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Defining Standard Eye Measurements in Young Indian Adults: A Normative Study

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KEYWORDS

Eye anthropometry, Intercanthal distance, Palpebral fissure, Orbital index, Photogrammetry

ABSTRACT:

Background: Ocular anthropometry provides critical reference data for clinical, surgical, and forensic applications. However, normative values for the Indian population remain limited, especially concerning sexual dimorphism in eye parameters. To analyze ocular dimensions among young Indian adults using 2D photogrammetry, and to assess gender differences in key parameters.

Material and Methods: A descriptive cross-sectional study was conducted on 640 healthy adults (equal males and females) aged 18–25 years. Exclusion criteria included ocular trauma, surgery, or craniofacial anomalies. For Indirect measurements, standardized frontal photographs were analyzed with Digimizer software. Parameters assessed included intercanthal distance, outer canthal distance, palpebral fissure length, palpebral fissure height, iris diameter, and derived indices. Statistical analysis was performed using unpaired t-test, with $p < 0.05$ considered significant.

Results: Males exhibited significantly larger intercanthal distance, outer canthal distance, and palpebral fissure length compared to females ($p < 0.05$). No significant differences were observed in palpebral fissure height and iris diameter. The orbital index was significantly higher in females, while intercanthal and palpebral fissure indices showed no gender variation. Percentile distributions provided normative reference values for clinical use.

Conclusion: This study highlights sexual dimorphism in ocular parameters among Indian adults. The generated normative values will serve as important benchmarks for ophthalmology, oculoplastic surgery, forensic science, and anthropological research.

INTRODUCTION

Facial anthropometry is an essential tool in anatomy, ophthalmology, and forensic science, as it provides standardized measurements of craniofacial features that aid in diagnosis, treatment planning, and personal identification. Among these features, the eyes hold a unique significance because of their central role in both visual function and facial aesthetics. Eye morphology contributes to overall facial harmony, and deviations in ocular dimensions often indicate congenital anomalies, trauma, or syndromic conditions [1].

Eye parameters such as intercanthal distance, outer canthal distance, palpebral fissure length, eye height, and canthal index are widely studied for their clinical and aesthetic importance. These measurements guide surgical corrections in conditions such as hypertelorism, telecanthus, congenital ptosis, blepharophimosis, and orbital fractures [2,3]. They are also valuable in prosthetic rehabilitation, cosmetic eyelid surgery, and forensic identification. Importantly, ocular dimensions vary significantly across populations due to ethnicity, sex, and age, highlighting the need for population-specific normative data [4].

In India, with its vast ethnic and regional diversity, comprehensive ocular anthropometric data remain scarce. The absence of normative reference standards for eye parameters limits the precision of clinical interventions and complicates forensic investigations. Studies in other populations have demonstrated sexual dimorphism and ethnic variation in ocular dimensions [5,6], but similar large-scale data in young Indian adults are limited. Establishing normative values in this

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demographic would aid ophthalmic surgeons, forensic experts, and aesthetic practitioners in providing more accurate and culturally relevant outcomes.

Traditionally, direct anthropometry using calipers has been considered the gold standard for ocular measurements. However, this method is operator-dependent, time-consuming, and often uncomfortable for participants. Recent advances in imaging technology have led to the adoption of two-dimensional (2D) photogrammetry, which allows for non-invasive, precise, and reproducible measurements from standardized digital photographs [7]. Photogrammetry also offers the advantages of data storage, reanalysis, and reduced observer variability. However, its reliability for periocular dimensions requires validation against direct methods, especially in ethnically diverse populations such as India [8].

This study aims to address two key objectives: (1) to establish normative ocular anthropometric data for Indian young adults aged 18–25 years, and (2) to evaluate the reliability of 2D photogrammetry compared with direct anthropometry. By analyzing parameters including intercanthal distance, outer canthal distance, palpebral fissure length, eye height, and canthal index, this research seeks to document sexual dimorphism and provide baseline references for clinical, forensic, and aesthetic applications. The findings are expected to enhance the accuracy of periocular assessments and support the use of photogrammetry as a valid alternative to conventional anthropometry.

