Correlating serum lipid profile with age-related cataract: A clinical perspective

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Abstract

Age-related cataract (ARC) is a major cause of visual impairment worldwide, particularly in low- and middle-income countries. Growing evidence suggests that dyslipidaemia may be associated with cataractogenesis. This study investigated the association between the serum lipid profile and age-related cataract among adults attending a tertiary healthcare facility in south-eastern Nigeria.A hospital-based comparative cross-sectional study was conducted at Chukwuemeka Odumegwu Ojukwu University Teaching Hospital (COOUTH), Amaku, Awka. A total of 210 participants were recruited, comprising 105 patients with ARC and 105 age- and sex-matched controls. Sociodemographic data and body mass index (BMI) were collected using structured questionnaires. Cataracts were diagnosed and classified as nuclear sclerotic (NSC), cortical (CSC), or posterior subcapsular (PSC) using slit-lamp bio-microscopy and direct ophthalmoscopy. Fasting blood samples were analysed for total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C). Data were analysed using SPSS version 23, with statistical significance set at $p < 0.05$. The mean age of ARC patients was higher than that of controls (65.9 vs. 61.0 years). NSC was the most common cataract subtype (51.4%), followed by PSC (28.6%) and CSC (20.0%). Dyslipidaemia was present in 84.8% of ARC patients. Serum TG and LDL-C levels were significantly higher, while HDL-C levels were significantly lower in ARC patients compared with controls ($p < 0.05$). Elevated TG levels significantly increased the odds of cataract occurrence and were the only significant predictor of cataract severity. These findings demonstrate a significant association between dyslipidemia and ARC, highlighting the importance of lipid screening and management in cataract prevention strategies.

Keywords: Age-related cataract, Dyslipidemia, Serum lipid profile, Lens opacity, visual impairment

Introduction

Cataract remains a leading cause of visual impairment and blindness worldwide, with the greatest burden in developing countries[1,2]. Beyond visual disability, age-related cataract (ARC) is linked to significant health and socioeconomic consequences, including depression, reduced quality of life, diminished independence, and loss of productivity[3,4]. The condition disproportionately affects individuals from low- and middle-income socioeconomic

backgrounds and is therefore more prevalent in developing countries. Cataracts account for approximately 50% of blindness in developing countries, compared with about 5% in developed nations[5,6]. The World Health Organization (WHO) has projected that population growth and rising life expectancy will further increase the global burden of visual impairment. Consequently, considerable research has focused on the epidemiology, risk factors, and broader health implications of age-related cataract. Several studies have examined the association between ARC and mortality, with some reporting an increased risk of death among affected individuals[7–9], while others found no significant relationship[10].

Age-related cataract typically develops in the fourth or fifth decade of life and is characterised by progressive opacification of the crystalline lens or its capsule, resulting in impaired light transmission. Clinical manifestations include blurred vision, glare, haloes around lights, faded colour perception, and cloudy vision. Cataractogenesis is a complex, multifactorial process influenced by genetic predisposition, age, sex, diabetes mellitus, geographical location, ultraviolet (UV) radiation exposure, educational status, occupation, and nutritional factors. Among these, advancing age remains the most important risk factor, accounting for approximately 85% of cataract cases, according to the American Academy of Ophthalmology.

Recognising the growing public health burden of avoidable blindness, the World Health Organization (WHO) and the International Agency for the Prevention of Blindness (IAPB) launched the "VISION 2020: The Right to Sight" initiative in 1999 to reduce preventable blindness worldwide. Despite substantial progress in understanding cataract epidemiology and its association with systemic diseases[11], the role of metabolic abnormalities, particularly dyslipidaemia, in cataract development remains incompletely understood. Therefore, this study aimed to investigate the relationship between the serum lipid profile and age-related cataract.

Methods

Study design and setting

This was a hospital-based, comparative, cross-sectional study using a case-control analytical framework. Participants attending Chukwuemeka Odumegwu Ojukwu University Teaching Hospital (COOUTH), Amaku, Awka, Anambra State, were recruited at a single point in time and categorised into two groups: patients with age-related cataract (cases) and age- and sex-matched individuals without cataract (controls). Serum lipid profiles were then compared between the two groups to assess associations with age-related cataract.

Study population and sampling

A total of 210 participants, comprising 105 patients with age-related cataract and 105 age- and sex-matched controls, were recruited. Participants were selected using purposive sampling. Eligible patients with ARC were consecutively recruited from the Ophthalmology Clinic until the required sample size was reached. Control participants without cataract were recruited from the hospital population and matched for age and sex.

