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Ocular Biometry and Anthropometric Measurement in Senile Cataract Patients

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Abstract

Background: Senile cataract is an age-related lens opacity and remains a leading cause of visual impairment. Accurate ocular biometry is essential before cataract surgery to determine appropriate intraocular lens (IOL) power. Ocular biometric factors may be influenced by anthropometric traits such as height, weight, and body mass index (BMI). This study aimed to explore the relationship between ocular biometry and these anthropometric characteristics in patients with senile cataracts
Methods: This retrospective analytic study used a cross-sectional design and included 1,466 senile cataract patients treated at a private hospital in Pekanbaru between June 2020 and January 2022. The anthropometric variables included height, body weight, and BMI, while ocular biometry measurements comprised axial length (AL), anterior chamber depth (ACD), keratometry (K), and central corneal thickness (CCT). Pearson correlation analysis was used to assess bivariate associations, and multivariate linear regression analysis was performed to determine independent relationships, controlling for age and gender. Due to collinearity between body weight and BMI, the latter was excluded from the final regression model.
Results: Height was positively correlated with AL ($p < 0.001$, $r = 0.281$) and ACD ($p < 0.001$, $r = 0.157$), and negatively with K ($p < 0.001$, $r = -0.238$). Body weight showed positive correlations with AL ($p < 0.001$, $r = 0.210$), ACD ($p < 0.001$, $r = 0.149$), and CCT ($p = 0.010$, $r = 0.067$), and a negative correlation with K ($p < 0.001$, $r = -0.188$). BMI demonstrated similar, albeit weaker, correlations. Age was negatively correlated with AL, ACD, and CCT. In multivariate analysis, height and body weight remained independently associated with AL and K, with body weight also independently linked to ACD.
Conclusion: Anthropometric parameters, particularly height and body weight, were independently associated with ocular biometric parameters in patients with senile cataracts. These findings suggest that body size and weight may influence ocular structural characteristics relevant to intraocular lens power calculation.

Keywords: *anthropometric measurement; axial length; intraocular lens; ocular biometry; senile cataract.*

Introduction

Cataract is an eye condition marked by clouding of the lens, which obstructs the passage of light to the retina.[1] Cataract is the foremost contributor to blindness and visual visual impairment globally. One of the most common forms is senile cataract, which develops as part of the aging process. According to the World Health Organization, approximately 48% of global blindness is attributed to cataracts.[2] Senile cataract occurs predominantly in individuals over 40 years of age and is characterized by progressive lens thickening, clouding, and decreased accommodative power.[3]

Most cases of reversible blindness in many nations are caused by cataracts. In Indonesia, the Rapid Assessment of Avoidable Blindness (RAAB) conducted in 15 provinces between 2014–2016 reported that the national prevalence of blindness was 3%, and untreated cataract accounted for 77.7% of these cases.[5] Furthermore, data from the 2013 National Basic Health Research (Riskesdas) estimated an annual cataract incidence of 0.1%, with Indonesian populations tending to develop cataracts approximately 15 years earlier than individuals in subtropical regions.[4,6] In Riau Province specifically, the prevalence of cataract was reported to be 1.9%.[6] These findings indicate that cataract represents a substantial public health burden in Indonesia, including in Riau Province, where access to timely surgical intervention and accurate preoperative assessment is essential to reduce avoidable visual impairment.

Currently, the only effective treatment for restoring visual function is cataract surgery, namely phacoemulsification with intraocular lens (IOL) implantation.[7] Accurate ocular biometry is essential in cataract surgery because it determines the appropriate IOL power required to achieve optimal postoperative refractive outcomes.[8] In the formulas used to calculate IOL power, parameters like as AL, ACD, and K are essential. Even small inaccuracies in these measurements may result in postoperative refractive errors, leading to suboptimal visual acuity and decreased patient satisfaction. Therefore, understanding factors that influence ocular biometry is clinically important to improve surgical precision and patient outcomes.

