Acta Ophthalmologica

Acta Ophthalmologica 2021

Associations of near work time, watching TV, outdoors time, and parents' myopia with myopia among school children based on 38-year-old historical data

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ABSTRACT.

Purpose: **To study the prevalence and risk factors of myopia with data from a questionnaire study conducted in 1983 among Finnish school children.**

Methods: **School children (n = 4 961) from the 1st, 5th and 8th grades of school (7-, 11- and 15-year-olds) in Central Finland were screened for vision followed by a questionnaire, which was returned by 4 352 (87.7%) participants. Myopia was categorized based on the questionnaire. Items concerned daily time spent on near work and outdoor activities, excluding time spent at school, watching TV and parental myopia and the associations of myopia with these factors were studied.**

Results: **The prevalence of myopia was 3%, 15% and 27% among the 7-, 11- and 15-year-olds, and if daily near work at home was ≤1 hr, myopia prevalence was 0.5%, 3.3% and 17.6%, respectively. The adjusted risk of myopia for each daily near work hour was OR 1.476 (95% confidence interval 1.099–1.984, p = 0.010), OR 1.346 (1.170–1.584, p < 0.001) and OR 1.206 (1.076–1.352, p = 0.001), in the 3 age groups, respectively. The adjusted risk of myopia for each daily hour spent outdoors was OR 0.764 (0.648–0.900, p = 0.001) in the 11-year-olds and OR (0.840, 0.743–0.950, p = 0.005) in the 15-year-olds. Outdoors time prevented myopia at different levels of near work, although less at the highest levels, and near work increased risk of myopia with the level of outdoors time. If the ratio between near work and outdoors time was ≤0.5 or >1.5, the prevalence of myopia was 1.4% versus 5.6%, 6.3% versus 24.7% and 15.9% versus 36.9%, among the 7-, 11- and 15-year-olds, respectively. The higher prevalence of myopia among the 11- and 15-year-old girls than boys was explained by more near work and less outdoor time among the girls. Having two myopic parents roughly doubled the risk of myopia compared to if one myopic parent in the 11- and 15-year-olds.**

Conclusions: **Myopic parents, greater near work time, less outdoors time, a higher near work/outdoors ratio, and being a girl increased the risk of myopia. Myopia was rare in the 7- and 11-year-olds if daily near work at home did not exceed one hour or if the near work/outdoors ratio was not higher than 0.5. Outdoors time was associated with the prevalence of myopia at all levels of near work, although the association was weaker at the highest level.**

Key words: near work – outdoors – parents' myopia – questionnaire – risk factors of myopia

Acta Ophthalmol.

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doi: 10.1111/aos.14980

Introduction

The prevalence of myopia has significantly increased during recent decades. In 2016, the WHO estimated that 1.89 billion people worldwide were myopic and predicted that, at current rates, this would rise to 2.56 billion by 2020 (WHO Report Myopia 2016). It has been estimated that by 2050 myopia will affect 4758 million people (49.8% of the world population), of whom 938 million will have high myopia (Holden et al. 2016). Increased myopia has been reported in the United States (Vitale et al. 2009), Europe (Williams et al. 2015), Finland (Pärssinen 2012) and numerous other countries. The increase has been most marked in many East and South Asian countries. It has been estimated that in East Asia, 80–90% of secondary school-leavers are myopic and as many as 10–20% have high myopia (Morgan et al. 2018). The major public health concerns connected with myopia are related complications, and the studies suggest that there is no safe threshold level of myopia for any of the known ocular complications connected with myopia (Flitcroft 2012; Haarman et al. 2020). Myopia increases the risk of pathological ocular changes such as cataract, glaucoma, retinal detachment and myopic macular degeneration, all of which can cause irreversible vision loss (Fricke et al. 2018). Myopic maculopathy is already one of the leading causes of low vision and blindness among working-aged adults in China

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(Xu et al. 2006; Wu et al. 2011). Globally, myopia is the most common cause of moderate and severe visual impairment, and the second most common cause of blindness (Bourne et al. 2013; Holden et al. 2016; Dolgin 2015).

Epidemiological studies have long shown associations between education, near work, higher occupational status, and attending school (Kepler 1611; Cohn 1867; Tscherning 1883). Several studies have since shown an association of myopia with more time spent in reading and near work and less time in outdoor activities (Pärssinen 1986; Huang et al. 2015; Xiong et al. 2017; He et al. 2015, and many others). The Sydney Myopia Study on 6- and 12-year-old school children showed that higher levels of total time spent outdoors, rather than sport per se, were associated with less myopia and a more hyperopic mean refraction (Rose et al. 2008). While most studies suggest that the rate of myopic progression among the already myopic is little influenced by differences in near work and outdoor time (Saw et al. 2000; Jones-Jordan et al. 2012), some studies have shown that this relationship also influences the progression of myopia (Pärssinen & Lyyra 1993).

