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Evaluation of serum calcium, iron, and vitamin D homeostasis in relation to cataract in western Iran

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Abstract

Background and Objectives: Cataract formation is influenced by genetic, environmental, and biochemical factors, with growing interest in the role of micronutrients like calcium, iron, and vitamin D. This study aims to examine the relationship between serum levels of these nutrients and cataract prevalence in western Iran, highlighting the potential for nutritional intervention to address this common issue.
Methods: This study involved cataract patients (n=100) in Imam Khomeini Hospital, Kermanshah, and a control group (n=100) with similar lifestyle factors. Demographic information and medical histories were obtained through a standardized checklist. Red blood cell indices, serum iron, calcium, and vitamin D levels were determined and compared in both groups. Statistical analysis was performed using R software.
Results: The study found no significant differences in vitamin D, calcium, iron, hemoglobin (Hb), and hematocrit (Hct) levels between the groups (all $p > 0.05$). Type 2 diabetes (OR = 3.19; 95% CI: 1.46, 6.99; p = 0.004) and hypertension (OR = 2.66; 95% CI: 1.18, 6.22; p = 0.020) were significantly associated with having cataract. Conversely, higher Hct concentrations (OR= 0.58; 95% CI: 0.45, 0.73; $p < 0.001$) were correlated with reduced odds of cataracts. Calcium, vitamin D, and iron levels did not show significant associations with cataracts (all $p > 0.05$).
Conclusion: In conclusion, our study found lower hematocrit levels, type 2 diabetes mellitus, and hypertension as significant factors associated with increased odds of cataract.

Highlights

- Type 2 diabetes and hypertension significantly increased cataract risk in Western Iranian patients.
- Higher hematocrit levels were associated with a protective effect against cataract development.
- Serum calcium, iron, and vitamin D levels showed no significant association with cataract.
- Metabolic health and hematological status may be more important than micronutrient levels in cataract prevention.

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Introduction

Cataracts are a leading cause of visual impairment and blindness worldwide, particularly among the elderly. Characterized by a lens opacity, cataracts lead to progressive vision loss [1]. The development of cataracts is influenced by a complex interplay of genetic, environmental, and biochemical factors. Notable mechanisms implicated in cataract formation include oxidative stress, the accumulation of lens proteins, and imbalances in nutrient homeostasis [2]. Although significant progress has been made in understanding these processes, the specific roles of certain micronutrients—such as calcium, iron, and vitamin D—in cataract development continue to be an active area of research [3-9].

Calcium is a crucial mineral for cellular function, bone growth and mineralization, muscle contraction, neurotransmitter secretion, digestion and blood coagulation. It also plays a vital role in maintaining lens transparency and homeostasis [10-12]. Dysregulated calcium levels in the lens can trigger the activation of calpain, leading to proteolysis and ultimately resulting in lens opacity [13]. Excessive accumulation of calcium has also been linked to increased oxidative stress and alterations in the structural proteins of the lens, both of which contribute to the formation of cataracts [14]. Iron, a trace element essential for various metabolic processes, presents a double-edged sword in eye health. While it is necessary for cellular function, iron can catalyze the formation of reactive oxygen species (ROS) through Fenton reactions, potentially increasing oxidative stress within the lens [15]. Elevated iron levels can lead to oxidative damage and lipid peroxidation, further exacerbating cataract formation [16]. Here, it is important to discuss the roles of transferrin and ferritin. Transferrin is involved in the transport of iron in the circulatory system so that cells can receive a regulated amount of iron. Ferritin, on the other hand, acts as a storage molecule by sequestering excess iron so as to prevent prospective toxicity. Abnormalities in the amount of these proteins can cause an increase in free iron concentrations that can raise oxidative stress and the subsequent development of cataracts [17, 18].

Vitamin D, a fat-soluble vitamin known for its anti-inflammatory and antioxidant properties, has garnered recent attention for its potential role in eye health [9]. In this regard the results of a meta-analysis revealed potential association between serum vitamin D level and cataract, more significant in female, and the subtypes of nuclear and posterior subcapsular cataract [9]. Beyond its well-established functions in calcium-phosphorus metabolism and bone health, vitamin D appears to have systemic effects on cellular homeostasis and the modulation of oxidative stress. Deficiency in vitamin D has been associated with several chronic diseases, including age-related eye conditions such as macular degeneration and diabetic retinopathy [19, 20]. Together, these factors highlight the intricate balance of minerals and vitamins crucial for maintaining lens health and preventing conditions such as cataracts.