Inclusion criteria for the cataract group comprised adults aged 40 years and above with a clinical diagnosis of age-related cataract in at least one eye, who attended the clinic for ophthalmic evaluation and examination. Individuals with congenital, traumatic, metabolic (diabetes, galactosemia, Wilson's disease and others known to affect lens metabolism) or other secondary cataracts, as well as those with systemic

conditions known to affect lens opacity, were excluded. Controls were adults without cataract who met the same eligibility criteria.

Sample size determination

The minimum sample size was calculated using the formula for comparative cross-sectional studies:

$$N = Z2 \text{ X } P\ (1 - P) \div d2$$

where *N* is the minimum sample size, *Z* is the standard normal deviate at a 95% confidence level (1.96), *P* is the estimated prevalence of age-related cataract from the study by Hashemi et al. [21], and *d* is the desired precision (0.05). Substitution into the formula yielded a minimum sample size of approximately 218 participants.

Given the case-control design of the study, the calculated sample size was apportioned equally between the cataract and control groups. To ensure balanced group allocation, facilitate recruitment, and account for potential nonresponse or incomplete data, 105 participants were recruited per group, resulting in a total sample size of 210. This sample size was considered adequate to provide sufficient statistical power for detecting differences in serum lipid profile parameters between participants with age-related cataract and age-matched controls.

Ethical considerations

Ethical approval was obtained from the Chukwuemeka Odumegwu Ojukwu University Teaching Hospital Ethics Committee (Reference No. COOUTH/CMAC/ETH.C/Vol.1/FN:04/294). The study adhered to the Declaration of Helsinki. Written or oral informed consent was obtained from all participants before enrolment. Participation was voluntary, confidentiality was maintained throughout the study, and participants were informed of their right to withdraw at any stage without any consequences for their medical care.

Data collection

Sociodemographic and anthropometric data, including age, sex, weight, and height, were collected via a structured questionnaire administered by trained personnel. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in metres (kg/m²).

Serum lipid profile assessment

After an overnight fast, 5 mL of venous blood was collected from all participants and aseptically transferred to a plain sample bottle. The blood samples were allowed to clot and subsequently centrifuged at 3000 rpm for 10 minutes to obtain serum. Serum concentrations of total cholesterol (TC), triglycerides (TG), high-density lipoprotein cholesterol (HDL-C), and low-density lipoprotein cholesterol (LDL-C) were measured using available enzymatic colorimetric assay kits according to the manufacturer's instructions. Dyslipidaemia was defined as TC ≥220 mg/dL, TG ≥150 mg/dL, or HDL-C ≤35 mg/dL[12].

Ophthalmic examination

All participants underwent a comprehensive ophthalmic examination conducted by qualified ophthalmologists. Visual acuity was assessed monocularly using a standard Snellen chart at 6 m under ambient illumination. Measurements were obtained without optical correction and recorded in Snellen notation.

Cataract assessment was performed using direct ophthalmoscopy and slit-lamp bio-microscopy. Direct ophthalmoscopy was used to evaluate the red reflex, while slit-lamp bio-microscopy provided a detailed examination of the crystalline lens and anterior segment structures. Lens opacities

were identified, localised, and characterised based on their morphological appearance.

Cataracts were classified according to the Lens Opacities Classification System III (LOCS III) as nuclear sclerotic cataract (NSC), cortical cataract (CSC), or posterior subcapsular cataract (PSC). The severity of lens opacity was graded using the LOCS III classification system.

Statistical analysis

Data were entered into Microsoft Excel 2019 and analysed using IBM SPSS Statistics version 23. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and percentages. Differences between groups were assessed using the independent-samples *t*-test for continuous variables and the chi-square test for categorical variables.

Associations between cataract status and serum lipid parameters were assessed using Pearson's point-biserial correlation and logistic regression analysis. Odds ratios (ORs) and 95% confidence intervals (CIs) were calculated to estimate the strength of associations. Multiple linear regression with forward stepwise selection was performed using LogMAR visual acuity as the dependent variable to identify predictors of cataract severity. Independent variables included age, BMI, total cholesterol, triglycerides, HDL-C, and LDL-C. Statistical significance was set at $p < 0.05$.