During recent decades, numerous theories have been presented on the possible influence of different environmental factors on the increase in the prevalence of myopia, but no consensus has been reached on which factors and how they influence myopia; whether myopia is due more to increased reading and near work, use of mobile devices, spending more time indoors or less time outdoors, or lack of exposure to sunshine.

The main aim of this study was to examine the associations of near work, outdoors time, and parental myopia with the prevalence of myopia, defined as poor uncorrected distant vision, among different aged school children, and the mutual effects of these factors on the prevalence of myopia by reanalysing data collected by questionnaire for a study conducted in 1983 in Central Finland (Pärssinen 1986).

Materials and Methods

According to the law on basic health services in Finland, all schoolchildren must be given health examinations, including screening for vision, in the 1st, 3rd, 5th and 8th grades of school (ages 7–8, 9–10, 11–12 and 14–15 years). This study further analyses questionnaire data gathered on schoolchildren in 1983 for a study that formed part of the doctoral thesis (monograph) of one of the present authors (Pärssinen 1986). The original study included all schoolchildren ($n = 4961$) in the 1st, 5th and 8th grades, henceforth 7-, 11- and 15-year-olds, resident in the same area of Central Finland. School nurses measured visual acuity from a 5-meter distance using an E-chart, without and, if any, with spectacles. If the best distant vision at screening was ≤0.7 (Snellen notation) in either eye, the child was referred for an ophthalmological examination. At the same time, the children were given a questionnaire to be completed together with parents. The questionnaire was sent to 4 961 children's parents and returned by 4344 (87.6%). Table 1 shows the number of questionnaires sent and returned by age group. All the children were native Finns (Caucasians).

Table 1. Study subjects.

Age, years	Questionnaires sent, *N*	Questionnaires replied, *N* (%)		
		N (%)	Boys, *N* (%)	Girls, *N* (%)
7	1 716	1 589 (92.6)	793 (49.9)	796 (50.1)
11	1 494	1 384 (86.8)	719 (52.0)	665 (48.0)
15	1 751	1 378 (78.7)	664 (46.7)	734 (53.3)
Total	4 961	4 361 (87.9)	2 176 (49.9)	2 195 (50.1)

The questionnaire on the children included items on (among other things) sex, near and distant vision, whether good or poor without or with spectacles, age of receiving first and last spectacles and the purpose of spectacles, i.e., to improve either near and/or distant vision. Other items concerned daily time spent doing homework, reading and other near work (sum of these = near work), time spent watching TV and time spent in outdoor activities and sports (= outdoors). The time spent on such activities at school was not included. All time estimates were to be given within the nearest half hour on a scale from 0 to 4.5 hr or more (categorized as 4.5 hr) separately for school days and weekends. Mean daily near work time and outdoors time were calculated from these time variables. In the >3 hr group, the mean and SD of daily near work time was 3.63 (0.52), 3.93 (0.73) and 3.93 (0.71) hours and the mean and SD of daily outdoors time 3.68 (0.42), 3.73 (0.43) and 3.69 (0.45) hours in the 7-, 11- and 15-year-olds, respectively. The ratio between near work time and outdoors time was also calculated (near work/outdoors). Near work and outdoor values of 0 were re-coded as 0.1 for the calculation of the near work/outdoor ratio. The time variables were treated in the analyses as both continuous and categorical variables.

Fathers and mothers were asked (among other things) about their basic education and vision. The items on vision were the same as those for their children.

Children and parents were deemed myopic if they had poor distant vision and good near vision without spectacles and, if they had spectacles, whether these improved their distant but not near vision. Those parents who had received their first spectacles for poor distant vision at the age of 35 or older were regarded as non-myopic. Parents' myopia was categorized into three groups: no myopic parents, and one or both parents myopic.

In 49 responses (1.1%), the questionnaire provided insufficient information for identifying myopia for children, and these cases were excluded.

The reliability of the questionnaire answers on distant vision of children was controlled for by comparing these with the results of the vision test administered by the school nurses to a random sample of children ($n = 354$). The sensitivity of the questionnaire to poor distant vision (≤0.7) in this comparison was 86% and specificity 84%.

The study was approved by the Ethics Committee of the Central Hospital of Central Finland. The participants consented to participate in the

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study at the same time as returning the questionnaire. The research followed the tenets of the Declaration of Helsinki.

