacles in the right eye and those whose vision was less than 1,0. % = percentage of those children whose right eye test result accorded with self-estimate.

Age (yrs.)	Sex	Good Vodx $\geq$ 1.0			Poor Vodx $<$ 1.0		
		n	n	%	n	n	%
7	Boys	21	20	95	8	5	63
	Girls	24	23	96	11	7	64
11	Boys	33	28	95	40	32	80
	Girls	42	34	81	44	40	91
15	Boys	35	34	97	29	24	83
	Girls	33	25	76	25	20	80

Chi-square = 5,05, df = 8, NS

Chi-square = 5,77, df = 8, NS

As the vision of 15-year-olds was tested about half year earlier than the time of questionnaire it can be supposed that some of those who had good vision at the time of the test may have become myopic during that half year. In 7- and 11-year-olds vision was tested during the same autumn term. The replies corresponded well statistically with the results of the vision tests. The replies were most unreliable among those 7-year-olds who regarded their distant vision as poor. The number of subjects among the 7-year-olds with poor distant vision were small, and that may also have influenced the results. However both with regard to poor and good distant vision, there was a significant dependence between vision test and own opinion.

Among 26- and 46-year-olds a comparison was made between their own opinions about distant vision and the spheric equivalent (sfe.) of the right eye (Table 3.).

Table 3. Comparison of questionnaire information about good or poor distant vision and spherical equivalent of right eye among 26- and 46-year-olds. Good = distant vision regarded as good, Poor = distant vision regarded as poor. Sfe. odx. = spheric equivalent of right eye.

Age (yrs.)	Sex	Good			Poor		
		Sfe. odx. positive			Sfe. odx. negative		
		n	n	%	n	n	%
26	Males	69	64	94	35	32	91
	Females	56	53	95	50	41	82
46	Males	107	97	91	28	18	64
	Females	79	68	86	43	23	54

Chi-square = 2,151, df = 5, NS                      Chi-square = 9,335, df = 5, NS

Distant vision, regarded as good had a highly significant relation with a positive sfe. of right eye. The same was true with opinions about poor distant vision and a negative sfe. among 26-year-olds. In the older agee group a great deal of poor distant vision was apparently dependent on reasons other than myopia.

The relation between poor distant vision and a negative sfe. was also tested in educational groups (Fig. 2.).

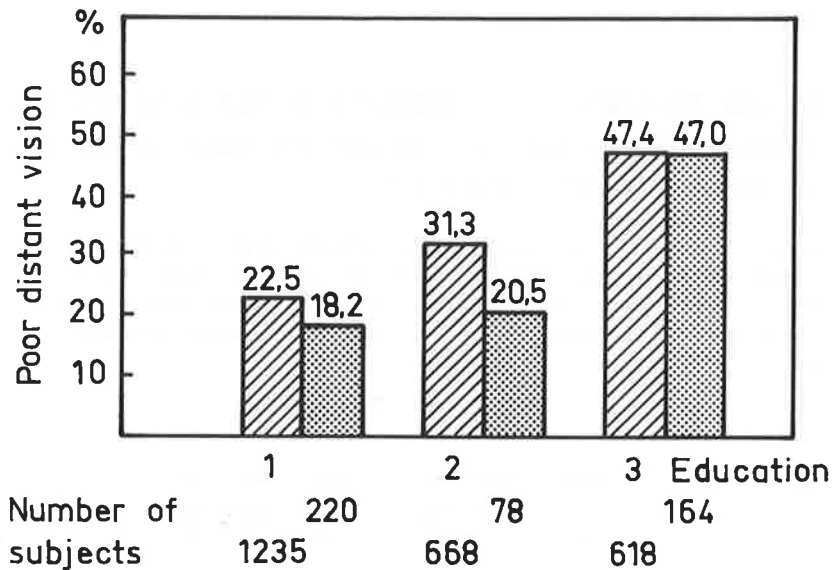


Fig. 2. Comparision between subjective opinions of poor distant vision and the prevalence of negative spheric equivalents in three educational groups. Lined bars = information from questionnaires, dotted bars = negative spheric equivalents in clinical examination.

The best similarity was in the most educated group. The percentage of poor distant vision rose with education as did the percentage of negative spheric equivalent.

#### 4.8. Statistical methods

Statistical analyses were carried out using standard procedures such as Chi-square test for independence, Chi-square test for goodness of fit, Student's t-test and analysis of variance.

Multivariate categorical analyses were performed by fitting loglinear models (Bishop et al. 1975).

The statistical analyses were performed using the GLIM programme, manual release I (Baker & Nelder 1978) and SPSS-programme (Nie et al. 1975: 427-8), with a Sperry Univac 1100 computer.

## 5. RESULTS

The results are given under three main sections; 5.1. Need for near vision and occurrence of ocular symptoms, 5.2. Wearing of spectacles; 5.3. Myopia.

### 5.1. Need for near vision and occurrence of ocular symptoms

Information about need for near vision and occurrence of ocular symptoms is based on the cross section questionnaire study. The age cohorts studied were 7-, 11-, 15-, 26- and 46-year-olds. The main interest was to study the three youngest age groups to see if eye-strain among school-children is connected with the wearing of spectacles, distant vision, and habits of reading. In the adult groups the purpose was to study the need for near vision in different occupations and work categories and the kinds of differences there exists between 26- and 46-year-olds and between men and women in needs for near vision in everyday employment. The connection of ocular symptoms with different close work categories were also studied.

#### 5.1.1. Eye-strain among school-children

Children in the same grade obviously have equal vision needs at school. Depending on their different interests in reading and other hobbies at home their eyes are prone to different amounts of accommodation.

Symptoms of eye-strain in reading and close work were commonly reported (Table 4.) (Pärssinen 1985).

Table 4. Symptoms of eye-strain (ES) or headache (HE) in reading and close work among school-children when reading without spectacles (S-) and when reading with spectacles (S+).

Age (yrs.)	Sex	Spectacles	n	ES %	HE %
7	Boys	S-	743	7,2	1,4
		S +	29	3,3	0,2
	Girls	S-	734	5,5	1,7
		S+	34	4,2	0,1
11	Boys	S-	631	14,0	6,0
		S+	78	1,1	0,0
	Girls	S-	531	28,5	8,3
		S+	127	2,8	1,1
15	Boys	S-	492	12,3	4,5
		S+	143	3,3	1,3
	Girls	S-	431	26,3	7,0
		S+	301	5,5	1,7

Such symptoms were remarkably less with spectacles, than without spectacles. 11- and 15-year-old girls reported significantly more symptoms than boys especially those who read without spectacles.

41 % of all the 7-11- and 15-year-old children who had spectacles reported some kind of eye-strain when reading without spectacles but only 8 % when reading with spectacles. Only 5 % of all spectacle-wearing children had eye-strain with spectacles but not without.

Symptoms of eye-strain were inspected also with regard to poor or good distant vision (Table 5.).

Table 5. Symptoms of eye-strain or headache (ES) in reading and close work without and with spectacles among school children with regard to distant vision.

Age (yrs.)	Sex	Distant vision	n	ES without spectacles %	ES with spectacles %
7	Boys	Good	737	5,3	0,1
		Poor	20	25,0	4,8
	Girls	Good	734	3,7	0,0
		Poor	24	41,7	4,3
11	Boys	Good	612	9,5	0,5
		Poor	69	33,3	4,2
	Girls	Good	501	20,0	0,8
		Poor	130	43,8	7,5
15	Boys	Good	511	8,4	1,6
		Poor	111	10,8	7,1
	Girls	Good	469	16,4	1,9
		Poor	238	28,2	8,7

Those having poor distant vision had significantly more symptoms of eye-strain in close range activities than those who had good distant vision. This difference was observed both without spectacles and with spectacles.

Symptoms of eye-strain were also related to reading distance (Table 6.).

Table 6. Percentage of children with eye-strain symptoms in reading with regard to reading distance and reading without spectacles or with spectacles. Symbols: S- percentage of children with eye-strain symptoms when reading without spectacles, S+ percentage of children having eye-strain symptoms when reading with spectacles. Children are divided into two groups; those who read at a close distance and those who read at a normal or long distance.

Age (yrs.)	Sex	Reading distance <u>close</u>		Reading distance <u>normal or long</u>	
		S-	S+	S-	S+
7	Boys	21	0	4	0
	Girls	18	0	4	0
11	Boys	30	2	10	1
	Girls	50	4	18	2
15	Boys	18	6	8	2
	Girls	45	9	16	3



Symptoms of eye-strain were at their highest when reading at a short distance without spectacles. The symptoms were also more common when reading at normal or long distance without spectacles than when reading at short distance with spectacles.

Those who had symptoms of eye-strain read and did other close work slightly more than the others. This relation between symptoms of eye-strain and daily time spent reading and doing close work was statistically significant among 11- and 15-year-old girls but not in other groups.

In conclusion, eye-strain among school-children can be said to be connected with reading at short distance, poor distant vision, reading without spectacles, and much reading.

#### 5.1.2. Need for near vision in everyday employment among 26- and 46-year-olds

Young adults (26-year-olds) and people of middle age (46-year-olds) were compared in order to see how many people did different kinds of close work in their everyday employment (Fig. 3. and 4.) (Pärssinen et al. 1984). Reading, writing (RW) and visual display unit work (VDU) were done mostly by women.

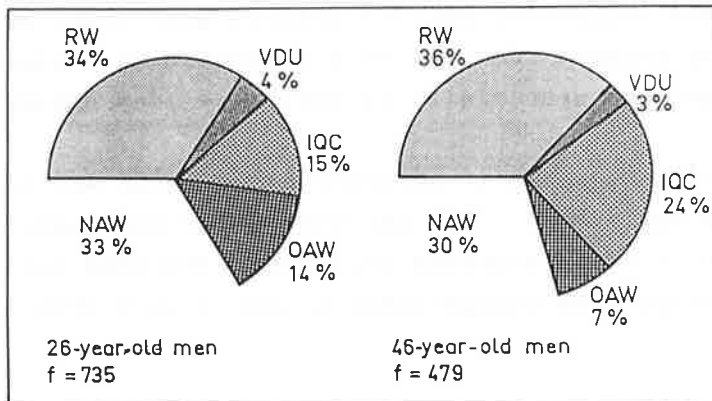


Fig. 3. Percentage of different job categories where accurate near vision is needed among 26- and 46-year-old men (f = number of subjects). Classification of close work: RW = reading and writing; VDU = visual display unit work, IQC = industrial quality control, OAW = other accurate close work, NAW = no accurate close work.

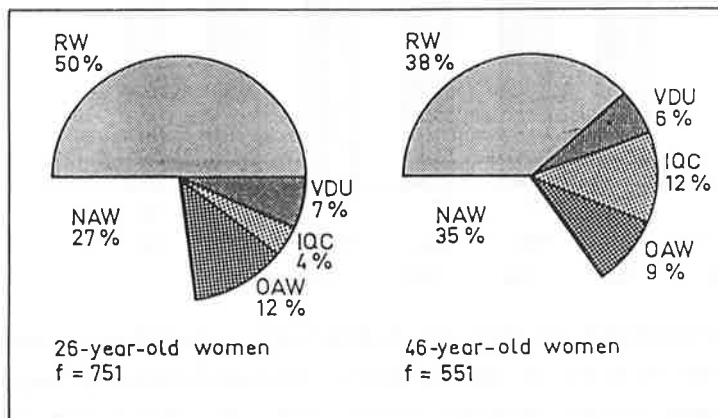


Fig. 4. Percentage of different job categories where accurate near vision is needed among 26- and 46-year-old women (f = number of subjects). Classification of close work: RW = reading and writing; VDU = visual display unit work, IQC = industrial quality control, OAW = other accurate close work, NAW = no accurate close work.

Older men did industrial quality control work (IQC) most commonly of these two groups. Only 27-35 % of people in these groups did not need accurate near vision in their everyday employment.

The questionnaire asked if accurate near vision was needed or not in everyday employment. The percentages of men needing accurate near vision in their everyday employment declined quite evenly in both age-groups from occupational groups I to V (Fig. 5.).

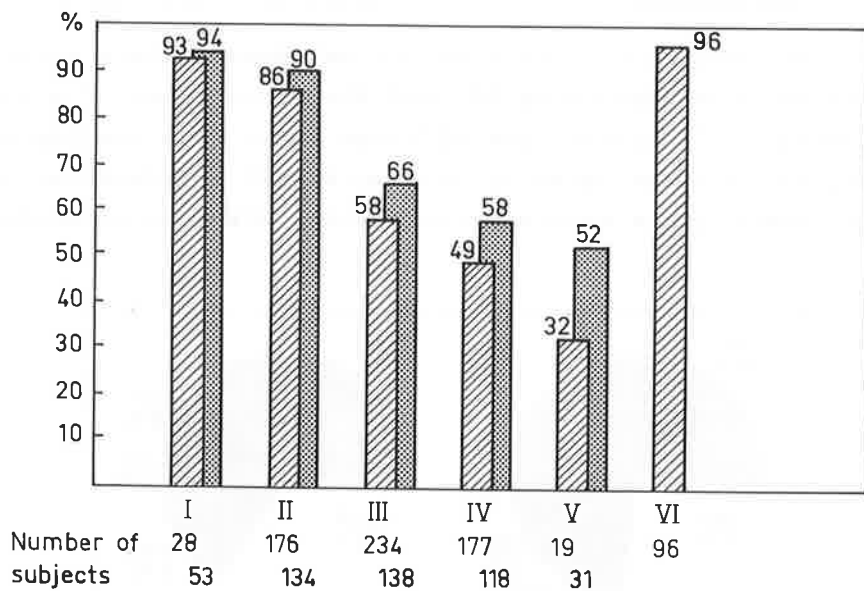


Fig. 5. Percentage of men in different occupations needing accurate near vision in daily work. Occupational groups: I managerial and other leading positions, II lower managerial, III skilled employees in manufacturing and services, IV unskilled or semi-skilled employees in manufacturing and services, V farmers or agricultural workers, VI students. 26-year-old subjects: lined bars, 46-year-old subjects: dotted bars. (Frequencies are in appendix 6.)

It is natural that almost all students need accurate near vision for reading. The dependence of accurate close work on occupation and age among men was analysed with a loglinear model. Accurate close work was dependent on age in addition to occupation. Among 26-year-olds there were fewer men in different occupations doing accurate close work than among 46-year-olds. The same was seen among women in occupational groups I-IV (Fig. 6.).

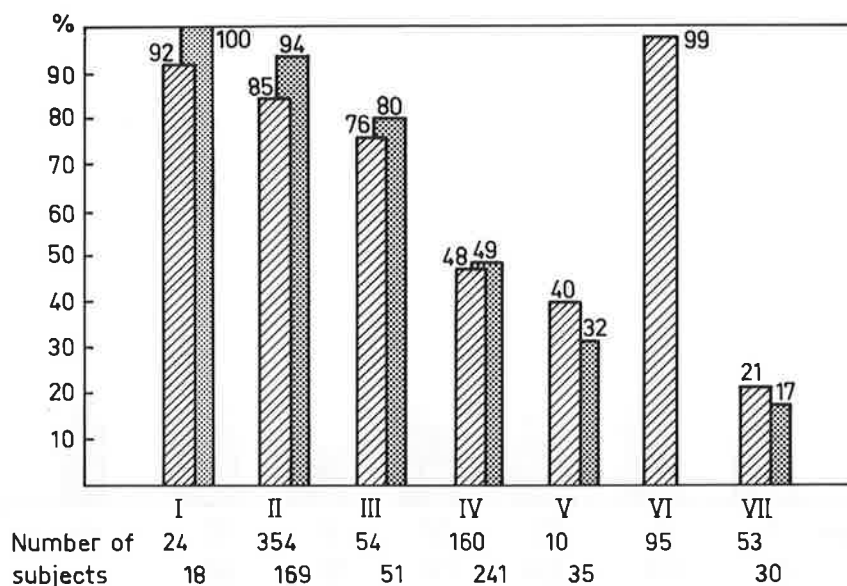


Fig. 6. Percentage of women in different occupations needing accurate near vision in daily work. Occupational groups: I managerial and other leading positions, II lower managerial, III skilled employees in manufacturing and services, IV unskilled or semi-skilled employees in manufacturing and services, V farmers or agricultural workers, VI students, VII house wives. 26-year-old subjects: lined bars, 46-year-old subjects: dotted bars. (Frequencies are in appendix 7.)

In the loglinear model the interaction of close work with occupation was significant but there was no significant interaction with age.

In the younger age group from 5 to 19 % of subjects in different occupational groups regarded their near vision as abnormal (Fig. 7.).

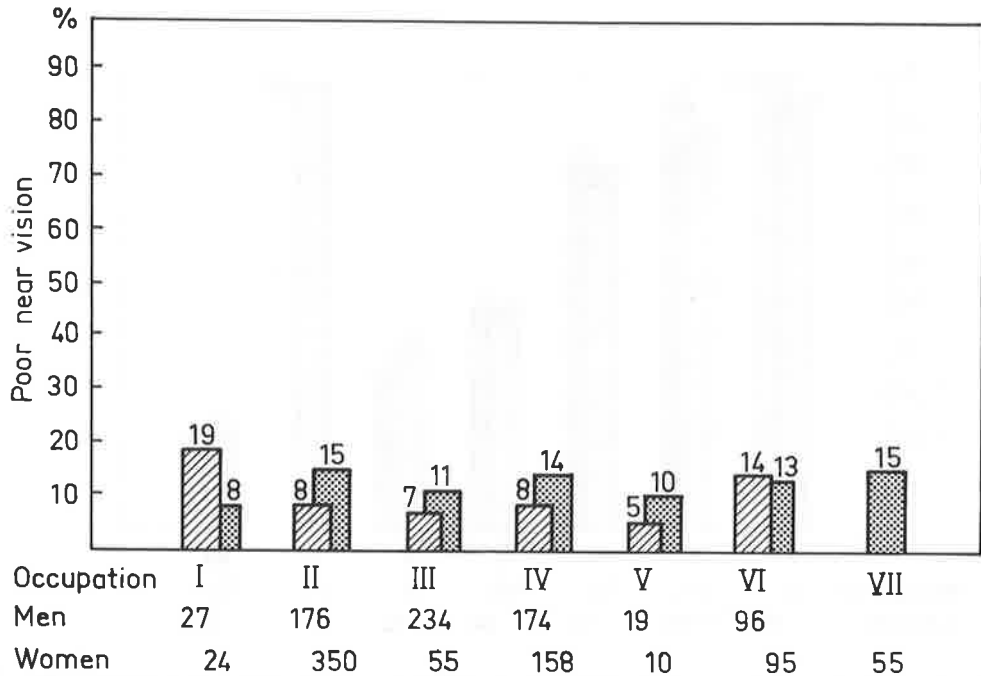


Fig. 7. Percentage of those not having good near vision in different occupations among 26-year-old men (lined bars) and women (dotted bars). Occupational groups: I managerial and other leading positions, II lower managerial, III skilled employees in manufacturing and services, IV unskilled or semiskilled employees in manufacturing and services, V farmers or agricultural workers, VI students.

The differences between different occupations were not significant, but the percentages of those who regarded their near vision as abnormal was significantly higher among women. There were significantly more women employed in occupational group II and fewer in occupational group III than men, respectively; women were employed more in offices and men in industries.