Results

Demographic characteristics of study participants

A total of 210 participants were enrolled in the study, comprising 105 patients with age-related cataract (ARC) and 105 age-matched controls. The ARC group comprised 56 (53.3%) males and 49 (46.7%) females, whereas the control group comprised 48 (45.7%) males and 57 (54.3%) females. Participants in the ARC group were older, with a mean age of 65.9 years (range: 42–96 years), compared with 61.0 years (range: 40–81 years) in the control group.

The mean body mass index (BMI) was comparable between the groups, with values of 24.38 kg/m² and 23.20 kg/m² for the ARC and control groups, respectively. Assessment of serum lipid parameters revealed lower mean HDL-C levels and higher mean LDL-C and triglyceride (TG) levels in the ARC group compared with controls. Mean total cholesterol (CHO) levels were similar between the two groups.

Table 1: Demographic data of subjects between ARC and control groups

	ARC group (n=105)	**Control group (n=105)**
Average age (years)	65.9	61.0
Age range (years)	42 – 96	40-81
Gender (male/Female)	56/49	48 / 57
Average BMI (kg/m^2)	24.38	23.2
Serum lipid profile (Range/Average)		
HDL-C	27-82 / 46.0	27-189 / 53.2
LDL-C	50-261 / 166.9	50-284 / 131.5
TG	123-536 / 312.2	40-446 / 170.9
CHO	118-352 / 223	128-339 / 229.1

Distribution of cataract types among arc patients

Among the 105 ARC patients examined, nuclear sclerotic cataract (NSC) was the most common type, occurring in 54 (51.4%) patients. Posterior subcapsular cataract (PSC) was observed in 30 (28.6%) patients, while cortical sclerotic cataract (CSC) was present in 21 (20.0%) patients.

Table 2: Types of cataracts observed

	Frequency	Percentage	Cumulative percentage
Cortical Spoking (CSC)	21	20	20
Nuclear Sclerotic (NSC)	54	51.4	71.4
Posterior-Subcapsular (PSC)	30	28.6	100
Total	105	100	

The eye with the least visual acuity result based on the Snellen's chart was subjected to cataract test

Association between cataract type and demographic characteristics

The relationship between cataract type and demographic variables among ARC patients is presented in Table 3. No statistically significant association was observed between cataract type and sex (χ^2, p = 0.814). Among male participants, NSC was the predominant cataract subtype (51.8%), followed by PSC (30.4%) and CSC (17.8%). Similarly, among female participants, NSC accounted for 51.0% of cases, followed by PSC (26.5%) and CSC (22.5%).

Although most participants had BMI values within the 21.0–25.9 kg/m² category, BMI was not significantly associated with cataract type (p = 0.128). Likewise, age category showed no significant association with cataract subtype (p = 0.734), despite a higher proportion of cataract cases among participants aged 61–70 years (38.1%) and 71–80 years (27.6%).

Table 3: Type of cataract observed in relation to sex, age and BMI of ARC participant

	Type of cataract observed				P value
	CSC	NSC	PSC	Total	(chi sq)
Sex of participant					
Male	10	29	17	56	0.814
Female	11	25	13	49	
Body mass index (BMI in Kg/m3)					
16.0-20.9	3	5	10	18	0.128
21.0-25.9	12	31	12	55	
26.0-30.9	6	14	7	27	
31.0-35.9	0	4	1	5	

Age of participants (years)					
41-50	1	7	1	9	0.734
51-60	5	9	5	19	
61-70	8	21	11	40	
71-80	7	12	10	29	
81-90	1	2	3	6	
91-100	0	2	0	2	

Dyslipidemia and cataract type

Of the 105 ARC patients, 89 (84.8%) had dyslipidemia, while 16 (15.2%) had normal lipid profiles. Among participants with dyslipidemia, NSC remained the predominant cataract subtype, accounting for 48 (53.9%) cases, followed by PSC (28.1%) and CSC (18.0%). No statistically significant association was observed between dyslipidemia status and cataract subtype ($p > 0.05$ for all comparisons).

Table 4: lipid status in relation to the type of cataract

Parameters	**Dyslipidemia**		**No dyslipidemia**		**P-value**
	n = 89		n = 16		
NSC	48	53.9%	6	37.5%	0.23
PSC	25	28.1%	5	31.3%	0.80
CSC	16	18.0%	5	31.3%	0.22
TOTAL	89		16		

Comparison of serum lipid levels across cataract types

Mean serum lipid concentrations according to cataract subtype are presented in Table 5. HDL-C levels differed significantly among cataract types ($p = 0.011$), with the highest mean concentration observed among CSC patients (50.3 ± 11.1 mg/dL) and the lowest among PSC patients (41.0 ± 8.8 mg/dL).

