Refractive trends in 15-year-old adolescents attending optometric practices in southern Sweden between 2007 and 2020

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Abstract

The purpose of this study was to analyse the distribution of refractive errors in 15-year-old adolescents at optometric practices in southern Sweden between 2007 and 2020.

Refractive data were collected retrospectively from clinical records in five optometric practices in southern Sweden. The inclusion criteria were individuals visiting the practice at an age of 15 years between 2007 and 2020. The refractive errors were classified by the spherical equivalent (SE) (sphere + ½ cylinder) as follows: myopia (SE ≤ -0.5 D), hyperopia (SE ≥ 0.5 D), emmetropia (-0.5 > SE < 0.5 D). The astigmatism axis (-1.5 DC) was analysed as with-the-rule, against-the-rule and oblique according to traditional methods. To examine trends, the average refraction and distribution of refractive errors were compared between two selected time periods, 2007–2013 and 2014–2020.

During the time frame 500 adolescents aged 15 years were examined in the selected optometric practices. Myopia was found in 34%, emmetropia in 35% and hyperopia in 31%. Among 37 individuals with astigmatism, the most common axis was with-the-rule (41%), followed by oblique (32%) and against-the-rule (27%). No significant differences could be found in the distribution of different refractive errors between the periods 2007–2013 and 2014–2020. Nor could any significant difference in average refraction be found.

In contrast to the expected global rise in myopia as predicted by WHO and the high prevalence of myopia reported in some parts of the world, we could not find convincing changes in distribution between myopia and hyperopia in this cohort of Swedish adolescents.

Keywords: Myopia, incidence, prevalence, children

Introduction

Myopia occurs when the eyeball is too long relative to its refractive power (axial myopia) or if the refractive power is too strong in relation to the length of the eye (refractive myopia). The condition causes need for optical correction. Although high myopia carries the highest risk of complications, even low or moderate myopia increases the risk of cataract, glaucoma, retinal detachment, and myopic macular degeneration (Haarman et al., 2020). According to the World Health Organization (WHO), there has been an alarming increase of myopia the past few decades (WHO, 2017). The global prevalence is estimated to have increased from 23% to 28% between 2000 and 2010. However, there are considerable regional differences with a prevalence of 5% in east Africa and 49% in high-income Asia-Pacific countries (Holden et al., 2016). However, the significance of the global increase is complicated to judge due to a lack of standardised definitions. Furthermore, the diagnosis is strongly dependent on whether examinations are performed with or without cycloplegia, since myopia, defined as spherical equivalent (SE) ≤ 0.5 diopters, has been shown to disappear in 34–47% of cases after instillation of cycloplegic agents (Hu et al., 2015; Lundberg et al., 2018). However, the increase in the proportion of young children with myopia is a critical issue, as early debut of myopia is an important predictor of high myopia in later childhood (Chua et al., 2016).

Different causes of myopia progression have been discussed. A sibling of a myopic identical twin has an up to 90% risk of developing the condition, and several genes linked to myopia have been identified (Kiefer et al., 2013). However, the rapid global increase cannot be explained only by hereditary factors; other factors such as environment must be considered. A meta-analysis including 27 cohorts of children from almost all continents showed that more time spent on near work activities was associated with higher odds of myopia (Huang et al., 2015). Time spent outdoors has also been presented as an independent protective factor. In a study including 2000 children in Australia the odds ratio for myopia increased more than 3 times in the groups that spent only a small amount of time outdoors per week (French et al., 2013). In Asian children (e.g. from China and Singapore), there is much high-level evidence, including randomised controlled studies and meta-analysis, showing that time spent outdoors slows down the change of axial length and reduces the risk of myopia (Cao et al., 2020). Genetic observations suggest that the underlying mechanism for the outdoor effects is based on a light-dependent release of retinal dopamine, which controls scleral growth and remodelling (Tedja et al., 2018). Data concerning the effect of gender is conflicting, females are shown to have both more and less myopia than males (Xiang & Zou, 2020).

In the last few decades, children have become digital users at younger ages, with an increase in the use of computers, smart phones and tablets (OFCOM, 2022). In 2018, 78% of Swedish children had their own computer compared to 56% in 2008 (Statistics Sweden, 2019). In 2017, 24% of Swedish children aged between 12 and18 had a daily screen time (including computer, TV, smartphone and tablets) of at least three hours on weekdays, and at least ten hours during weekends (Statistics Sweden, 2017). Screen time has been argued to play a role in myopia development but consistent evidence for this hypothesis is still lacking (Lanca & Saw, 2020).