Statistical analyses

The significance of differences between categorical variables was tested by cross-tabulation, and Chi-square test for discrete variables (e.g., prevalence of myopia). Somers' delta (Somers' D) was used to test the strength and direction of associations between the graded values of near work, outdoors and the near work/outdoors ratio with the prevalence of myopia. In the case of continuous variables (e.g., time spent on different activities), Student's t-test was used to compare myopic groups or differences between boys and girls. The significance of differences between age groups in the near work/outdoors ratio was tested by one-way ANOVA with the LSD post-hoc procedure for the pairwise comparisons of means.

Predictors of myopia were studied using multiple logistic regression models. Time spent on near work, time spent on outdoor activities, and sex were used as predictors in models. General statistical analyses were performed using IBM SPSS version 24.0 (SPSS Inc., Chicago, IL) software and Stata version 12.0 (Stata Corp., College Stations, TX, USA). The level of statistical significance was set at $p < 0.05$ (two-sided).

Results

The prevalence of myopia was 3.2, 15.4 and 27.2% among the 7-, 11- and 15-year-olds, respectively. The prevalence of children in the same age groups who, prior to screening, had spectacles that improved distant, but not near, vision and had been prescribed by an ophthalmologist was 2.7%, 10.3% and 22.7%.

The father was myopic in 13.7% and the mother in 26.3% of cases, one parent was myopic in 30.4% of cases and both parents were myopic in 4.8% of cases. Myopia in parents (no, one, two myopic parents) was not associated with myopia in their children in the 7-year-olds (Chi-Square, $p = 0.945$). The association was significant in the 11- and 15-year-olds ($p < 0.001$ in both age groups). Both fathers' and mothers' myopia was associated with a higher level of basic education ($p < 0.001$ for both). However, no significant associations were found between parents' basic education and their children's myopia.

The prevalence of myopia was not significantly different between the 7-year-old boys and girls. However, it was approximately twice as high among girls than boys in the 11- and 15-year-olds and was highest, 35%, among the 15-year-old girls (Table 2).

In all the children, mean daily near work time was 2.28 (±1.04) hours, TV viewing time 1.63 (±0.86) hours and outdoors time 2.54 (±1.00) hours. The myopic children spent significantly more time in near work and less time in outdoor activities than the non-myopic children (Table 2). An exception was the group of 7-year-old girls, where the differences between the myopic and non-myopic children were statistically non-significant.

The mean value of the near work/outdoors time ratio was 0.21–0.38 higher among the myopic than non-myopic children (Table 2).

TV viewing time was not associated with myopia in any age group (Table 2).

The binary logistic regression models showed that, in the 11- and 15-year-old boys and girls, myopia risk increased with more daily near work time and decreased with more daily outdoors time (Table 3). The difference in the prevalence of myopia between the sexes was mainly explained by differences in near work time and outdoors time.

Predictors of myopia were studied using multiple logistic regression models. Sex, time spent on near work, time spent on outdoor activities, and parents' myopia were used as predictors in models (Table 4). Among the 7-year-olds (Model 1), near work significantly increased the risk of myopia. The opposite, although non-significant, effect was found for outdoors hours. Parents' myopia and sex were not statistically significant predictors of

Table 2. Prevalence of myopia, time spent daily in near work and outdoors, the near-work/outdoors ratio and time watching TV among non-myopic and myopic boys and girls.

	7-year-olds				11-year-olds				15-year-olds			
Variable	Boys		Girls		Boys		Girls		Boys		Girls	
Prevalence of myopia	Non-myopic $n = 56$	Myopic $n = 25$ 3.2%	Non-myopic $n = 55$	Myopic $n = 26$ 3.3%	Non-myopic $n = 634$	Myopic $n = 74$ 10.5%	Non-myopic $n = 524$	Myopic $n = 137$ 20.7%	Non-myopic $n = 523$	Myopic $n = 117$ 18.3%	Non-myopic $n = 476$	Myopic $n = 256$ 35.0%
Near- work, hrs (SD)	1.87 (0.84)	2.31 (0.98)	2.08 (0.84)	2.25 (0.81)	2.42 (1.03)	2.77 (1.10)	2.81 (1,00)	3.20 (1.09)	1.84 (0.96)	2.01 (1.00)	2.49 (1.43)	2.68 (1.05)
t-test, p	**0.035**		0.239		**0.011**		**<0.001**		**0.018**		**0.025**	
Outdoors, hrs (SD)	2.98 (0.89)	2.61 (0.85)	2.44 (0.88)	2.41 (0.95)	2.91 (0.96)	2.58 (0.96)	2.46 (0.92)	2.23 (0.96)	2.45 (1.07)	2.23 (1.05)	2.14 (1.01)	1.96 (0.97)
t-test, p	**0.042**		0.875		**0.007**		**0.012**		**0.038**		**0.018**	
Near-work/ Outdoors ratio (SD)	0.71 (0.49)	1.02 (0.70)	0.98 (0.61)	1.19 (1.01)	1.02 (1.02)	1.33 (1.26)	1.39 (1.03)	1.71 (0.99)	1.09 (1.97)	1.45 (2.56)	1.65 (2.40)	2.02 (2.70)
t-test, p	**0.037**		0.086		0.46		**0.001**		0.152		0.064	
Watching TV hrs (SD)	1.38 (0.52)	1.31 (0.64)	1.15 (0.48)	1.27 (0.62)	1.85 (0.81)	1.75 (0.85)	1.63 (0.95)	1.63 (0.84)	1.97 (0.95)	2.11 (0.92)	1.91 (0.00)	1.87 (0.91)
t-test, p	0.487		0.218		0.320		0.983		0.145		0.643	