Anthropometric characteristics such as height, body weight, and BMI reflect overall growth patterns and may impact ocular development. Prior studies have reported associations between increased axial length (AL), deeper anterior chamber depth (ACD), flatter corneal curvature (K), and greater central corneal thickness (CCT) and these factors.[10,11] These structural variations are clinically relevant, as axial length and corneal curvature are key determinants of refractive status and directly affect intraocular lens (IOL) power calculation.

However, findings across populations were inconsistent. A study in Ethiopia found no significant association between body weight, BMI, AL, and ACD.[12] Studies conducted in Turkey also found no association between AL or central corneal thickness (CCT) and BMI.[11] Prior studies have reported associations between anthropometric characteristics and ocular biometry.[13] Other research found no association between height and several ocular biometric parameters in women.[14] These inconsistencies suggest that the relationship between anthropometric parameters and ocular biometry may vary across ethnic, genetic, and environmental backgrounds.

Research on the relationship between anthropometric characteristics and ocular biometry is still scarce in Indonesia and has mostly concentrated on children, whose height has been shown to affect anterior chamber depth and axial length.[15] Evidence in adult populations, particularly among senile cataract patients who require precise IOL calculation, is still scarce. Examining associations between anthropometric parameters and ocular biometry in this population may contribute to more accurate preoperative planning and better refractive outcomes in cataract surgery, in light of the high prevalence of cataract in Indonesia and the clinical importance of precise biometry.

Methods

Study Design and Population

This study assessed the relationship between anthropometric characteristics and ocular biometry in patients with senile cataracts using a cross-sectional, retrospective analytic strategy. The study population consisted of patients diagnosed with senile cataract who presented to a private hospital in Pekanbaru between June 2020 and January 2022. The study included patients over 40 with complete medical records, including height, body weight, axial length (AL), anterior chamber depth (ACD), keratometry (K), and central corneal thickness (CCT). The age threshold of 40 years was chosen based on the definition of senile cataract as an age-related condition that develops after the age of 40. Sampling was performed using a total sampling technique. The final analysis included 1466 patients who satisfied the inclusion criteria, chosen from a total of 1779 ocular samples collected during the study period.

Variables and Operational Definitions

This study assessed three anthropometric parameters: height, body weight, and BMI. Height and weight were obtained from medical records (cm and kg, respectively), and BMI was calculated as weight (kg) divided by height squared (m²) to categorize participants as underweight, normal weight, overweight, obese type I, or obese type II. Ocular biometry included central corneal thickness (CCT, µm), keratometry (K, D), axial length (AL, mm), and anterior chamber depth (ACD, mm). All biometric data were collected from preoperative ocular biometry examinations in the medical records.

Statistical Analysis

Data were analyzed using univariate analysis to describe the distribution of demographic and clinical variables. Bivariate relationships between anthropometric parameters and ocular biometry measurements were assessed using Pearson correlation. Independent associations were assessed through multivariate linear regression, controlling for demographic variables (age and gender). Variables with $p < 0.25$ in the bivariate analysis were included in the regression model. Collinearity among independent variables was assessed, and since body weight and BMI were collinear, only body weight was retained in the final model.

Study Limitations

Because this study used a retrospective design based on medical record data, the available variables were limited to those consistently documented in the records. Some potential confounding factors, such as systemic comorbidities, were not included due to incomplete documentation. These constraints may have influenced the comprehensiveness of the regression model and should be taken into account when interpreting the results.

Ethical Considerations

This study was approved by the Medical and Health Research Ethics Unit, Faculty of Medicine, Riau University (No.B/112/UN19.5.1.1.8/UEPKK/2021_Addendum). Patient confidentiality was maintained by analyzing anonymized data without including personal identifiers. All data were obtained from medical records and were used solely for research purposes.

Results

A total of 1,779 eye records were initially identified. Following the application of the inclusion and exclusion criteria, 1,466 eye samples from 1,466 patients were included in the final analysis. The demographic characteristics of the patients are presented in Table 1.