Among 46-year-old men from 45 to 73 % in different occupations regarded their near vision as abnormal. Poor near vision was least in occupational groups II and V. There were more women than men who regarded their near vision as poor in all occupational groups (Fig. 8.).

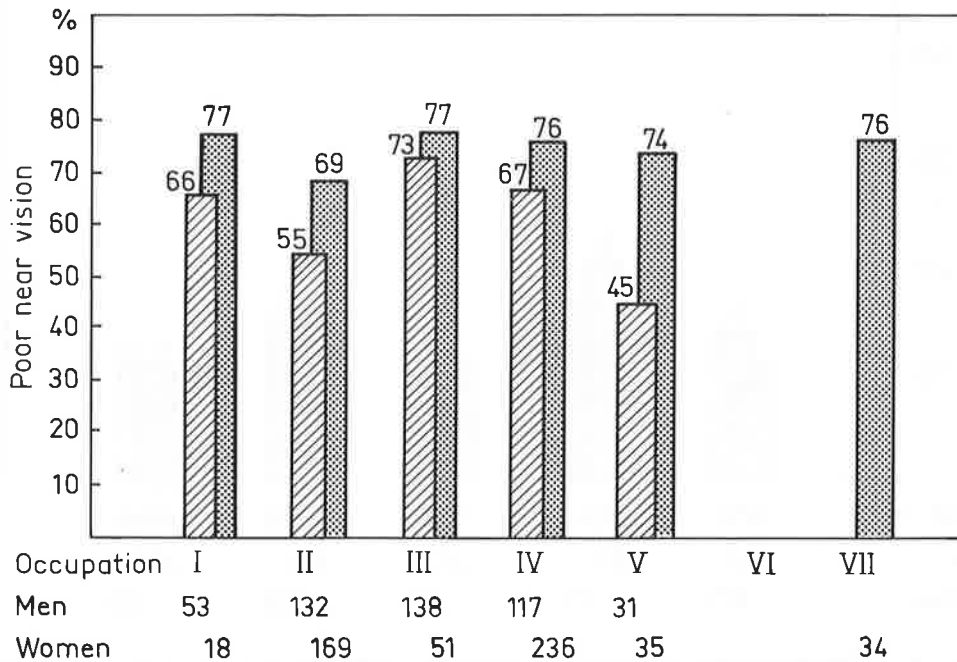


Fig. 8. Percentage of those not having good near vision in different occupations among 46-year-old men (lined bars) and women (dotted bars). Occupational groups: I managerial and other leading positions, II lower managerial, III skilled employees in manufacturing and services, IV unskilled or semiskilled employees in manufacturing and services, V farmers or agricultural workers, VI students. (Frequencies are in appendix 8.)

According to the loglinear model in occupational groups II and V occupation and sex interacted with poor near vision.

### 5.1.3. Relation of ocular symptoms to close work and sex among 26- and 46-year-olds

The percentages of those who had ocular symptoms like itching, smarting, epiphora, redness etc. in different close work categories among 26-year-olds are shown in figure 9.

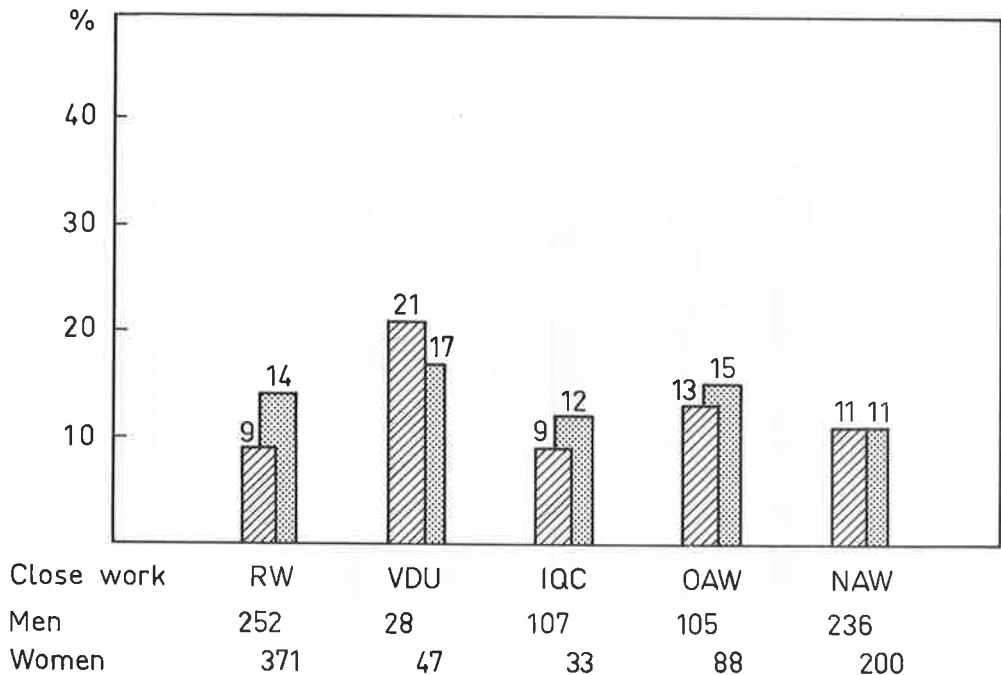


Fig. 9. Percentage of people having subjective ocular symptoms in different close work categories among 26-year-old men (lined bars) and women (dotted bars). Classification of close work: RW = reading and writing; VDU = visual display unit work, IQC = industrial quality control, OAW = other accurate close work, NAW = no accurate close work. (Frequencies are in appendix 9.)

A loglinear model was used to determine whether symptoms were related to close work category or sex. It was seen that there were no significant differences in symptoms in different close work categories or with regard to sex.

In the older age group symptoms were more common in groups IQC, OAW and NAW, than in groups RW and VDU, which consist of different kinds of office jobs (Fig. 10.).

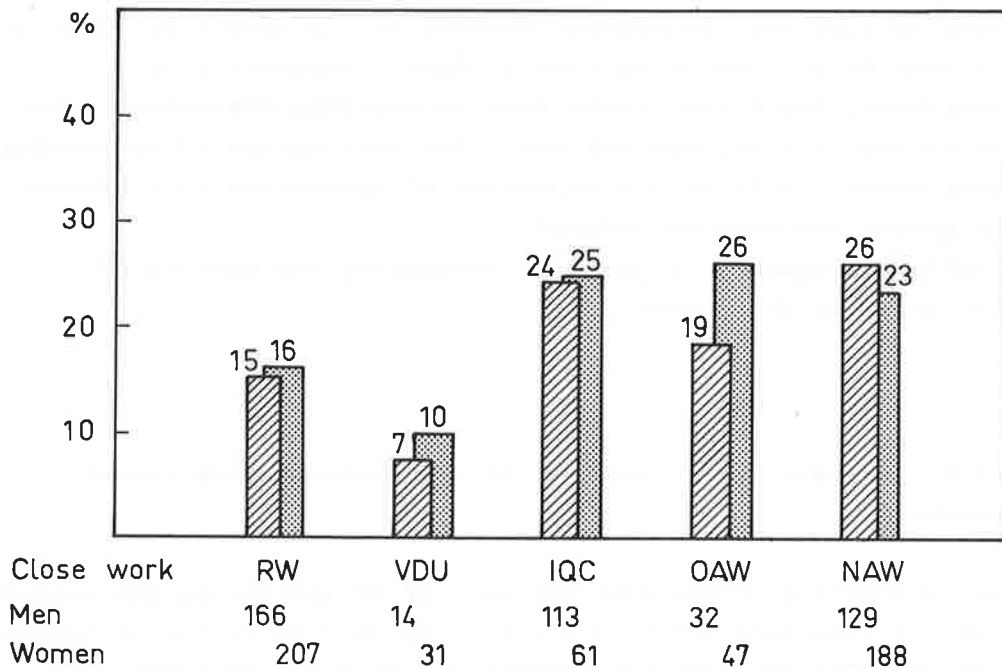


Fig. 10. Percentage of people having subjective eye symptoms in different close work categories among 46-year-old men (lined bars) and women (dotted bars). Classification of close work: RW = reading and writing; VDU = visual display unit work, IQC = industrial quality control, OAW = other accurate close work, NAW = no accurate close work. (Frequencies are in appendix 10.)



In the loglinear model ocular symptoms had connections with close groups. Differences in symptoms between men and women were not statistically significant.

## 5.2. Wearing of spectacles

This section deals first with changes in the wearing of spectacles during recent decades. It is attempted to explain these changes and the present wearing of spectacles by comparing the wearing of spectacles with different factors: social background, education, close work in everyday employment, near and distant vision, age and sex. The consumption of spectacles among school children and rejection of spectacles in different age groups are also considered.

Finally a prognosis is proposed concerning the wearing of spectacles in the future.

### 5.2.1. Changes in the wearing of spectacles during recent decades

The information concerning the wearing of spectacles was gathered from the responses of 7-, 11-, 15-, 26- and 46-year-olds together with information from the parents of the three youngest age-groups.

To examine the changes in the wearing of spectacles during the last five decades the wearing of spectacles was compared from the age of 5 at 5 year intervals in the different age cohorts (Fig. 11. and Fig. 12.).

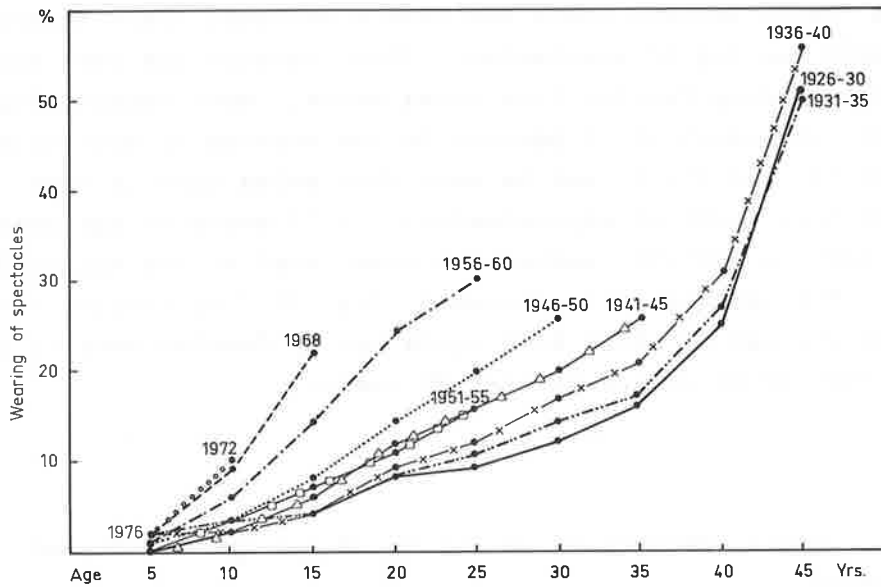


Fig. 11. The wearing of spectacles among males at different ages according to year of birth. (Frequencies are in appendix 11.)

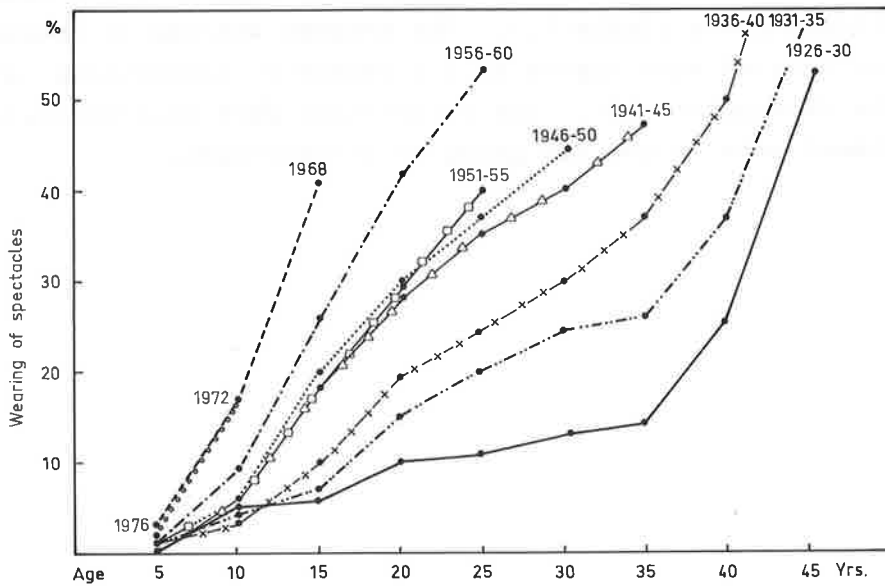


Fig. 12. The wearing of spectacles among females at different ages according to year of birth. (Frequencies are in appendix 12.)

During recent decades there has been a unbroken trend towards the increased wearing of spectacles. This increase has been more pronounced among females than among males. When considering, for example, the level of 15 percent in the wearing of spectacles in figures 10. and 11. it can be seen that males born in 1968 reached that level at approximately 12-13 years of age whereas those born in 1926-30 reached the same level at the age of 30-35 years. The same level was reached (fig. 11.) by females born in 1968 at the age of about 9-10 years and by females born in the years 1926-30 at an age of over 35 years.

#### 5.2.2. Social background in childhood and the wearing of spectacles

In comparing social background and the age at which the first spectacles were received it was seen that there were no significant differences in the latter with regard to the father's occupational group (Table 7.). The present wearing of spectacles was also studied with regard to the father's occupational group with the Chi-square test. The differences were statistically significant only in the age group of 26-year-olds.

Table 7. Wearing of spectacles according to father's occupation. Occupational groups: I = higher managerials or those in leading positions, II = lower managerials, III = skilled employees in manufacturing and services, IV = semiskilled or unskilled employees in manufacturing and services, V = farmers and agricultural workers. n = subjects in group. % = percentage wearing spectacles.

Father's occupation	Age (yrs.)									
	7		11		15		26		46	
	n	%	n	%	n	%	n	%	n	%
I	262	5	179	20	151	40	95	48	23	74
II	423	4	355	14	347	33	321	52	147	71
III	459	4	399	16	346	32	459	42	193	69
IV	249	4	262	13	282	32	240	38	164	76
V	77	4	75	15	142	30	324	37	466	66
Total	1470	4	1270	15	1268	33	1447	42	993	69
Other or Unknown	119		112		111		64		47	
Chi-square =	.23		3.89		4.22		19.42		6.03	
df =	4		4		4		.4		4	
p =	.99		.40		.40		<.001		.20	

According to the loglinear models the only dependency between the wearing of spectacles and father's occupation was in that same age group. Children of occupational groups II had more spectacles than the others (Scaled deviance 5.0,  $df = 3$ ,  $p > .10$ ).

Children from occupational group II had more educated than children from the other occupational groups and that explained most of the differences in the wearing of spectacles with regard to father's occupation.

5.2.3. Wearing of spectacles to improve distant and/or near vision with regard to requirements for near vision in everyday employment among 26- and 46-year-olds

The wearing of spectacles was inspected among 26 and 46-year-olds with regard to time spent daily in accommodation requiring close work and with regard to different categories of employment (Pärssinen et al. (a) 1984).

Among 26-year old men the wearing of spectacles was positively related to the time spent daily on close work (Fig. 13.).

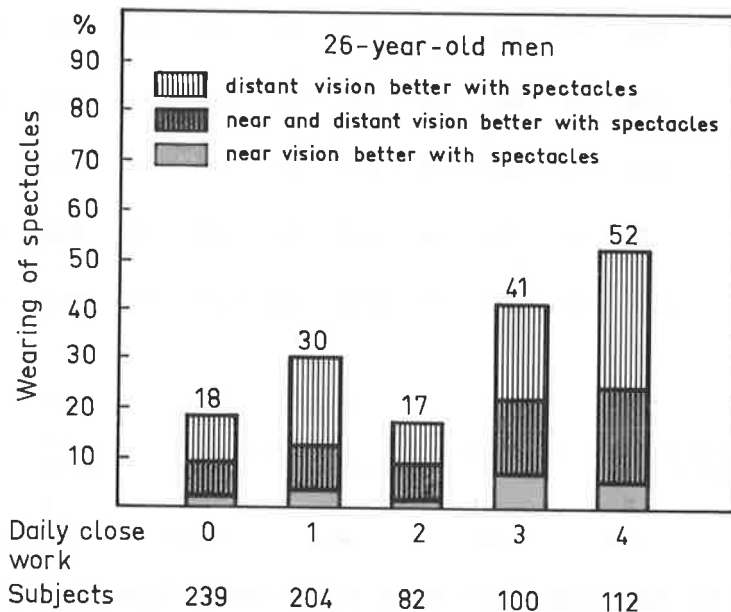


Fig. 13. The wearing of spectacles among 26-year-old men with regard to daily close work. Daily close work: 0 = no close work, 1 = close work occasionally during the working day, 2 = close work less than half of the working day, 3 = close work about half the working day, 4 = close work most of the working day.

Wearing spectacles which improved near vision increased when the time used daily in close work increased (Chi-square = 54,631, df = 8,  $p < .0001$ ). The same was true with spectacles which improved distant vision (Chi-square = 48,369, df = 8,  $p < .0001$ ).

Among 26-year-old women dependences respectively were not statistically significant (Fig. 14.).

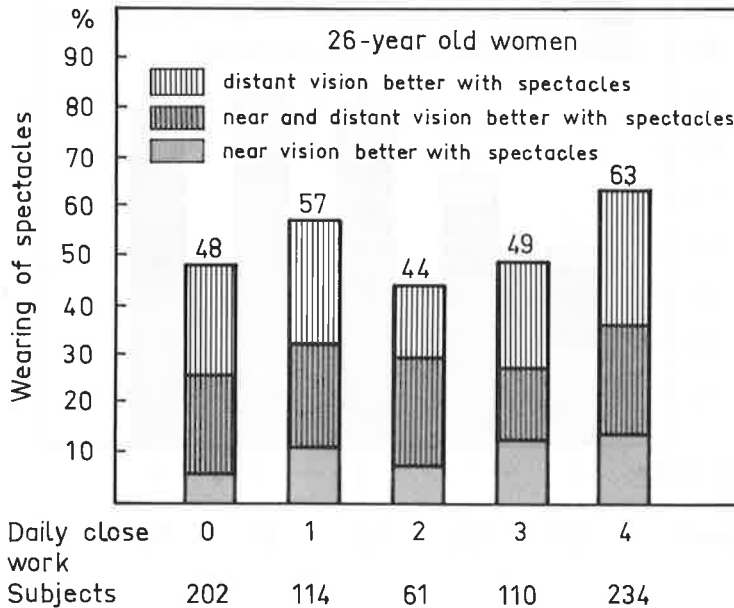


Fig. 14. The wearing of spectacles among 26-year-old women with regard to daily close work. Daily close work: 0 = no close work, 1 = close work occasionally during the working day, 2 = close work less than half the working day, 3 = close work about half the working day, 4 = close work most of the working day.

In the oldest age-group the wearing of spectacles which improved both distant and near vision increased with the daily time spent on close work (15. and Fig. 16.).