The trends for myopia prevalence in the Nordic population vary between the countries. Danish data have showed a decrease in myopia among conscripts in 2004 (12.9%) compared to 1964 (14.5%) (Jacobsen et al., 2007). However, no changes in prevalence of myopia could be demonstrated in a systematic literature search including nearly 140 years of research in Denmark (Hansen et al., 2021). A recent study of Norwegian adolescents has also shown low prevalence of myopia (13%), despite the fact that the study population had few daylight hours in the autumn-winter period, and high levels of indoor activity and near work (Hagen et al., 2018). In Finland, however, myopia is believed to have doubled from 11% to 22% among children aged around 15 during the 20th century (Pärssinen, 2012). Only a few Swedish studies have been published on the subject in the last 20 years. Myopia in cycloplegia (induced by tropicamide) was found in 50% of about a thousand children aged 12–13 years old in 1999 (Villarreal et al., 2000). Ten years later, 650 male conscripts aged between 17 and 23 years were examined. Myopia was found in 38%, but this study used no cycloplegia (Uhlin et al., 2009). An older smaller study of 143 children aged 4–15 years found myopia in cycloplegic refraction in 6% (Grönlund et

Table 1: *Distribution of myopia and hyperopia in previous comparable reports of refractive errors among adolescents in optometric populations.*

Country	Period	Author	Population	*n* (females %)	Ratio between myopia (SE ≤ -0.5) and hyperiopa (SE ≥ 0.5)	Ratio between number of myopic females and males
Sweden	2007–2020	Bro (current)	15 years	500 (59%)	1.0	1.4
Ireland	2015–2019	Longwill et al. (2022)	10–19 years	17 011 (57%)	1.8	1.4
South Africa	2017–2019	Wajuihian and Mashige (2021)	6–18 years	1080 (NR)	1.4	NR
Canada	2007–2008	Hrynchak et al. (2013)	15–19 years	349 (NR)	4.5	NR
Portugal	1999–2004	Queirós et al. (2009)	9–19 years	588 (65%)	1.4	1.6

Note: SE = Spherical equivalent; NR = Not reported for subgroup.

al., 2006). A more recent study found myopia (in cycloplegic refraction in the right eye) in 10% of 128 children aged 8–16 years. Parental myopia was associated with both the level of myopia and the length of the eye (Demir et al., 2021).

Besides conventional prospective studies of epidemiology of refractive errors, studies of records from optometric practices have also been shown to be useful. Although not representative of the population as a whole, such studies provide a reasonable representation of the distribution of symptomatic refractive errors, and serve as a baseline for future analysis. Previous retrospective reviews of records from adolescent patients at optometric practices have been performed in South Africa, Portugal and Canada, with proportions of myopia varying from 19 to 54% (Hrynchak et al., 2013; Queirós et al., 2009; Wajuihian & Mashige, 2021). Such studies usually require manual review of each case. Optometric practices with connected electronic patient databases enable larger studies in the same field (Longwill et al., 2022). Routinely collected data of government funded subsidies for spectacles for children are another valuable source for large amounts of data when available (Kearney et al., 2022). To the best of our knowledge, no previous studies of retrospective data from optometric practices have been performed in a Nordic population (see Table 1).

The purpose of this study was to analyse trends in refractive errors in a population that visited an optometrist at an age of 15 years in the period from 2007 to 2020 in the region of Småland in southern Sweden.

Methods

This was a retrospective study of computerised records from five optometric practices within Synsam Group AB in Småland Sweden (Eksjö, Nässjö. Sävsjö, Tranås and Vetlanda). All managers gave permission for data from their practice to be used in research. An average of 73 000 inhabitants lived in the region during the study time (SCB, 2021), but the included practices were not the only ones within the area. The refractive methods of the different practitioners were not standardised and not performed in cycloplegia. Refractive data were extracted from all youngsters examined at an age of 15 years between 2007 and 2020. This age was chosen as it usually implies a stabilisation of myopia (COMET Group, 2013) in both males and females (Qin et al., 2022).

