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The Prevalence of Astigmatism and Spectacle Wear in Polish Schoolchildren

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ABSTRACT

Introduction: Unilateral or asymmetric astigmatism is considered a principal refractive error leading to amblyopia and regular eye examinations should be carried out during childhood to prevent visual impairment. The aim of this study was to evaluate the prevalence of astigmatism and spectacle wear among Polish schoolchildren.

Methods: A cross sectional study was carried out in children aged 6 to 14 years old from 50 schools in Poland. The presence of astigmatism was assessed by non-cycloplegic autorefraction, and defined as a cylinder equal or greater than 0.75 D. Children were classified as living in urban or rural areas according to the school location. Spectacle wear was defined as having spectacles at school.

Results: The study included 1041 children and 52.3% were girls ($n = 544$). The mean age was 8.62 ± 2.04 years. The prevalence of astigmatism was 7.3% (95% confidence interval [CI]: 5.8–9.1%). Only 21.7% of children with astigmatism wore spectacles at school. Astigmatism was diagnosed in 8.2% of boys (95% CI: 6.0–11.0%) and 6.4% of girls (95% CI: 4.5–8.8%; $p = .13$); cylindrical anisometropia was present in 19/76 (25.0%) of children with astigmatism (95% CI: 15.8%–36.3%). Against-the-rule astigmatism was the most common; it was observed in 48.7% of children with astigmatism, followed by with-the-rule astigmatism (44.7%) and oblique astigmatism (6.6%). The prevalence of astigmatism was not linearly correlated with age ($r = 0.24$; $p = .53$). Gender, age and place of living were not significantly associated with the presence of astigmatism.

Conclusions: This study reports a low prevalence of astigmatism in Polish school children. However, the majority of children with astigmatism were uncorrected. Further longitudinal studies are warranted.

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Astigmatism; children; spectacles; refractive errors; amblyopia

Introduction

Astigmatism is one of the most common refractive errors. The prevalence of astigmatism varies worldwide from 2.7% in Nigeria (children aged 5–15 years)[1] to 51% in Taiwan (children aged 7–15 years).[2] Although astigmatism is a correctable cause of visual impairment in children, if left uncorrected can lead to a significant reduction in visual function and impact educational performance depending on its magnitude.[3,4] Moreover, large amounts of unilateral astigmatism which is uncorrected during early childhood affects the visual development and can result in amblyopia.[5] Some have reported that astigmatism might be the principal refractive error leading to amblyopia[6] and regular eye examinations should be carried out during childhood to prevent visual impairment.[7] Astigmatism is also associated with increased risk of myopia.[8]

There are several safe and effective methods for correcting astigmatism like glasses for regular astigmatism or specialty contact lenses for irregular astigmatism.[9] However, evidence suggests that astigmatism is commonly uncorrected in children.[6] The prevalence of astigmatism has been well documented in several countries, but few studies report the rates among European schoolchildren. The rate of spectacle wear among children with astigmatism is also not known. The aim of this study was to evaluate the prevalence of astigmatism and spectacle wear among Polish schoolchildren.

Methods

This cross-sectional school-based study was conducted in the years of 2017–2018 in 50 primary (6–12 years) and middle (12–14 years) public schools in the Pomorskie, Warmińsko-Mazurskie and Mazowieckie voivodeships of Poland. The classes were randomly selected. Examinations were performed by a private company, Augen-Med, Olsztyn, Poland, in a dedicated room in selected public schools. The choice of participating schools was not random, but based on the will of

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cooperating with the examining company. The study adhered to the tenets of the Declaration of Helsinki and the study protocol was approved by the local bioethical committee (*Komisja Bioetyczna przy Okręgowej Izbie Lekarskiej w Gdańsku*, Approval No. KB-5/18). Written consent was obtained from the participant's parents.