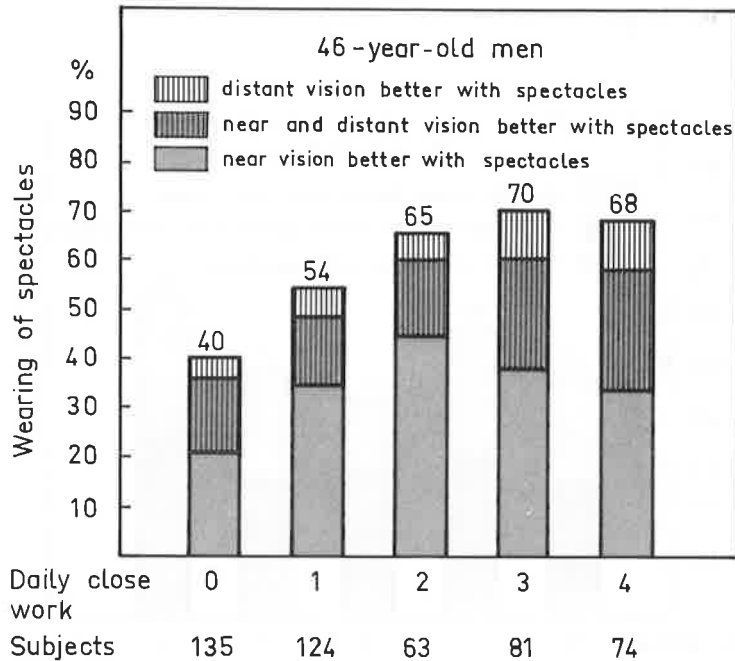


Fig. 15. The wearing of spectacles among 46-year-old men with regard to daily close work. Daily close work: 0 = no close work, 1 = close work occasionally during the working day, 2 = close work less than half the working day, 3 = close work about half the working day, 4 = close work most of the working day.

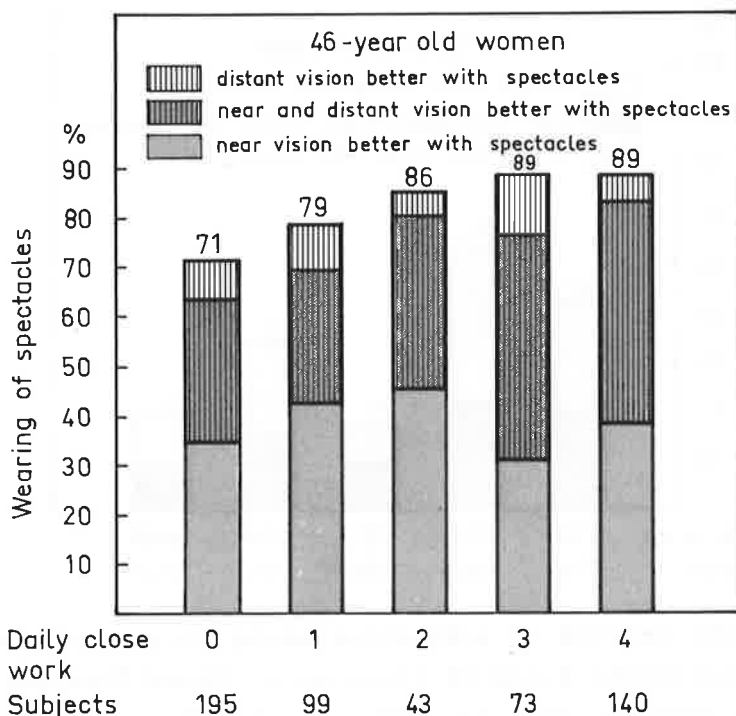


Fig. 16. The wearing of spectacles among 46-year-old women with regard to daily close work. Daily close work: 0 = no close work, 1 = close work occasionally during the working day, 2 = close work less than half the working day, 3 = close work about half the working day, 4 = close work most of the working day.

Statistical analyses showed following significant dependences both among men and women: men; spectacles for distant vision: Chi-square = 31,867,  $df = 8$ ,  $p = .0001$ ; spectacles for near vision: Chi-square = 29,320,  $df = 8$ ,  $p = .0003$ , women; spectacles for distant vision: Chi-square = 27,434,  $df = 8$ ,  $p = .0006$ ; spectacles for near vision: Chi-square = 24,839,  $df = 8$ ,  $p = .002$ .

The wearing of spectacles was inspected also with regard to different close work categories (Fig. 17.). There were significant dependences among 26-year-old men doing different types of close work.



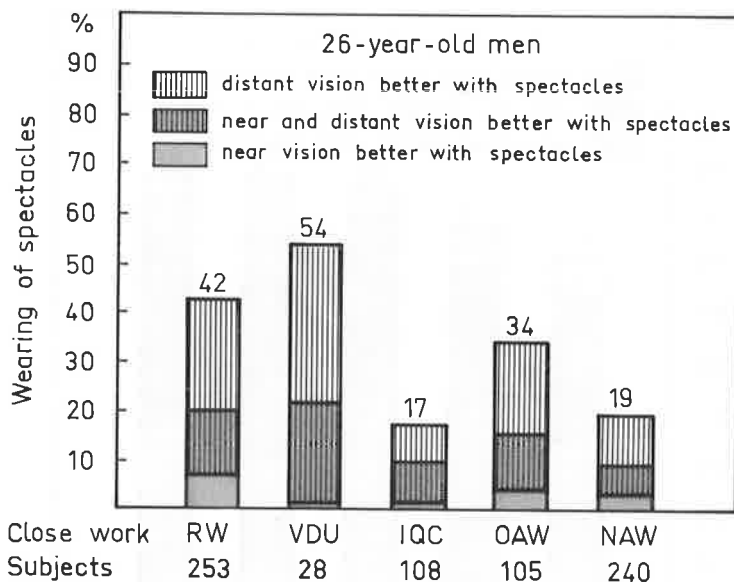


Fig. 17. The wearing of spectacles among 26-year-old men with regard to different kinds of close work. Classification of close work: RW = reading, writing, VDU = visual display unit work, IQC = industrial quality control, OAW = other accurate close work, NAW = no accurate close work.

The dependences were significant both with regard to spectacles which improved distant vision (Chi-square = 45,349,  $df = 8$ ,  $p < .0001$ ) and with spectacles which improved near vision. (Chi-square = 45,176,  $df = 8$ ,  $p < .0001$ ). Spectacles used for distant vision were most common among those whose jobs involved using visual display units, reading, and writing. Among women dependence with regard to the nature of close work was not significant (Fig. 18.).

Among 46-year-old men and women a significant dependence was also found between the wearing of spectacles for near vision and different close work categories, (Chi-square = 27,591,  $df = 8$ ,  $p = .0006$ ), but no significant dependence could be found between spectacles for distant vision and different close work categories (Fig. 19.).

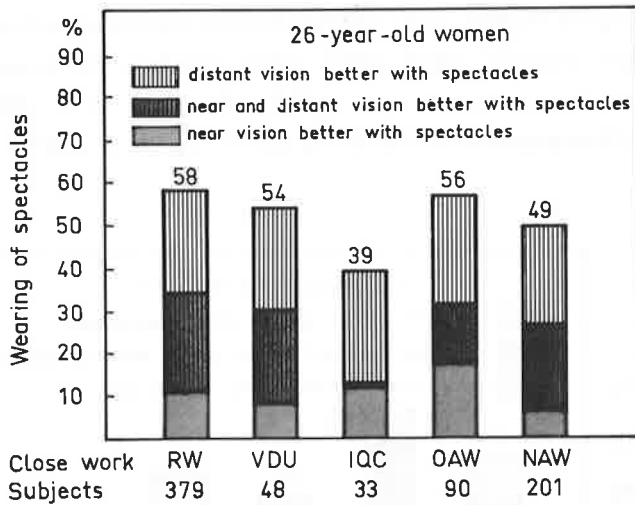


Fig. 18. The wearing of spectacles among 26-year-old women with regard to different kinds of close work. Classification of close work: RW = reading, writing, VDU = visual display unit work, IQC = industrial quality control, OAW = other accurate close work, NAW = no accurate close work.

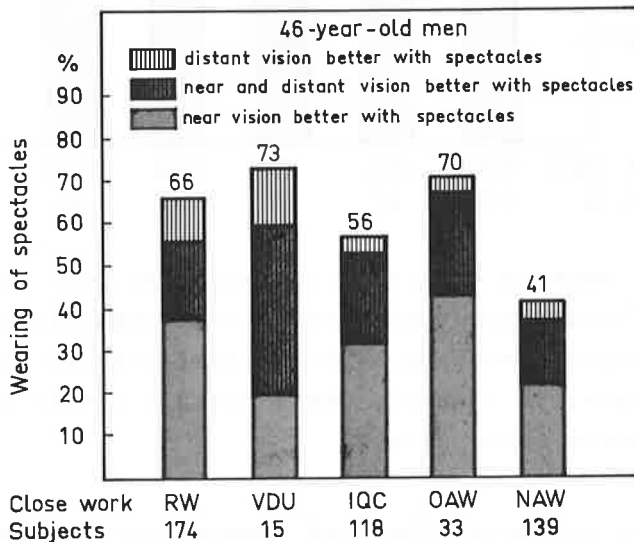


Fig. 19. The wearing of spectacles among 46-year-old men with regard to different kinds of close work. Classification of close work: RW = reading, writing, VDU = visual display unit work, IQC = industrial quality control, OAW = other accurate close work, NAW = no accurate close work.

Among 46-year-old women the dependences between close work and spectacles were significant both with regard to spectacles for distant vision (Chi-square = 31,571, df = 8, p = .0001) and for near vision (Chi-square = 25,981, df = 8, p = .001) (Fig. 20.).

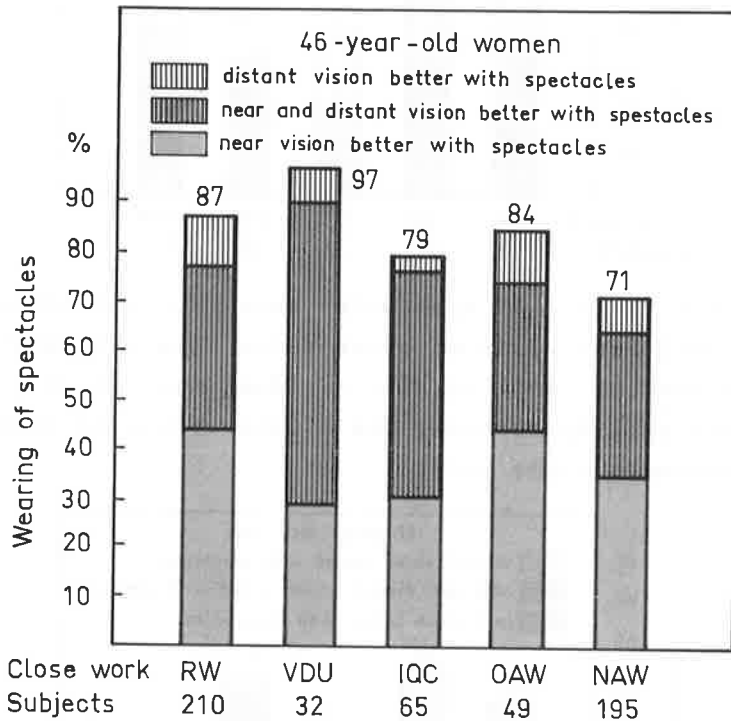


Fig. 20. The wearing of spectacles among 46-year-old women with regard to different kinds of close work. Classification of close work: RW = reading, writing, VDU = visual display unit work, IQC = industrial quality control, OAW = other accurate close work, NAW = no accurate close work.

Both among men and women the most spectacles were worn by those who did visual display unit work and the least by those who did no accurate close work.

5.2.4. Wearing of spectacles with regard to age and sex, and to poor distant vision and rejection of spectacles

The wearing of spectacles was compared with questionnaire information in age groups 7-, 11-, 15-, 26- and 46-year-olds, among males and females (Fig. 21.).

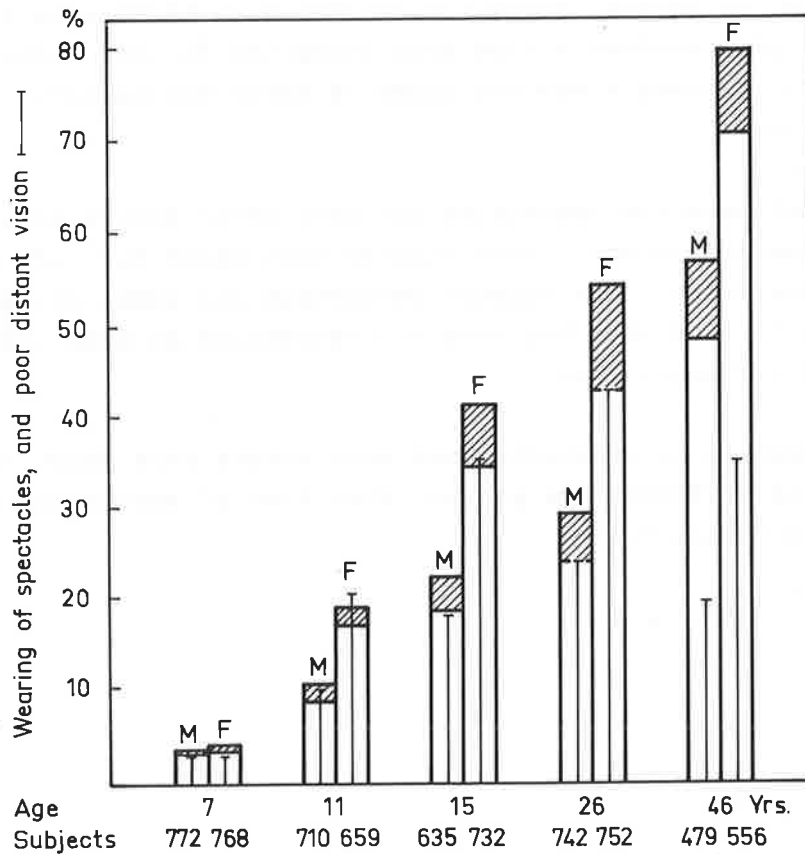


Fig. 21. The proportions of those in five age-groups who have received spectacles (whole columns) who have since rejected them (lined columns) and who reported poor distant vision (lines in the columns). M = males, F = females.

Females had spectacles significantly more than males in all age-groups except that of the 7-year-olds. From the age of 11 to 26 there were about twice as many spectacle-wearing females as males. It could be seen that the percentages of those wearing spectacles and poor distant vision were rather similar from the age of 7 up to 26. It seems that most of the actual wearing of spectacles in these four age groups is due to poor distant vision and, obviously, to myopia. Among the 46-year-olds there were fewer cases of poor distant vision than among the 26-year-olds, but obviously presbyopia was the cause of their having more spectacles.

The actual need for spectacles was seen after deducting spectacles not in use. More females than males had left off using spectacles. The highest percentage was among 26-year-old females; 11 % of them had received spectacles at some time but had left off using them.

The percentage of spectacles not worn varied from about 10 to 20 percent in different age groups. What kind of spectacles were discarded (Table 8.)?

Table 8. Recommended wearing of spectacles in five age groups and rejection of spectacles with regard to the recommendation to wear them.

Age (yrs.)	Sex	Recommended wearing of spectacles							
		Continuously		For reading		At distance		Bi- or multifocal	
		n	Percent rejected	n	Percent rejected	n	Percent rejected	n	Percent rejected
7	Males	21	0	3	33	2	50	0	0
	Females	23	13	3	0	2	50	0	0
11	Males	33	6	7	71	23	22	0	0
	Females	62	8	23	26	28	4	0	0
15	Males	70	4	10	50	29	10	0	0
	Females	145	4	30	43	79	8	0	0
26	Males	161	11	17	53	31	19	0	0
	Females	274	13	62	47	62	18	3	33
46	Males	64	9	136	18	15	20	46	7
	Females	124	9	183	10	19	21	111	9

In order to get a bigger group for statistical calculation 11- and 15-year-old children were combined into one group. Among 11- and 15-year-old children generally 11 % of spectacles were prescribed for reading. 41 % of these spectacles were given up after a mean use of 2,5 years. If spectacles were recommended for distant vision 10 % of children in these age groups had stopped wearing them, but only 4-5 % of spectacles recommended to be worn continuously had been discarded.

The differences in the rejection of spectacles with regard to recommendations were statistically significant in these age groups. Among 26-year-olds 48 % of spectacles for reading had been discarded. This was significantly more than the 13 % rejection of spectacles for other purposes ("continuously" and "for distant vision").

Among 46-year-olds the differences between the recommended wearing of spectacles and their rejection were not significant.

### 5.2.5. Consumption of spectacles among school-children

The mean periods of possession of the last spectacles from the date of receipt to the present were calculated (Table 9.).

Table 9. Mean period of wearing spectacles and total consumption of spectacles at different ages.

Age (yrs.)	Mean period of use of last spectacles (yrs.)		Number of spectacles obtained/subjects in whole age group	
	Boys	Girls	Boys	Girls
7	1,1	1,0	0,07	0,08
11	1,3	1,1	0,21	0,36
15	2,0	1,8	0,45	0,88

In the age-groups of 7-, 11- and 15-year-olds spectacles were worn for 1 to 2 years. In the same table the total number of spectacles obtained in these age groups was calculated. It was seen that up to the age of 7 years new spectacles were needed 7 - 8/100 children. Up to the age of 15, 45 spectacles per 100 boys and 88 spectacles per 100 girls had been needed.

### 5.2.6. Wearing of spectacles with regard to formal education

There was a relationship between basic education and the wearing of spectacles (Fig. 22. and 23.). When comparing education and the wearing of spectacles in 26- and 46-year-olds it was seen that least spectacles were worn in educational group 1.

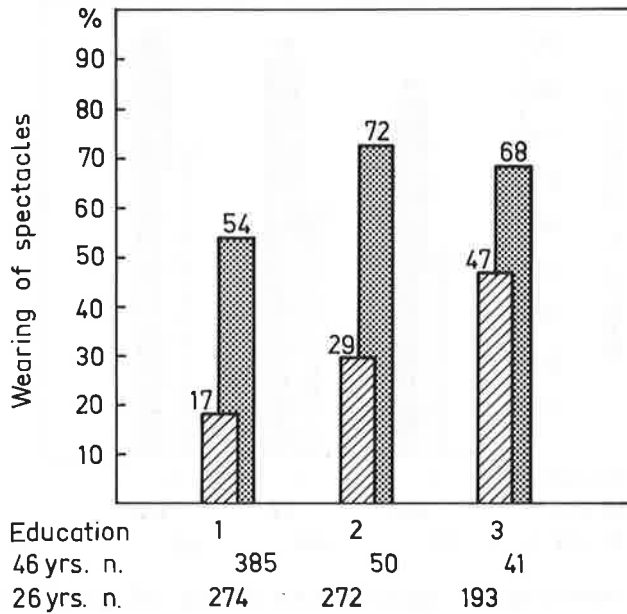


Fig. 22. The wearing of spectacles among 26-year-old males (lined bars) and 46-year-old males (dotted bars) with regard to formal education: 1 = elementary, 2 = lower secondary, 3 = higher secondary.

The dependence were significant in the younger age group (the  $\text{Chi}^2$ -test: 26-year-old men and women  $p < .0001$ ). Among 46-year-old men  $p < 05$  whereas among 46-year-old women the differences were not significant. In all these three educational groups there were more spectacles among women than among men.