The spherical equivalent (defined as sphere plus half the cylinder) for subjective refraction for the right eye was used for analysis, as there was no statistically significant difference in mean spherical equivalent between right and left eyes (mean −0.23 and −0.18 respectively) ($p=0.08$ with a paired t-test, Pearson's $r = 0.927$, $p < 0.001$). Myopia was defined as spherical equivalent (SE) ≤-0.5 D and hyperopia as SE ≥ 0.5 D. Eyes with an astigmatic refractive error ≤ -1.5 DC were considered astigmatic. Thereafter the proportion of, and the mean SE, for different refractive errors were calculated for the time period 2007–2013 compared to 2014–2020. Statistical significance was tested with t-tests and z-tests of proportions. The alpha level was set at 0.05. During the year 2020 the numbers of patients seeking optometric care and the reasons for attending may have been atypical because of Covid-19, therefore this period was analysed separately.

The study was approved by the Swedish National Ethical Review Agency (Dnr 2019-00562) and followed the tenets of the Declaration of Helsinki.

Results

During the time frame of 2007–2020, 500 children aged 15 years were examined in the selected optometric practices. The study group consisted of more females (59%) than males (34%). For the remaining 6% no information was given about gender. Myopia was found in 34%, emmetropia in 35% and hyperopia in 31% (see Table 2). The ratio between myopia and hyperopia was 1.0 and the ratio between myopic females and myopic males was 1.4 (see Table 1). Astigmatism was found in 7%. Among these, with-the-rule astigmatism (41%) was more common than against the rule (27%) (see Table 3). No significant difference was found in the distribution of different refractive errors when the period of 2007–2013 was compared with 2014–2020 (z-test). Nor could any significant difference in average refraction be detected (t-test) (see Table 2 and Figure 1). Myopia occurred in 40% of males and 29% of females. As for the total group, there were no significant differences in the distribution of different refractive errors or in the mean spherical equivalent refractive error between the two time periods in a gender separated analysis (see Tables 4 and 5). Even if the year 2020 may have caused differences in the numbers and reasons for seeking optometric care because of Covid-19, no significant difference in the proportion of myopia was seen during this period (38%) compared with 2014–2019 (31%) ($p=0.44$ z-test).

Table 2: *Refractive data in a cohort of 15-year-old adolescents seeking optometric care in Sweden between 2007 and 2020 (95% confidence intervals).*

	2007-2020	2007–2013	2014–2020	*p*
n	500	241	259	
Female	59%	62%	57%	
Male	34%	35%	34%	
Unknown	6%	3%	9%	
Proportions				
Myopia	34% (30–38%)	35% (29–41%)	33% (27–39%)	0.70
Emmetropia	35% (31–39%)	35% (29–42%)	34% (29–41%)	0.91
Hyperopia	31% (27–36%)	30% (24–36%)	33% (27–39%)	0.54
Mean SE in diopters				
Myopia	-2.1 (-2.3 – -1.8)	-1.9 (-2.2 – -1.6)	-2.2 (-2.6 - -1.8)	0.31
Emmetropia	0.1 (0 – 0.1)	0.1 (0 – 0.1)	0.1 (0 – 0.1)	0.94
Hyperopia	1.4 (1.2 – 1.6)	1.6 (1.3 – 1.9)	1.3 (1 – 1.5)	0.12

Note: SE = Spherical equivalent.

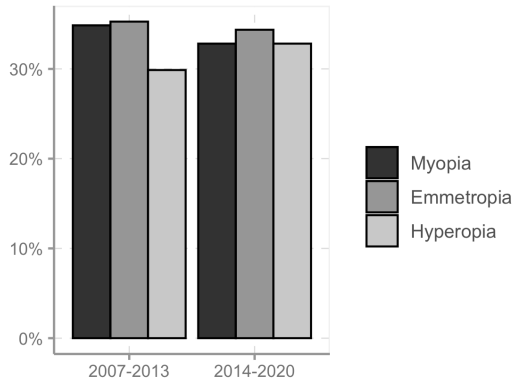

Figure 1: *Distribution of refractive errors in Swedish 15-year-olds seeking optometric care in Småland, Sweden for the time periods 2007–2013 and 2014–2020.*

Table 3: *Astigmatism in a cohort of 15-year-old adolescents seeking optometric care in Sweden between 2007 and 2020.*

	Females	Males	Unknown	Total
Astigmatism (≤ -1.5 D)	23 (8%)	10 (6%)	4 (13%)	37 (7%)
Astigmatic axis				
WTR	39%	30%	75%	41%
ATR	39%	10%	0%	27%
OBL	22%	60%	25%	32%

Note: WTR = with-the-rule (within 30° of vertical axis), ATR = against-the-rule (within 30° of horizontal axis), OBL = oblique (more than 30° from vertical or horizontal axis).