No statistically significant differences were observed in LDL-C ($p = 0.694$), TG ($p = 0.176$), or CHO ($p = 0.234$) levels across the different cataract subtypes.

Table 5: Comparison of mean and standard deviation of serum plasma lipids in different type of cataract

Plasma lipids	**CSC (n= 21)**	**NSC (n= 54)**	**PSC (n= 30)**	**P value**
HDL-C	50.3 (SD = 11.1)	47.0 (SD = 12.4)	41.0 (SD = 8.8)	0.011

LDL-C	171.0 (SD =33.9)	163.7 (SD = 38.8)	169.7 (SD = 44.0)	0.694
TG	296.1 (SD = 110.1)	300.0 (SD = 117.8)	345.4 (SD = 111.9)	0.176
CHO	224.2 (SD = 34.8)	228.1 (SD = 46.1)	212.1 (SD = 35.1)	0.234
TOTAL				

Gender-stratified comparison of serum lipid levels

When stratified by sex, LDL-C and TG concentrations were significantly higher among ARC patients than controls in both males and females. Among males, mean LDL-C levels were 161.9 ± 40.0 mg/dL in the ARC group compared with 129.8 ± 42.5 mg/dL in controls ($p < 0.001$), while mean TG levels were 310.8 ± 110.1 mg/dL and 168.9 ± 79.6 mg/dL, respectively ($p < 0.001$).

Similarly, female ARC patients exhibited significantly higher LDL-C levels (172.6 ± 37.9 mg/dL vs 130.8 ± 39.2 mg/dL, $p < 0.001$) and TG levels (313.8 ± 122.5 mg/dL vs 172.6 ± 57.1 mg/dL, $p < 0.001$) compared with female controls. No significant differences were observed in HDL-C or total cholesterol levels between ARC patients and controls within either sex subgroup.

Table 6: Comparison of serum lipid levels between ARC and control, stratified according to gender

	ARC group	Control group	t value	P value
HDL-C				
Male	45.6 (SD = 11.10)	64.7 (SD = 63.4)	-2.06	0.44
Female	46.4 (SD = 12.2)	62.2 (SD = 89.9)	-1.22	0.227
LDL-C				
Male	161.9 (SD = 40.0)	129.8 (SD = 42.5)	3.96	1.37×10^{-4}
Female	172.6 (SD = 37.9)	130.8 (SD = 39.2)	5.56	2.12×10^{-7}
TG				
Male	310.8 (SD = 110.1)	168.9 (SD = 79.6)	7.60	1.66×10^{-11}
Female	313.8 (SD = 122.5)	172.6 (SD = 57.1)	7.41	3.10×10^{-10}
CHO				
Male	222.7 (SD = 44.8)	230.2 (SD = 50.4)	-0.81	0.42
Female	222.8 (SD =37.4)	228.2 (SD =51.2)	-0.62	0.54

{Independent t-test performed; Male: ARC = 56 participants and Ctrl = 48 participants; Female: ARC = 49 participants and Ctrl = 57 participants}

Distribution of lipid abnormalities among arc and control participants

The distribution of participants by lipid profile category is shown in Table 8. A higher proportion of ARC patients exhibited abnormal lipid profiles than controls. Low HDL-C (<40 mg/dL),

elevated LDL-C (≥190 mg/dL), and elevated triglycerides (≥150 mg/dL) were more frequently observed among ARC patients. However, comparisons within the defined lipid categories did not reveal statistically significant differences between groups ($p > 0.05$).