Examinations

Refraction was obtained with a stationary autorefractor (Unicos URK-700) without cycloplegia. Three separate measurements of sphere, cylinder, and axis were acquired and averaged by the autorefractor. Refractions were recorded in negative cylinder notation. Results were obtained for the right and left eye, while the analysis of astigmatism rate was performed for right eyes only; the measurements of the left eye were used to calculate the level of cylindrical anisometropia. Children with ocular diseases or unobtainable autorefractor measures were excluded from the study. Children were evaluated for the use of glasses at the time of the examination and additionally asked if they wore glasses on a daily basis. Children were classified as living in urban or rural areas according to the school location using legal definitions.[10]

Definitions

Astigmatism was defined as cylinder power equal or greater than 0.75 D.[11] The astigmatism axis was classified as with-the-rule if the axis was between 0° and 30° or between 150° and 180°, against-the-rule if the axis was between 60° and 120° and oblique if it was at any other meridian. Cylindrical anisometropia was defined as a difference between the right and left eye in cylinder power equal to or greater than 1 D.[12] Astigmatism was presented both as polar and vector values; the vector values J0 and J45 were calculated as recommended by Thibos *et al.*[13]

Statistical methods

Statistical analysis was performed using Medcalc v. 14 (Medcalc BVBA, Ostend, Belgium), OpenEpi software (version 3.01, Dean and Sullivan, Atlanta, GA) and SPSS (IBM, United States, version 26). The prevalence of ocular astigmatism was reported as a percentage with 95% confidence intervals (CIs). The Wilson method for calculating CIs was applied, as it provides more reliable results than normal approximation with symmetrical CIs.[14] For analyzing differences among categorical data the Chi Square was applied. Effects of gender, age and place of residence on astigmatism ≥ 0.75 were examined in unadjusted and multivariable-adjusted logistic regression analyses. Results with p levels under 0.05 were considered as statistically significant.

Results

A total of 1041 children aged 6 to 14 years were included in the study. The mean age was 8.62 ± 2.04 years. The proportion of females was 52.3% ($n = 544$) girls. All measures were obtainable and there were no children excluded from the study. The proportion of children living in urban areas was 73.48%. The mean cylinder power was −0.30 D (95% CI: −0.33 to −0.27 D) in the right eye. Astigmatism greater than or equal to 0.75 D was found in 7.3% of children (95% CI: 5.8–9.1%), while astigmatism greater than or equal to 1.0 D was present in 4.9% of children (95% CI: 3.7–6.3%). The prevalence of astigmatism based on cylinder power according to age, gender and place of living is presented in Table 1. The prevalence of astigmatism equal to or greater than 0.75 D was higher in children living in urban areas than in rural areas (5.1%, 95% CI: 3.7–6.9% vs. 4.3%, 95% CI: 2.2–7.4%; $p < .01$), but the differences were non-significantly among boys and girls (8.2%, 95% CI: 6.0–11.0% vs. 6.4%, 95% CI: 4.5–8.8%; $p = .13$). The prevalence of astigmatism was not linearly correlated with age ($r = 0.24$; $p = .53$; Figure 1). The magnitude of astigmatism was not significantly different among boys and girls (−0.33 D vs. −0.28 D, respectively; $p = .97$).

Against-the-rule astigmatism was the most common; it was observed in 37 children (48.7%), followed by with-the-rule astigmatism (43 children, 44.7%) and oblique astigmatism (5 children, 6.6%; Figure 2). Only 14 out of 76 children (18.4%) with astigmatism 0.75 D or greater wore glasses. The rate of spectacle wear was non-significantly higher in children with higher degrees of astigmatism: 24.1% (7/29), 27.3 (6/22) and 30.8% (4/13) for astigmatism >1 D, ≥1.5 D, and >2 D, respectively ($p = .37$). A lower proportion of children with against-the-rule astigmatism wore glasses compared to those with-the-rule and oblique astigmatisms (2.8%, 32.4% and 40.0%, respectively; $p < .01$). The rate of spectacle wear did not differ between boys and girls ($p = .74$), nor between urban and rural regions of living ($p = .26$). Figure 3 presents the joint distribution of the J0 and J45 vector values. The mean J0 value was −0.01 ± 0.23 D, while the mean J45 value was −0.00 ± 0.12 D ($R^2 = 0.10$).