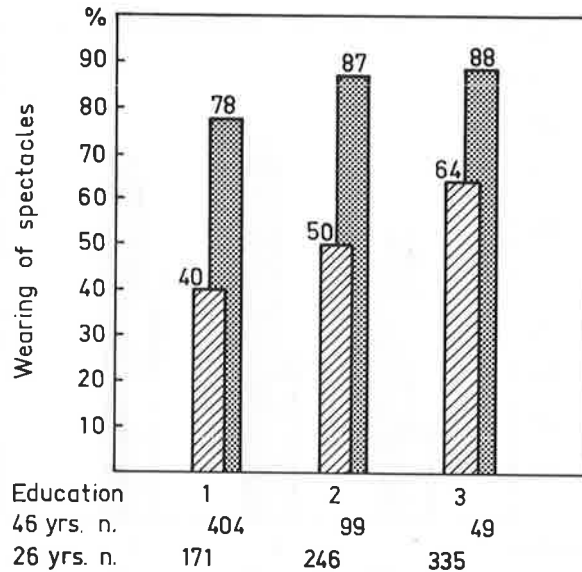


Fig. 23. The wearing of spectacles among 26-year-old females (lined bars) and 46-year-old females (dotted bars) with regard to formal education: 1 = elementary, 2 = lower secondary, 3 = higher secondary.

#### 5.2.7. Wearing of spectacles with regard to formal education, distant vision and sex among 26 and 46-year-olds

Loglinear regression models were used for inspecting the wearing of spectacles with regard to sex, education, and distant vision among 26- and 46-year-olds (Fig. 24.). In this case the wearing of spectacles was explained by sex, education, and distant vision.

84-97 % of those with poor distant vision among 26-year-olds had spectacles. In each of the educational groups there were more females than males with poor distant vision. If distant vision was good there were significantly more spectacles among women than among men in all educational groups. More educated women also had more spectacles for reading than women having only elementary education. Among men with good distant vision there was no interaction between education and the wearing of spectacles.

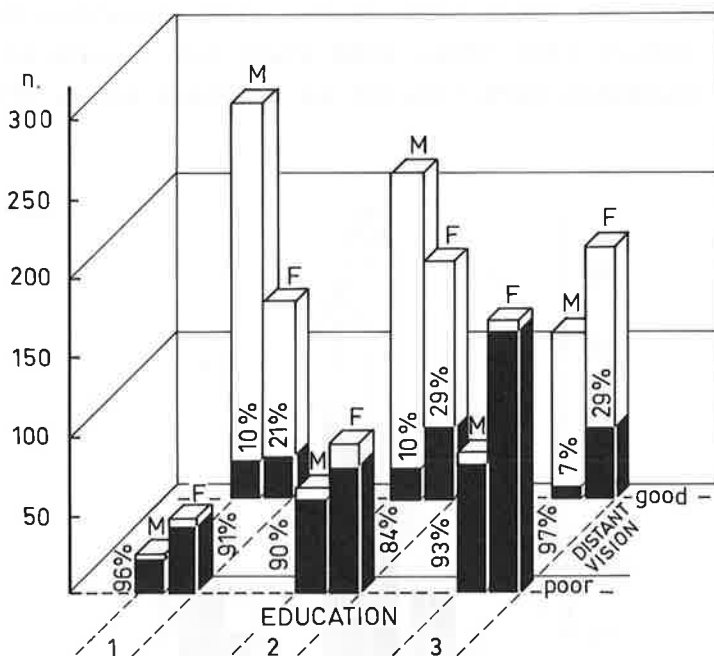


Fig. 24. The wearing of spectacles among 26-year-olds with regard to formal education, distant vision, and sex (M = males, F = females). Whole columns = number of cases in the group, black columns = the wearing of spectacles (percentages of the whole group). Basic education: 1 = elementary, 2 = lower secondary, 3 = higher secondary. (Frequencies are in appendix 13.)

The loglinear regression model with the all related effects of the two variables showed a good fit. Neither of the variables could be omitted.

Wearing spectacles was related to education and distant vision. These relationships were different among men and among women.

Among 46-year-olds there were so few with education beyond elementary school that those with lower and according to higher secondary education were treated as a single group (Fig. 25.).

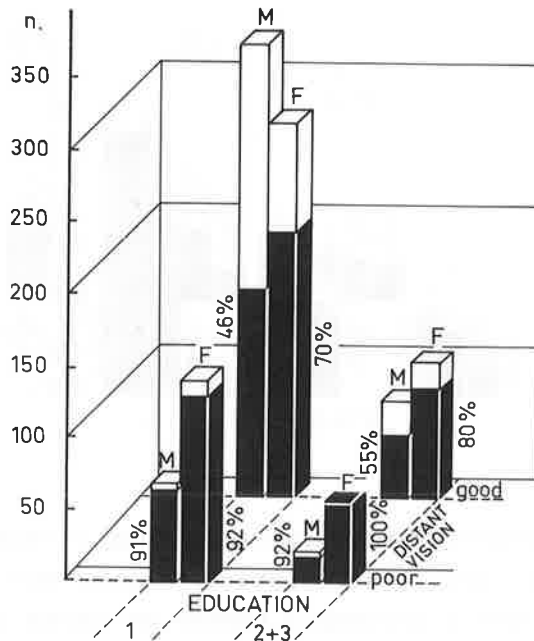


Fig. 25. The wearing of spectacles among 46-year-olds with regard to formal education, distant vision, and sex M = males, F = females. Whole columns = number of cases in the group, black columns = the wearing of spectacles (percentages of the whole group). Formal education: 1 = elementary, 2+3 = lower secondary and higher secondary. (Frequencies are in appendix 14.)

According to the loglinear model the wearing of spectacles could be explained by sex education and poor distant vision: women having more spectacles than men; by education with the more educated having more spectacles than the less educated; and by poor distant vision.

### 5.2.8. Wearing of spectacles with regard to formal education, accurate close work, and sex among 26- and 46-year-olds

If accurate close work (reading, writing, visual display unit work, industrial quality control etc.) was done there was more wearing of spectacles among 26-year-olds (Fig. 26.). The salient feature of the correlation was rather education. Among people with the same level of education the differences in the wearing of spectacles with regard to close work were slighter than differences with regard to education. There was also a clear difference with regard to sex, women having more spectacles regardless of education or close work.

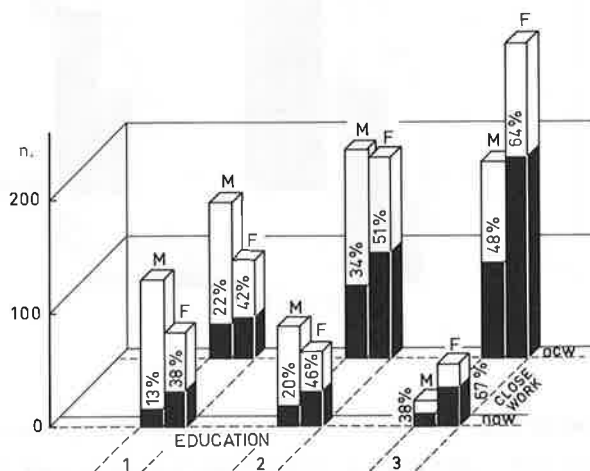


Fig. 26. The wearing of spectacles among 26-year-olds with regard to formal education, accurate close work and sex M = males, F = females. Whole columns = number of cases in the group, black columns = the wearing of spectacles (percentages of the whole group). Formal education: 1 = elementary, 2 = lower secondary, 3 = higher secondary. acw = accurate close work, naw = no accurate close work. (Frequencies are in appendix 15.)

Based on the loglinear model the wearing of spectacles was separately dependent on sex, education, and accurate close work.

By the loglinear model it could also be verified that in addition to sex and education, accurate close work had the effect of increasing the wearing of spectacles among 46-year olds (Fig. 27.).

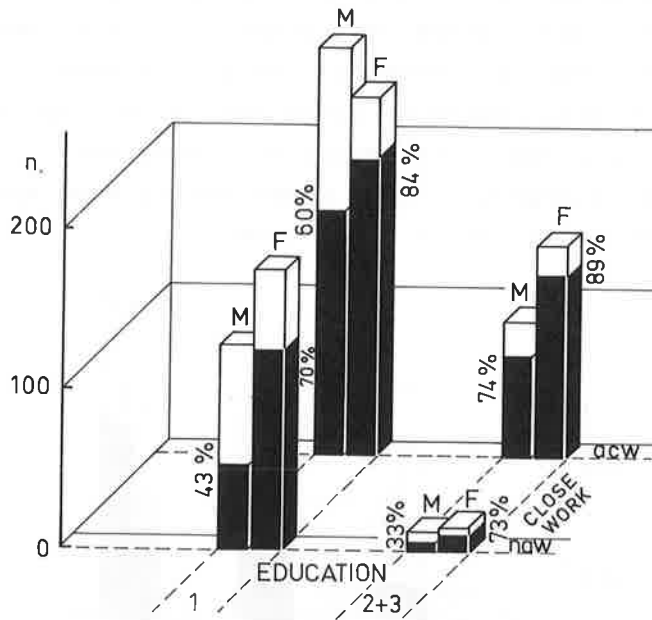


Fig. 27. The wearing of spectacles among 46-year-olds with regard to formal education, accurate close work, and sex M = males, F = females. Whole columns = number of cases in the group, black columns = the wearing of spectacles (percentages of the whole group). Formal education: 1 = elementary, 2 + 3 = lower and higher secondary, acw = accurate close work, naw = no accurate close work. (Frequencies are in appendix 16.)

### 5.2.9. Wearing of spectacles in the decades to come

In the years to come the proportion of those whose formal education has been only primary will gradually decrease until in future about half of the population (53,3 % in 1995) will have gone through lower secondary and other half will have higher secondary education. (Repo 1983). At the same time it is supposed that occupations will change so that agricultural and industrial work will decrease and more people will be employed in offices where accurate close work, eg. reading, writing and visual display unit work is done. If the future changes in education only are taken into account and a rough calculation is made that about half of the population will pass through secondary school and the other half will continue on to higher secondary school the following prognosis can be made (Fig. 28.).

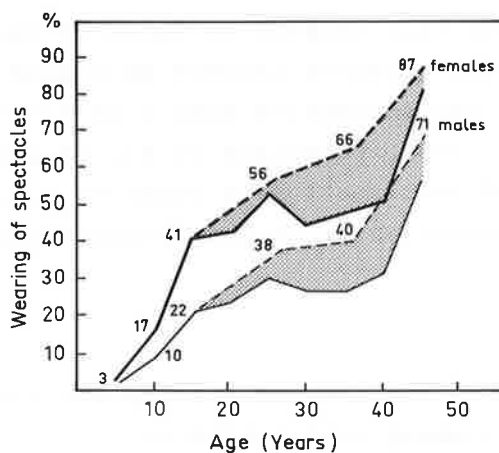


Fig. 28. A prognosis concerning the wearing of spectacles in Finland for after two-three decades based on correlations between the wearing of spectacles and education. The dotted area shows the supposed increase in the wearing of spectacles separately among males and females.

The calculation shows that the wearing of spectacles is increasing. Changes in occupations may still increase the figures of prognosis.

### 5.3. Myopia

This section deals with different relationships of myopia with hereditary and external factors. The cross sectional information about myopia is based partly on questionnaire information about poor distant vision and its connections and partly on clinical examination. It must be remembered that questionnaire information is only approximate about myopia, but as was seen in chapter 4.7., the dependence between myopia and poor distant vision was statistically significant. In the following poor distant vision and myopia are regarded as synonyms.

The first part of this section consists of questionnaire information about 7-, 11- and 15-year-old children and about their parents and siblings. In addition, a part of the 11-year-olds were clinically examined one year later, at the age of 12 years.

The second part of this section is based on studies made as part of a more extensive research project on health and functional capacity among a representative sample of 33-37-year-old men (Heikkinen et al. 1984, Pärssinen et al. (a and b) 1985.)

The third part of this section is based on a questionnaire study and clinical examination of 26 and 46-year-olds.

#### 5.3.1. Hereditary factors and reading and close work as risk factors of myopia among schoolchildren

The relation between myopia and parents' poor distant vision is shown in table 10.

Table 10. Prevalence of myopia (My %) with regard to parents' poor distant vision myopia). Interdependence between myopia and parents' myopia Chi-square tested.

Age (yrs.)	Sex	n	Both parents		One parent		Both parents		Chi <sup>2</sup> - test p
			<u>non-myopic</u> n	My %	<u>myopic</u> n	My %	<u>myopic</u> n	My %	
7	Boys	735	415	2.9	258	3.9	62	1.6	NS
	Girls	735	411	2.7	275	3.3	49	8.2	NS
11	Boys	662	389	7.2	226	14.6	47	17.0	= .005
	Girls	616	348	14.7	221	24.4	47	48.9	< .001
15	Boys	569	385	13.8	156	25.6	28	39.3	< .001
	Girls	684	456	32.9	202	41.6	26	50.0	= .03

NS = not significant

The prevalence of myopia was higher among 11- and 15-year-olds if one of the parents had spectacles for poor distant vision and still higher if both parents had spectacles for poor distant vision.

The prevalence of myopia was also investigated with regard to the poor distant vision of parents, to having a spectacle-wearing sibling, and to daily reading and close work. The interdependence of these variables in the 15-year-old boys is shown in figure 29. Having at least one spectacle-wearing sibling was an additional risk for myopia independent of parents' poor distant vision the results were practically the same when analyses were done by controlling the amount of siblings. There were no significant differences in the number of siblings between the myopic and non-myopic. Reading and doing close work more than the mean for the age-group also seemed to increase the risk of myopia. The only exception was group (P++S-), but the number of subjects in that group was quite small.



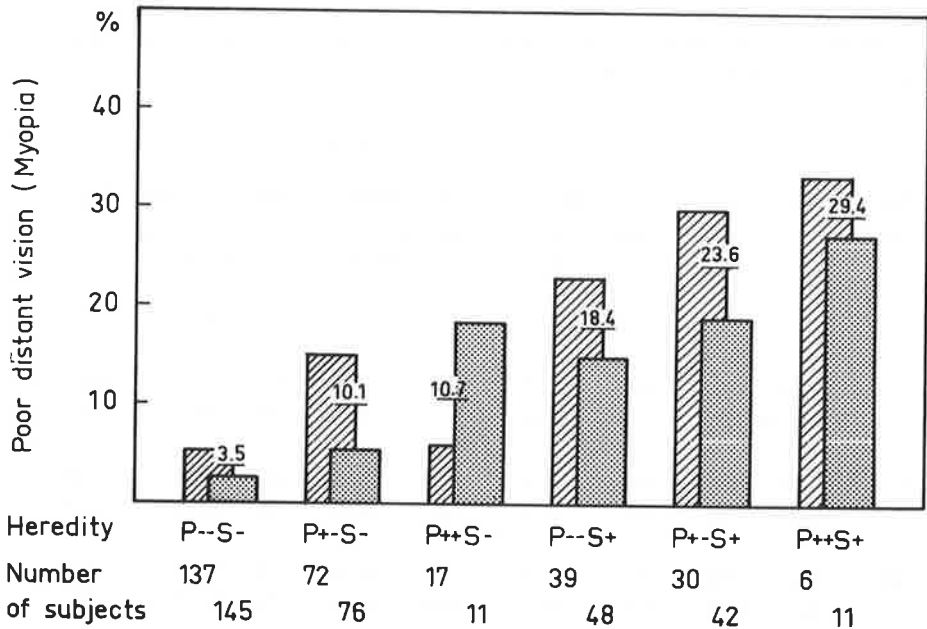


Fig. 29. The prevalence of myopia among 15-year-old boys with regard to heredity; P - - = both parents have good distant vision, P + - = one of the parents has poor distant vision, P + + = both parents have poor distant vision, S - = no spectacle-wearing sibling, S + = at least one spectacle wearing sibling. The hereditary groups were divided into two groups with regard to the amount of daily reading and close work. Lined columns = those boys whose daily reading and close work was more than the mean of the age group, dotted columns = those boys whose daily reading and close work was less than the mean of age group.

A similar distribution for the prevalence of myopia could be seen also among girls (Fig. 30.) and among 7- and 11-year-olds of both cases.

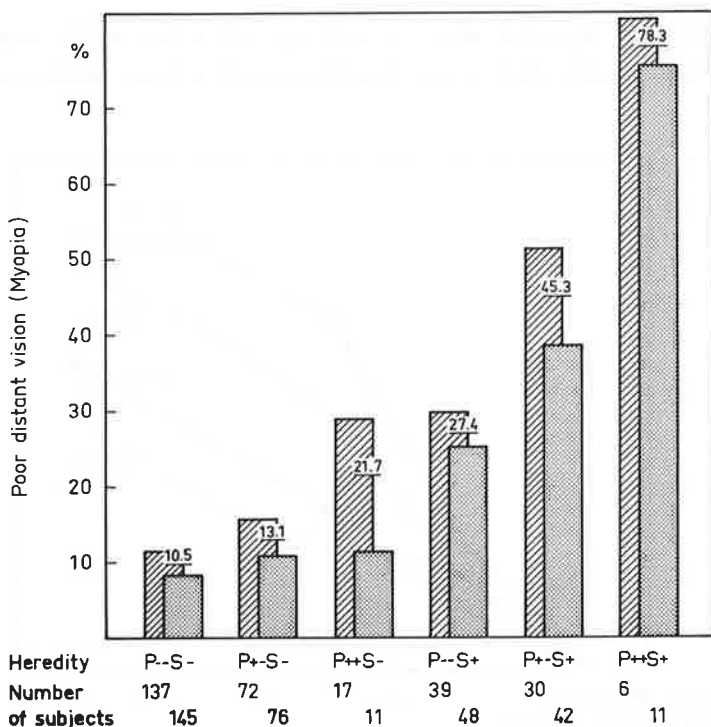


Fig. 30. The prevalence of myopia among 15-year-old girls with regard to heredity; P - - = both parents have good distant vision, P + - = one of the parents has poor distant vision, P + + = both parents have poor distant vision, S - = no spectacle-wearing sibling, S + = at least one spectacle wearing sibling. The hereditary groups were divided into two groups with regard to the amount of daily reading and close work. Lined columns = those girls whose daily reading and close work was more than the mean of the age group, dotted columns = those girls whose reading and close work was less than the mean of the age group.

The myopic children read and did other close work more than the nonmyopic. That difference was not statistically significant among 7-year-old girls. On the average girls spent more time on reading and close work than boys.

The prevalence of myopia was investigated also with regard to the amount of time spent daily on reading and close work (Fig. 31.).

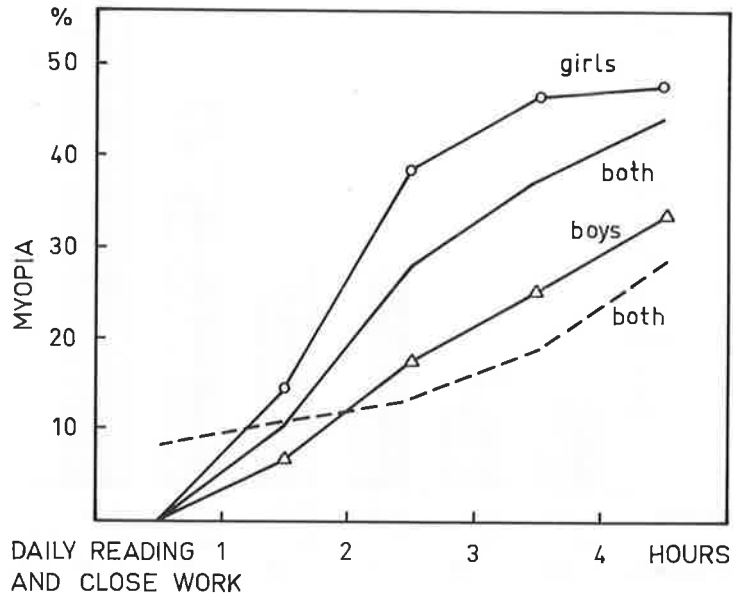


Fig. 31. The prevalence of myopia among 11- and 12-year-year-olds with regard to daily reading and close work. The broken lines show the anamnestic prevalence of myopia in the whole age-group of the questionnaire and the whole lines show the prevalence of myopia one year later in the clinically-examined group.