Table 1. Demographic Characteristics of Patients

Patient Characteristic	n (%)
Gender	
Male	807 (55)
Female	659 (45)
BMI*	
Underweight (BMI <18.5)	139 (9.5)
Normal (BMI 18.5 – 22.9)	593 (40.5)
Overweight (BMI 23 – 24.99)	277 (18.9)
Obese Type I (BMI 25 – 29.99)	362 (24.7)
Obese Type II (BMI ≥30)	95 (6.5)
Total	**1466 (100)**

*BMI (Body Mass Index)

The study population consisted of 807 male patients (55%) and 659 female patients (45%). Based on body mass index (BMI) classification, the largest group was the normal BMI category (18.5–22.99 kg/m²), comprising 593 patients (40.5%).

Mean characteristic and biometry parameters of patients (Table 2).

Table 2. Mean Characteristic and Biometry Parameters of Patients

Variable	Mean ± SD
Age (years)	62.43 ± 8.46
Weight (kg)	58.72 ± 11.40
Height (cm)	158.23 ± 7.14
Body Mass Index (kg/m²)	23.42 ± 4.12
Axial Length (mm)	23.47 ± 1.00
Anterior Chamber Depth (mm)	3.22 ± 0.42
Keratometry (D)	44.18 ± 1.48
Central Corneal Thickness (µm)	524.48 ± 32.59

*AL (Axial Length), ACD (Anterior Chamber Depth), K (Keratometry), CCT (Central Corneal Thickness)

Table 2 presents the descriptive statistics for the anthropometric and ocular biometry parameters. The average age was 62.43 ± 8.46 years. The average body weight, height, and BMI were 58.72 ± 11.40 kg, 158.23 ± 7.14 cm, and 23.42 ± 4.12 kg/m², respectively. The average AL, ACD, K, and CCT were 23.47 ± 1.00 mm, 3.22 ± 0.42 mm, 44.18 ± 1.48 diopters, and 524.48 ± 32.59 µm, respectively.

Relationship between anthropometry and ocular biometry (Table 3).

Table 3. Relationship Between Anthropometry and Ocular Biometry

Parameter	AL (r)	ACD (r)	K (r)	CCT (r)
Height	0.281***	0.157***	−0.238***	0.028*
Weight	0.210***	0.149***	−0.188***	0.067*
BMI	0.089***	0.088***	−0.087***	0.061*

*p < 0.05, *** p < 0.001

Table 3 presents the Pearson correlation results. Height was positively correlated with ACD (p < 0.001, r = 0.157) and AL (p < 0.001, r = 0.281), and negatively correlated with K (p < 0.001, r = -0.238). CCT and height did not significantly correlate (p = 0.277). Body weight had a negative correlation with K (p < 0.001, r = -0.188) and a positive correlation with AL (p < 0.001, r = 0.210), ACD (p < 0.001, r = 0.149), and CCT (p = 0.010, r = 0.067). BMI had a negative correlation with K (p < 0.001, r = −0.087) and a positive correlation with AL (p < 0.001, r = 0.089), ACD (p < 0.001, r = 0.088), and CCT.

Correlation between age and ocular biometry parameters (Table 4).

Table 4. Correlation Between Age and Ocular Biometry Parameters

Variable	AL	ACD	K	CCT
Age	r = −0.078, p = 0.003	r = −0.187, p < 0.001	r = −0.028, p = 0.281	r = −0.058, p = 0.028

analyzed using Pearson correlation test

The age-related Pearson correlation data are shown in Table 4. Axial length (AL) (p = 0.003, r = -0.078), anterior chamber depth (ACD) (p < 0.001, r = -0.187), and central corneal thickness (CCT) (p = 0.028, r = -0.058) were all negatively correlated with age. Age and keratometry (K) did not significantly correlate (p = 0.281).

Comparison of ocular biometry parameters by gender (Table 5).

Table 5. Comparison of Ocular Biometry Parameters by Gender

Parameter	Male (n = 807) Mean ± SD	Female (n = 659) Mean ± SD	p-value
AL (mm)	23.70 ± 0.95	23.19 ± 1.00	< 0.001
ACD (mm)	3.29 ± 0.41	3.14 ± 0.42	< 0.001
K (D)	43.87 ± 1.42	44.56 ± 1.47	< 0.001
CCT (μm)	524.78 ± 32.32	524.12 ± 32.93	0.702

Gender differences were analyzed using Independent t-test.