hrs = hour a day, SD = standard deviation, significant p-values bolded.

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Table 3. Binary logistic regression models explaining the prevalence of myopia by daily near work and outdoors time among 11- and 15-year-old boys and girls.

Reference 1 hr	OR	CI 95%	p	Increased risk of myopia %
Near-work				
Boys	1.196	1.069–1.324	**0.001**	+19.6
Girls	1.190	1.039–1.376	**0.013**	+19.0
Outdoors				
Boys	0.727	0.625–0.846	**<0.001**	−37.6
Girls	0.760	0.627–0.860	**<0.001**	−31.6

Significant p-values bolded.

Table 4. Multiple logistic regression models (OR, 95% confidence interval CI) for myopia in different age groups.

Predictors	OR	95% CI	p
7- year-olds (Model 1)			
Sex (ref. boy)	0.847	0.422–1.517	0.576
Near work (ref.1 hr increase)	1.476	1.099–1.984	**0.010**
Outdoors (ref.1 hr increase)	0.762	0.533–1.050	0.096
Parents' myopia (ref. no myopic)			
1) One – no myopic	0.919	0.503–1.681	0.785
2) Both – no myopic	0837	0.250–2.804	0.773
11- year-olds (Model 2)			
Sex (ref. boy)	1.774	1.285–2.449	**<0.001**
Near work (ref.1 hr increase)	1.346	1.170–1.548	**<0.001**
Outdoors (ref.1 hr increase)	0.764	0.648–0.900	**0.001**
Parents' myopia (ref. no myopic)			
1) One – no myopic	1.655	1.201–2.279	**0.002**
2) Both – no myopic	3.285	1.870–5.771	**<0.001**
15-year-olds (Model 3)			
Sex (ref. boy)	2.022	1.546–2.645	**<0.001**
Near work (ref.1 hr increase)	1.206	1.076–1.352	**0.001**
Outdoors (ref.1 hr increase)	0.840	0.743–0.950	**0.005**
Parents' myopia (ref. no myopic)			
1) One – no myopic	1.835	1.388–2.425	**<0.001**
2) Both – no myopic	3.221	1.537–6.747	**0.002**

Ref = rererence, significant p-values bolded.

myopia in this age group. In the 11-year-olds (Model 2), near work and outdoors time showed similar significant but opposite associations with myopia risk. Girls were at almost double the risk for myopia than boys. Having one and having two myopic parents increased the risk for myopia by 1.66- and 3.29-fold, respectively. In the 15-year-olds (Model 3), all the predictors were statistically significant and differed little from those of the 11-year-olds.

It is noteworthy that the OR for near work time was highest in the younger children; however, the OR for outdoors time showed little change by age. With increasing age, girls showed an increasing OR for myopia compared to boys.

Figure 1 shows the prevalence of myopia in the four categories of near work time. Higher near work time significantly increased the prevalence of myopia in all age groups. The data and statistics pertaining to the figure are shown in Table 5.

Figure 2 shows the prevalence of myopia in four groups by time spent outdoors. The differences between the groups were non-significant among the 7-year-olds, although the prevalence in the group with ≤1 hr outdoors was about three times that in the group with >3 hr outdoors, apparently mainly due to the small number of myopic children. Among the 11- and 15-year-olds, the differences in the prevalence of myopia between the outdoors groups were highly significant.

