e-ISSN: 0975-9506, p-ISSN: 2961-6093

Available online on www.ijpqa.com

International Journal of Pharmaceutical Quality Assurance 2026; 17(4); 12-16

Original Research Article

Association of Metabolic Disorders with Refractive Errors Across Different Age Groups: A Cross-Sectional Study

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Received: 08-02-2026 / Revised: 19-03-2026 / Accepted: 07-04-2026
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Conflict of interest: Nil

Abstract:

Background: Recent demographic and epidemiological trends indicate that populations are living longer with an increasing burden of chronic diseases worldwide. Metabolic disorders such as fatty liver changes, hypercholesterolemia and impaired glycemic control are rising globally and may influence ocular refractive status through biochemical and osmotic mechanisms. However, the relationship between metabolic disorders and refractive errors has not been adequately explored.

Objective: To evaluate the prevalence and age-wise concurrence of metabolic disorders (fatty liver changes, hypercholesterolemia, and elevated HbA1c levels) with refractive errors (normal vision, myopia, presbyopia and astigmatism).

Methods: A cross-sectional observational study was conducted among adults aged 20–60 years. Participants were stratified into four age groups. Metabolic parameters were assessed using ultrasonography for fatty liver changes, serum cholesterol estimation for hypercholesterolemia and HbA1c levels for glycemic status. Other investigations such as blood pressure monitoring, electrocardiography (ECG) and treadmill test (TMT) were performed but excluded from the present analysis. Refractive status was determined using standard refractive examination techniques. The association between metabolic disorders and refractive errors was analyzed using the chi-square test.

Results: Fatty liver changes and hypercholesterolemia peaked in the 30–50 years age group, while elevated HbA1c predominated in the 50–60 years group (88.9%). Refractive errors showed a transition from myopia in younger subjects to presbyopia in the older age group (81.5% in 50–60 years). Significant associations were observed between age group and metabolic disorders ($p < 0.0001$) and between age group and refractive errors ($p < 0.0001$).

Conclusion: The present study highlights the association between metabolic disorders and refractive errors across different age groups, emphasizing the importance of metabolic evaluation in patients presenting with refractive abnormalities.

Keywords: Metabolic Disorders, Refractive Errors, Fatty Liver, Hypercholesterolemia, HbA1c, Myopia, Presbyopia, Astigmatism.

DOI: 10.25258/ijpqa.17.4.3

Introduction

Refractive errors remain a major cause of visual impairment worldwide and are influenced by both genetic and environmental factors. Refractive errors are highly prevalent in adults, with studies estimating over 50% prevalence in some populations (53.1% in India) Myopia is the most common (27.7%) with significant hyperopia (22.9%) and rising myopia after 60years. Uncorrected refractive error impacts 10.2% in adults, while uncorrected presbyopia impacts roughly one third of (33%) of the adult population. [1,2,3]

Refractive errors including myopia, hypermetropia, astigmatism and presbyopia are common conditions causing distorted or blurry vision because light does not focus properly on retina. There are many ocular and systemic factors contributing to development of refractive errors ocular causes are irregular eyeball, corneal curvature and aging.

Metabolic disorders affect roughly 30% of Indian adults, prevalence increase sharply with age, jumping from 13% in 18-29age group to 50% in 50-59 age group with rates higher in urban (32%) vs rural (22%). Major studies indicate a severe burden including 101million diabetics, 136 million prediabetics, 39.5% with abdominal obesity and 81.2% with dyslipedemia. Females are more affected (35%) than males (26%) with risk increasing significantly in postmenopausal women.[4]

Systemic metabolic disorders such as dyslipidemia, impaired glycemic control, and fatty liver disease are increasingly prevalent and are known to affect microvascular and connective tissue integrity and may also modulate ocular refractive physiology.[5] Chronic hyperglycemia alters lens hydration and protein structure, producing refractive fluctuations. Similarly, lipid dysregulation contributes to oxidative stress affecting ocular tissues. The refractive status of the eye is not merely localised eye issue but shares underlying systemic metabolic disorders requiring regular screening.[6]

The high prevalence of refractive errors necessitates better integration of eye care services with routine annual health screening checkup. Vision and physical fitness play an important role in the working adult population; neglected refractive and metabolic disorders result in a gradual decrease in work efficiency, which directly impacts the overall economic growth of a country. Many studies have explored impact of various ocular conditions on overall systemic wellbeing. Although refractive errors stabilize after early adulthood, persisting as long term conditions, their association with common chronic metabolic conditions is poorly understood. Evaluating the age-wise distribution of association between refractive errors and common chronic metabolic disorders with the goal of informing and developing effective preventive strategies, through modifiable risk factors and healthy lifestyle habits.[7]

This study aims to analyze the age-wise prevalence and concurrence of metabolic disorders with refractive errors, thereby providing insight into the systemic influence on ocular refractive status.

