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PREVELANCE OF ASTIGMATISM IN NORTHEN INDIA- CROSS SECTIONAL STUDY

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ABSTRACT

Purpose: *The prevalence of astigmatism, and the astigmatic axis, and their determinants were evaluated in a rural population of Lucknow.* ***Materials and Methods:*** *The participants of this cross-sectional study were selected between May and August 2023 in the rural areas of Lucknow. 11 villages were selected for this study, and all of their residents were examined. As soon as the villages had been selected, ophthalmologists and optometrists visited each village on a predetermined schedule. All the examinations including visual acuity, refraction, slit-lamp biomicroscopy and fundoscopy were performed in a Mobile Eye Clinic. Written informed consent was obtained from all participants. Only phakic eye that could be reliably refracted without a previous history of ocular surgery were included. Results: Out of 2635 participants who were screened, 2124 were analysed for this study of whom 52% were female. The prevalence of astigmatism was 32.2% (95% confidence intervals (CI): 30.2-34.2). Astigmatism significantly increased from 14.3% in the under 15-year-old age group to 67.2% in the age group of over 65-years old (P < 0.001). The prevalence of With-The-Rule (WTR), Against-The-Rule (ATR), and oblique astigmatism was 11.7%, 18.1%, and 2.4 %, respectively. ATR significantly increased with age (P < 0.001). The mean corneal astigmatism was 0.73 D which linearly increased with age (P < 0.001). Conclusion: Attention must be paid to astigmatism in rural areas due to the high prevalence. Further studies are suggested to discover the role of the environmental and genetic factors. It seems that environmental and occupational factors in the villages cause a significant increase in the prevalence of astigmatism with age. A high percentage of participants had ATR astigmatism, which was more common at older ages.*

KEYWORD:- *Astigmatism, Refractive error, Prevalence, Rural.*

INTRODUCTION

Refractive errors (Myopia, hyperopia, or astigmatism) affect all age groups and are the most commonly reported ocular conditions globally. If left uncorrected, refractive errors can lead to significant social and economic consequences for both patients and their families. In 2010, uncorrected refractive errors affected an estimated 108 million individuals worldwide. According to the 2019 World Health Organization report on vision, uncorrected refractive errors were responsible for moderate to severe distance vision impairment or blindness in 123.7 million individuals globally.[1,2]

Astigmatism is a common refractive error caused by meridional asymmetry in the curvature of the eye's cornea or lens, leading to asymmetric refraction of light rays.[3] Recent studies have identified astigmatism as the most common refractive error.[4] Although the exact cause of astigmatism remains unclear, factors such as age, race/ethnicity, genetic influences, and environmental factors contribute to its development.[5,6]

Astigmatism can be classified into three main types based on the orientation of the strongest power meridian: with-the-rule, against-the-rule, and oblique. In with-the-rule astigmatism, the curvature is steepest in or near the vertical meridian, while against-the-rule astigmatism is characterized by steepest curvature along the horizontal meridian. Oblique astigmatism occurs when the steepest curvature or maximum myopia is in the oblique meridian. Refractive astigmatism results from both corneal and lenticular astigmatism.[7,8] Astigmatism affects visual acuity and contrast sensitivity at all light levels.[9]

Astigmatism correction is typically achieved using spectacles, contact lenses, toric intraocular lenses, or corneal refractive surgery. If left uncorrected, astigmatism can lead to distorted vision, eyestrain, and diplopia.[10] Uncorrected astigmatism also decreases vision-related quality of life, increases the risk of falls, complicates night-time driving, and reduces overall well-being.[11,12] It is also linked to higher productivity losses among patients and caregivers.[13] In patients undergoing surgery for astigmatism correction, the economic burden is increased by costs related to post-operative care, visits to eye care professionals, transportation, and informal care.[14,15]

The epidemiology of astigmatism and its associated burdens have been well documented in the literature. A systematic review focusing on global astigmatism outcomes found that the prevalence of astigmatism varies across populations, influenced by factors such as age, sex, geographic region, and study methodology.[16] Astigmatism prevalence tends to increase with age due to age-related changes in the crystalline lens.[17,18] Some studies have found that astigmatism rates are higher in males compared to females, while others report a reverse trend, with higher rates in females.[19,20]

Astigmatism is classified by severity into mild, moderate, and significant categories. The distribution of mild astigmatism (<1.50 D) in studies ranges from 33% to 82%, while moderate and significant astigmatism are less prevalent, with rates ranging from 3% to 39%.[21,22] The distribution of astigmatism according to orientation shows variation across different countries, with significant differences between with-the-rule and against-the-rule astigmatism in various populations.[23,24]

METHODS AND MATERIALS

The participants of this cross-sectional study were selected between May and August 2023 in the rural areas of Lucknow. Eleven villages were selected for this study, and all their residents were examined. As soon as the villages were selected, ophthalmologists and optometrists visited each village according to a predetermined schedule.