Cylindrical anisometropia was present in 19 out of 76 of children with astigmatism (25.0%; 95% CI: 15.8%–36.3%) (Table 2). The rate of cylindrical

Table 1. Prevalence of astigmatism based on cylinder power according to age, gender and region ($n = 1041$).

Variable	n	Cylinder power ≥0.75 D (95% CI)	Cylinder power >1 D (95% CI)	Cylinder power >2D (95% CI)
Gender				
Male	497	8.2% (6.0–11.0)	4.0% (2.5–6.2)	1.8% (0.8–3.4)
Female	544	6.4% (4.5–8.8)	1.7% (0.8–3.1)	0.7% (0.2–1.9)
Region				
Urban	765	5.1% (3.7–6.9)	3.0% (1.9–4.5)	1.4% (0.7–2.6)
Rural	276	4.3% (2.2–7.4)	2.2% (0.8–4.7)	0.7% (0.1–2.6)
Age [years]				
6	174	5.7% (2.8–10.3)	2.3% (0.6–5.8)	0.6% (0.0–3.2)
7	192	7.3% (4.0–11.9)	2.6% (0.9–6.0)	1.0% (0.1–3.7)
8	173	8.7% (4.9–13.9)	2.3% (0.6–5.8)	1.7% (0.4–5.0)
9	150	6.7% (3.2–11.9)	3.3% (1.1–7.6)	1.3% (0.2–4.7)
10	114	7.0% (3.1–13.4)	1.8% (0.3–6.2)	0.9% (0.0–4.8)
11	86	8.1% (3.3–16.1)	3.5% (0.7–9.9)	0.0% (0–0)
12	72	5.6% (1.5–13.6)	1.4% (0.0–7.5)	1.4% (0.0–7.5)
13	45	13.3% (5.1–26.8)	6.7% (1.4–18.3)	2.2% (0.1–11.8)
14	35	5.7% (0.7–19.2)	5.7% (0.7–19.2)	5.7% (0.7–19.2)
Overall	**1041**	**7.3% (5.8–9.1)**	**2.8% (1.9–4.0)**	**1.2% (0.7–2.1)**

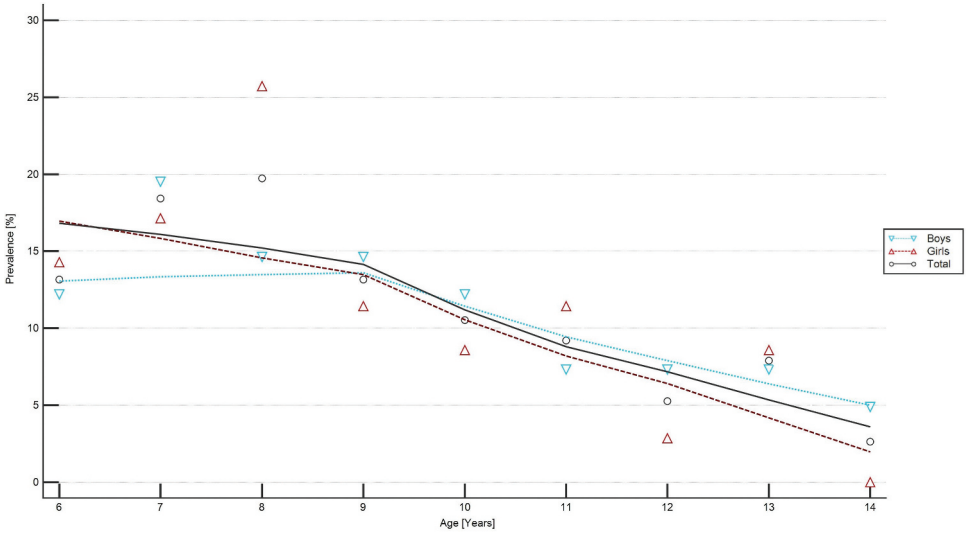

Figure 1. The prevalence of astigmatism among boys and girls aged 6–14 years.

anisometropia was non-significantly higher in children with astigmatism greater than 1 D and greater than 2 D ($p = .45$). Out of children with cylindrical anisometropia and astigmatism the rate of spectacle wear was 15.8% (3/19), 30.0% (3/10) and 40.0% (2/5) for children with cylindrical power ⩾0.75 D, >1.0 D, and >2.0 D, respectively. Multiple logistic regression analysis showed that age ($p = .56$), gender ($p = .28$) and region ($p = .48$) were not associated with the presence of astigmatism.