Table 4: *Refractive data in a cohort of 15-year-old females seeking optometric care in Sweden between 2007 and 2020 (95% confidence intervals).*

	2007–2020	2007–2013	2014–2020	*p*
n	297	149	148	
Proportions				
Myopia	29% (24–35%)	32% (25–40%)	26% (19–34%)	0.27
Emmetropia	38% (33–44%)	38% (31–47%)	39% (31–47%)	1.00
Hyperopia	33% (27–38%)	30% (22–38%)	36% (28–44%)	0.30
Mean SE in diopters				
Myopia	-1.9 (-2.2 – -1.6)	-1.8 (-2.2 – -1.4)	-2.1 (-2.5 – -1.6)	0.40
Emmetropia	0.1 (0 – 0.1)	0.0 (0.0 – 0.1)	0.1 (0.0 – 0.1)	0.63
Hyperopia	1.3 (1 – 1.5)	1.5 (1.0 – 1.9)	1.1 (0.8 – 1.4)	0.20

Note: SE = Spherical equivalent.

Table 5: *Refractive data in a cohort of 15-year-old males seeking optometric care in Sweden between 2007 and 2020 (95% confidence intervals).*

	2007–2020	2007–2013	2014–2020	*p*
n	172	84	88	
Proportions				
Myopia	40% (32-47%)	39% (29-51%)	40% (30-51%)	1.00
Emmetropia	28% (21-35%)	30% (21-41%)	26% (18-37%)	0.72
Hyperopia	33% (26-40%)	31% (22-42%)	34% (25-45%)	0.78
Mean SE in diopters				
Myopia	-2.1 (-2.5 – -1.8)	-2 (-2.6 – -1.5)	-2.2 (-2.7 – -1.7)	0.54
Emmetropia	0.1 (0 – 0.2)	0.1 (0 – 0.2)	0.1 (0.0 – 0.2)	0.98
Hyperopia	1.6 (1.3 – 2)	1.8 (1.2 – 2.3)	1.5 (1.0 – 2.0)	0.50

Discussion

In contrast to the expected global rise in myopia as predicted by WHO and the high prevalence of myopia reported in some parts of the world, this study, despite its limitations, did not indicate any convincing changes in the distribution between myopia and hyperopia over the last decade. The ratio between myopia and hyperopia of 1.0 is comparable to studies from Portugal and South Africa (both 1.4) (Queirós et al., 2009; Wajuihian & Mashige, 2021). However, it is lower than data from Ireland and Canada (1.8 and 4.5 respectively) (Hrynchak et al., 2013; Longwill et al., 2022). As in previous studies of adolescent optometric populations, females outnumber males both in total number and in myopic individuals (see Table 1).

To the best of our knowledge, this is the first published study using data from optometric practices in Sweden. Compared to population-based studies, our data probably have a skewed distribution towards myopia, as low to moderate hyperopes sometimes do not seek optometric care due to lack of visual symptoms. The proportion of myopic subjects may also be overestimated since cycloplegic drugs were not used. One way to address this issue is to define myopia as SE ≤ -0.75, which results in a proportion of myopia of 28% in 2007–2013 and 29% in 2014–2020 ($p = 0.93$ z-test). However, in our main results we prefer to use the recommended definition of SE ≤ -0.5 (WHO, 2017). Nevertheless, our results could be used as a basis to evaluate changes in the distribution of refractive errors in the two periods evaluated (2007–2013 vs. 2014–2020). During this period no change in the distribution of refractive error was found. This result is not in line with the global increase of the prevalence in myopia (WHO, 2017). However, it is in agreement with recent Nordic data (Demir et al., 2021; Hagen et al., 2018; Hansen et al., 2021). Thus, adolescents in the Nordic countries seem to defy the world-wide trend of increasing myopia, which challenges the picture of a "myopia epidemic".

Despite its limitations, this retrospective study of 15-year-old adolescents does not indicate any convincing changes in the distribution of myopia and hyperopia over the last decade.