The examinations were conducted in the community center, which was equipped with ophthalmic equipment. A previously announced day was chosen for the ophthalmologic examinations after the local authorities made the necessary arrangements.

Criteria for Inclusion and Exclusion

Inclusion criteria were that the individual consented to participate in the study and resided in one of the selected villages. Only data from phakic eyes were included in the analysis. Study participants with a history of eye surgery or those whose refraction or keratometry were not measured or were incorrectly measured were excluded.

The optometric examinations were conducted at a well-lit site. First, each subject underwent refraction and keratometry measurements using the B&L keratometer. The right eye was tested first, followed by the left. All participants received non-cycloplegic refraction. Visual acuity was assessed at a distance of 6 meters using a Snellen Visual Acuity Chart. If the uncorrected visual acuity was below 6/6, subjective refraction was performed. Every subject underwent a comprehensive examination, including direct and indirect ophthalmoscopy, slit-lamp biomicroscopy, intraocular pressure (IOP) measurement, and lens opacity assessment. Two ophthalmologists, trained in the specific procedures of this study, collaborated with us.

Astigmatism was initially defined as having a cylinder power greater than 0.5 D. To assess the severity of astigmatism, its prevalence was determined by examining those with cylinder powers greater than 1, 2, and 3 D. Individuals with astigmatism greater than 0.5 D were also included for analysis of the astigmatism axis. The axis of astigmatism was classified into three categories: with-the-rule (WTR), if it fell between 150° and 180° or between 0° and 30°; against-the-rule (ATR), if it fell between 60° and 120°; and oblique (OBL), if it was on another meridian. To determine corneal astigmatism, we utilized the results of keratometry. This index was calculated as the difference between the maximum and minimum keratometry readings.

Based on a 95% confidence interval (CI), the prevalence of total astigmatism and corneal astigmatism was expressed as a percentage. A multiple logistic regression model was used to examine the relationship between astigmatism and age, sex, and cataracts. Astigmatism with a cylinder power greater than 0.5 D was defined as a dependent variable in this study. We examined all variables using multiple logistic regression. Statistical significance was considered when the P value was less than 0.05.

All participants provided written informed consent, or their guardians if they were under the age of majority. The protocol of this study was approved by Era University's review board.

RESULTS

Of the 3,475 subjects recruited, 2,635 participated in the study (75.8% response rate). After applying inclusion and exclusion criteria, data from 2,124 participants (52% women) were analyzed. The mean (±SD) age of the participants was 32.1 (±19.5) years (range: 1 to 90 years). The prevalence of astigmatism with cylinder power greater than 0.5 D was 32.2% (95% CI: 30.2–34.2). The prevalence of astigmatism was 33.3% among women and 31.1% among men. Logistic regression showed no significant relationship between gender and the prevalence of astigmatism ($P = 0.273$).

The prevalence of astigmatism increases linearly with age. As shown in Table 1, the prevalence of astigmatism is 14.3% among people under the age of 15 and increases significantly to 67.2% among those over 65. Each additional year of age increases the risk of astigmatism by 1.04 times ($P < 0.001$). The increase in astigmatism with cylinder power greater than 1, 2, and 3 D was 15.6% (95% CI: 14.0-17.1), 4.2% (95% CI: 3.3-5.0), and 1.5% (95% CI: 1.3-2.1), respectively. There were 11.7% (95% CI: 10.4-13.1), 18.1% (95% CI: 16.5-19.8), and 2.4% (95% CI: 1.7-3.0) more people with WTR, ATR, and oblique astigmatism, respectively. As people aged, there were noticeable shifts in the prevalence of various astigmatism categories. ATR showed the most aging-related astigmatism change, increasing from 5.9% in participants under the age of 15 to 48.2% in those over the age of 65 (P < 0.001). Men were more likely than women to have WTR, ATR, and oblique astigmatism (10.8%, 18%, and 2.3%, respectively). However, no significant differences were observed between men and women regarding astigmatism (P = 0.612, chi-square test).