The relationship between serum calcium, iron, and vitamin D levels and the development of cataracts remains poorly understood. Therefore, it is crucial to investigate how these nutrients interact and their effects on lens health. By exploring this correlation, we can gain insights into the biochemical pathways involved in cataract formation, which may lead to the identification of potential biomarkers and therapeutic targets. This study aims to examine the association between serum levels of calcium, iron, and vitamin D and the prevalence of cataracts.

Materials and Methods

Study population

This retrospective, monocentric case-control study aims to investigate the relationship between serum calcium, iron, and vitamin D levels and the presence of cataracts in patients referred to Imam Khomeini Hospital in Kermanshah, Western Iran. The study's protocols were reviewed and approved by Kermanshah University of Medical Sciences' Ethics Committee (Ethics code: IR.KUMS.MED.REC.1403.380). All procedures were performed in compliance with relevant guidelines and regulations.

The study included patients diagnosed with cataracts by a specialist ophthalmologist at the hospital using the slit lamp examination (with reference to the LOCS III classification system). All enrolled patients presented with moderate cataracts. Lens opacification was predominantly localized to the nuclear region, with subcapsular involvement observed in all cases (nuclear and subcapsular types). Demographic information, medical history, and lifestyle factors were collected using a standardized checklist administered to all participants. For sociodemographic characteristics, we gathered data on age, gender, education level, and employment status through direct interviews. The identification of underlying diseases was based on a combination of self-reported medical histories and verification with available clinical records. In both groups, the presence or absence of cataracts, as well as their type, was confirmed by a specialist ophthalmologist through a slit-lamp examination. The control group was chosen from the companions of patients attending the ophthalmology clinic. These individuals were selected because they shared similar lifestyle characteristics with the case group, including socioeconomic status, dietary habits, and levels of physical activity. A thorough screening process was conducted to determine their eligibility, which involved a detailed review of medical histories and comprehensive ocular examinations. In total, 100 individuals who were confirmed to be completely healthy—free from cataracts and any other ocular diseases—were included in the control group.

Inclusion Criteria: individuals needed to be over 40 years of age and able to provide written informed consent to participate in the study. Exclusion Criteria: Participants were excluded if they had severe chronic conditions such as renal or hepatic failure that could affect serum levels of calcium, iron, or vitamin D; had taken medications—including supplements or corticosteroids—that might influence these serum levels within the three months prior to the study; were pregnant or lactating; were unable to complete study information or withdrew from participation; had a diagnosis of pseudophakia, to ensure accurate assessment of lens status and eliminate confounding effects from prior cataract surgery. All procedures were conducted in accordance with relevant ethical guidelines and regulations.

To compare two groups in the present study, we calculated the required sample size using the following formula:

$$n_{۱} = \frac{(r+1)}{r} \times \frac{\sigma^2 (Z_{1-\beta} + Z_{\alpha/2})^2}{(d)^2}$$

In this formula, n_1 represents the sample size for the smaller group, r is the ratio of the larger group to the smaller group, σ is the standard deviation of the trait being studied, and d is the minimum difference between the means of the two groups deemed significant. The values of $Z_{1-\beta}$ and $Z_{\alpha/2}$ correspond to the power of the test (1-β) and the type I error rate (α), respectively. The effect size is represented as d/σ. For this study, we selected a test power of 80%, which corresponds to $Z_{1-\beta} = ۰/84$, and a type I error rate of 5%, yielding $Z_{\alpha/2} = 1/96$. Assuming an approximately equal group size (with (r ≅ 1)) and choosing an effect size of 0.4, the required sample size for each group is calculated to be 99 individuals:

$$n_{۱} = \frac{(1+1)}{1} \times \frac{(۰/84 + 1/96)^2}{(۰/4)^2} \cong 99$$

Consequently, in this study, we include 100 patients diagnosed with cataracts as the case group, and 100 patients as the control group. This results in a total sample size of 200 participants.

Parameter analysis (calcium, iron, and vitamin D)

In this study, the Biorex fars (Biorex Co. Iran), Frasamed (Frasamed Co. Iran), and Monokit (Samantajhiz Co. Iran) kits were employed to measure iron, calcium, and vitamin D levels, respectively. Iron and calcium concentrations were analyzed using an autoanalyzer (DIRUI CS-480 Auto Chemistry Analyzer, DIRUI Co; China), while vitamin D levels (total 25-hydroxyvitamin D (25(OH)D) were assessed through the ELISA method according to the manufacturer’s instructions. In this study the main circulating form of 25-hydroxyvitamin D (25(OH)D) were measured.