Among the 11-12-years-olds myopia was the more frequent the more the time spent daily on reading and close work. The figures for the two other age groups were rather similar but among the 7-year-olds the association between myopia and reading was not statistically significant.

The figures for myopic and non-myopic were about the same in all groups of school-children. The myopic spent more time on reading and close work than the non-myopic and less time on outdoor activities than the non-myopic.

The mean times of these activities for myopic and non-myopic 12-year-olds are in table 11.

Table 11. Mean periods (mean hours = M and SD) spent on reading and close work (Reading) and outdoor activities (Outdoor) among myopic and non-myopic 12-year-old children.

Variable	Myopic			Non-myopic			2-tailed t-test p
	n	M. hours	SD	n	M. hours	SD	
Reading	38	3.3	1.1	98	2.7	1.3	= .01
Outdoor	38	2.4	0.9	103	2.9	1.1	= .02

In the clinical examination 9 boys and 8 girls out of 141 12-year-olds answered that they had experienced some kind of eye-strain when reading. Of that group 12 (71 %) read or did other close work more than the mean for their age group. So it might be supposed that eye-strain does not on the average lead to reading less than the average for the age group.

There was no significant relation between the usual posture for reading and myopia. The estimated angle of reading was statistically the same in both myopic and non-myopic groups.

The reading distance of the myopic seemed to be slightly shorter than that of the non-myopic but the difference was not statistically significant. When refraction and effect of spectacles was taken into account it appeared that the non-myopic accommodated more on reading than the myopic (Table 12.).

Table 12. Mean accommodation when reading (Dioptres = D.) among myopic and non-myopic 12 year-old children. Number of subjects (n), means of accommodation, and standard deviation (SD) are shown. Differences between myopic and non-myopic t-tested.

Sex	Myopic			Non-myopic			2-tailed t-test p
	n	M. (D.)	SD	n	M. (D.)	SD	
Boys	8	4.0	1.2	47	5.8	1.4	= .001
Girls	27	4.3	1.7	48	6.4	1.6	< .001

The time spent daily on reading and close work was investigated with regard to heredity in all three age groups. The following significant dependences could be seen: Among 7-year-old boys and among 11-year-old girls reading was as its highest if both parents were myopic. So it seems that at least a part of the differences in habits of reading and close work are hereditary or family related.

The loglinear models were used for investigating myopia with regard to heredity, reading and close work, and sex among 11- and 15-year-olds.

Among 11-year-old boys myopia was mostly explained by heredity especially if both parents were myopic (Fig. 32.). Among 11-year-old girls myopia was dependent both on heredity and reading and close work.

Among 15-year-old-boys and girls myopia was dependent both on heredity and reading. (Fig. 33).

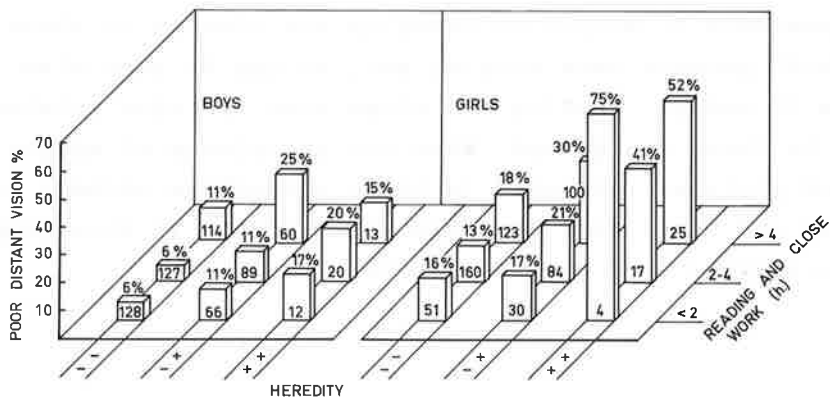


Fig. 32. The prevalence of myopia among 11-year-olds with regard to heredity and amount of daily reading and close work; -- = both parents have good distant vision, + - = one of the parents has poor distant vision, + + = both parents have poor distant vision. Daily reading and close work is shown divided into three groups. Numbers in columns = subjects in groups. (Frequencies are in appendix 17.)

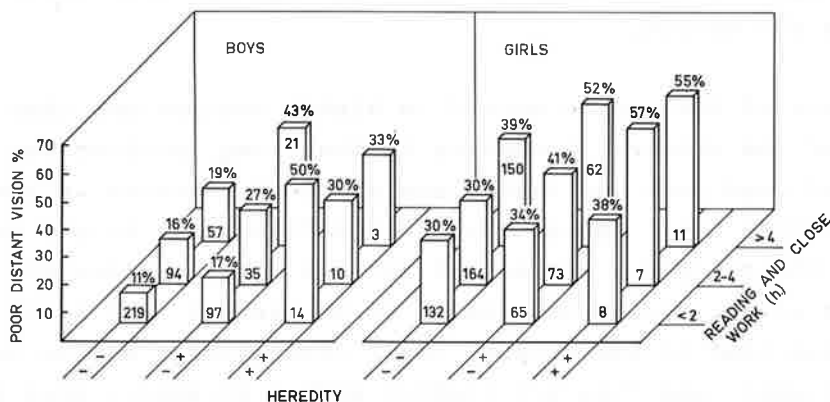


Fig. 33. The prevalence of myopia among 15-year-olds with regard to heredity and amount of daily reading and close work; -- = both parents have good distant vision, + - = one of the parents has poor distant vision, + + = both parents have poor distant vision. Amount of daily reading and close work is shown divided into three groups. Numbers in columns = subjects in groups. (Frequencies are in appendix 18.)

The dependence of myopia on heredity was clearer in these cases where both parents were myopic, but, as can be seen also in figures 32 and 33, reading and close work was also related to myopia in these age groups. When the prevalence of myopia among boys and girls was compared in their respective columns of heredity and close work it could be seen also in this comparison that more girls were myopic than boys.

### 5.3.2. Myopia, use of eyes, and living habits among men aged 33-37 years

As a part of a more extensive research project on health and functional capacity among a representative sample of men Heikkinen et al. 1984, Pärssinen et al. (b) 1985, the living habits and backgrounds of myopic men between 33 and 37 years of age living in the town of Jyväskylä in Central Finland were studied in comparison with non-myopic men of the same age. The negative spheric equivalent of the right eye was considered the criterion for myopia.

The fathers of the myopic worked in higher occupations than the fathers of the others. According to their own opinions the myopic had read more and taken less physical exercise in their childhood than their age-peers. It was found that myopia was the stronger the younger a person had got his first spectacles. The education of the myopic had lasted on an average 2.7 years longer than that of the others, their occupational status was clearly higher, and they did lighter work. Moreover, they had jobs which demanded more accurate near vision (ANV) than the non-myopic. During their leisure the myopic read and did other tasks demanding ANV clearly more than the non-myopic, being also more interested in studying and reading informative literature. Active interest in reading, longer education, higher occupation, and lighter body structure, showed the clearest connection with myopia.

Because approximately half of the myopic had got their spectacles as late as in adulthood, and there had obviously been no delay in getting them, it can be assumed that poor distant vision or the disturbing effect of spectacles in outdoor games was not directing the interest of these cases of myopia towards reading in childhood. The results support the suggestion made in some earlier studies that myopia appearing in adulthood may, at least partly, be a consequence of an active interest in reading during growth and development, and of the effects of close work. A genetic disposition to myopia may be a prerequisite but the actual development of myopia may be associated with the way the eyes are used e.g. in reading and close work.

### 5.3.3. Some physiological and psychological characteristics of myopic and non-myopic 33-37-year-old men

As a part of a study on health and functional capacity of men in different ages (Heikkinen et al. 1984) some physiological and psychological characteristics of myopic and non-myopic men between 33 and 37 years of age were studied (Pärssinen et al. (a) 1985).

The anthropometric measurements indicated that myopic men were leaner than non-myopic men. The body mass index of the myopic was about 5 % smaller than that of the non-myopic. Body fat content was lower among the myopic than among the non-myopic. The latter difference seemed to be connected with differences in voluntary physical activity the myopic being more interested in physical activity during leisure.

Frailty of locomotive organs was assessed by a physiotherapist and more symptoms were found among the non-myopic than among the myopic (Table 13.).



Table 13. Some properties of physical condition among myopic and non-myopic men

Variable	Myopic			Non-myopic			2-tailed t-test p
	n	M.	SD	n	M.	SD	
Frailness of locomotive organs	31	17,1	2,0	98	18,1	2,9	.05
Index of physical fitness	31	89,4	18,1	92	77,0	20,0	.003
Reaction and movement time (ms.)	31	352	38	97	373	53	.02
Index of muscle strength of three muscle groups	32	3,8	0,5	96	3,9	0,6	NS
Directly assessed $\dot{V}O_2$ max (ml/kg x min)	17	42,2	6,8	31	36,4	5,4	.002
Anaerobic capacity (W/kg)	27	25,5	6,3	89	23,1	7,0	NS

NS = not significant

A lower level of frailty seemed to be connected with more education and higher occupational status. The isometric strength of three major muscle groups when body weight was allowed for was the same in both groups. The index of physical fitness and aerobic capacity were both better among the myopic. These differences were related to interest in physical activity during leisure and to the lighter body structure of the myopic. In anaerobic capacity there was no statistical difference between the groups. Reaction and movement times among the myopic were faster than those of the non-myopic and this difference seemed to be related to differences in education and frailty of locomotive organs.

The myopic scored better than the non-myopic in all four cognitive tests which were done (Table 14.).

Table 14. Performance of subjects in the four cognitive tests.

Variable	Myopic			Non-myopic			2-tailed t-test p
	n	M.	SD	n	M.	SD	
Vocabulary (points)	32	13,2	6,3	99	10,4	5,4	.02
Arithmetic (points)	32	14,0	2,5	99	11,9	3,2	.001
Digit span (points)	32	12,5	2,4	99	10,6	2,8	.001
Block design (points)	32	13,6	4,0	99	11,5	3,4	.005

The differences found could be explained by the higher education of the myopic so that there were no significant differences in these tests between the myopic and non-myopic within the educational groups.

There were no differences between the groups in corrected vision and dark adaptation. The mean tension of the right eye among the myopic was 15.7 mmHg and among the non-myopic 15.5 mmHg.

### 5.3.4. Relationship between refraction, education, occupation, and sex among 26- and 46-year-olds

The subjects of this part of the study participated both in the questionnaire study and clinical examination.

No remarkable eye pathology was found in clinical examination of the sample. Only in 8 cases (1,8 %) was the best vision of the right eye 0,6 or less.

As one pathological myopia of a 46-year-old man (-21 D.) and two aphacias, one 26-year-old man and woman of the same age, were excluded, refraction varied from -8,5 D. to + 7,8 D.

#### 5.3.4.1. Astigmatism with regard to age, sex, education and refraction

An astigmatism of 0,25 D. or more was seen in 56,2 % of all cases. Of the younger age group 51,4 % and of the older age group 60,2 % had astigmatism.

The distribution of astigmatisms in the whole sample is shown in figure 34.

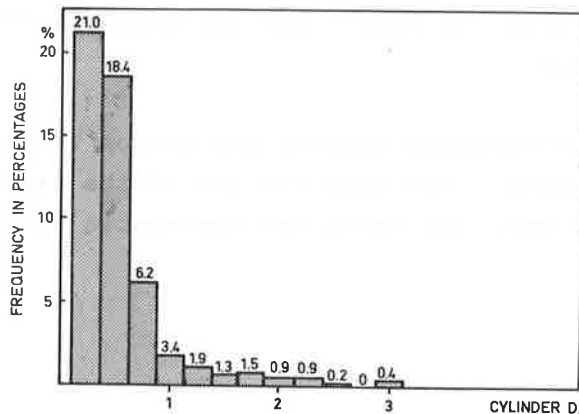


Fig. 34. Distribution of astigmatism in the whole clinical sample of 26- and 46-year-olds.

The figure resembles curve of normal distribution. There was no difference in mean astigmatism with regard to age, sex or education. Mean astigmatism was 0,60 D. for 26-year-olds and 0,59 D. for 46-year-olds.

The mean astigmatism of the myopic (0,74 D.) was higher than that of the non-myopic (0,51 D.) (t-test,  $p = .003$ ). If cases without astigmatism ( $<0,25$  D.) were also included the means were 0,50 D. for the myopic and 0,27 D. for the non-myopic. This difference was highly significant (t-test,  $p < .001$ ).

The sample was divided into three groups with regard to sfe. of the right eye in order to see if astigmatism is related only to myopic ametropia (Table 15.).

Table 15. Astigmatism among the myopic (more than -2 D.), hyperopic (more than +2 D.), and others (from -2 D. to +2 D.). Refractions are the spheric equivalent (sfe) of the right eye. Means, standard deviations, and number of subjects are given. Comparison of means over all three cohorts calculated by analysis of variance.

Sfe of right eye	n	Astigmatism (D.)	
		M.	SD
Myopia more than -2 D.	60	0,50	0,65
From -2 D. to +2 D.	382	0,30	0,44
Hyperopia more than +2 D.	21	0,54	0,53

Analysis of variance  $p < .001$

The hyperopic (more than +2 D.) and the myopic (more than -2 D.) had more astigmatism than those whose refraction was closer to emmetropia (from -2 D. to +2 D.).

Among the 26-year-olds, in 42 % of cases the astigmatism was direct, oblique in 5 % and inverse in 53 % of cases. Among the 46-year-olds, in 29 % of cases the astigmatism was direct, oblique in 1 % and inverse in 70 % of cases. The dependence of the direction of the astigmatism on age was significant (Chi-square test,  $p < .001$ ). There was no significant dependence on the axis of astigmatism between the myopic and non-myopic.

#### 5.3.4.2. Refraction with regard to age, sex and education

The distributions of sfe. among 26- and 46-year-olds are shown in figure 35 (Frequencies are in appendix 19.).

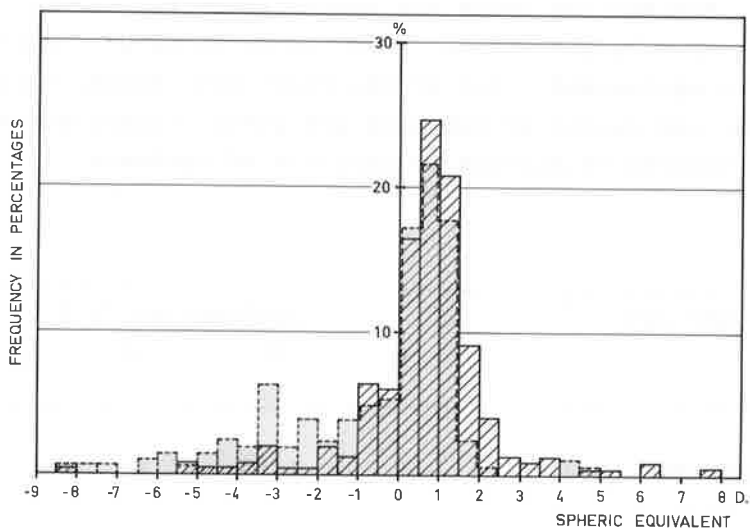


Fig. 35. Distribution of spheric equivalents with regard to age. Dotted columns = 26-year-olds, lined columns = 46-year-olds.

Myopia was more common in the younger age group than in the older age group. The means of refractions were -0,55 D. for 26-year-olds and +0,52 D. for 46-year-olds. The difference was highly significant (two tailed t-test,  $p < .001$ ).

There were significantly more cases of myopia among students than among the less educated. The proportions of myopia among students and less educated in both age groups in males and females are shown in figure 36.

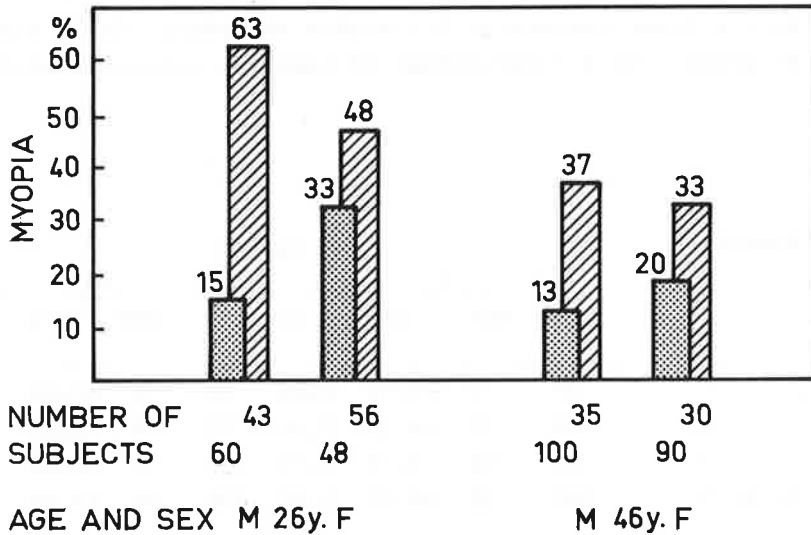


Fig. 36. Percentage of negative spherical equivalents. Lined bars = students or higher educated, dotted bars = less educated persons. (Frequencies are in appendix 19.)

That difference was seen in both age-groups and among both males and females. Based on the loglinear model education and sex had an interaction with refraction, the more educated and females having more myopia than the less educated. The dependence of refraction on age and sex was smaller in the more educated group. The dependence of myopia on education was more prominent among men than among women.

The distribution of means of refraction with regard to age, sex, and education is shown in table 16.

Table 16. Distribution of myopia and spherical equivalents (sfe) according to age, sex and education. Formal education: 1 = elementary, 2 = lower secondary, 3 = higher secondary. (n) = number of subjects in group. My % = percentage of negative spherical equivalents in group.

Sex	Education	Age (yrs.)							
		26				46			
		n	My%	sfe	SD	n	My%	sfe	SD
Males	1	34	12	+0,40	2,09	82	12	+0,82	1,37
	2	25	19	-0,32	2,30	17	18	+0,34	3,01
	3	43	63	-1,13	2,19	35	37	-0,20	1,61
	1, 2, 3	102	35	-0,42	2,25	134	19	+0,54	1,74
Females	1	19	40	-0,06	1,26	83	22	+0,70	1,43
	2	28	28	-0,26	1,70	7	0	+0,92	0,55
	3	56	48	-1,10	2,19	30	33	-0,10	1,80
	1, 2, 3	103	41	-0,69	1,97	120	23	+0,52	1,53

In both age groups among males and females there were more cases of myopia in the highest educational group (group 3.) than in the others.