Materials and Methods

Study Design: A cross-sectional observational study was conducted among adults aged 20- 60 years attending outpatient services. Participants were stratified into four age groups: 20- 30 years, 30- 40 years, 40- 50 years, and 50- 60 years. All participants underwent comprehensive systemic screening, including X-ray, ultrasound, ECG, echocardiography, TMT and blood investigations to rule out major systemic illness and ensure uniform borderline health status. For the purpose of the study, fatty liver changes on ultrasound, serum cholesterol levels and HbA1c were selected as representative metabolic parameters because they directly reflect lipid metabolism and glycemic control, which are biologically linked to ocular changes. Other investigations like blood pressure measurement, ECG and TMT were performed as part of routine systemic evaluation but were not considered primary study variables.

Refractive error is defined as any spherical equivalent of refractive error=>0.5diopters detected by standard refraction testing. Types of refractive error included are myopia (>=-0.5diopters), Hypermetropia (>=+0.5diopters), Astigmatism (>=+or-0.5diopters) and Presbyopia (>+0.5diopters).

Metabolic disorders defined as one or more of the following

- Elevated HbA1c more than 6.5%
- Dyslipedemia on lipid profile
- Fatty liver detected on ultrasonography (echogenicity more than or equaltent to adjacent healthy right kidney)

Inclusion Criteria

1. Individuals attending OPD for annual health checkup during the study period
2. Participants willing to undergo ophthalmic and metabolic evaluation
3. Participants aged 20-60years
4. Participants providing informed consent for the study

Exclusion Criteria

1. Patients with prexisting ocular pathology that interferes with accurate refraction measurement
2. Patients with known systemic disease
3. Patients not willing for metabolic investigation

Metabolic Assessment: Fatty changes were assessed by abdominal ultrasound, hypercholesterolemia by serum lipid profile and glycemic status by measuring HbA1c levels.

Ophthalmic Assessment: Refraction was performed using visual acuity testing by objective and subjective refraction methods and was classified into normal vision, myopia, astigmatism and presbyopia.

Statistical Methods and Analysis: Data were expressed as frequency and percentage. Associations between age group and metabolic disorders and between age group and refractive errors were analyzed using the chi-square test. A p-value of <0.05 was considered statistically significant.

Results

Visual abnormalities were least prevalent in the 20–30 years age group and increased progressively with age.

Fatty liver and raised cholesterol levels showed higher burden in individuals with refractive errors, particularly in the 30–50 years age group.

Elevated HbA1c mainly observed in participants with combined refractive abnormalities in older age group.

Combined myopia and presbyopia at 40–60 years shows marked increase along with cholesterol and HbA1c, proving the link between normal screening and metabolic changes.

Table 1: Age-wise Percentage Distribution of Metabolic Disorders

Age Group	Fatty changes (%)	Hypercholesterolemia (%)	Raised HbA1c (%)	Total (n)
20-30	0.0	0.0	0.0	0
30–40	74.3	25.7	0.0	720
40–50	69.5	25.5	5.0	705
50–60	45.0	15.0	40.0	700
Chi-square test: $\chi^2 = 531.48$, $p < 0.001$ (statistically significant) Fatty liver peaked in the 30-50 years age group HbA1c abnormally increased sharply after 50 years				

Table 2: Age-wise Percentage Distribution of Refractive Errors

Age Group	Normal (%)	Myopia (%)	Astigmatism (%)	Presbyopia (%)	Total (n)
20–30	66.7	33.3	0.0	0.0	630
30–40	71.0	28.0	1.1	0.0	651
40–50	31.6	6.8	3.8	57.9	266
50–60	2.4	5.6	1.3	90.7	750
Chi-square test: $\chi^2 = 1203.47$, $p < 0.001$ (statistically significant)					

Presbyopia related visual impairment increased progressively with age, reaching 98% in the 50-60 years age group.