Statistical analysis

First, we examined the distribution of quantitative variables using the Kolmogorov-Smirnov test. If the distribution was found to be normal, we applied the Student's t-test; otherwise, we used the Mann-Whitney test to compare distributions (or median values) between the cataract and non-cataract groups. Qualitative variables were described using frequency and percentage, and their relationships with the response variable were analyzed using the chi-square test. Additionally, we calculated the Spearman correlation coefficient among the quantitative variables and presented the results in a graph. The response variable in this study was binary, categorized as cataract or non-cataract. We investigated the factors affecting the response using a multiple logistic regression model, employing the backward method for variable entry. In this method, the analysis began with a full model incorporating all the clinically relevant covariates that had been identified in consultation with clinical experts. This was followed by the sequential removal of non-significant variables, using an elimination threshold of α = 0.10. The “dplyr”, “broom”, “corrplot” and “Hmisc” packages, which are available in R software version 4.0.3, were used to perform statistical analyses and draw graphs. All tests were performed at a significance level of 0.05.

Results

In the present study, we analyzed data from 200 participants, divided evenly into two groups: 100

individuals with cataracts and 100 without. Table 1 presents the characteristics of participants within these two groups. Based on the results, the mean age of participants in the cataract group was significantly higher, at 65.87 ± 8.29 years, compared to the non-cataract group, which had a mean age of 48.66 ± 6.49 years ($p < 0.001$). The results indicated notable differences in gender distribution, with more than half (56%) of the cataract group being male. A statistically significant was found between gender and cataract status, with a p-value of 0.034. Regarding educational attainment, 37.5% of participants held academic degrees, which was higher than those with other educational levels, yielding a highly significant result (p-value < 0.001). Employment status also reflected significant differences between the groups. The predominant occupation among participants was housewives, accounting for 38.5% of the total. In the cataract group, retirees represented the next largest segment at 26%. This difference in employment status was statistically significant (p-value < 0.001). Most participants in both groups reported not using addictive substances. However, in the cataract group, a notable percentage of individuals had underlying health conditions, with 18% reporting hypertension and 18% having type 2 diabetes. Conversely, the non-cataract group had a higher prevalence of participants without any underlying disease, accounting for 71%. This difference in underlying health conditions was also significant, with a p-value of < 0.001. Overall, the findings highlight critical differences between the cataract and non-cataract groups concerning gender distribution, education level, employment status, and health conditions.

Table 1 Characteristics of participants by non- cataract and cataract groups

Features		Non-cataract (n=100)	Cataract (n=100)	Total (n=200)	p-value
Age (year)		48.66±6.49	65.87±8.29	57.26±11.38	< 0.001*
Gender	Male	41 (41)	56 (56)	97 (48.5)	0.034*
	Female	59 (59)	44 (44)	103 (51.5)	
Level of education	< High school	13 (13)	57 (57)	70 (35)	< 0.001*
	High school	37 (37)	18 (18)	55 (27.5)	
	Academic	50 (50)	25 (25)	75 (37.5)	
Employment status	employment	28 (28)	13 (13)	41 (20.5)	< 0.001*
	self-employment	33 (33)	21 (21)	54 (27)	
	retired	2 (2)	26 (26)	28 (14)	
	Housekeeper	37 (37)	40 (40)	77 (38.5)	
Addiction status	No	84 (84)	70 (70)	154 (77)	0.080
	Smoking	10 (10)	22 (22)	32 (16)	
	Opium	1 (1)	3 (3)	4 (2)	
	Hookah	5 (5)	5 (5)	10 (5)	
Underlying disease	Not disease	71 (71)	40 (40)	111 (55.5)	< 0.001*
	CVD	5 (5)	8 (8)	13 (6.5)	
	DM 2	1 (1)	18 (18)	19 (9.5)	
	Hypertension	12 (12)	18 (18)	30 (15)	
	High TG levels	11 (11)	6 (6)	17 (8.5)	
	Mixed disease	0 (0)	10 (10)	10 (5)	

* Indicates p-value < 0.05. CVD: Cardiovascular disease, DM 2: Type 2 diabetes mellitus, TG: Triglycerides, Mixed disease: CVD/ DM 2/ Hypertension/ High TG levels.