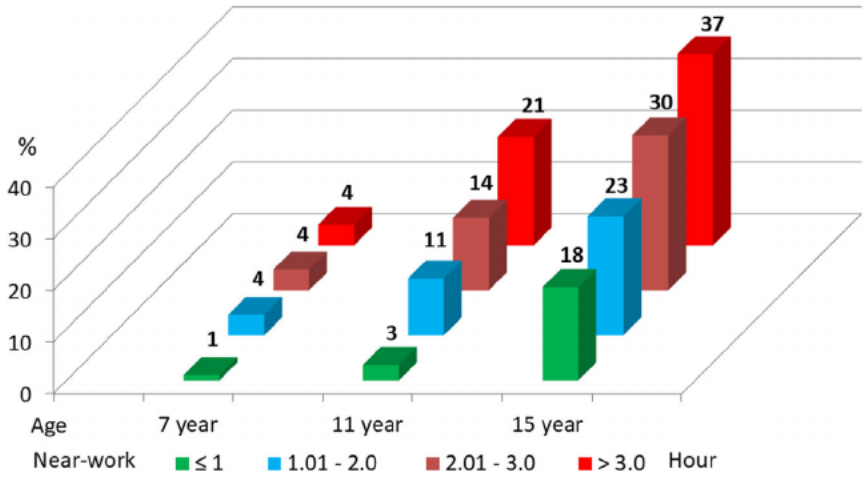


Fig. 1. Prevalence of myopia at different ages by daily time spent on near work in different time categories (data and statistical significances in Table 4).

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Table 5. Prevalence of myopia in different categories with regard to daily near-work and outdoors time and near-work/outdoors ratio by age group.

Age, years	7	11	15
Daily near-work hours	*n*/*N*, %	*n*/*N*, %	*n*/*N*, %
≤1	1/206 0.5	2/60 3.3	33/187 17.6
1.01–2	26/ 750 3.5	42/367 11.4	112/ 492 22.8
2.01–3	17/ 420 4.0	71/511 13.9	120/ 401 29.9
>3.0	7/181 3.9	96/429 21.2	107/ 288 37.2
Somer's d, p	**0.036**	**<0.001**	**<0.001**
Daily oudoor hours			
≤1	4/48 8.3	16/54 29.6	67/185 36.2
1.01–2	11/ 358 3.1	78/345 22.6	131/ 448 29.2
2.01–3	20/ 566 3.5	65/479 13.6	108/ 406 26.6
>3.0	16/ 585 2.7	52/489 10.6	66/329 20.1
Somer's d, p	0.308	**<0.001**	**<0.001**
Near-work/ Outdoor ratio			
≤0.5	6/429 1.4	11/176 6.3	40/252 15.9
0.51–1.0	27/ 701 3.9	59/512 11.5	100/ 447 22.4
1.01–1.5	10/ 282 3.5	53/321 16.5	84/267 31.5
>1.5	8/144 5.6	88/356 24.7	148/ 401 36.9
Somer's d, p	**0.011**	**<0.001**	**<0.001**

n/*N*: *n* = number of myopes, *N* = total number of subjects; % = prevalence of myopia; significant p-values bolded.

Near work time was less than outdoors time (near/out ratio <1) in 56.7% of all children. The prevalence of myopia in this group was 9.5% compared to 21.6 in the remaining children (near/out ratio ≥1). Only one of the 238 7-year-old children (0.4%) whose near work/outdoors ratio was ≤0.4 was myopic, whereas of the thirty children whose near work/outdoors ratio was ≥2.5, four (13.3%) were myopic (p = 0.001). Figure 3 shows the associations between the near work/outdoors ratio and myopia: the greater the near work/outdoors ratio, the higher the prevalence of myopia. The relevant data and statistics are shown in Table 5.

To study whether spending more time outdoors prevents myopia in both those doing less and those doing more near work, the near work and outdoors time variables were divided into three categories of <2, 2–3 and >3 hr, and multiple logistic regression models were computed separately for the different age groups. Age, sex, time spent on near work and outdoor activities, and parental myopia were used as predictors of myopia. Figure 4 shows the adjusted risk factors (OR) for the prevalence of myopia in different combinations of near work and outdoors time (data and statistical significances are shown in Table 6).

Less outdoors time increased the risk of myopia in all three near work categories. Comparison of the OR values suggested that the positive influence of increasing the amount of time spent outdoors on the prevalence of myopia diminished in the children with higher levels of near work time.

Analysis of the associations in the other direction showed that more time spent in near work significantly increased myopia risk in all three outdoors time categories (Table 6).

Discussion

Parents' myopia

Several studies have shown that having myopic parents increases the prevalence of myopia (Jones et al. 2007; Zhang et al. 2015; Shah et al. 2017; Tedja et al. 2019). Parental myopia significantly increased the risk of myopia in the two older age groups in this study, but not in the 7-year-olds. One reason for the absence of the same association in the 7-year-olds may be the low prevalence of myopia in these children. Although the myopic parents in this study were more educated, parental education was not associated with myopia in their children. A recent study comparing myopic progression between Finnish and Singaporean children showed that higher education in mothers was related to younger age of myopia onset in their children, and that younger onset of myopia was associated with faster myopic progression (Pärssinen et al. 2020). Mutti et al. (2002) found that parental myopia, near work, sports activity and school achievement were each independently associated with myopia. However, while parental myopia in this study was also strongly associated with myopia in their children, the link is obviously not solely genetic but also environmental, including such factors such as parental education and socioeconomic status.