Discussion

In this study of 6 to 12-year-old Polish children we found a relatively low (7.3%) prevalence of astigmatism equal or greater than 0.75 D. The prevalence of

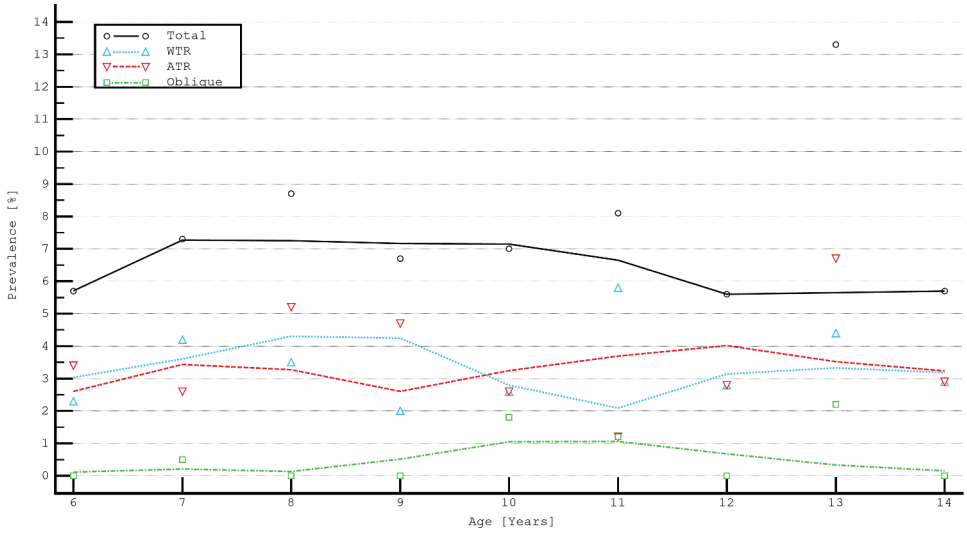

Figure 2. The distribution of different types of astigmatism in children aged 6–14 years.