The results of describing and comparing biochemical and hematological parameters in the two non-cataract and cataract groups are summarized in Table 2. Based on the results in this table, the mean concentrations of calcium (Ca), vitamin D and Hb in the cataract group were higher than in the non-cataract group, but these differences were not statistically significant ($p > 0.05$). The mean concentrations were 11.12 ± 10.89, 26.14 ± 10.39 and 13.96 ± 1.80 in the cataract group, and 10.11 ± 4.49, 25.38 ± 8.45 and 13.77 ± 1.61 in the non-cataract group. In the non-cataract group, the mean Fe concentration (90.94 ± 29.39) and Hct (43.04 ± 6.50) were higher than in the cataract group (Fe: 89.67 ± 35.25; Hct: 42.00 ± 4.61). However, these differences were not statistically significant ($p > 0.05$).

Table 2 Biochemical and hematological parameters of participants by non- cataract and cataract groups

Features	Non-cataract (n=100)	Cataract (n=100)	Total (n=200)	p-value
Ca (mg/dL)	10.11±4.49	11.12±10.89	10.61±8.32	0.392
Fe (µg/dL)	90.94±29.39	89.67±35.25	90.31±32.38	0.783
Vitamin D (ng/mL)	25.38±8.45	26.14±10.39	25.76±9.45	0.574
Hb (g/dL)	13.77±1.61	13.96±1.80	13.87±1.71	0.431
Hct (%)	43.04±6.50	42.00±4.61	42.52±5.65	0.193

* Indicates p-value < 0.05. Hb: Hemoglobin, Hct: Hematocrit

The Spearman correlation analysis of the quantitative variables examined is illustrated in Figure 1. In the non-cataract group (shown on the left), a strong correlation was observed between Hct and Hb, with a correlation coefficient of r = 0.92. Additionally, this group demonstrated weak positive correlations between Hct and Fe showed r = 0.28, Fe and Hb had r = 0.37, and Hb and age registered r = 0.23. Conversely, the cataract group (depicted on the right) also exhibited a strong correlation between hemoglobin (Hb) and Hct, which had a correlation coefficient of r = 0.90. In this group, weak positive correlations were noted among Fe and Hb (r = 0.46), Fe and Hct (r = 0.40), as well as Vitamin D and age (r = 0.26). These findings highlight distinct patterns of correlation in the two groups studied.