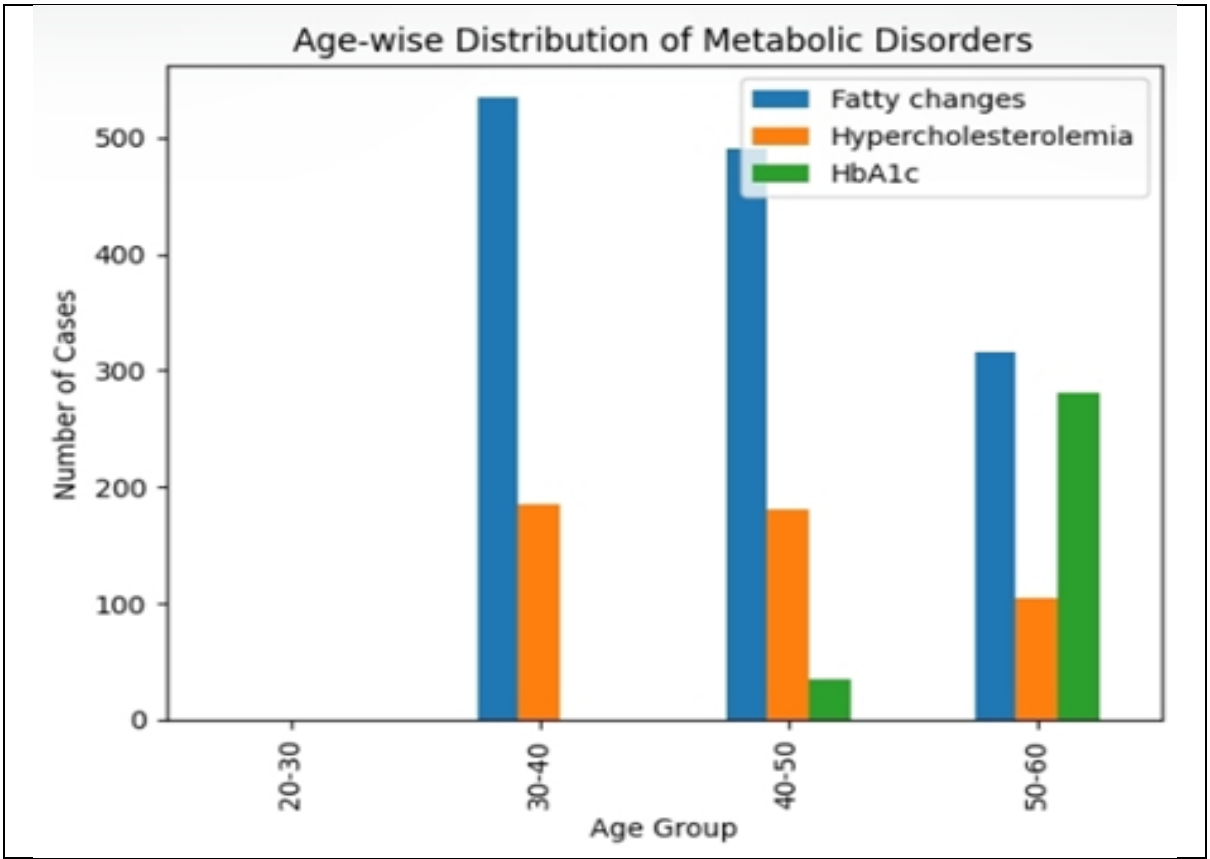

Figure 1: Age-wise Percentage Distribution of Metabolic Disorders

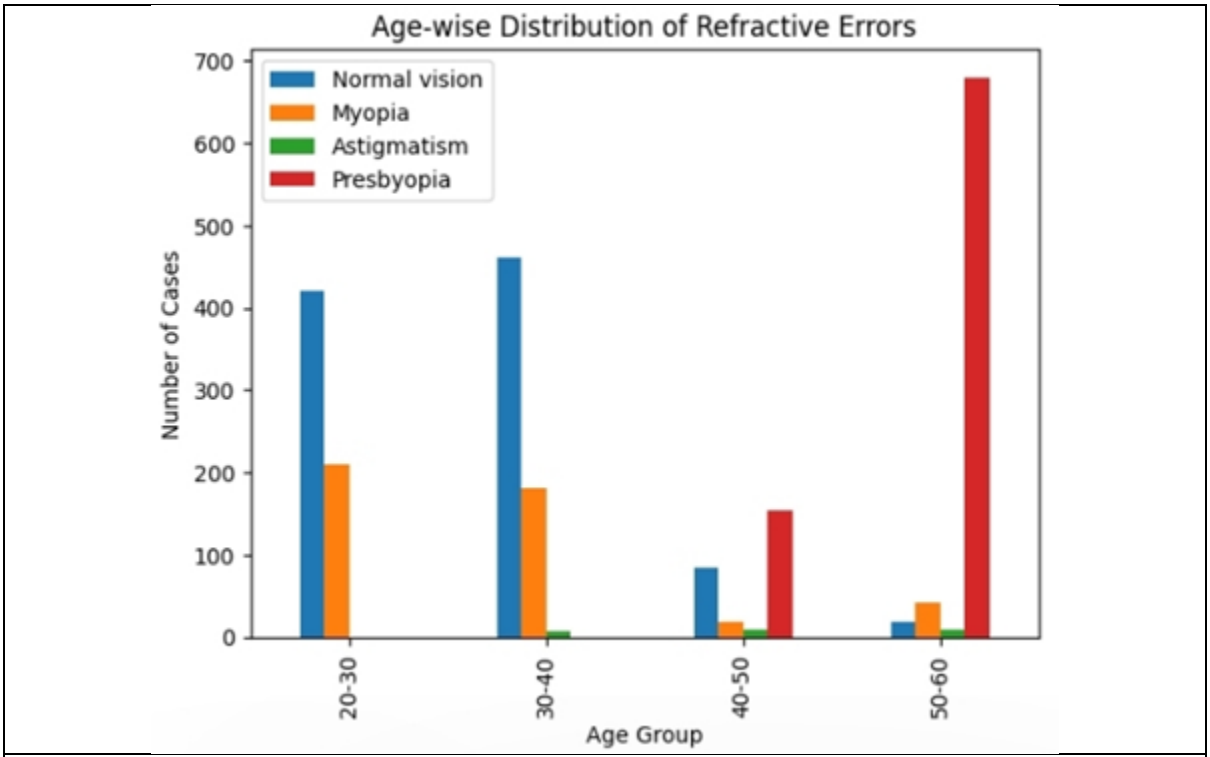

Figure 2: Age-wise Percentage Distribution of Refractive Errors

Discussion

The present study demonstrates a marked age-related increase in refractive errors and metabolic disorders across adult age groups. Presbyopia-related visual impairment showed a clear rise after 40 years, consistent with the physiological ageing of accommodative function.

Similarly, the high prevalence of fatty liver disease and hypercholesterolemia in middle-aged individuals reflects early metabolic dysregulation, while a sharp increase in glycaemic abnormalities after 50 years suggests progressive impairment of glucose control.[4]

The eye is a highly vascular and metabolically active organ; therefore, alterations in glucose metabolism, lipid homeostasis, and hepatic function can directly or indirectly influence refractive status, accommodative function and retinal function.[8]

Metabolic disorders were defined as the presence of one or more of the following:

Elevated HbA1c > 6.5%

Dyslipidemia on lipid profile

Fatty liver detected on ultrasonography

A. Diabetes Mellitus

Chronic hyperglycaemia alters the refractive index of the crystalline lens through osmotic changes caused by sorbitol accumulation, leading to transient or permanent myopic shifts, early presbyopic symptoms and accommodative weakness. Poor metabolic control is also associated with microvascular alterations that may impair retinal function and overall visual performance. [9-12]

B. Dyslipidaemia

Elevated serum cholesterol contributes to atherosclerotic changes in ocular blood vessels, affecting choroidal and retinal circulation. Lipid abnormalities have been linked to lenticular changes and are associated with visual fatigue and reduced contrast sensitivity, further impacting functional vision.[13]

C. Non-Alcoholic Fatty Liver Disease (NAFLD)

Nonalcoholic fatty liver disease is considered the hepatic manifestation of metabolic syndrome. Emerging evidence suggests an association between NAFLD and refractive errors, both correctable and non-correctable, as well as alterations in retinal microvasculature. NAFLD is closely linked to insulin resistance, chronic inflammation and oxidative stress, all of which may influence ocular physiology. [6,14]