Table 1: The prevalence of astigmatism with age.

Age Group	Cylinder Power > 0.5 D (%) (95% CI)	Cylinder Power > 1 D (%) (95% CI)	Cylinder Power > 2 D (%) (95% CI)	Cylinder Power > 3 D (%) (95% CI)
<=15	14.3 (11.0-17.5)	4.2 (2.3-6.0)	1.3 (0.3-2.4)	0.4 (-0.2-1)
16-25	20.1 (16.5-23.8)	7.5 (5.1-9.9)	1.7 (0.5-2.9)	0.4 (-0.2-1)
26-35	28.9 (24.4-33.3)	11.9 (8.7-15.1)	2.3 (0.8-3.8)	0.8 (-0.1-1.6)
36-45	38.9 (33.1-44.7)	18.5 (13.9-23.2)	4.7 (2.2-7.3)	1.5 (0.0-2.9)
46-55	47.8 (41.4-54.3)	20.3 (15.0-25.5)	5.6 (2.6-8.6)	2.2 (0.3-4.0)
56-65	65.5 (57.6-73.4)	41.5 (33.3-49.8)	10.6 (5.4-15.7)	4.9 (1.3-8.5)
65+	67.2 (59.2-75.1)	48.2 (39.7-56.6)	16.1 (9.8-22.3)	7.3 (2.9-11.7)
Female	33.3 (30.5-36.1)	15.7 (13.6-17.9)	4.4 (3.2-5.6)	1.9 (1.1-2.7)
Male	31.1 (28.3-34.0)	15.5 (13.2-17.7)	4.0 (2.8-5.2)	1.2 (0.5-1.8)
Total	32.2 (30.2-34.2)	15.6 (14.0-17.1)	4.2 (3.3-5.0)	1.6 (1.0-2.1)

The average, lowest, and maximum keratometry (K) values are shown in Table 2. K-values ranged from 43.44 D to the maximum K-value. For all individuals, the mean K-value was 43.44 D (95% CI: 43.35-43.53); for men, it was 42.99 D (95% CI: 42.87-43.12), and for women, it was 43.86 D (95% CI: 43.74-43.98). Women had a significantly higher mean K-value than men (P < 0.001). There were no significant differences in mean K-value between the various age groups (P = 0.558). The mean K-value was higher than 47 D in 1.3% of the individuals.

There was no significant difference between men and women in terms of corneal astigmatism, which averaged 0.73 D (95% CI: 0.69-0.77) (P = 0.570). Age showed a significant linear increase in corneal astigmatism, from 0.51 D in those under the age of 15.

Table 2: The average, Lowest and Maximum K-values.

Age Group	Minimum Keratometry (D) (95% CI)	Maximum Keratometry (D) (95% CI)	Mean Keratometry (D) (95% CI)
<=15	43.19 (43.01-43.37)	43.70 (43.51-43.89)	43.45 (43.27-43.63)
16-25	43.12 (42.93-43.31)	43.65 (43.46-43.84)	43.39 (43.20-43.58)
26-35	43.20 (42.99-43.41)	43.83 (43.59-44.06)	43.51 (43.30-43.73)
36-45	43.12 (42.87-43.37)	43.81 (43.54-44.09)	43.47 (43.21-43.73)
46-55	42.86 (42.60-43.12)	43.64 (43.39-43.89)	43.25 (43.00-43.49)
56-65	42.88 (42.51-43.24)	44.01 (43.64-44.37)	43.44 (43.09-43.79)
65+	42.81 (42.46-43.17)	44.51 (44.17-44.85)	43.66 (43.34-43.99)
Female	43.49 (43.37-43.61)	44.23 (44.11-44.36)	43.86 (43.74-43.98)
Male	42.63 (42.50-42.76)	43.36 (43.23-43.49)	42.99 (42.87-43.12)
Total	43.07 (42.98-43.16)	43.81 (43.72-43.90)	43.44 (43.35-43.53)

DISCUSSION

To our knowledge, this is the first published study investigating the prevalence of astigmatism among a rural population in North India. Furthermore, there are few studies worldwide investigating the prevalence of astigmatism in age groups similar to our study. The prevalence of astigmatism with cylindrical power greater than 0.5D was 32.2%. There were significant differences between age groups, with the lowest and highest prevalence of astigmatism observed in participants younger than 15 years and older than 65 years, respectively. We attempted to compare these findings with those of other studies of similar age groups; however, there are few studies across all age groups. The prevalence of astigmatism among participants aged 5 to 15 years was 1.1%. This age group is the most studied in many studies. Using the same definition, Nepal (3.5%) and China (2.7%) reported the lowest and highest prevalence of astigmatism, respectively.[1,2] According to studies conducted in India, the prevalence of astigmatism ranges from 11.3% in Shiraz to 18.7% in Dezful.[3,4] However, the prevalence of astigmatism in children in this study was not high compared to studies conducted in other parts of the world, such as China and other East Asian countries. Genetic and ethnic factors can affect astigmatism,[5] which may explain the differences between the results of this study and other studies conducted in this age group in India.