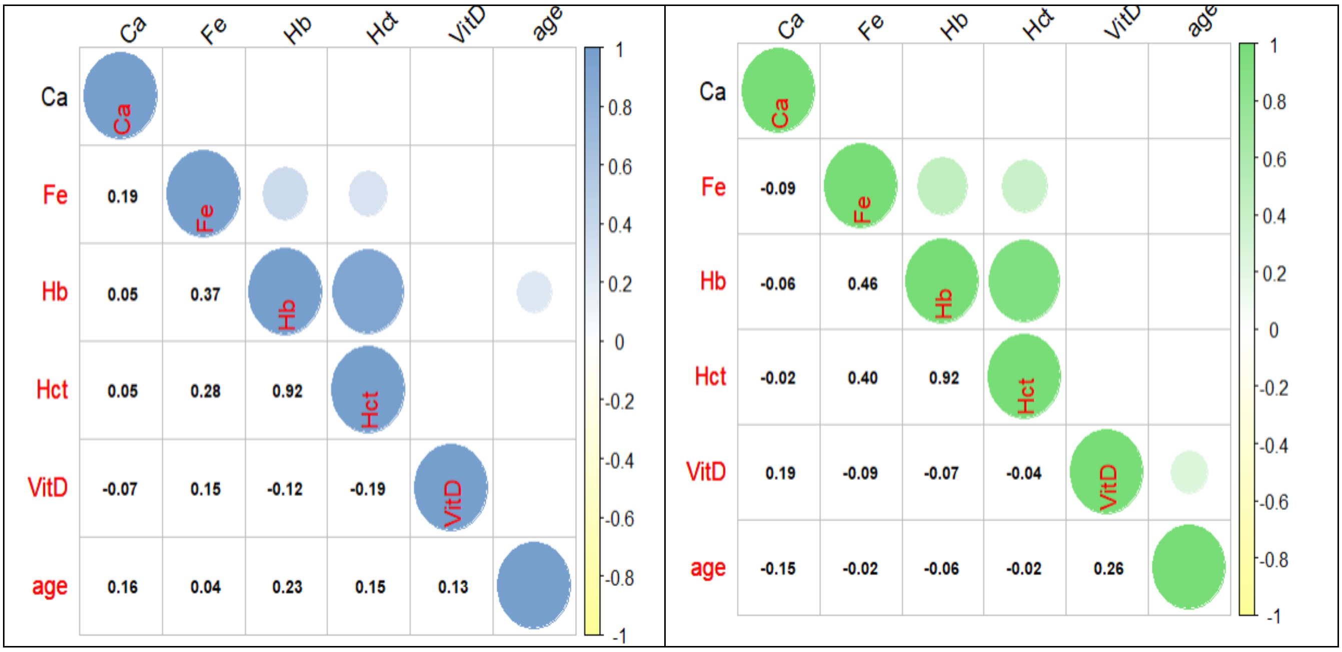

Fig 1. This figure illustrates the strength and direction of associations between quantitative variables, categorised as either cataract or non-cataract. Correlations between quantitative variables within the non-cataract group (on the left) and the cataract group (on the right). The circles are colored according to the sign of the values, with negative values represented by yellow and positive values represented by blue within the non-cataract group. In contrast, the cataract group exhibits a color scheme of green.

The results presented in Table 3 illustrate the univariate associations with cataract, focusing on each variable individually without accounting for their combined effects. To assess the simultaneous influence of all variables on cataract development, a logistic regression model was applied, with the findings detailed in Table 3. This table provides crucial information, including the effect estimates (Beta), p-values, odds ratios (ORs), and 95% confidence intervals (CIs) related to these ORs. It should be noted that the effects of the age and gender variables have been adjusted. Hct demonstrated an inverse association with cataracts; higher Hct levels were associated with lower odds of cataract (OR = 0.58; 95% CI: 0.45, 0.73; $p < 0.001$). Type 2 diabetes emerged as a significant factor associated with cataracts, with individuals diagnosed with diabetes exhibiting higher odds of cataract compared with those without diabetes (OR = 3.19; 95% CI: 1.46, 6.99; p = 0.004). Additionally, hypertension was associated with an increased risk of cataract formation, as individuals with high blood pressure had a greater chance of developing cataracts than those without (OR = 2.66; 95% CI: 1.18, 6.22; p-value = 0.02). The same was true for the Hb variable: with a one-unit increase in Hb level, the odds of developing a cataract were 4.19 times greater than in the non-cataract group in the study sample (OR = 4.19; 95% CI: 2.31, 8.12; *p*-value < 0.001). It is important to note that Ca, Fe, and vitamin D concentrations did not show a significant association with cataract development, as indicated by p-values greater than 0.05.

Table 3 Coefficients of logistic regression for identifying factors associated with cataract, adjusted for age and gender

Estimation of coefficients				
Variable	**Beta (SE)**	**p-value**	**OR**	**95% CI**
Log (Ca)	0.63 (0.62)	0.31	1.89	(0.58, 8.32)
Log (Fe)	-0.66(0.44)	0.13	0.52	(0.21, 1.21)
Log (Vitamin D)	-0.18(0.35)	0.61	0.84	(0.42, 1.65)
Hct	—0.54 (0.12)	< 0.001*	0.58	(0.45, 0.73)
Hb	1.43 (0.32)	< 0.001*	4.19	(2.31, 8.12)
Underlying disease (reference: no underlying disease)				
CVD	1.04 (0.60)	0.08	2.84	(0.89, 9.95)
DM 2	1.16 (0.40)	0.004*	3.19	(1.46, 6.99)
Hypertension	0.98 (0.42)	0.02*	2.66	(1.18, 6.22)
High TG	-0.03 (0.54)	0.95	0.97	(0.31, 2.75)
Mixed disease	1.02 (0.62)	0.10	2.77	(0.82, 9.34)

* Indicates p-value < 0.05. Hb: Hemoglobin, CVD: Cardiovascular disease, DM 2: Type 2 diabetes mellitus, TG: Triglycerides, Mixed disease: CVD/ DM 2/ Hypertension/ High TG levels.