Young age groups show high prevalence of myopia often associated with a incrased risk of metabolic dysfunction. Identifying at early stage and taking regular annual health checkup and following healthy lifestyle may prevent from development of metabolic disorders. [15,16]

Middle aged adults show shift from myopia toward hyperopia due to declining accommodation (presbyopia) and lens changes. This age group shows altered metabolic parameters in lipid profile, fatty changes of liver and HbA1c causing lens swelling

and refractive fluctuations. This shows importance of whole-body annual health checkup helps early detection of eye disorders and metabolic disorders and their strong association.[3]

Older age group shows high prevalence of presbyopia and elevated HbA1c, altered lipid profile. So regular health checkup will play a major role in diagnosis and management of ocular diseases and metabolic disorders there by decreasing morbidity related complications, promoting healthy lifestyle. [3,16,17]

Visual impairment may therefore serve as an early clinical indicator of underlying metabolic dysfunction. Linking ophthalmic findings with metabolic parameters enables a more comprehensive assessment of systemic health and supports the concept of integrated screening. Studying them together helps in understanding whether visual impairment may serve as an early indicator of underlying metabolic dysfuntion.

Therefore, linking visual data with metabolic parameters allows for assessment of systemic health and supports the concept that routine eye examination can play a role in early detection of metabolic disorders.

Conclusion

There is a statistically significant association between age-related metabolic disorders and refractive errors. The transition from myopia to presbyopia parallels increasing metabolic derangements, emphasizing the need for integrated ophthalmic and metabolic screening in the adult population.

Recommendations: Longitudinal studies incorporating detailed biometric and biochemical markers are warranted to clarify the causal pathways linking systemic metabolic dysfunction with refractive status and visual outcomes.

Ethical Considerations: Ethical approval was obtained in the form of informed consent from all participants.

Funding: None.

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