Near work

The association of near work with myopia has been well known for a long time and confirmed in several studies (Pärssinen 1986; Huang et al. 2015; Sun et al. 2018). In this study, near work increased the risk of myopia in all three age groups, although the risk was highest among the youngest (7-year-old) children.

While it remains unclear precisely why younger children are more susceptible to myopia induced by near work, it can be suggested that the more sensitive to environmental influences a child is, the earlier and "more easily" myopia develops. The association between more near work at a younger age and higher risk of myopia is also supported by animal experiments, where deprivation myopia caused faster axial elongation in younger animals (Zhi et al. 2010). Whatever the reason, younger age of myopia onset is the most significant factor contributing to a higher rate of myopic progression and higher adulthood myopia (Pärssinen 1986; Zhang et al. 2015; Morgan et al. 2018; Pärssinen & Kauppinen 2019) and hence increasing risks of myopia-related eye complication. Thus, if the onset of myopia could somehow be delayed, the complications associated with high myopia could significantly be reduced.

One important finding of this study was that if the amount of daily near work was low (≤1 hr, excluding time at school), the prevalence of myopia was uncommon in the 7-year-olds (0.5%) and 11-year-olds (3.3%). In Finland, students in the early school grades are not usually given much homework, and there is little educational competition. In many East and South Asian countries, where the prevalence of myopia is high, young children do more homework. For example, schoolchildren in Singapore did approximately twice as much near work as same-age Finnish schoolchildren (Pärssinen et al. 2020). In Australia, children of East Asian ethnicity spent significantly more time in near work activities than European Caucasian children (French et al. 2013). In a late 20th century Singaporean study, the

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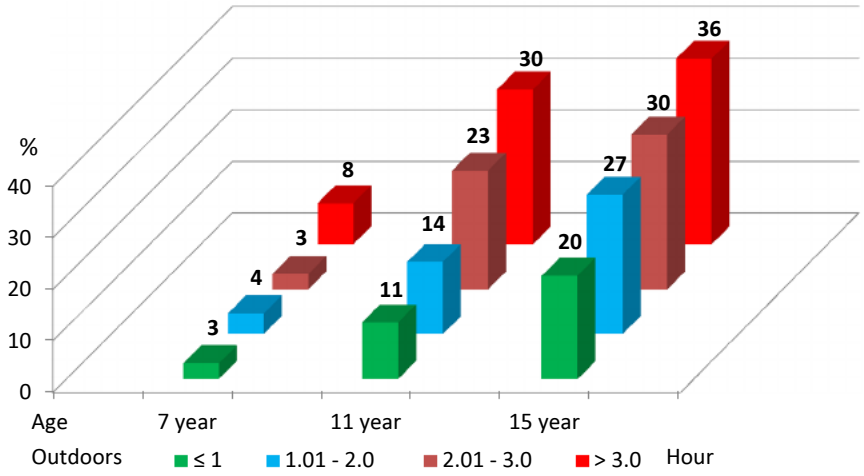


Fig. 2. Prevalence of myopia at different ages by time spent outdoors in different time categories (data and statistical significances in Table 4).

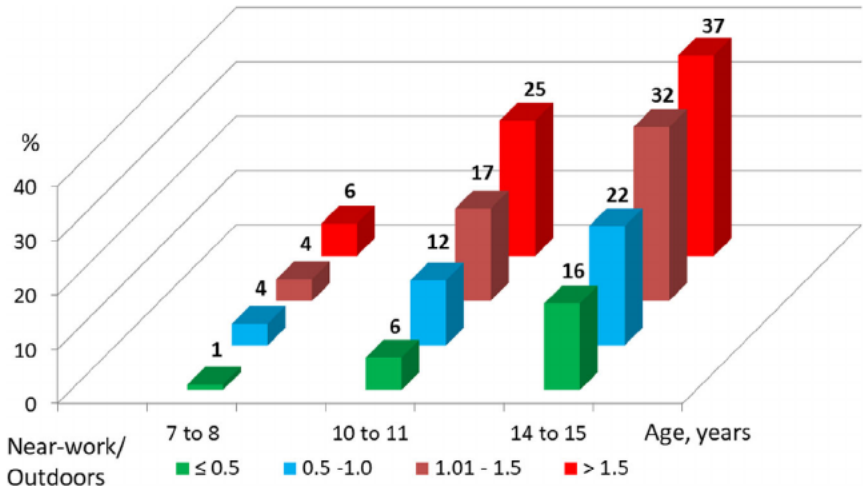


Fig. 3. Prevalence of myopia at different ages by four different categories of the near work/outdoors ratio (data and statistical significances in Table 4).