Discussion

In the current research hemoglobin and hematocrit levels, DMT2, and hypertension showed significant associations in regression analysis but Ca, Fe, and vitamin D concentrations did not show a significant association. Cataract is described as a multifactorial disease, and advanced age is a proven non-modifiable risk factor [3, 21]. Conversely, smoking, alcohol consumption, obesity, malnutrition, and diabetes are described as modifiable risk factors that lead to elevated levels of oxidative stress and inflammation [3]. Research examined Korean National Health and Nutrition Examination Survey data (2008-2012) containing 20,419 participants who were at least 40 years old. The researchers determined that cataract developed primarily in older patients ($p < 0.001$), hypertensive subjects ($p < 0.001$), male participants (P = 0.032) and people with diabetes mellitus (DM $p < 0.001$) as well as those from lower income backgrounds (P = 0.031) and less-educated individuals ($p < 0.001$). Cataract surgery appeared continuously in relation to older age and anemia as well as occupation and diabetes mellitus and asthma [22]. Foster et al. included subjects between the ages of 40 and 81 years and showed a significant association between nuclear cataract and age (OR = 5.6, 95% CI. 4.6–6.8, $p < 0.001$) [23].

The relationship between serum vitamin D levels and the development of cataract is controversial. According to a systematic review and meta-analysis, lower serum vitamin D levels are associated with the presence of cataract (P=0.047; MD: -4.87; 95%CI: [-9.67, -0.07]) [9]. Some observational studies indicate that higher serum concentrations of 25-hydroxy vitamin D (25(OH)D) are associated with a lower prevalence of cataract [3, 20, 24]. Abdellah et al. (2019) examined patients aged 50 years and above with nuclear, cortical and subcapsular cataract. Vitamin D levels were lower compared to healthy control subjects in patients with cataract and especially in those with a nuclear cataract. Authors considered this result as support for the possible involvement of deficiency in 25-OH vitamin D in age-related cataract [3]. Deficiency in vitamin D has been linked to the development of a posterior subcapsular cataract (PSC) in another study of associated risk factors [19]. Additionally, a study conducted on Korean individuals by Jee and Kim revealed that cataract risk declines as serum vitamin D levels increase. The significance of elevating levels of vitamin D, such as through the intake of vitamin D supplements, was cited as a potential step in the prevention of cataract development [25]. Park and Choi, in their paper examining the relationship between serum 25-OH vitamin D and age-related cataracts, established a negative relationship between serum 25-OH vitamin D concentrations and the risk of nuclear cataract development. They suggest that these findings could point to the future clinical use of vitamin D in the prevention of age-related cataracts, specifically nuclear cataracts [26].

Aidenloo et al, (2021) discovered that serum 25(OH) D levels were negatively associated with cataract in women, and there is no association found in men [27]. In contrast, Jee et, al analyzed 18 804 Participants aged ≥40 years from the fourth (2008 to 2009) and fifth (2010 to 2012) Korea National Health and Nutrition Examination Survey (KNHANES) and came to the conclusion that serum vitamin D was associated with cataract in men but not in women [25].

There is also controversy regarding different types of cataracts. Park speculated negative correlation between serum 25(OH) D level and risk of nuclear cataract [26], while Rao's study found no significant correlation of serum 25(OH)D with nuclear cataract in women of all ages [28]. Brown and Akaichi also found decreased serum 25-OH D in posterior subcapsular cataract [19]. More studies should be conducted to examine this finding on a wider scale, nonetheless, considering the varying findings realized in the studies conducted previously [29, 30]. The effectiveness of vitamin D supplementation in cataract prevention, as well as the mechanisms by which this presumed effect, has yet to be established [8]. A double-blind, placebo-controlled randomized trial of monthly vitamin D supplementation in the general Australian population showed that monthly high-dose vitamin D supplementation in older adults living where there is a low prevalence of vitamin D deficiency is unlikely to reduce the need for cataract surgery [31]. Vitamin D functions as an antioxidant vitamin and is known to reduce oxidative stress. It has also been found to be anti-inflammatory and aids the body's protection against chronic inflammation. Specifically, Vitamin D limits overactivation of cytotoxic T cells, inhibits pro-inflammatory cytokine secretion, and stimulates the release of anti-inflammatory cytokines. Oxidative stress is a major contributor to the formation of cataracts [20, 32, 33]. In addition, because of its beneficial influence on the photooxidation reaction in proteins, vitamin D can even play a protective role in reducing the onset of cataracts [8, 25, 34]. Aside from that, vitamin D also has a significant relationship with calcium. The lens fibers of human beings possess an extracellular calcium-sensing receptor (CaR), which is activated by modest change in extracellular calcium concentration [35]. In view of the calcium metabolism of CaR, PTH, and vitamin D, lower than normal levels of vitamin D may be involved in the degeneration of lens fibrils [4]. The protective role of calcium dobesilate on steroidmediated cataract was demonstrated in animal studies by Velpandian et al. likely owing to its antioxidant and aldose reductase inhibitor actions [36]. On the other hand, several studies also revealed that excess intracellular calcium levels may contribute to abnormal degradation of proteins and cell apoptosis and, ultimately, be a causative factor for structural abnormalities in the lens [37, 38].