Table 7: Number of subjects in the ARC and control groups, according to serum lipid profile levels

	ARC group	Control group	t value	P value	R^2 adjusted
HDL-C					
<40 mg/dl	40	24	-1.32	0.19	
≥ 60 mg/dl	15	33	-1.17	0.25	
LDL-C					
<100	6	20	-0.77	0.45	
≥ 190 mg/dl	27	6	-0.54	0.59	0.158
TG					
<150 mg/dl	9	49	1.53	0.13	
≥ 500mg/dl	5	0	**		
CHO					
< 200 mg/dl	28	36	0.24	0.81	
≥ 240mg/dl	30	42	-1.27	0.21	

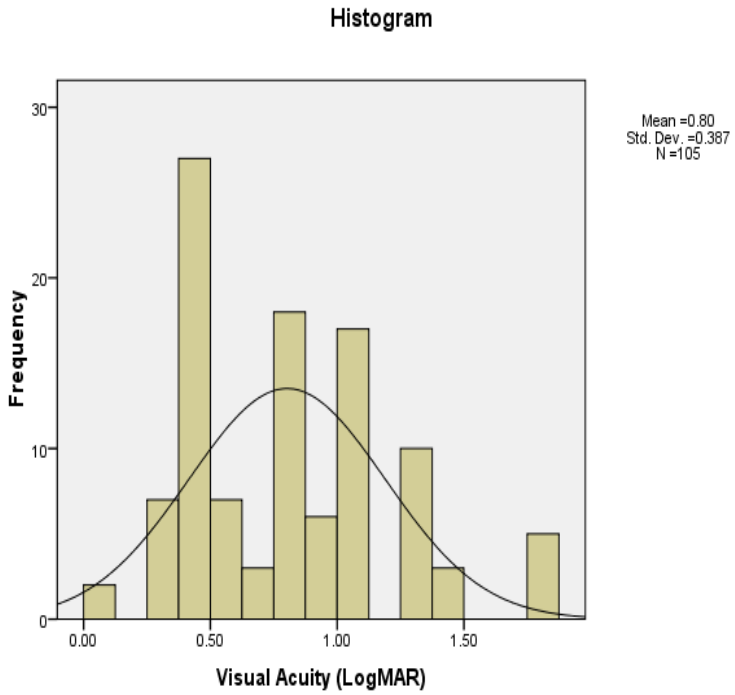
** Independent t-test cannot be computed because at least one variable is empty

Association between serum lipids and cataract severity

Linear regression analysis was performed to assess the relationship between serum lipid parameters and cataract severity, with LogMAR visual acuity scores as the dependent variable. Predictor variables included age, BMI, HDL-C, LDL-C, TG, and total cholesterol levels.

LogMar was calculated as log10 (Snellen denominator / Snellen numerator). This was used as a marker of cataract severity because it provides a continuous, linear scale of visual impairment that is better suited to parametric statistical analyses than Snellen acuity. Unlike Snellen measurements, equal intervals on the LogMAR scale represent equal changes in visual function, thereby enabling more accurate assessment of the relationship between the severity of visual impairment and serum lipid parameters. Higher LogMAR values indicate poorer visual acuity and, consequently, greater cataract-related visual impairment.

Among the variables examined, triglyceride concentration emerged as the only significant predictor of cataract severity. The regression model was significantly different from the null model and explained 15.8% of the variance in LogMAR values (adjusted $R^2 = 0.158$). The analysis indicated that for each 1-unit increase in triglyceride concentration, LogMAR visual acuity increased by 0.001 units, indicating worsening visual acuity with higher triglyceride levels.



Discussion

This study investigated the association between serum lipid profile and age-related cataract (ARC) among adults in a tertiary hospital in south-eastern Nigeria. The findings demonstrated that patients with ARC had significantly higher serum triglyceride (TG) and low-density lipoprotein cholesterol (LDL-C) levels, and significantly lower high-density lipoprotein cholesterol (HDL-C) levels, compared with age- and sex-matched controls. Dyslipidaemia was markedly more prevalent among cataract patients, with elevated TG levels showing the strongest association with disease presence. Furthermore, regression analysis identified triglyceride concentration as the only significant predictor of cataract severity, measured using LogMAR visual acuity, explaining a modest but meaningful proportion of variability in visual impairment. Total cholesterol, however, did not differ significantly between groups, suggesting that specific lipid fractions, rather than the overall cholesterol burden, may be more relevant to cataract pathogenesis.

+Previous studies have reported inconsistent findings on the association between lipid abnormalities and cataract development. Hiller et al.[14] reported that fasting hypertriglyceridaemia (≥250 mg/dL) was associated with an increased risk of posterior subcapsular cataract (PSC) among men. Similarly, Ripa et al.[15] identified LDL-C and HDL-C as independent risk factors for age-related cataract. Other investigators have suggested that abnormal blood lipid concentrations may increase the risk of ARC, whereas some studies have reported either no association or conflicting findings. The variability in these observations may be attributable to differences in study design, population characteristics, cataract classification methods, and definitions of dyslipidaemia.