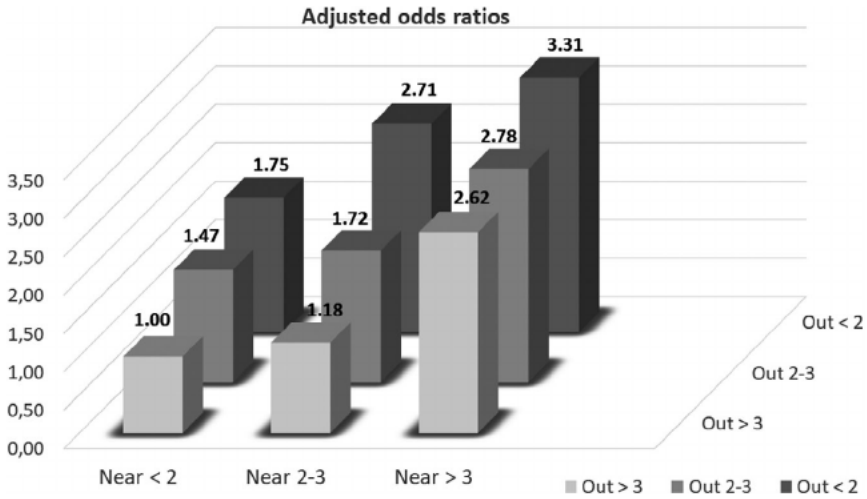


Fig. 4. Risk factors for prevalence of myopia at different combined levels of near work and outdoors time adjusted by age, sex and parents' myopia. Near = daily hours in near work, Out = daily hours outdoors.

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Table 6. Risk factors (OR, 95% confidence interval CI) for prevalence of myopia at different combinations of daily near work and outdoors time adjusted by age, sex and mother's and father's myopia.

Combination of times in near work and outdoors	OR	95% CI	p
Risk of myopia associated with outdoors at different levels of near work activities	1		
N < 2 hr, O > 3 hr, reference			
N < 2 hr, O 2–3 hr	1.47	0.978–2.212	0.064
N < 2 hr, O < 2 hr	1.75	1.205–2.537	**0.003**
N 2–3 hr, O > 3 hr	1.18	0.736–1.888	0.493
N 2–3 hr, O 2–3 hr	1.72	1.129–2.624	**0.012**
N 2–3 hr, O < 2 hr	2.71	1.833–4.012	**<0.001**
N > 3 hr, O > 3 hr	2.62	1.699–4.051	**<0.001**
N > 3 hr, O 2–3 hr	2.78	1.850–4.170	**<0.001**
N > 3 hr, O < 2 hr	3.31	2.239–4.895	**<0.001**
Risk of myopia associated with near work at different levels of outdoors activities			
O > 3 hr, N < 2 hr, reference			
O > 3 hr, N 2–3 hr	1.17	0.736–1.888	0.493
O > 3 hr, N > 3 hr	2.62	1.699–4051	**<0.001**
O 2–3 hr, N < 2 hr	1.47	0.978–2.212	0.064
O 2–3 hr, N 2–3 hr	1.72	1.129–2.624	**0.012**
O 2–3 hr, N > 3 hr	2.78	1.850–4.170	**<0.001**
O < 2 hr, N < 2 hr	1.75	1.250–2.537	**0.003**
O 2–3 hr, N 2–3 hr	1.49	1.151–1.919	**0.002**
O > 3 hr, N > 3 hr	1.78	1.451–2.175	**<0.001**

N = daily time spent in near work; O = daily time spent in outdoors; significant correlations bolded.

prevalence of myopia was 28% in 7-year-olds and 50% in 10-year-olds (Tan 2004), whereas in earlier Finnish studies and in the present study, it varied between 2–3% and 7–15% in the same age groups (Laatikainen & Erkkila 1980; Mantyjarvi 1985). It can be suggested that differences in near work time and educational load may, together with less time spent outdoors, at least partly, explain the differences between countries in the prevalence of myopia.