Some previous reports have demonstrated an association between anemia and cataract, for instance, Raman et al. (2010) have demonstrated that higher hemoglobin levels (OR, 0.38; 95% CI, 0.22–0.64) were protective against the development of cataract. Other risk factors for any cataract were older age (OR, 1.14; 95% CI, 1.11–1.16), macroalbuminuria, and rising glycosylated hemoglobin levels [39]. A research on 143 cataract patients (50 to 70 y) and 100 age- and sex-matched controls revealed that Hemoglobin and serum ceruloplasmin levels and plasma levels of Fe, vitamin C, vitamin A, -carotene, thiamine, and riboflavin were lower than normal in all patient [40].

High iron content was found in cataractous lenses in earlier research [6, 41], but Aydin et al. (2005) did not notice any significant deposition of iron in the blood, aqueous humor, or cataractous lenses of diabetic eyes when compared with non-diabetic eyes [5] or in concurrence with Dawczynski et al. [7]. In a study, elevated TIBC was reported as a significant risk factor for cataract (OR = 1.01, 95% CI, 1.00–1.02, p = 0.0059) [42]. Elevated TIBC level is related to iron deficiency. These discrepancies underscore the need for further studies.

Limitations

Our study has several limitations due to its retrospective design, making it challenging to establish causal relationships. Additionally, the case and control groups were not matched by age or gender during the design phase, which could introduce selection bias. To mitigate this issue, we statistically adjusted for age and gender in our multivariate logistic regression model. However, we acknowledge that residual confounding cannot be entirely eliminated. We also did not assess other potential confounding factors, such as detailed socioeconomic status and dietary habits. Furthermore, the lack of specific markers like ferritin, transferrin, and albumin-corrected calcium, as well as the absence of a detailed grading system for lens opacities (e.g., by location or density), limits the depth of our findings. While we employed analytical methods to address some of these limitations, future prospective studies would benefit from matched cohort designs, the inclusion of a wider range of biochemical and clinical indicators, and more detailed cataract classifications to provide more robust and comprehensive evidence.

Conclusion

In summary, our findings have indicated that lower hematocrit levels, type 2 diabetes mellitus, and hypertension are significantly associated with increased odds of cataract. These results underscore the importance of understanding of underlying mechanisms behind theses associations. We emphasize the need for large-scale prospective studies to further evaluate these effects, with particular focus on different types and severity of cataracts.

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Authors' Contributions

ZT, FSS, and BM generated the idea and design of the study. ZT, SN, and PA searched the literature in databases, and wrote parts of the manuscript. ZM participated in statistical analyses and edited the result part. SN, ZM, and BM reviewed the manuscript. SN wrote the discussion section, and with FSS and BM supervised all parts of the revision part of the manuscript. BM served as the corresponding author.

Data availability

The datasets used and/or analyzed during the current study available from the corresponding author on reasonable request.

Conflicts of interest

The authors declare that they have no competing or conflicting interests in conducting this study.

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Ethics approval and consent to participate

The study's protocols were reviewed and approved by Kermanshah University of Medical Sciences' Ethics Committee (Ethics code: IR.KUMS.MED.REC.1403.380). Also, each participant reviewed the study protocol and signed an informed consent form prior to being enrolled in the study.

Abbreviations

Hemoglobin (Hb)
Calcium (Ca)
Iron (Fe)
Reactive oxygen species (ROS)
Odds ratios (ORs)
Diabetes mellitus (DM)
Confidence intervals (CIs)
Posterior subcapsular cataract (PSC)
Calcium-sensing receptor (CaR)
National Health and Nutrition Examination Survey (KNHANES)

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