Body mass index (BMI) has been implicated as a potential risk factor for cataract development due to its close association with metabolic disorders. In the present study, both cataract patients and controls had mean BMIs within the normal range. However, a substantial proportion of overweight and

obese cataract patients exhibited dyslipidaemia. These findings support earlier reports showing higher BMIs among patients with age-related cataract than among non-cataract controls[16–18]. In contrast, Rim et al.[19] reported lower BMIs among cataract patients. The observed discrepancies may reflect differences in ethnicity, lifestyle factors, and study populations.

Analysis of serum lipid parameters revealed significantly elevated TG and LDL-C levels and significantly reduced HDL-C levels among cataract patients compared with controls. These findings align with previous reports by Raman et al.[20], and Rim et al.[19], which demonstrated an association between dyslipidaemia and cataract formation. Meyer et al.[21] also reported a strong association between low HDL-C levels and cataract development. HDL-C is believed to exert protective effects through its antioxidant and anti-inflammatory properties; therefore, reduced HDL-C concentrations may increase susceptibility to oxidative damage within the crystalline lens.

Although Hiller et al.[14] reported a specific association between elevated TG levels and PSC among men, the present study did not find a significant association between triglyceride levels and any specific cataract subtype. Nevertheless, a high proportion of patients with nuclear sclerotic cataract (NSC), cortical cataract (CSC), and PSC exhibited dyslipidaemia. The lack of statistical significance for cataract subtypes may be related to the relatively small subgroup sample sizes. In contrast, Al-Talqani et al.[13] reported stronger associations between dyslipidaemia and specific types of cataracts.

The independent t-test showed significant differences in TG, LDL-C, and HDL-C levels between cataract patients and controls. Individuals with cataract had significantly higher TG and LDL-C concentrations and significantly lower HDL-C concentrations. However, no significant difference was observed in total cholesterol levels between the two groups. These findings suggest that specific lipid fractions, rather than total cholesterol, may be more relevant to cataract pathogenesis.

Logistic regression analysis further demonstrated that cataract patients were substantially more likely to have dyslipidaemia than controls. Participants with cataract had approximately 9.7-fold higher odds of elevated triglyceride levels, 4.4-fold higher odds of elevated LDL-C levels, and 2.1-fold higher odds of reduced HDL-C levels than controls. Furthermore, regression analysis identified triglycerides as the only significant predictor of cataract severity. This finding suggests that elevated triglyceride concentrations may play a particularly important role not only in the occurrence of cataract but also in its progression.

The biological mechanisms linking dyslipidemia and cataract formation remain incompletely understood. It has been proposed that lipid abnormalities may promote oxidative stress, chronic inflammation, and microvascular dysfunction, thereby accelerating lens protein aggregation and opacification. Hyperlipidemia may also contribute indirectly through its association with cardiovascular and metabolic disorders, which themselves have been linked to cataract development[13]. Further mechanistic studies are required to clarify these pathways.

Study limitations

A major strength of this study is the use of age- and sex-matched controls, standardised ophthalmic examinations, and comprehensive lipid profile assessment, which enhanced the reliability of the findings. However, certain limitations should

be considered. The cross-sectional design does not permit causal inference regarding the association between dyslipidemia and age-related cataract. Information on lipid-lowering medication use and other potential confounding factors, such as smoking, alcohol consumption, cardiovascular disease, dietary habits, and physical activity, was not collected. Additionally, the biological mechanisms underlying the observed associations were not investigated. Despite these limitations, the study provides valuable evidence supporting an association between dyslipidemia, particularly elevated triglyceride levels, and age-related cataract.

Conclusion

This study demonstrated a significant association between dyslipidemia and age-related cataract. Cataract patients had significantly higher triglyceride (TG) and low-density lipoprotein cholesterol (LDL-C) levels and lower high-density lipoprotein cholesterol (HDL-C) levels than controls. Among the lipid parameters evaluated, triglyceride level was the only significant predictor of cataract severity. These findings suggest that dyslipidemia, particularly hypertriglyceridemia, may contribute to the development and progression of age-related cataract. Routine lipid profile assessment may therefore be beneficial in individuals at risk of cataract.

Conflict of interest: The authors declare no conflict of interest.

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Author contribution: UAU and ECE, conceptualization and design; ECE, CKE, acquisition of data, data analysis and drafting of article. All authors reviewed the manuscript.

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