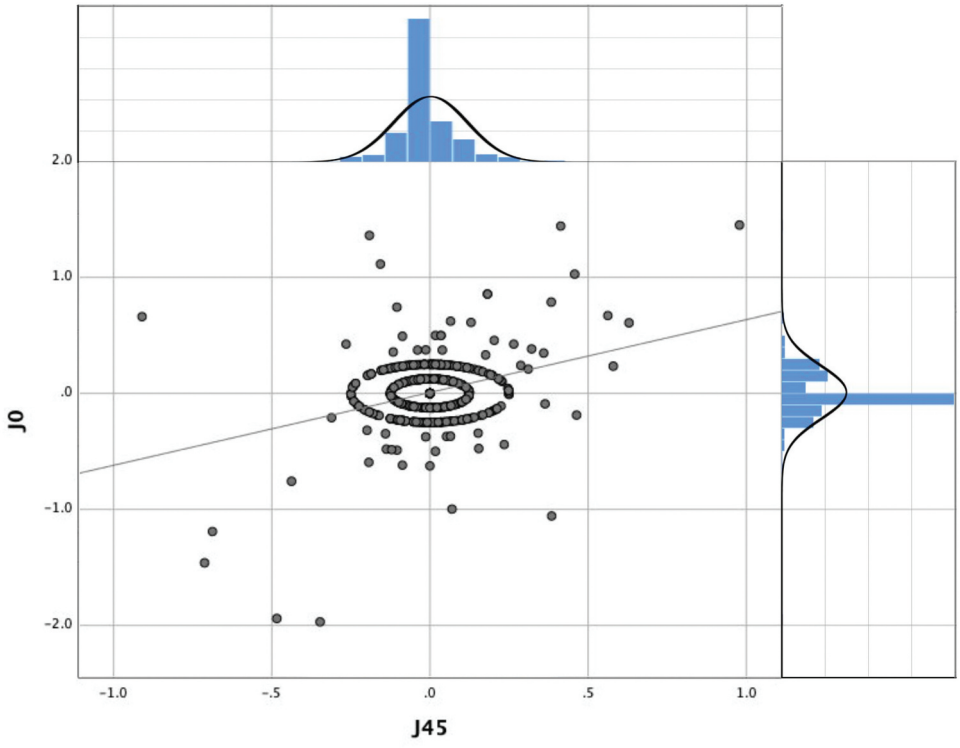

Figure 3. Joint distribution of power vectors in the right eyes of Polish schoolchildren aged 6–14 years [D]. J0 is the Jackson cross-cylinder power at axis 90° and 180°, J45 is the Jackson cross-cylinder power at axis 45° and 135°. In this representation, positive values of J0 indicate with-the-rule astigmatism and negative values indicate against-the-rule astigmatism. Power J45 represents oblique astigmatism.

astigmatism correlated with age, although the correlation was weak. Only 18.4% of children with astigmatism equal or greater than 0.75 D wore glasses. The rates of spectacle wear were non-significantly greater for children with higher levels of astigmatism. Potentially, this could contribute to substantial reductions in visual performance and learning problems.

The prevalence of astigmatism in our population was significantly lower than in several published studies. Several studies have reported the prevalence of astigmatism in schoolchildren [Table 3]. However, there are few studies reporting the rates among European schoolchildren. Particularly high rates of astigmatism were found in Southeast Asia and Taiwan, where the reported

Table 2. The presence of cylindrical anisometropia.

Variable	Total ($N = 1041$) n (%)	Cylinder power ≥0.75 D ($N = 76$) n (%)	Cylinder power >1 D ($N = 29$) n (%)	Cylinder power >2D ($N = 13$) n (%)
Isometropia	988 (94.9%)	57 (75.0%)	19 (65.5%)	8 (61.5%)
Cylindrical anisometropia	53 (5.1%)	19 (25.0%)	10 (34.5%)	5 (38.5%)

prevalence was over 40.0%.[2,21,22] The reported prevalence of astigmatism varies between countries and ethnicities. Additionally, those variations should be interpreted with caution due to differences in methodology, children's ages and astigmatism definitions.

This study found that the presence and severity of astigmatism was not significantly different between boys and girls. Previous studies reported minimal gender differences in the prevalence of astigmatism. Yekta *et al.* reported that Iranian boys had a higher prevalence of astigmatism than girls (12.11% vs. 10.37%, respectively).[33] In another study, the overall prevalence of astigmatism in Tunisian schoolchildren was non-significantly higher in boys than in girls (7.51% vs. 5.88%, respectively; $p = .051$). However, against-the-rule astigmatism was more common in boys ($p = .033$).[31] Those mixed findings may be related with lifestyle but further research and longitudinal studies are necessary to understand the role of gender in refractive error development. In our study, we also found that astigmatism was more prevalent among children in urban than rural areas (5.1% vs 4.3%, respectively). A similar relationship was observed among Indian children.[23,24]

A unique feature of our study is that it shows the proportion of astigmatic children wearing glasses. Large amounts or unilateral astigmatism often leads to amblyopia,[6] which could often be undetected as children may not complain about insufficient vision. The awareness of vision difficulties in children is associated with older age and greater visual impairment.[34,35] The results of our study confirm that several cases of astigmatism in children were uncorrected, and, if it is unilateral or the difference between eyes is large, may potentially lead to amblyopia. In this study, cylindrical anisometropia was non-significantly common in children with higher levels of astigmatism (25.0%, 34.5% and 38.5%, respectively). Still, only 15.8–40.0% of

Table 3. The prevalence of astigmatism in children in different studies worldwide.