Spherical equivalents were also most negative in the educated groups. It was seen by analysis of variance that the spherical equivalent was significantly dependent on age and education but not on sex. These variables had no connected interaction on the spherical equivalent.

The comparison between men and women and between different educational groups with regard to myopia and means of sfe. in the whole sample of 26- and 46-year-olds is shown in table 17.

Table 17. Prevalence of myopia (My %) and means of spherical equivalents in dioptres and SD according to sex and education in the 26- and 46-year-old groups. Formal education: 1 = elementary, 2 = lower secondary, 3 = higher secondary.

Sex	Education	n	My%	M. (D.)	SD
Male	1, 2, 3	236	26	+0,12	2,03
Female	1, 2, 3	223	32	-0,03	1,84
Male and Female	1	218	18	+0,63	1,53
	2	77	21	-0,04	2,19
	3	164	47	-0,70	2,06

In the clinical sample the most educated groups were slightly over-represented due to study design.

The distribution of educational groups in the study locality in these two age groups was obtained from the questionnaires. As the relationship with education and sfe. and the distribution of education in the age groups were taken into account, the mean refraction in the population could be more exactly calculated (Table 18.).

There seemd to be a difference of approximately 1 D. in refraction between these age groups.



Table 18. Means of spherical equivalents in dioptres among 26- and 46-year-old males and females and means calculated with regard to education in the population of the study locality. The distribution of education was taken from the questionnaire.

Age (yrs.)	Sex	Means of sfe for clinical sample	Calculated means of sfe for the population of the locality
26	Male	- 0,42	- 0,26
	Female	- 0,69	- 0,58
46	Male	+ 0,54	+ 0,67
	Female	+ 0,52	+ 0,59

#### 5.3.4.3. Refraction with regard to occupation and close work

The means of sfe. were also examined with regard to occupational group among 26- and 46-year-olds (Table 19.).

The mean of sfe. was myopic for occupational group I and hyperopic for occupational groups IV and V. The significance of differences between means of refraction was calculated using the 2-way analysis of variance. Among 26-year-olds the refraction was more myopic than among the 46-year-olds ( $p < .001$ ). There was also a significant relation between refraction and occupation ( $p < .001$ ). The differences were about the same for both males and females. In this study occupational group was highly related to education, and most of the differences with regard to occupation could be explained by differences in education. According to two way analysis of variance age and occupation had no interaction with the spherical equivalent but the spherical equivalent was separately dependent on sex and education ( $p < .001$ ).

Among 46-year-olds in occupational group I 85 % of the subjects had schooling of lower secondary or more. In occupational group IV only 6 % and in occupational group V 8 % had this level of education. Among 26-year-olds formal education was higher secondary in 89 % of cases in occupational group I, but only 18 % in occupational group IV and 25 % in occupational group V.

Table 19. Means of spherical equivalents in dioptres (D.) in three occupational groups among 26- and 46-year-olds. Occupational groups: I = higher managerials or others in leading positions, IV = semi-skilled or non-skilled workers or persons engaged in service trades, V = farmers or agricultural workers.

Occupational group	Age (yrs.)					
	26			46		
	n	D.	SD	n	D.	SD
I	61	-1,40	2,36	86	+0,15	1,71
IV	91	+0,34	1,78	107	+0,63	1,80
V	28	-0,32	1,94	60	+0,63	1,03
Others	28	-1,04	2,35	2	-1,77	1,77

Analysis of variance: (p < .001) (p < .001)

The relation of myopia to sex, education, and close work is shown in figure 37.

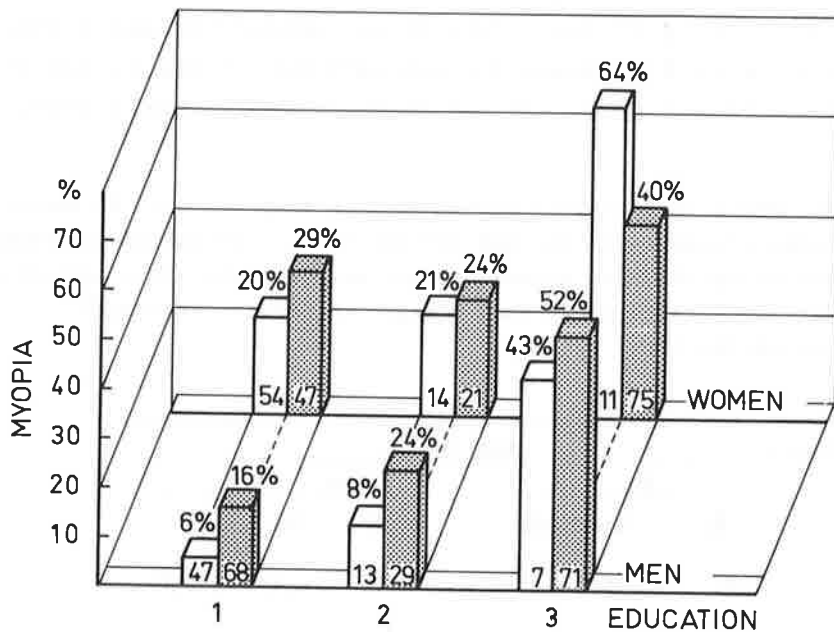


Fig. 37. The prevalence of myopia among 26- and 46-year-olds with regard to sex, education, and accurate daily close work. Classification of education: 1 = elementary, 2 = lower secondary, 3 = higher secondary. Bare columns = subjects not doing accurate daily close work, dotted columns = subjects doing accurate daily close work. Numbers in columns = subjects in group. Percentages over columns = prevalence of negative spherical equivalent in group. (Frequencies are in appendix 21.)

In all educational groups men who did accurate close work in their daily work had more myopia than other men. The same was true among women in educational groups 1 and 2, but differences in myopia with regard to accurate close work were slighter than among men. In the loglinear model myopia was, in this material, significantly dependent on education, but not on sex or close work.

5.3.4.4. Relation between the wearing of spectacles or poor distant vision to habits of reading and outdoor activities at school age

In the clinical examination the subjects were asked if any matters connected with the eyes, or vision, for example spectacles or the lack of them, influenced their habits of reading or outdoor activities at school age. Replies from 446 people showed that in 97 % of cases spectacles or vision problems had had no effect on reading or outdoor activities. 1 % of those who answered believed that reading had increased due to poor distant vision and 2 % said that straining the eyes had diminished reading. With regard to outdoor activities 98 % of those who answered said that vision or spectacles had had no influence.

The prevalence of myopia was 14,3 % among those who answered that they had read less than their age peers at school age. The respective percentage among those who answered that reading had been the same as their age peers, was 29,0 %. The prevalence of myopia among those who answered that they had read more than their age peers at school age was 35,4 %. The differences were statistically significant (Chi-square = 10.308, df = 2, p < .01). Interest in reading at school age seems to have some connection with myopia as an adult.

### 5.3.4.5. Present myopia in relation to age of receiving first spectacles

The amount of myopia was the higher the earlier it had begun (Fig. 38.).

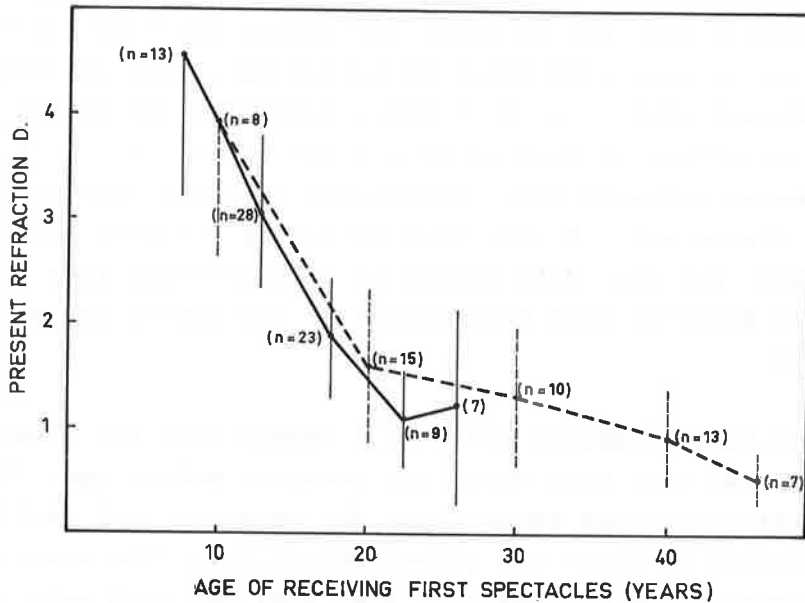


Fig. 38. Present spheric equivalents with regard to the age of receiving first spectacles. Unbroken line = 26-year-olds, broken line = 46-year-olds. (Analysis of variance:  $p < .0001$ )

Myopic persons who received their first spectacles at the age of ten years or earlier had, as adults, refractions from -4,5 to -4,0 D. If the first spectacles were obtained around 20 years of age the refraction was about -1,5 D. The differences between means were statistically significant, verified by analysis of variance.

Ages of receiving first spectacles among 26- and 46-year-old myopic men and women separately are shown in table 20.

Table 20. Distribution of myopia with regard to age of receiving first spectacles among 26- and 46-year-old men and women. f = number of subjects receiving spectacles at different ages.

Age of receiving first spectacles(yrs.)	Age group			
	26-year-old		46-year-old	
	men	women	men	women
	f	f	f	f
0 - 9	5	5	0	1
10 - 19	21	30	8	8
20 - 29	7	4	6	4
30 - 39			3	5
40 - 46			5	7
No spectacles	3	4	4	3
Total	36	43	26	28

Quite number of myopic men and women received their first spectacles as adults. If those (10 % of whole groups) who had not up to that time received spectacles was taken into account, in the myopic group 28 % of 26-year-old men and 34 % of 26-year-old women myopia can be calculated as beginning at about 20 years of age or later. Among the 46-year-old myopic out of those who were myopic at 26 years of age 33 % of men and 25 % of women had received their spectacles as 20-26-year-olds. If so called "late myopia" (Goldschmidt 1968) is said to begin at about 20 years of age or later, the percentage of late myopia can be calculated to be 25-34 % at 26-years of age. It seems that new cases of myopia continue to occur in all age groups up to 46-years of age.

### 5.3.4.6. Present refraction in relation to the wearing of spectacles for poor distant vision

The distribution of the spherical equivalent was studied among those 26- and 46-year olds in the group examined clinically who wore spectacles for distant vision (Table 21.).

Table 21. Distribution of spheric equivalent (Sfe.) among those 26- and 46-year olds who had spectacles for poor distant vision.

Sfe. D.	26-year-old		46-year-olds	
	M	F	M	F
- 8 - 8,99	1	1	1	
- 7 - 7,99	1	0	0	
- 6 - 6,99	3	0	0	
- 5 - 5,99	2	2	1	1
- 4 - 4,99	1	5	1	2
- 3 - 3,99	7	11	4	2
- 2 - 2,99	5	5	1	1
- 1 - 1,99	5	10	3	5
- 0 - 0,99	9	6	7	13
+ 0 - 0,99	1	7	6	11
+ 1 - 1,99	1	2	2	14
+ 2 - 2,99	0		3	5
+ 3 - 3,99	0		3	1
+ 4 - 4,99	1		1	0
+ 5 - 5,99			0	0
+ 6 - 6,99			0	2
+ 7 - 7,99			1	
Together	37	49	34	57

There were more cases of hyperopy in the older age group than in the younger and more among women than among men. Those cases where sfe. was from 0 to +1,0 D. were analysed separately case by case. Most of them had an astigmatism ( $\geq 0,5$  D.) in one or both eyes or myopia in the left eye. Only in three cases (46-year-old women) had spectacles not obviously improved distant vision.

## 6. DISCUSSION

### 6.1. Discussion on need for near vision and the occurrence of ocular symptoms

#### 6.1.1. Eye-strain among school-children

The symptoms of eye-strain occurred more often among those who read more than the mean of their age-group, and among those who had spectacles, and also among those who had poor distant vision and apparent myopia. It thus seems reasonable to suggest that the hyperopic do not have more eye-strain than the myopic, and eye-strain is obviously not the cause of the hyperopic reading less than the myopic. There is a close relationship between accommodation and convergence so that if a child converges without accommodation or vice versa problems of eye-strain can develop. A part of these common symptoms of eye-strain especially among the apparently myopic when reading without spectacles may be due to disturbance of this accommodation-convergence relationship.

The information from the questionnaire did not give answers as to the severity and frequency of symptoms of eye-strain. However the fact that the symptoms were so common offers a challenge to health-care personnel. Most of these symptoms were relieved with spectacles, but some of them remained. It can be supposed that in most cases the wearing of optic correctives, awareness of a suitable reading distance and position, and resting between long-standing reading sessions, could relieve the symptoms.

#### 6.1.2. Need for near vision in daily work

The results of this study indicate that there is a need for accurate near vision in most occupations. About two thirds of



both 26- and 46-year-old subjects considered that they required accurate near vision in their daily work. In this study 70 % of the older age group and 11 % of the younger age group considered that their near vision was not good enough without spectacles. Women more often than men regarded their near vision as not good enough without spectacles. The reason for this is not clear but it may be dependent on shorter working distances in women than in men.

The accommodation and convergence adjustments required in close work may be fatiguing and annoying particularly if different working distances are constantly demanded. The use of spectacles was more common in accurate close work (Pärssinen et al. (a) 1984). The results of this study indicated that the occupational change from agricultural and non-skilled to more educated occupations obviously have increased the need for accurate near vision. This may lead to a more frequent use of spectacles and more a frequent need for eye examinations. If the assumptions of the connection between close work and myopia (Richler & Bear (a) 1980) are true the increased frequency of accurate close work the in population may lead to an increased frequency of myopia.

The results of this study indicated that except in agriculture there is in most occupational groups a need for occupational accurate near vision suggesting that employees should have an opportunity for their visual acuity and refraction to be examined when having problems in near work. The results of such an examination may give adequate information about whether the subject has the necessary capacities to carry out his work and may be a basis for prescribing aids.

### 6.1.3. Ocular symptoms in different close work categories

In this study different ocular symptoms occurred more frequently among industrial work categories than in other occupations in the age-group of 46-year-olds. This is in good agreement with the observation that many diseases are more common in the lower social groups than in the higher social groups (Blaxter 1976, Brotherston 1976). In occupational groups III, IV and V there may be a potential need for eye examinations both due to ocular symptoms and perhaps due to uncorrected refractions whereas in other occupational groups, especially among women, there seems to be a frequent need for the correction of refractive errors because they commonly have spectacles.

A part of eye-strain in close work may be due to uncorrected or wrongly corrected refractive errors, heterophoria, unusual ocular torticollis, disturbances in accommodation and convergence, or due to bad ergonomics (Nyman 1984). (Klave et al. 1984) found in their study that women had more ocular complaints than men when doing visual display unit work. That was not found in this study. In this study 46-year-old subjects in VDU work had slightly less subjective eye symptoms than 46-year-old subjects in other work categories.

The fact that the 46-year-olds who were working with visual display units had most spectacles and least ocular symptoms may be due to the proper correction of refractive errors and to the effect of spectacles to relieve eye-strain.

## 6.2. Discussion on wearing of spectacles

### 6.2.1. Social background in childhood and wearing of spectacles

In many contexts a relation between social background and the wearing of spectacles has been found. In Finland Heinonen (1927 and 1934) studied school-children and found that the prevalence of myopia was higher among the higher social classes.

Among 10-23-year-olds the prevalence of myopia was 19,2 % in children from social class I and only 7,3 % in children from social class III. Krause et al. (1982) noticed that among 14-year-olds the wearing of spectacles was higher in social classes I + II than in class IV and among farmers.

In the United States the wearing of spectacles among 6-16-year-olds was lowest in those families where the education of the head of the family was the shortest. (NHS 1984). Similarly in older age-groups; among 17-24- and 25-44-year-olds the wearing of spectacles rose quite evenly with increases in the education of the head of the family.

In the present study there was a slight trend to more spectacles among children from the higher occupational groups, although the differences were mostly not statistically significant. The obtaining of spectacles thus seems nowadays be only slightly influenced by the occupation of the head of the family. Propably, as differences in living standards are reduced, the differences in the wearing of spectacles among children with regard to father's occupation are also reduced.

### 6.2.2. Relations between wearing of spectacles, education, close work, and distant vision

In Finland relations have been found between the wearing of spectacles and education (Aine 1984). Similar results have obtained also in the United States (NHS 1984). In this study the wearing of spectacles was more common among those having poor distant vision, more education, and doing accurate close work.

The results thus lend support to earlier theories that environmental factors may influence refraction and thus the wearing of spectacles (Goldschmidt 1968, Richer & Bear (a) 1980, Sperduto 1983). The other possibility is that poor distant vision and the wearing of spectacles could direct persons to more reading, more education and to accurate close work. Results of this study did not support that possibility. Only few subjects in clinical examination regarded the wearing of spectacles or poor vision as having any influence in reading habits and education.

### 6.2.3. Consumption of spectacles among schoolchildren

Most spectacles among school-children are ordered for myopia (NCHS 1974). Myopic progression is calculated to be 0,5 D. per year on the average at school age (Oakley & Young 1975). This is usually the amount of myopia which causes difficulties in distant vision and leads to spectacles being prescribed. It can thus be calculated that on an average every myopic child of school age needs an annual ophthalmic consultation. Laatikainen and Erkkilä (1980) calculated that about 15 % school children would annually need an ophthalmological examination, but about one-fifth of them might not require any treatment. In this study the respective

calculation can be made on the basis of prescribed spectacles. Between the ages of 7 and 15 boys needed  $0,45 - 0,07 = 0,38$ , and girls  $0,88 - 0,08 = 0,80$  spectacles/child. If these figures are divided with 8 years, 5 % of boys and 10 % of girls have annually between 7 and 15 years of age received spectacles. The need for ophthalmic consultations thus calculated is less than the figures of 15 % of Laatikainen and Erkkilä (1980). Some of this difference is obviously due to differences in the samples and study methods.

#### 6.2.4. General discussion on wearing of spectacles and on changes in wearing of spectacles

Spectacles are obtained mainly for getting better vision, or relieving ocular symptoms. It was seen that poor distant vision was more common among females than among males from 11 to 46 years of age. Females also had more spectacles in these age-groups. Similar results have obtained in studies by Aine in Finland (Aine 1984), and also in the United States (NHS 1984). It seems then, that females have more myopia in all these age-groups.

Most of the spectacles which were rejected were ordered for reading. This may be due to a too liberal ordering of them, or, especially among children, to changes in refraction during growth, or to changes in vision needs.

In Figure 19. it was seen that from the ages of 7 to 26 the wearing of spectacles was highly related to poor distant vision. In the United States it was found that 83 % of the spectacles prescribed between the ages of 12-17 years are used for myopia (NCHS 1974). This is also quite close to the percentages of Bear & Richler (1982) (nearly 90 % of spectacles worn between the ages of 12-19 were ordered for myopia). It can be said that most of

the spectacles used by the 4 youngest age-groups of subjects in the sample studied were used for myopia. Thus most of the increase in the wearing of spectacles must be due to the use of them for myopia.

It is commonly agreed that adolescence girls have more myopia and also more spectacles (NCHS 1974, Aine 1979, Krause et al. 1982). In some studies higher prevalence rates of myopia for females also as adults have also been found (Sperduto et al. 1983, Aine 1984). Duke-Elder (1970; V: 238), on the other hand, believed that there is no correlation between refraction and sex.