MATERIAL AND METHODS

A descriptive cross-sectional study was carried out in the Department of Anatomy over one year. A total of 640 healthy Indian adults (equal number of males and females), aged 18–25 years, were included. Participants with history of ocular trauma, surgery, congenital craniofacial anomalies, or systemic disorders affecting eye morphology were excluded. This study was approved by the Institutional Ethics Committee (Ref. No. TMU/IEC/20-21/103), and written informed consent was obtained from all participants in accordance with the ethical principles outlined in the Declaration of Helsinki (1975). Eight ocular parameters were assessed: inner canthal distance (ICD), outer canthal distance (OCD), interpupillary distance (IPD), palpebral fissure height and length (right and left), upper eyelid height, lower eyelid height, and margin-reflex distance (MRD1). Measurements were performed by 2D photogrammetry.

2D Photogrammetry: Frontal photographs were taken with a 24.2-megapixel DSLR camera mounted on a tripod at a fixed distance of 1.5 m. The camera was aligned parallel to the occlusal plane; subjects maintained Frankfurt horizontal alignment. A millimeter scale was placed near the face for calibration. Images with poor orientation or artifacts were excluded. The selected JPEG files were analyzed using Digimizer Software (Version 5.7.5). All parameters were measured digitally, and mean values from two independent observers were recorded to enhance reliability.

Statistical Analysis: Data were expressed as mean ± standard deviation. Differences between genders were assessed using unpaired *t*-test, with $p < 0.05$ considered statistically significant.

RESULTS

Table 1. Descriptive statistics of linear eye parameters (mean ± SD, in cm)

Parameter	Male (n = 320)	Female (n = 320)	*t*-value	*p*-value
Intercanthal Distance	3.21 ± 0.25	3.05 ± 0.24	5.12	<0.05
Outer Canthal Distance	9.12 ± 0.43	8.76 ± 0.39	6.34	<0.05
Palpebral Fissure Length	2.88 ± 0.21	2.75 ± 0.20	4.87	<0.05
Palpebral Fissure Height	1.13 ± 0.15	1.08 ± 0.13	2.46	>0.05
Iris Diameter	1.11 ± 0.08	1.10 ± 0.07	0.91	>0.05

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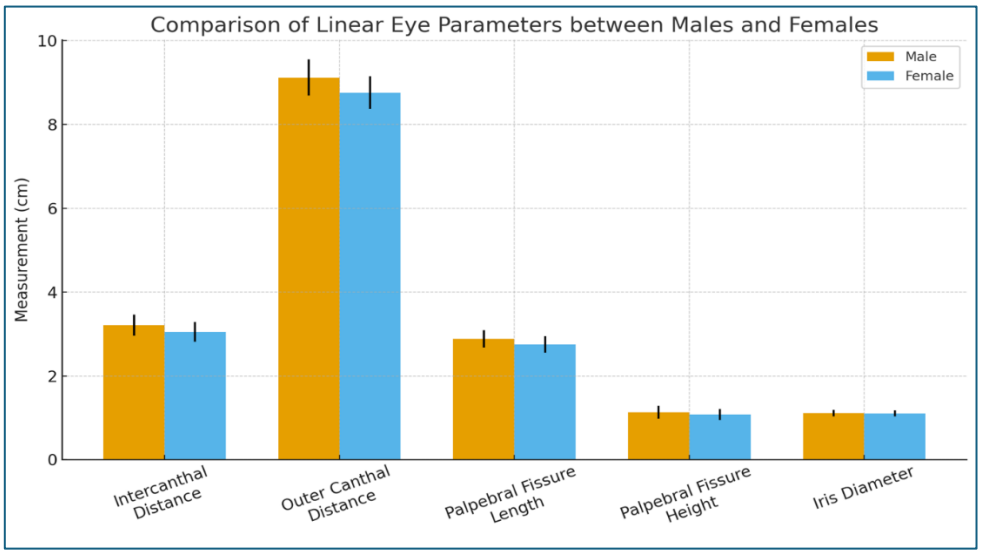
Table 2. Indices derived from eye parameters