Table 5 presents the gender differences in ocular biometry. Males had significantly greater AL (23.70 ± 0.95 mm vs. 23.19 ± 1.00 mm) and ACD (3.29 ± 0.41 mm vs. 3.14 ± 0.42 mm), and lower K values (43.87 ± 1.42 D vs. 44.56 ± 1.47 D) compared to females (all p < 0.001). No significant difference in CCT was observed between genders (p = 0.702).

Multivariate linear regression analysis was performed to determine whether anthropometric parameters independently influenced ocular biometry after controlling for age and gender.

Collinearity was identified between body weight and BMI; therefore, BMI was excluded from the regression model due to its weaker correlation coefficients.

Results of linear regression analysis of anthropometry and demographic characteristics on ocular biometry parameters (Table 6).

Table 6. Results of Linear Regression Analysis of Anthropometry and Demographic Characteristics on Ocular Biometry Parameters

Variable	Axial Length (AL) β	p-value	Anterior Chamber Depth (ACD) β	p-value
Height	0.149	< 0.001	0.018	0.576
Body Weight	0.105	< 0.001	0.069	0.015
Age	−0.042	0.103	−0.174	< 0.001
Gender	0.151	< 0.001	0.163	< 0.001

Standardized β coefficients are shown. The model was adjusted for height, body weight, age, and gender.

Axial length was independently associated with height (β = 0.149, p < 0.001) and body weight (β = 0.105, p < 0.001) after adjusting for age and gender. Gender also showed a significant association (β = 0.151, p < 0.001), while age was not significant (p = 0.103).

ACD was significantly predicted by body weight (β = 0.069, p = 0.015), age (β = −0.174, p < 0.001), and gender (β = 0.163, p < 0.001); however, height was no longer a significant predictor after adjustment (p = 0.576).

Results of linear regression analysis of anthropometry and demographic characteristics on ocular biometry parameters (Table 7).

Table 7. Results of Linear Regression Analysis of Anthropometry and Demographic Characteristics on Ocular Biometry Parameters

Variable	Keratometry (K)* β	p-value	Central Corneal Thickness (CCT)** β	p-value
Height	−0.112	0.001	—	—
Body Weight	−0.147	< 0.001	—	—
Age	−0.107	< 0.001	0.058	0.030
Gender	—	—	−0.045	0.089

*** adjusted for height, weight, and gender**
**** adjusted for weight and age**

In the multivariate analysis, keratometry (K) was significantly predicted by height (β = −0.112, p = 0.001), body weight (β = −0.147, p < 0.001), and age (β = −0.107, p < 0.001). Conversely, central corneal thickness (CCT) was

Frontiers on Healthcare Research
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significantly associated with age (β = 0.058, p = 0.030), while other anthropometric variables were no longer significant after adjustment.

Discussion

Findings from this study indicate a higher prevalence of senile cataracts in men compared to women, in agreement with prior studies showing comparable patterns.[2] However, it differed from other studies that reported a higher prevalence among females.[7,16] Hormonal changes during menopause have been suggested as a contributing factor, as decreased estrogen levels may reduce the protective mitogenic and antioxidative effects on lens epithelial cells.[7,16] Nevertheless, cataractogenesis is multifactorial, and sex hormones alone cannot fully explain the observed differences. Systemic conditions, environmental exposure, lifestyle, and occupational factors may also contribute to cataract development.

The anthropometric profile of the patients in this study differed from findings of a previous study that reported a higher proportion of obesity among cataract patients.[17] Elevated BMI has been associated with protein denaturation within the lens, potentially accelerating lens opacity formation.[18] However, the predominance of normal BMI in the present study suggested that cataract development in this population was not primarily driven by obesity-related mechanisms. Age-related degenerative processes likely played a more substantial role than body composition alone.