Myopia with regard to time spent outdoors and the ratio between near work and outdoors time

Several studies and meta-analyses have shown that increased time outdoors is effective both in slowing the myopic shift in refractive error and preventing the onset of myopia (Rose et al. 2008; Xiong et al. 2017). In this study, higher the prevalence of myopia, lower the amount of time spent outdoors. Across the present sample, the mean daily time spent in near work (2.28 hr) and outdoors (2.54 hr) was almost the same. Many studies, especially those on East and South Asian populations, where the prevalence of myopia is higher, have found that schoolchildren spend much more time engaged in near work than in outdoor activities. For example, in their study of schoolchildren in China, Lu et al. (2009) reported a mean weekly near work time of 22.2 hr and a mean weekly outdoors time of 6.1 hr. In their study, almost all (83.1%) students (mean age 14.6 ± 0.8 years) had myopia (≤ −0.5 D) in both eyes, and time spent in near work and outdoors was not associated with the prevalence of myopia. It is possible that in samples where most or almost all participants are myopic, the association of the prevalence of myopia with near work time and outdoors time decreases or disappears.

In this study, additional time spent outdoors decreased the prevalence of myopia irrespective of the amount of near work time. Thus, to prevent myopia, it can be recommended that any increase in near work time should be accompanied by an equivalent increase in outdoor time.

Watching TV

This study, along with many others (Jones-Jordan et al. 2012; Pärssinen et al. 2014; Guan et al. 2019), found no association between myopia and watching TV. Today, TV viewing time has decreased, while the use of mobile devices has increased, especially in children. There are some indications that the use of smart phones and mobile devices in early life, unlike TV viewing, is a risk factor for myopia (Lanca & Saw 2020; Yang et al. 2020). The diopter hours (Dh) variable has quite commonly been used as a measure of near workload as a risk factor for myopia (Mutti et al. 2002; Lu et al. 2009; Jones-Jordan et al. 2012). Diopter-hours was defined as Dh = 3 × (hours spent studying and/or/reading for pleasure) + 2 × (hours spent playing video games and/or working on a computer at home) + 1 × (hours spent watching television) (Mutti et al. 2002). When using diopter-hours as a measure of near workload as a risk factor for myopia, for example, the Dh value obtained from 1 hr spent solely on reading is the same as the value obtained from spending 3 hr spent solely on watching TV. As little evidence exists for TV viewing time as a risk factor for myopia, we suggest that Dh (including TV time) is not a good measure of near work as a risk factor for myopia and has potentially confounded the results.

Limitations

The main limitation of the 1983 study was the definition of myopia, which was based solely on anamnestic information obtained by screening for poor distant and good near vision prior to a questionnaire. Although myopia has been found to be the main cause of poor distant vision in schoolchildren (Sloan 1951; Yang 1959; Laatikainen & Erkkila 1980), hyperopia and astigmatism may potentially have confounded the results. At approximately the same time as the 1983 study, Laatikainen & Erkkilä (1980) conducted a survey of Finnish children in the same grades. In their study, the prevalence of myopia in the same graders (spherical equivalent in cycloplegia ≤0.5 D) was somewhat less than in our questionnaire (1.9%, 7.2% and 21.8%). Hyperopia ≥ +4 D was found in only a few scattered cases across all eyes and astigmatism, ≥1 D, in 1.7% of the children. Given the similarities between their participants and ours, it can be suggested that the impact of hyperopia and astigmatism as confounding factors in our study is likely to have been small. Using the same questionnaire-based definition of myopia in a later study of 26-year-olds (Pärssinen1986), 86% of those categorized as myopic also showed myopic refraction in cycloplegia. Hence, we this

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assume the limit of error in defining myopia among children and their parents in the 1983 study would have been within 15%.

It should be noted that the near work and outdoor time variables did not include the time spent on these activities at school. Thus, the true amounts of near work and outdoors time would have been higher for every student included in the study. Although this enables comparisons of the associations within the present sample, this fact must be considered in comparisons with the corresponding time parameters in other studies.

The data analyzed in this study were drawn from a questionnaire study conducted almost 40 years ago. Since then, children's near work has shifted away from television viewing towards the use of smartphones and mobile devices. This shift in near work behavior in children is not, of course, reflected in the present results.

Conclusions

In this 38-year-old questionnaire-based study, in myopic parents, more time spent in near work and less time spent outdoors independently increased the risk of myopia. The significantly higher prevalence of myopia among girls than boys was mainly explained by differences between the sexes in near work and outdoors time. If daily near work time, excluding near work at school, did not exceed 1 hr, the prevalence of myopia was rare among the 7- and 11-year-olds, and the same held true if the ratio between near work and outdoors did not exceed 0.5. Watching TV was not a risk for myopia. The influence of outdoors time in preventing myopia was seen at all levels of near work time, although it was less marked at the highest levels.

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Received on March 19th, 2021.
Accepted on July 1st, 2021.

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The study was supported by Silmäsäätiö Foundation and Evald ja Hilda Nissi Foundation.

Printed by [Wiley Online Library - 063.241.244.162 - /doi/epdf/10.1111/aos.14980] at [24/08/2021].