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Trender for brytningsfeil hos 15-årige ungdommer som besøkte optikere i Sør-Sverige mellom 2007 og 2020

Sammendrag

Formålet med denne studien var å analysere fordelingen av brytningsfeil hos 15-årige ungdommer, mellom 2007 og 2020, som besøkte optikere i Sør-Sverige.

Data på brytningsfeil ble samlet retrospektivt fra kliniske journaler i fem optometriske praksiser i Sør-Sverige. Inklusjonskriteriene var personer som besøkte praksisen i en alder av 15 år mellom 2007 og 2020. Brytningsfeilene ble klassifisert etter den sfæriske ekvivalenten (SE) (sfære + 1/2 sylinder) og klassifisert som: myopi (SE ≤ -0,5 D), hyperopi (SE ≥ 0,5 D), emmetropi (-0,5 > SE < 0,5 D). Astigmatismeaksen (≤ -1,5 DC) ble analysert som med-regelen, mot-regelen og skrå etter tradisjonelle metoder. For å se på trender ble gjennomsnittlig brytning og fordeling av brytningsfeil sammenlignet mellom to utvalgte tidsperioder, 2007–2013 og 2014–2020.

I løpet av tidsrommet ble 500 ungdommer i alderen 15 år undersøkt i de utvalgte optikerpraksisene. Myopi ble funnet hos 34%, emmetropi hos 35% og hyperopi hos 31%. Blant 37 individer med astigmatisme var den vanligste aksen med-regelen (41%), etterfulgt av skrå (32%) og mot-regelen (27%). Det ble ikke funnet signifikante forskjeller i fordelingen av ulike brytningsfeil mellom periodene 2007–2013 og 2014–2020. Det kunne heller ikke påvises noen signifikant forskjell i gjennomsnittlig brytning.

I motsetning til den forventede globale økningen i nærsynthet som spådd av WHO og den høye forekomsten av nærsynthet rapportert i enkelte deler av verden, kunne vi ikke finne noen endringer i distribusjon mellom nærsynthet og hyperopi i denne kohorten av svenske ungdommer.

Nøkkelord: Myopi, insidens, prevalens, barn

Tendenze refrattive in adolescenti di 15 anni visitati in cliniche optometriche della Svezia meridionale tra il 2007 e il 2020

Riassunto

Lo scopo di questo studio e' stato quello di analizzare la distribuzione degli errori refrattivi in adolescenti di 15 anni visitati in cliniche optometriche della Svezia meridionale tra il 2007 e il 2020. I dati refrattivi sono stati raccolti retrospettivamente dalle cartelle cliniche in 5 cliniche optometriche della Svezia meridionale.

I criteri di inclusion sono stati individui visitati nelle cliniche con un eta' di 15 anni tra il 2007 e il 2020. Gli errori refrattivi sono stati classificati con l'equivalente sferico (SE) (sfera + ½ del cilindro) come segue: miopia (SE ≤ -0.5 D), ipermetropia (SE ≥ 0.5 D), emmetropia (-0.5 > SE < 0.5 D). L'asse dell'astigmatismo (-1.5 DC) e' stato analizzato come secondo regola, contro regola ed obliquo secondo i metodi tradizionali. Per l'esaminare le tendenze, la media della refrazione e distribuzione degli errori refrattivi sono stati comparati tra due periodi temporali selezionati, 2007–2013 e 2014–2020.

Durante questo periodo di tempo 500 adolescenti di 15 anni sono stati esaminati nelle selezionate pratiche optometriche. Miopia e' stata trovata al 34%, emmetropia al 35% ed ipermetropia al 31%. Tra 37 soggetti con astigmatismo, l'asse piu' comune e' stato quello secondo regola (41%), seguito da obliquo (32%) e contro regola (27%). Nessuna differenza significativa e' stata trovata tra i differenti errori refrattivi nei periodi 2007–2013 e tra 2014–2020. Ne e' stata ritrovata una differenza significativa nella media delle refrazioni. In contrasto a quanto e' stato predetto dal WHO per quanto riguarda l'aumento globale della miopia e l'elevata prevalenza della miopia riportata in alcune parti del mondo, non abbiamo trovato cambi convincenti nella distribuzione tra miopia ed ipermetropia in questo gruppo di adolescenti svedesi.

Parole chiave: Miopia, incidenza, prevalenza, bambini