Country	Study	Age [Years]	Definition of astigmatism	Cycloplegic measurement	Prevalence
Europe					
Northern Ireland	O'Donogue et al. 2015[15]	6–7	≥1D	Yes	22.9%
		12–13			18.4%
Poland	Czepita et al. 2007[16]	6–18	≥0.5 D	Yes	4.0%
Poland	This study	6–14	≥0.75 D	No	7.3%
			≥1 D		4.9%
North America					
USA	Kleinstein et al. 2003[17]	5–17	≥1 D	Yes	28.4%
South America					
Chile	Maul et al. 2000[18]	5–15	≥0.75 D	Yes	27.0%
Asia					
China	Zhao et al. 2000[19]	5–15	≥0.75 D	Yes	1.0%
China (Hong Kong)	Fan et al. 2004[20]	5–16	≥1.0 D	Yes	18.1%
China (Guangzhou)	He et al. 2008[21]	5–15	≥0.75 D	Yes	42.7%
China (Southern)	He et al. 2004[22]	5–15	≥0.75 D	Yes	42.8%
India (urban)	Murthy et al. 2002[23]	5–15	≥0.75 D	Yes	14.6%
India (rural)	Dandona et al. 2002[24]	7–15	≥0.75 D	Yes	9.7%
Iran (Dezful)	Fotouhi et al. 2007[25]	7–15	≥0.75 D	Mix	18.7%
Malaysia	Goh et al. 2005[26]	7–15	≥0.75 D	Yes	21.3%
Nepal	Negrel et al. 2000[27]	5–15	≥0.75 D	Yes	3.5%
Singapore	Tong et al. 2002[28]	7–9	≥0.75 D	Yes	28.3%
Taiwan	Shih et al. 2004[2]	7–15	≥0.5 D	Yes	42.5% (1995)
					51.0% (2000)
Africa					
Marocco	Anera et al. 2009[29]	6–16	≥0.75 D	Yes	23.5%
Nigeria	Maduka-Okafor et al. 2021[1]	5–15	≥0.75 D	Yes	2.3%
Republic of South Africa	Naidoo et al. 2003[30]	5–15	≥0.75 D	Yes	14.7%
Tunisia	Chebil et al. 2015[31]	6–14	≥0.75 D	Yes	6.7%
Australia					
Australia	Robaei et al. 2006[32]	12	≥1 D	Yes	21.8%

children with astigmatism and cylindrical anisometropia were wearing spectacles during the examination. Those results highlight the importance of regular eye checks and vision examinations which should be carried out during childhood.[7] Furthermore, there is a requirement for high awareness among parents and teaching staff regarding vision problems in children. The results of this study also warrant further investigations on early detection and correction of astigmatism during childhood.

Our study has several limitations. Firstly, there is a risk of sampling bias.[36] We did not employ random sampling to select pupils that were included in the study. The choice of participating schools was not random, but based on the will of cooperating with the examining company. Only public schools participated in this study, although in Poland 93.8% of primary school children and 92.8% of middle-school children attend public schools.[37] Second, measurements of objective refraction were performed without cycloplegia. As such accommodation may have affected the measurement of the refractive error despite the autofogging used by the autorefractor to minimize accommodation. Cycloplegia is known to strongly influence spherical equivalent refraction, but the effect only minimally affects the refractive cylinder.[38–41] In a recent study by Guo *et al.* the observed mean cylindrical differences by refractive error types and magnitude generally were < 0.10 D despite the variance being statistically significant.[42]

Conclusion

We found only 18.4% of Polish children with astigmatism wore glasses. Age, gender and place of living were not associated with the presence of astigmatism. Future research should be undertaken with cycloplegic refraction and studies with a longitudinal design to examine the progression of astigmatism into adolescence and adulthood and to explore further the causes for the low rates of wearing glasses.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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