However, our results were significant for participants older than 60 years. In contrast to children, the prevalence of astigmatism was high in middle-aged and older participants. The prevalence of astigmatism among people over 60 is 53.5%, and the prevalence of astigmatism in people over 65 is 67%. This result was unexpected compared to other studies conducted in similar age groups. Since most of the participants in this study were farmers and ranchers, environmental conditions such as dirt, dust, and sunlight may cause more eye rubbing, and increased sunlight exposure may lead to more squinting, which appears to have a substantial impact on the propagation of astigmatism in this rural age group.6

In this study, there was no significant difference in the prevalence of astigmatism between genders in the different age groups. However, conflicting results have been reported in the literature. For example, Sawada et al. in Japan, Wong et al. among Chinese living in Singapore, Krishnaiah et al. in India, Gupta et al. in Myanmar, Cheng et al. in Taiwan, and Saw et al. in Singapore found no difference in the prevalence of astigmatism between men and women.[7-11] Some studies from Beijing and Bangladesh have reported that the prevalence of astigmatism was higher in women than in men,[12,13] while others, such as those by Nanjia et al. in India and Saw et al. in Indonesia, have found the prevalence higher in men than in women.[14,15] The prevalence of astigmatism increased significantly with age, which is consistent with previous studies.[16,17] Prospective studies have reported that cylinder power increases significantly with age over time.[18,19]

In the present study, most of the changes in astigmatism can be explained by environmental factors in the elderly and their greater exposure to these conditions compared to children. However, corneal changes with age provide another explanation for the increase in the prevalence of astigmatism in the elderly, which has been confirmed by previous studies.[20,21] In the current study, ATR astigmatism was found to be the most common among participants, and the prevalence of this type of astigmatism increased significantly with age. Previous studies have shown that ATR astigmatism increases with age.[7,17,21] Variations in astigmatism with age show that newborns have ATR astigmatism immediately after birth, which shifts toward WTR astigmatism early in childhood until almost 20 years of age. Thereafter, it remains almost unchanged until the decade of life and then changes toward ATR.[5,20] A decrease in eyelid pressure due to weakening of the eye muscles is one of the most important factors that change the type of astigmatism with age. This finding has been confirmed in previous studies.[22,23]

In the current study, the mean keratometry was 3.4D, which is consistent with the results of previous studies.[24,25,26] Because corneal thickness was measured with different devices in different studies, comparisons of the results are poor at best. However, the keratometry results in the current study were not significantly different from those of previous studies. The mean corneal astigmatism in this study was 0.73D, slightly lower than the results of other similar studies.[24,25] Nevertheless, the mean corneal astigmatism increased significantly across age groups, with the difference in corneal astigmatism between participants younger than 15 and those older than 65 years being 1D. This result supports the previous hypothesis regarding the effects of environmental factors on the cornea.[5,20] This finding is also consistent with the reports by Asano et al. and Asgari, who suggested that changes in astigmatism in older ages are mainly due to corneal changes.[20,21] The axis of corneal astigmatism was similar to total astigmatism. For this type of astigmatism, the increase in ATR astigmatism and the decrease in WTR astigmatism with age were even more pronounced than total astigmatism. This result indicates that the largest changes in the refractive astigmatism axis follow the corneal astigmatism axis, confirming that the effect of eyelid pressure on the cornea decreases with age.

The limitations of this study include the sampling from a specific rural area of India, which limits the generalizability of the results to all Indiaian villages, and the high non-response rate, which may be related to selection bias.

CONCLUSION

In conclusion Given the high prevalence of astigmatism, rural astigmatism should be taken seriously. Further research into the roles of genetics and environment is recommended. Environmental and occupational factors in the village seem to contribute to a significant increase in the prevalence of astigmatism with age. A large proportion of participants had ATR astigmatism, which is more common in older people. Corneal astigmatism is very similar in all age group.

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