In this study more females than males from the ages of 11 to 46 had poor distant vision and they also wore more spectacles. It seems then, that in these age groups females have more myopia.

Among 26-year-olds the differences in the wearing of spectacles were marked with regard to education. This was partially true also with 46-year-olds. The use of spectacles during the last five decades has shown a continuous increase. A part of that increase may depend on vision requirements with more televisions. A part of increase among the youngest age groups may depend on the fact that refraction service for school children has begun in 1979 in Central Hospital of Central Finland.

On the basis of the relation between education and refraction it was suggested that the wearing of spectacles in the population is continuing to increase. With regard to males the prognosis showed almost the same figures in the wearing of spectacles as those in the United States in 1979 and 1980 (NHS 1984). The prognosis concerning females showed higher percentages than those in the United States. The obvious increase in the need for near vision, especially with visual display units, may also increase the wearing of spectacles. It can be supposed that in addition to an increased wearing of spectacles in future there will also be a trend towards the more frequent changing of spectacles. All these changes it may be assumed, will lead to a greater need for ophthalmological and optic services.

### 6.3. Discussion on myopia

#### 6.3.1. Hereditary factors and reading and close work as risk factors for myopia among schoolchildren

In this study having a spectacle-wearing sibling was a greater risk factor for myopia than having myopic parent(s). On the basis of the relation between the wearing of spectacles and myopia (NCHS 1974, Bear & Richler 1982) it can be assumed that most siblings' spectacles are worn for myopia. This relationship agrees with the usual genetic probability of becoming diseased (Khamis & Hinkelmann 1984) as well as with the results of Bear et al. (1981) that sib-sib resemblances in ocular refraction exceed those of offspring to their parents. It is difficult to say what part of this relation between siblings results from family environment, and what part from heredity.

It is difficult to estimate the exact time spent daily on different activities. In any case there was a quite normal distribution in answers in that respect. Those who spent more time on reading and close work spent less time on outdoor activities. To minimise the effect of minor errors in answers the time spent on reading and close work was later classified into two or three larger groups. Although time spent reading and doing close work had a connection with myopia it is still difficult to estimate the possible effects of alternations in reading distance, intensity and duration of close work sessions, and luminosity of object.

The suggestion that accommodation is a cause of myopic progression has led to many attempts to prevent myopic progression by reducing accommodation. This has been accomplished by eliminating corrective lenses for near work (Donders 1864), by using plus lenses (Viikari 1978), by using

bifocal lenses (Oakley & Young 1975), and by using cycloplegic drugs (Bedrossian 1971) and by many other methods. In this study the accommodation of the myopic was less than that of the non-myopic. It seems reasonable to suppose that the difference was smaller, zero or opposite before refraction began a progression towards myopia. So if reading has an connection on myopia as seems to be the case, the time spent on reading seems to be more connected with it than the amount of accommodation. One possibility is that the eyes of the myopic are more susceptible to accommodation than the eyes of the non-myopic. Many authors have cited the activity of the extraocular muscles, horizontal recti or oblique muscles as a cause of myopia owing to their compression of the eye in convergence (von Graefe 1857, Greene 1981). As the amount of accommodation in reading was not higher among the myopic convergence more than accommodation could be connected with myopic progression. In every case heredity had a significant relation with myopia but myopic and non-myopic differed already at school age from each other with regard to their reading habits.

#### 6.3.2. Myopia, use of eyes, some living habits, and physiological and psychological characteristics of 33-37-year-old men

The myopic using spectacles had got their first spectacles on average at the age of 21 years (range 10 to 31 years). Because optical services are readily available in the town of Jyväskylä in Central Finland it can be assumed that possible faults in vision have been detected fairly quickly and spectacles received when necessary.



Furthermore, eye examinations are performed in schools at two-year intervals and men's eye-sight is examined on conscription at the age of 19 years. The results thus support the earlier reports that there are changes in the eyes leading to myopia in adulthood (Goldschmidt 1968). Results also suggest that so-called "late myopia" (Goldschmidt 1968) is quite common, at least among men.

The results showed a clear interdependence between myopia and a marked interest in reading from childhood onwards. Because approximately half of those examined had got their spectacles as late as in adulthood, and there had obviously been no delay in getting them, it can be assumed that poor distant vision or the disturbing effect of spectacles in outdoor games was not directing the interest of these cases of myopia towards reading in childhood.

The myopic men had higher occupations, longer education, and lighter body structure than non-myopic. These characteristics were explained by length of education, which on the other hand, may be associated with an interest in reading in childhood. Similar associations found in this study between myopia and anthropometric properties have also been reported in earlier studies (France 1938, Goldschmidt 1966). These differences in this study could mainly be explained by more education, higher occupation, and more interest in movement during leisure among the myopic.

The results support the suggestion made in some earlier studies (Goldschmidt 1968; Angle & Wissman 1978; Bear et al. 1981; Goldschmidt 1981, Rehm 1981) that myopia appearing in adulthood may, at least partly, be a consequence of an active interest in reading during growth and development, and of the effects of close work.

### 6.3.3. Relations between refraction, education and occupation among 26- and 46-year-olds

The amount of astigmatism ( $\geq 0,25$  D.) in this study was 56,2 %. That is significantly more than the 25,9 % of Aine's material (1984). This difference may at least partly depend on differences in study populations.

Fulton et al. (1982) have recently suggested that astigmatism during visual immaturity could be a factor causing myopia. In this study both myopic and hyperopic with errors of refraction of more than  $\pm 2$  D. had more astigmatism than those whose refraction was more emmetropic (error of refraction less than  $\pm 2$  D.). On this basis it seems more reasonable to suggest that astigmatism is more likely a symptom of refraction anomaly than a cause of it. This also agrees with some earlier observations that the amount of astigmatism is smallest around the emmetropia (Kronfelt & Devney 1930).

As there is a very significant relation between education and sfe., it can be assumed that the proportion of myopia in the population is dependent on the level of education. Duke-Elder (1970; V: 232) described a slight but steady increase in hypermetropia from the third to the seventh decade of age. The increase in hypermetropia was 0,25 D. from 30 to 55 years of age. In the material of Slataper (1950) the spherical equivalent was +0,719 D. for 26-year-olds and + 0,799 D. for 46year-olds. On the basis of this sample it can be calculated that among males there is a trend towards hyperopia of 0,93 D. from the mean level found in 26-year-olds. The respective difference among females was 1,17 D. Similar differences were found by Richler and Bear (1980) in New Foundland. Differences on this scale were not seen in adult refractions for example in the United States (Richler & Bear 1980). It seems improbable that those now at the age of 46

in Finland could have been so much more myopic 20 years earlier or that those now at the age of 26 will be so much more hypermetropic 20 years in the future. On the basis of the comparison between these two age groups, 26- and 46-year-olds, it is a very reasonable proposition that a change of between 0,75 and 1,0 D. in refraction in the direction of myopia occurred during the last two decades in the area of examination and also in Finland generally. Longitudinal studies are needed to confirm this.

There has been a high increase in basic education during the last few decades in Finland.

As education and refraction were highly related it can be assumed that the differences in refraction between 26- and 46-year-olds and between men and women could be dependent, at least partly, on the increase and differences in education.

Refraction had so clear a relation with age, sex, education and occupation, that all these factors must be taken into account when comparing refractions, for example between different periods, races and populations.

In any case the results of this part of the study also support theories that reading and close work are one cause of myopia. A genetic disposition to myopia may be a prerequisite but the actual development of myopia may be associated with the way the eyes are used e.g. in reading and close work.

#### 6.3.4. General discussion on myopia

There are numerous theories concerning the etiology and pathogenesis of myopia (Curtin 1985: 61-153). One of the main object in this study was to study the relations of myopia to heredity, reading and close work.

The results showd connections between the wearing of spectacles and myopia with reading, close work and education in addition to obvious hereditary influence. These results support earlier multifactorial theories of myopia (Goldschmidt 1981, Danning 1981). Heredity without any environmental influence may theoretically lead to different refraction and in addition to that it may cause differences in susceptibility to external factors, perhaps to accommodation and/or convergence or to some other factors. It can be suggested that myopia would be a kind of ocular adaptation to near vision. As 63 % of the male students and 48 % of the female students in the 26-year-old group had myopic refraction it may on the other hand be supposed that the rest of that group is for hereditary or other reasons "resistant" to myopia.

Goldschmidt (1968) earlier suggested that so called "late" myopia is mainly caused by environmental factors.

In this sample the myopic, both males and females, had in many cases received their first spectacles as adults. It thus seems that "late myopia" with obvious environmental influences is common both among males and females and new cases of myopia appear at least up to the age of 46-years.

#### 6.4. Need for further studies

Those children in this study who had poor distant vision and read without spectacles had more symptoms of eye-strain than those reading with spectacles. The need for accommodation is higher when the myopic read with spectacles than without spectacles. It is not known if the wearing of spectacles when reading has any influence over the progression of myopia. A random controlled clinical trial is presently going on in Jyväskylä to study this.

Although myopia had a clear relationship with reading, education, and close work, follow-up studies are needed to confirm the possible causalities. It is also not known why females had more spectacles, poor distant vision and myopia, and whether this might depend on their doing more reading, sewing, and other close work.

If the use of eyes has some influence in refraction further studies are needed to be definite about the actual nature of that influence, whether it is accommodation or convergence or both or some other mechanism. The nature of hereditary influence, whether some people are hereditarily more susceptible to accommodation and for convergence or some other environmental factors, also remains to be precisely clarified.

## 7. SUMMARY

The main purposes of this study have been to investigate the following: 1) The occurrence of symptoms of eye-strain among school-children and the connections of these symptoms with habits of reading, distant vision, and the wearing of spectacles; 2) the extent to which 26- and 46-year-olds need near vision in their everyday employment and the effect of those vision requirements at work on symptoms of eye-strain, the wearing of spectacles and myopia; 3) the changes that have occurred and are occurring in the wearing of spectacles; 4) the prevalence of myopia in different age-groups and the kinds of connections myopia has with external factors and especially with reading and close work, and with some physiological and psychological characteristics.

The study was conducted by questionnaires among 7-, 11-, 15-, 26-, 33-37- and 46-year-olds (7047 subjects) and by clinical examinations among 12-, 26-, 33-37, and 46-year-olds (672 subjects).

The locality of the study was the town of Jyväskylä in Central Finland and six rural parishes around it. The total population living in this area was 118758 people in the beginning of the study.

Symptoms of eye-strain and headache when reading were common among school-children. These symptoms were related too poor distant vision, reading without spectacles, a short reading distance and, to a more limited extent, reading for long periods. When reading without spectacles 10,8 % - 43,8 % of children with poor distant vision reported at least occasional symptoms of eye-strain. Their symptoms were significantly less when reading with spectacles.

Most of 26- and 46-year-olds needed accurate near vision in their daily work. The more the daily close work, the more was wearing of spectacles. The wearing of spectacles was also related to education, occupation, and, especially poor distant vision. The longer the education, the higher the occupational status, the more were spectacles worn. Most of the spectacle wearing among the 7-, 11-, 15- and 26-year-olds were to correct poor distant vision. Females had more spectacles than males in all the age groups studied from age of 11 to at the age of 46. Among 7-year-olds there was no statistical difference in respect of this.

A rapid increase in the wearing of spectacles in Finland has taken place during recent decades and some increase is expected to continue during the decades to come.

Risk factors for myopia among school-children included, among other things, a sibling wearing spectacles, myopic parents, being a girl, and doing a lot of reading and close work.

Myopic 33-37-year-old men had lighter body structure, lower body fat content, and better physical fitness and aerobic capacity than the nonmyopic. They also scored better in cognitive tests than the non-myopic. These differences in the myopic could mainly be explained by higher education, higher occupational status, and greater interest in physical exercise during leisure as adults.

The mean refraction of the 26-year-olds was about 1 D. more myopic than that of the 46-year-olds. It seems that myopia has increased during recent decades in Finland.

The prevalence of myopia among the group of 26- and 46-year-olds studied whose primary education was higher secondary was 47 % whereas it was 18 % among those whose primary education was elementary. The mean refraction for the groups respectively was -0,70 D. and +0,63 D.

Among 26- and 46-year-olds as a whole those in leading positions the mean refraction was  $-0.49$  D. whereas the unskilled or semi-skilled in manufacturing or services had a mean refraction of  $+0.49$  D. and farmers  $+0.33$  D.

The myopic and hyperopic had more astigmatism than the emmetropic. New cases of myopia seemed to begin at all ages up to 46. 26-33% of people at the age of 26 years had received their first spectacles at 20 years or later. Myopia had obviously begun in adulthood among most of them.

The degree of myopia was the higher the earlier it had begun.



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## 10. DEFINITIONS AND SYMBOLS

accommodation process by which the refractive power of the lens is increased through contraction of the ciliary muscle, causing an increased thickness and curvature of the lens.

accommodometer an instrument to measure the amount of accommodation.

aerobic capacity maximal oxygen uptake during exercise.

ametropia optical condition in which parallel rays of light do not focus on the retina; a refractive error.

anaerobic capacity is estimated at the end of exercise by  $\text{CO}_2$ -production and ventilation curves and by the accumulation of lactate in capillary blood.

aniseikonia optical condition in which the retinal images in the two eyes are of different sizes.

anthropometric deals with the size, weight, and various dimensions of the body.

aphacia absence of the crystalline lens of the eye.

astigmatism optical condition in which the refractive power is not uniform in all meridians.

autosomal a property which is connected with any ordinary paired chromosome as distinguished from a sex chromosome.

biological theory a theory which regards heredity as the main cause of ocular refraction.

bifocal lens spectacles which contain two different foci.

cataract opacity of the lens of the eye.

cognitive test various tests of "intelligence".

convergence a deviation of the eyes inwards to retain single binocular vision.

cornea the transparent anterior part of the outer supporting coat of the eye.

cross-cylinder a mixed cylindrical combination of varying strengths in which the spherical component is one half the power of the cylindrical with the axes at right angles.

cycloplegia paralysis of the ciliary muscle preventing accommodation.

cylinder a lens having no refracting power in one meridian and maximal refracting power at the meridian at right angles to this.

D. see diopetre.

dark adaptation biochemical and neurologic process by which the eye becomes more sensitive to light.

df. degrees of freedom.

diopetre (D.) unit of measurement of the refractive power of lenses equal to the reciprocal focal length of the lens expressed in meters.

dizygotic pertaining to or derived from two separate zygotes; union of male and female cell in sexual reproduction.

emmetropi/a/c refractive condition in which no refractive error is present with accommodation at rest.

F female(s).

fogging a method of refraction using positive lenses in front of the eyes to make distant vision foggy.

f frequency of cases.

fusion the stimulus of which is the simultaneous stimulation of the two retinas by two images of an object.

hematologic pertaining to blood and blood-forming tissues.

heterophoria condition in which a latent tendency of the eyes to deviate is prevented by fusion.

hyperopi/a /c (= hypermetropia) refractive state of the eye in which the parallel rays of light would come to focus behind the retina if not intercepted by it.

isometric strength mechanical power of the muscle to contract.

lens glass or other transparent material used optically to modify the path of light.

lens a transparent structure of the eye located immediately behind the iris.

M male(s).

M. mean.

monozygotic pertaining to or derived from one zygote; union of male and female cells in sexual reproduction.

multifactorial inheritance arising as a result of the interaction of several genes.

multifocal lens spectacles which contain more than two different foci.

myopi/a/c optical condition in which parallel rays of light come to focus in front of the retina.

n number of cases.

non-myopic person whose eyes are not myopic but hyperopic or emmetropic.

orthoptic a state of eye muscle balance.

presbyopi/a/c refractive condition in which there is a diminished power of accommodation arising from impaired elasticity of the crystalline lens, as occurs with aging.

refraction deviation of rays of light when passing from one transparent medium into another of a different density. It is also the act or process of refracting; specifically the determination the refractive errors of the eye and their correction by glasses.

retina the innermost layer of the three tunics of the eyeball.

SD standard deviation.

sfe. spherical equivalent.

spectacles a pair of lenses in a frame to assist vision.

spheric/al pertaining to a sphere; sphere-shaped.

spheric/al equivalent the algebraic sum of the spherical power of the lens system and half the power of the cylinder.

torticollis a contracted state of the cervical muscles, producing twisting of the neck and an unnatural position of the head.

use-abuse theory which says that use of eyes in reading and close work will induce myopia in some subjects.

vitreous a transparent gel in the eye behind the lens.

vision ability to distinguish light in the visible spectrum and different objects. Result of vision tests are in this study expressed as decimal numbers and 1.0 or more is regarded as normal or good vision.

Y. year(s).

Yrs. years.



## 11. APPENDIXES

Appendix 1. Distribution of occupations among 26- and 46-year-old respondents and non-respondents. Occupational groups: I = higher managerials or others in leading positions, II = lower managerials, III = skilled industrial workers or persons engaged in service trades, IV = semi-skilled or non-skilled workers or persons engaged in service trades, V = farmers or agricultural workers, VI = students, VII = house wives. Re = percentage of occupational group in responses, Po = percentage of occupational group among non-respondents. The percentages of non-respondents was taken from the register of population.