The age distribution observed in this study was consistent with previous research reporting that senile cataract predominantly occurred in individuals aged 60 years and older.[4] Aging has been associated with progressive lens hardening, nuclear sclerosis, and biochemical alterations, including non-enzymatic protein modification and increased light scattering within the lens.[4,19] These physiological changes contribute directly to cataract formation and remain the primary underlying mechanism in senile cataract.

The ocular biometric parameters observed in this study were generally comparable to those reported in South China, although slight variations were noted.[20] These differences may reflect racial, genetic, nutritional, and environmental influences. Such variability underscores the importance of generating local biometric data, particularly in regions with high cataract burden, to support accurate intraocular lens (IOL) power calculation.

Bivariate analysis revealed that height correlated significantly with axial length, anterior chamber depth, and keratometry, and the associations with axial length and keratometry persisted after multivariate adjustment. Taller individuals tended to have longer axial length and flatter corneas. These results were in agreement with studies conducted in Nigeria, Myanmar, China, and Central India.[10,21–23] The inverse relationship between axial length and keratometry suggested a compensatory mechanism aimed at maintaining refractive equilibrium. Since axial length elongation increases the eye's refractive power, corneal flattening may function to balance this change and preserve emmetropia.[10,22]

Although height initially showed a correlation with anterior chamber depth, this association did not remain significant after controlling for confounders. Similar findings were reported in Ethiopia and Myanmar.[12,21] This indicated that the apparent relationship between height and anterior chamber depth may have been influenced by other demographic or anthropometric factors rather than representing an independent effect.

Axial length (AL), anterior chamber depth (ACD), keratometry (K), and central corneal thickness (CCT) all consistently and independently correlated with body weight. Higher body weight participants had flatter corneas, deeper ACD, longer AL, and higher CCT. These findings aligned with studies from Myanmar and China.[21,22] In addition to total body size, body weight may also be a reflection of anatomical and metabolic elements that affect eye development. Ocular size changes may coincide with changes in tissue composition and systemic growth.[22] The combination of longer AL and flatter corneas further supports the concept of refractive compensation.

Bivariate results indicated that elevated BMI was linked to longer axial length, deeper anterior chamber depth, a flatter corneal profile, and increased central corneal thickness, aligning with previous research from Myanmar, China, Thailand, and Central India. [21–24] However, studies from Central India and Turkey reported contrasting results, where higher BMI was linked to shorter AL or shallower ACD. [11,23] These discrepancies may be explained by differences in obesity severity among populations. In the Turkish study, extreme obesity likely increased retrobulbar fat volume, resulting in anterior segment compression and reduced ACD. These findings suggest that the relationship between body composition and ocular biometry may vary according to population characteristics and the degree of adiposity.

The results of this study suggested that anthropometric characteristics were linked to ocular structural parameters that are directly pertinent to cataract surgery. Axial length and keratometry are fundamental components in IOL power calculation formulas. Variations in these parameters may influence postoperative refractive outcomes. Although anthropometric variables are not currently included in standard IOL calculation models, awareness of their influence may assist clinicians in interpreting biometric variability, particularly in populations with distinct body composition patterns.

Body weight and BMI are dynamic parameters that can change throughout life. To date, limited evidence has evaluated whether longitudinal changes in body composition influence ocular biometric parameters. Future studies will be needed to investigate whether weight reduction or metabolic modification results in measurable changes in axial length, anterior chamber depth, or corneal parameters. Such research will help clarify whether the observed associations represent stable developmental traits or modifiable physiological adaptations.

Conclusions

Anthropometric measures were significantly associated with ocular biometry in senile cataract patients, with height and weight independently linked to axial length and keratometry, and weight additionally correlated with anterior chamber depth and central corneal thickness. Age showed negative correlations with several ocular biometric parameters. These findings suggested that body stature and weight were important factors related to ocular biometric characteristics in this population.

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Declaration concerning generative AI and AI-augmented technologies in the compositional process

In the course of preparing this paper, the authors utilized ChatGPT to enhance readability and linguistic quality. Subsequent to utilizing this tool/service, the writers assessed and amended the information as necessary and assume complete accountability for the publication's content.

Declarations of competing interest

No conflicts of interest were reported by the authors.

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