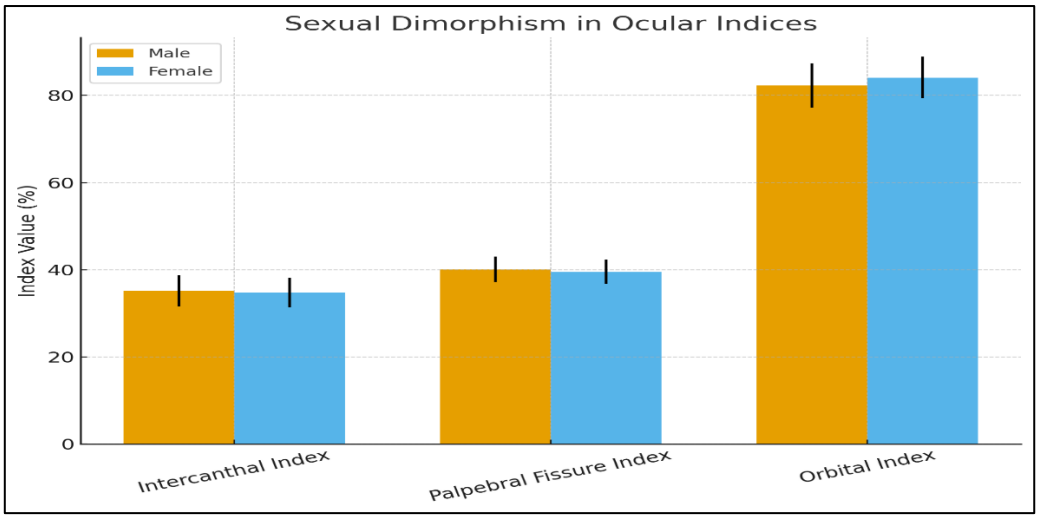
Parameter/Index	Male (mean ± SD)	Female (mean ± SD)	*p*-value
Intercanthal Index (%)	35.2 ± 3.6	34.8 ± 3.4	>0.05
Palpebral Fissure Index	40.1 ± 2.9	39.5 ± 2.8	>0.05
Orbital Index	82.3 ± 5.1	84.1 ± 4.8	<0.05

Figure 1. Comparison of linear eye parameters between males and females



(Bar chart – showing intercanthal, outer canthal, palpebral fissure length, height, and iris diameter for both sexes with error bars).

Figure 2. Sexual dimorphism in ocular indices



(Clustered bar chart – comparing intercanthal index, palpebral fissure index, and orbital index for males and females).

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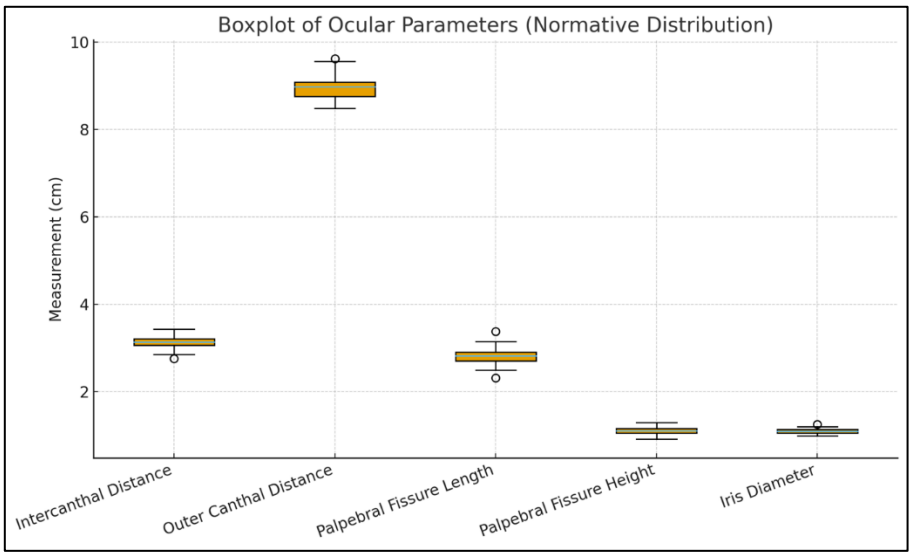
Table 3. Percentile distribution of selected ocular parameters (in cm)