Occupational group	Men				Women			
	Age (yrs.)				Age (yrs.)			
	26		46		26		46	
	Re	Po	Re	Po	Re	Po	Re	Po
I	3,8	3,3	11,1	9,1	3,2	2,5	3,2	3,4
II	23,7	21,1	28,0	26,6	46,6	41,7	30,3	31,0
III	31,8	33,5	28,7	30,3	7,2	7,6	9,1	9,3
IV	23,8	24,4	24,5	25,3	21,2	26,2	43,2	42,9
V	2,6	2,4	6,5	6,9	1,3	1,2	6,3	5,7
VI	12,9	14,2	0,0	0,2	12,5	13,3	0,2	0,2
VII	0,0	0,0	0,0	0,0	7,2	6,6	6,1	5,8
Other	1,4	0,1	1,2	0,6	0,8	0,9	1,6	1,7
Together	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0
Total (n)	743	935	478	636	760	953	554	641
Unknown (n)	0	81	3	5	0	28	5	34

Appendix 2. List of variables from questionnaire  
given to 7-, 11- and 15-year-olds

Sex

1. Boy
2. Girl

Distant vision without spectacles

1. Good
2. Poor

Distant vision with spectacles

1. Good
2. Poor

Distant vision without and with spectacles

1. Good without and with spectacles
2. Good without and poor with spectacles
3. Poor without and with spectacles
4. Poor without and good with spectacles

Eye-strain without spectacles in near vision

1. None
2. Tired
3. Headache
4. Poor vision, fogging
5. Tired and headache
6. Tired and poor vision
7. Tired, headache and poor vision
8. Headache and poor vision

Eye-strain with spectacles

- 1.-8. Same as without spectacles

## Receiving spectacles

1. None
2. Yes
3. Contact lenses

## Age at receiving first spectacles, years

0. If no spectacles

## Age at receiving last spectacles, years

0. No spectacles
1. First spectacles still in use

## How many pairs of spectacles have been received?

## Prescribed use of spectacles

1. Continuously
2. For distant vision
3. For near vision
4. Do not remember
5. Ordered to discontinue using spectacles
6. Prescribed for use only for accurate near or distant vision
7. Prescription, but no spectacles bought
8. Prescribed for use outdoors

## Compliance with prescription for spectacles

1. As prescribed
2. Prescription not complied with
3. Do not know
4. Worn continuously
5. Worn for near vision
6. Worn for distant vision
7. Ceased wearing

8. Worn very occasionally
9. Not get purchased

Answers to the following eight questions

0. 0 hours
1. 1/2 an hour
2. 1 hour
3. 1 1/2 hours
4. 2 hours
5. 2 1/2 hours
6. 3 hours
7. 3 1/2 hours
8. 4 hours
9. more than 4 hours

Doing homework on days of school attendance

Doing homework during weekends and holidays

Other close work on days of school attendance

Other close work during weekends and holidays

Watching television on days of school attendance

Watching television during weekends and holidays

Outdoor activities and sports on days of school attendance

Outdoor activities and sports during weekends and holidays

Time spent indoors as compared with age fellows

1. More
2. The same
3. Less
4. Cannot say

Position during reading

1. Sitting
2. Lying on belly
3. Lying on back
4. Various
5. Other

Reading distance

1. Near
2. Normal
3. Far

Mean ability in all subjects at school

Mean ability in academic subjects at school

Father's year of birth

Father's occupation

1. Higher managerial
2. Lower managerial
3. Skilled industrial or service trade
4. Unskilled or semi-skilled industrial or  
service trade
5. Farmer or agricultural worker
- 6.7. Studying or training

**Father's wearing of spectacles**

1. Yes
2. No
3. Do not know
4. Has spectacles but does not wear

**Father's last spectacles**

0. No spectacles
1. Reading only
2. Distant vision
3. Continuous use
4. Bifocal, trifocal etc.
5. Do not know
6. Does not wear

**Father's age on receiving first spectacles****Father's first spectacles prescribed for poor distant vision**

1. No spectacles
2. For poor distant vision
3. For other reasons
4. Do not know

**Mother's year of birth****Mother's wearing of spectacles**

1. Yes
2. No
3. Do not know

**Mother's last spectacles**

(Same variables as fathers)

Mother's age on receiving first spectacles

Mother's first spectacles prescribed for poor distant  
vision

(Same variables as fathers)

Number of children in family

Number of siblings wearing spectacles

Appendix 3. List of variables from written questions given to 12-year-olds in connection with clinical examination

Effect of eye-symptoms or spectacles on reading

1. No effect
2. Eye-strain is diminishing reading
3. Dimming of vision is diminishing reading
4. Eye-strain after reading
5. Headache during reading
6. Eyes watering during reading
7. Difficulties in understanding reading
8. Difficulties in near and distant vision disturb reading

Time of reading as compared with age peers

1. Less
2. The same
3. More
4. Cannot say

Time spent on outdoors activities as compared with age peers

1. Less
2. The same
3. More
4. Cannot say



Appendix 4. List of variables from questionnaire  
given to 26- and 46-year-olds

Basic education

1. Elementary school
2. Lower secondary
3. Higher secondary
4. No schooling

Vocational training

1. None
2. Vocational courses
3. Vocational school
4. College education
5. University

Own opinion about health of eyes

1. Healthy
2. Not healthy
3. Eye-strain, smarting, itching
4. Poor near vision
5. Poor distant vision
6. Suffer from dazzle
7. Allergic
8. Muscae volitantes
9. Dryness, epiphora etc.

Wearing of spectacles

1. No
2. Yes

Distant vision without spectacles

1. Good
2. Poor

Effect of spectacles on distant vision

1. Better with spectacles
2. Not better with spectacles

Near vision without spectacles

1. Good
2. Poor

Effect of spectacles on near vision

1. Better with spectacles
2. Not better with spectacles

Age at receiving first spectacles, years

0. No spectacles

Last spectacles received in year

0. No spectacles
1. First spectacles still in use

Last spectacles ordered for

0. No spectacles
1. Continuous use
2. Reading only
3. Distant vision
4. Bifocals, trifocals etc.
5. Do not know

Spectacles worn as prescribed

1. Yes
2. No
3. Do not know
4. Worn continuously

5. Worn for close work
6. Worn for distant vision
7. Not worn at all nowadays
8. Worn very occasionally
9. No prescription received

Occupation

1. Higher managerial
2. Lower managerial
3. Skilled industrial or service trade
4. Unskilled or semi-skilled industrial or service trade
5. Farmer or agricultural worker
6. Studying or training
7. Housewife

Accurate near vision needed in work

1. Yes
2. No

Category of accurate close work mainly done daily

0. No accurate close work
1. Reading and writing
2. Visual display unit
3. Industrial quality control
4. Sewing, drawing, or other accurate close work

Proportion of accurate close work out of daily working time

1. Most of daily working time
2. About half of daily working time
3. Less than half of daily working time

4. Occasionally during working day
5. No accurate close work

Fathers occupation

Classification same as own occupation

Sex

1. Male
2. Female

Appendix 5. List of variables from questionnaire given to 26- and 46-year-olds in connection with clinical examination

Interest in reading at school age as compared with age peers.

1. Less
2. Same
3. More
4. Cannot say

Did factors connected with vision or spectacles or lack of spectacles have any effect on reading at school age?

1. No
2. Poor distant vision increased reading
3. Poor near vision or eye-strain  
diminished reading
4. Spectacles disturbed outdoor activities  
and increased reading

Interest in outdoor activities at school age as compared with age peers

1. Less
2. Same
3. More
4. Cannot say

Effect of vision or spectacles on outdoor activities at school age

1. No effect
2. Poor distant vision diminished outdoor activities
3. Eye-strain in reading increased outdoor activities
4. Spectacles disturbed outdoor activities

Municipality of residence

Municipality of birth

Appendix 6. Frequencies for loglinear model in figure 5. The table shows the numbers (n) of 26- and 46-year-old men doing accurate close work (ACW) and not doing accurate close work (NAW) in their everyday employment in different occupations. The percentages of these men in different occupations doing accurate close work are also shown. Occupational groups: I higher managerials or others in leading positions, II lower managerials, III skilled industrial workers or persons engaged in service trades, IV semi-skilled or non-skilled workers or persons engaged in service trades, V farmers or agricultural workers, VI students.

Age (yrs.)	Close work	Occupation					
		I	II	III	IV	V	VI
26	ACW (n)	26	151	136	87	6	92
	NAW (n)	2	25	98	90	13	4
46	ACW (n)	50	120	91	69	16	0
	NAW (n)	3	14	47	49	15	0
26	ACW + NAW (n)	28	176	234	177	19	96
	$\frac{ACW \times 100}{ACW + NAW}$ (%)	93	86	58	49	32	96
46	ACW + NAW (n)	53	134	138	118	31	0
	$\frac{ACW \times 100}{ACW + NAW}$ (%)	94	90	66	58	52	0

Scaled deviance = .65, df = 5, p > .95.

Appendix 7. Frequencies for loglinear model in figure 6. The table shows the numbers (n) of 26- and 46-year-old-women doing accurate close work (ACW) and not doing accurate close work (NAW) in their everyday employment in different occupations. The percentages of men in different occupations doing accurate close work are also shown. Occupational groups: I higher managerials or others in leading positions, II lower managerials, III skilled industrial workers or persons engaged in service trades, IV semi-skilled or non-skilled workers or persons engaged in service trades, V farmers or agricultural workers, VI students, VII house wives.

Age (yrs.)	Close work	Occupation						
		I	II	III	IV	V	VI	VII
26	ACW (n)	22	302	41	78	4	94	11
	NAW (n)	2	52	13	82	6	1	42
46	ACW (n)	18	159	41	119	12	0	5
	NAW (n)	0	10	10	122	23	0	25
26	ACW + NAW (n)	24	354	54	160	10	95	35
	$\frac{ACW \times 100}{ACW + NAW}$ (%)	92	85	76	48	40	99	21
46	ACW + NAW (n)	18	169	51	241	35	0	30
	$\frac{ACW \times 100}{ACW + NAW}$ (%)	100	94	80	49	32	0	17

Scaled deviance = 10.68, df = 7, p > .10.

Appendix 8. Frequencies for loglinear model in figure 8. The table shows the numbers (n) of 46-year-old-men and women in different occupations who regarded their near vision as poor or good. The percentages of those having poor near vision in different occupations are also shown. Occupational groups: I higher managerials or others in leading positions, II lower managerials, III skilled industrial workers or persons engaged in service trades, IV semi-skilled or non-skilled workers or persons engaged in service trades, V farmers or agricultural workers, VI students.

Sex	Near vision	Occupation					
		I	II	III	IV	V	VI
Men	Poor (n)	35	73	101	79	14	0
	Good (n)	18	59	37	38	17	0
Women	Poor (n)	14	116	37	180	26	26
	Good (n)	4	53	12	56	9	8
Men	All (n)	53	132	138	117	31	0
	Poor (%)	66	55	73	67	45	0
Women	All (n)	18	169	51	236	35	34
	Poor (%)	78	69	77	76	74	76

Scaled deviance = 7,51, df = 10, p > 50.



Appendix 9. Frequencies for loglinear model in figure 9. The table shows the numbers (n) of 26-year-old men and women in different close work categories with ocular symptoms of some kind. The percentages (%) of those having symptoms in close work categories are also shown. Classification of close work: RW = reading and writing, VDU = visual display unit work, IQC = industrial quality control, OAW = other accurate close work, NAW = no accurate close work.

Sex	Ocular symptoms	Close work category				
		RW	VDU	IQC	OAW	NAW
Men	Yes (n)	23	6	10	14	26
	No (n)	229	22	97	91	210
Women	Yes (n)	51	8	6	13	22
	No (n)	320	39	27	75	178
Men	All (n)	252	28	107	105	236
	Symptoms (%)	9	21	9	13	11
Women	All (n)	371	47	33	88	200
	Symptoms (%)	14	17	18	15	11

Scaled deviance = 9.09, df = 9, p > 50.

Appendix 10. Frequencies for loglinear model in figure 10. The table shows the numbers (n) of 46-year-old men and women in different close work categories with ocular symptoms of some kind. The percentages (%) of those having symptoms in close work categories are also shown. Classification of close work: RW = reading and writing, VDU = visual display unit work, IQC = industrial quality control, OAW = other accurate close work, NAW = no accurate close work.

Sex	Ocular symptoms	Close work category				
		RW	VDU	IQC	OAW	NAW
Men	Yes (n)	24	1	27	6	33
	No (n)	142	13	86	25	96
Women	Yes (n)	34	3	15	12	44
	No (n)	173	28	46	35	144
Men	All (n)	166	14	113	32	129
	Symptoms (%)	15	7	24	19	26
Women	All (n)	207	31	61	47	188
	Symptoms (%)	16	10	25	26	23

Scaled deviance = .89, df = 5, p > .95.





Appendix 13. Frequencies for loglinear model in figure 24. The table shows the numbers (n) of 26-year-old men and women with spectacles in three educational groups. The wearing of spectacles is shown separately for those having poor distant vision and for those having good distant vision. Formal education: 1 = elementary, 2 = lower secondary, 3 = higher secondary.

Education	Spectacles	Distant vision			
		Poor		Good	
		Men	Women	Men	Women
1	No	1	4	226	99
	Yes	22	42	25	26
2	No	7	15	185	107
	Yes	60	80	20	44
3	No	6	6	97	144
	Yes	83	169	7	46

Scaled deviance = .82, df = 2, p > .50.

Appendix 14. Frequencies for loglinear model in figure. 25. The table shows the numbers (n) of 46-year-old men and women with spectacles in two educational groups. The wearing of spectacles is shown separately for those having poor distant vision and for those having good distant vision. Formal education: 1 = elementary, 2 = lower secondary, 3 = higher secondary.

Education	Spectacles	Distant vision			
		Poor		Good	
		Men	Women	Men	Women
1	yes	63	129	144	184
	no	6	11	172	78
2 and 3	yes	23	54	41	75
	no	1	0	26	19

Scaled deviance = 5.02, df = 5, p > .30.

Appendix 15. Frequencies for the loglinear model in figure 26. The table shows the numbers (n) of 26-year-old men and women with spectacles in three different educational groups. The wearing of spectacles is shown separately for those doing accurate close work and for others. Formal education: 1 = elementary, 2 = lower secondary, 3 = higher secondary.

Education	Spectacles	Accurate close work			
		Yes		No	
		Men	Women	Men	Women
1	Yes	30	36	17	31
	No	109	50	112	50
2	Yes	62	92	18	30
	No	121	87	70	35
3	Yes	82	178	8	36
	No	90	101	13	18

Scaled deviance = 11.87, df = 9, p > .30.

Appendix 16. Frequencies for loglinear model in figure 27. The table shows the numbers (n) of 46-year-old men and women with spectacles in two educational groups. The wearing of spectacles is shown separately for those doing accurate close work and for others. Formal education: 1 = elementary, 2 = lower secondary, 3 = higher secondary.

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Education	Spectacles	Accurate close work			
		Yes		No	
		Men	Women	Men	Women
1	Yes	153	186	54	126
	No	104	36	73	53
2 and 3	Yes	61	117	3	11
	No	21	15	6	4

---

Scaled deviance = 3.39, df = 5, p > .50.



Appendix 17. Frequencies for loglinear models in figure 32. The table shows the numbers (n) of myopic and non-myopic 11-year-old boys and girls in three hereditary groups: -- = both parents have good distant vision, +- = one of parents has poor distant vision, ++ = both parents have poor distant vision. Numbers are given separately for each hereditary group in three groups according to daily reading and close work (RW).

---

Heridity	--			+-			++		
	<2	2-4	>4	<2	2-4	>4	<2	2-4	>4
<u>Boys</u>									
Myopic (n)	7	7	12	7	10	15	2	4	2
Non-myopic (n)	121	120	102	59	79	45	10	16	11
<u>Girls</u>									
Myopic (n)	8	21	22	5	8	30	3	7	13
Non-myopic (n)	43	139	101	25	66	70	2	10	12

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Boys: Scaled deviance = 9.21, df = 6, p > .10.

Girls: Scaled deviance = 3.58, df = 6, p > .30.

Appendix 18. Frequencies for loglinear models in figure 33. The table shows the numbers (n) of myopic and non-myopic 15-year-old boys and girls in three hereditary groups: -- = both parents have good distant vision, +- = one of parents has poor distant vision, ++ = both parents have poor distant vision. Numbers are given separately for each hereditary group in three groups according to daily reading and close work (RW).

Hereditiy	--			+-			++		
	<2	2-4	>4	<2	2-4	>4	<2	2-4	>4
<u>Boys</u>									
Myopic (n)	24	15	11	18	12	9	7	3	15
Non-myopic (n)	195	79	46	79	23	12	7	7	2
<u>Girls</u>									
Myopic (n)	40	49	59	22	30	32	3	4	6
Non-myopic (n)	92	115	91	43	43	30	5	3	5

Boys: Scaled deviance = 3.69, df = 6, p > .30.

Girls: Scaled deviance = 8.05, df = 6, p > .20.

Appendix 19. Distribution of spherical equivalent (Sfe.) in the clinical sample of 26- and 46-year-olds.

Sfe. D.	26-year-olds				46-year-olds				
	Men		Women		Men		Women		
	n	%	n	%	n	%	n	%	
- 8,5 - 8,99			1	1,0	2	1	0,7		1
- 8,0 - 8,49	1	1,0	0	0,0	0	0,0	0	0,0	
- 7,5 - 7,99	0	0,0	0	0,0	0	0,0	0	0,0	
- 7,0 - 7,49	1	1,0	0	0,0	0	0,0	0	0,0	0
- 6,5 - 6,99	1	1,0	0	0,0	0	0,0	0	0,0	
- 6,0 - 6,49	2	1,9	0	0,0	0	0,0	0	0,0	0
- 5,5 - 5,99	1	1,0	1	1,0	0	0,0	1	0,8	2
- 5,0 - 5,49	1	1,0	1	1,0	4	1	0,7	0	0,0
- 4,5 - 4,99	0	0,0	4	3,8	0	0,0	1	0,8	
- 4,0 - 4,49	1	1,0	2	1,9	0	0,0	1	0,8	2
- 3,5 - 3,99	3	2,9	2	1,9	19	2	1,5	0	0,0
- 3,0 - 3,49	5	4,9	9	8,6	0	0,0	2	1,6	4
- 2,5 - 2,99	2	1,9	1	1,0	0	0,0	1	0,8	
- 2,0 - 2,49	4	3,9	6	5,7	10	2	1,5	0	0,0
- 1,5 - 1,99	2	1,9	0	0,0	10	2	1,5	2	1,6
- 1,0 - 1,49	2	1,9	9	8,6	10	1	0,7	3	2,5
- 0,5 - 0,99	6	5,8	4	3,8	27	8	6,0	11	9,2
- 0,0 - 0,49	13	12,6	4	3,8	27	5	3,7	6	5,0
+ 0,0 - 0,49	10	9,7	18	17,1	70	19	14,2	21	17,3
+ 0,5 - 0,99	22	21,4	23	21,9	70	39	29,1	24	19,9
+ 1,0 - 1,49	19	18,4	18	17,1	42	29	21,6	24	19,9
+ 1,5 - 1,99	3	2,9	2	1,9	42	8	6,0	15	12,4
+ 2,0 - 2,49	1	1,0			1	8	6,0	2	1,6
+ 2,5 - 2,99	0	0,0			1	0	0,0	3	2,5
+ 3,0 - 3,49	0	0,0			0	0	0,0	2	1,6
+ 3,5 - 3,99	0	0,0			0	0	0,0	0	0,0
+ 4,0 - 4,49	2	1,9			3	3	2,2	0	0,0
+ 4,5 - 4,99	1	1,0			3	0	0,0	0	0,0
+ 5,0 - 5,49					1	1	0,7	0	0,0
+ 5,5 - 5,99					1	1	0,7	0	0,0
+ 6,0 - 6,49					0	0	0,0	0	0,0
+ 6,5 - 6,99					0	0	0,0	2	1,6
+ 7,0 - 7,49					0	0	0,0	0	0,0
+ 7,5 - 7,99					1	1	0,7	0	0,0
Together	103	100	105	100	134	100	121	100	

208

255

463

1500

14,7%

Appendix 20. Frequencies for loglinear model in figure 36. The table shows the numbers (n) of myopic and non-myopic 26- and 46-year-old men and women in two educational groups. Formal education: 1 = primary, 2 = lower secondary, 3 = higher secondary. M = males, F = females.

---

Education	Myopic				Non-myopic			
	26-year-old		46-year-old		26-year-old		46-year-old	
	M	F	M	F	M	F	M	F
1 and 2	9	16	12	18	51	31	87	72
3	27	27	13	10	16	29	22	20

---

Scaled deviance = 4.57, df = 4, p > .30.

Appendix 21. Frequencies for loglinear model in figure 37. The table shows the numbers (n) of myopic and non-myopic men and women doing accurate close work and not doing accurate close work in their daily employment in three educational groups. Formal education: 1 = primary, 2 = lower secondary, 3 = higher secondary. M = myopic, N-M = non-myopic.

Education	Accurate close work							
	Yes				No			
	Men		Women		Men		Women	
	M	N-M	M	N-M	M	N-M	M	N-M
1	11	57	14	33	3	44	11	43
2	7	22	5	16	1	12	3	11
3	37	34	30	45	3	4	7	4

Scaled deviance = 14.44, df = 11, p > .20.

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