Parameter	5th Percentile	50th Percentile (Median)	95th Percentile
Intercanthal Distance	2.85	3.15	3.45
Outer Canthal Distance	8.42	8.95	9.40
Palpebral Fissure Length	2.55	2.80	3.15
Palpebral Fissure Height	0.95	1.10	1.30
Iris Diameter	1.00	1.10	1.20

Figure 3. Box plot of ocular Parameters



Boxplot showing the distribution of ocular parameters (intercanthal, outer canthal, palpebral fissure length & height, and iris diameter). It visually represents the **median, interquartile range, and variability** in normative eye measurements.

DISCUSSION

The present study evaluated linear ocular parameters and derived indices among young Indian adults using 2D photogrammetry. The findings demonstrate notable sexual dimorphism in certain parameters, particularly intercanthal distance, outer canthal distance, and palpebral fissure length, which were significantly higher in males compared to females. In contrast, palpebral fissure height and iris diameter showed minimal gender variation. These results are consistent with the established concept that horizontal ocular dimensions exhibit greater sexual dimorphism than vertical ones.

Our observations align with the work of Farkas et al. [9], who reported significant differences in intercanthal and outer canthal distances between sexes in multiple ethnic populations. Similarly, Evereklioglu et al. [10] found larger intercanthal and outer canthal distances in Turkish males compared to females, corroborating our findings in the Indian cohort. A study by Gupta et al. [11] also reported wider palpebral fissures in North Indian males, supporting the notion of population- and gender-specific ocular anthropometric standards.

Interestingly, the orbital index was significantly higher in females in the present study, suggesting a relatively taller orbit in proportion to width. This agrees with observations by Al-Dairi et al. [12] in Middle Eastern populations, where females consistently demonstrated

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higher orbital indices. Such differences may be attributed to genetic, hormonal, and ethnic factors influencing craniofacial growth.

The percentile distribution of eye parameters (Table 3) provides normative reference values, which are essential for clinical applications. Surgeons rely on these standards for reconstructive procedures, correction of congenital anomalies, and trauma repair. Ophthalmologists and forensic experts also benefit from such datasets to differentiate normal morphometric variations from pathological deviations.

The present study supports the use of 2D photogrammetry as a reliable and non-invasive tool for ocular anthropometry, echoing the findings of Lim et al. [13] and Kwon et al. [14], who demonstrated the accuracy of photogrammetric analysis in facial measurements. The digital method minimizes intra-observer variability and allows long-term record keeping, making it suitable for large-scale anthropometric research.

Despite its strengths, this study has certain limitations. The sample was restricted to healthy adults aged 18–25 years, which may not capture age-related changes in ocular morphology, as highlighted by Kwon et al. [14]. Furthermore, only binary gender identity was considered, without inclusion of intersex or transgender populations, which may be relevant for future research.[15,16]

Overall, the findings validate that sexual dimorphism exists in key ocular parameters, and they emphasize the importance of developing population-specific reference standards. These normative values will aid clinical decision-making in oculoplastic surgery, ophthalmology, and forensic identification.

CONCLUSION

This study provides normative data on ocular anthropometric parameters among young Indian adults using 2D photogrammetric methods. Significant sexual dimorphism was observed in intercanthal distance, outer canthal distance, and palpebral fissure length, whereas palpebral fissure height and iris diameter showed minimal gender variation. The orbital index was significantly higher in females, reflecting proportional differences in orbital dimensions. These normative references will be valuable for oculoplastic surgery, ophthalmology, forensic analysis, and anthropological studies, emphasizing the importance of population-specific standards in clinical assessment and reconstructive procedures.

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