Original Article

Serum Levels of Vitamin C among Patients with and Without Age-Related Cataract at The University of Abuja Teaching Hospital, Abuja, Nigeria

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Abstract

Objectives: To evaluate serum levels of vitamin C in patients aged between 45 and 60 years with and without age-related cataract. **Methods:** One hundred and eighty consenting adults were recruited for this hospital-based comparative cross-sectional study and distributed equally into the cataract and no-cataract groups. They were interviewed using a pretested questionnaire on their demographics, health, lifestyle, and nutritional habits followed by full ocular examination. All the subjects had blood drawn and serum vitamin C assayed using the Cell Biolabs' Oxiselect Ascorbic Acid Assay kit. Data were analyzed using IBM SPSS version 21 statistical software. *P*-value of <0.05 was considered statistically significant. **Results:** One hundred and seventy-eight serum vitamin C assays were analyzed (response rate of 98.9%). One hundred and fifty-eight (88.8%) participants had low levels of vitamin C, whereas 20 (11.2%) had normal levels. Serum vitamin C levels were significantly higher among the no-cataract group than the cataract group with mean values of 0.121 to 0.567 mg/dL [mean ± 2 standard deviation (SD)] and 0.160 to 0.454 mg/dL (mean ± 2SD), respectively [$P = 0.004$ and 95% confidence interval of −0.64 to −0.013]. Serum vitamin C levels were significantly higher among the male participants in each group ($P = 0.004$). Serum vitamin C was found to have a weak positive correlation with the age of the participants ($P = 0.577$). **Conclusion:** In a vitamin C-depleted study population, serum vitamin C was found to have an inverse relationship with age-related cataract.

Keywords: Age related, cataract, serum vitamin C

Introduction

Cataract is defined as clouding of the lens of the eye and is responsible for 51% of the world's blindness.[1] In Nigeria, cataract is the commonest cause of severe visual impairment and blindness responsible for 45.3% and 43.0%, respectively, in those aged 40 years and above.[2] The number of people blind from cataract in the world is increasing by approximately 1 million per year.[3]

Researchers have shown that oxidative stress which is caused by the accumulation of free radicals is a cause of cataract and can be ameliorated by the effect of antioxidants such as vitamin C in the aqueous humor.[4]

Serum vitamin C levels correlates directly to aqueous levels and were shown to vary based on age, gender, race, ethnicity, body mass index, socioeconomic status, and with supplement use.[5,6] About 3% of vitamin C in the human body is lost per day on average assuming there is no intake and is no longer detected after 30 to 45 days.[7]

Research has shown an inverse relationship between the serum vitamin C levels and the incidence of age-related cataract (ARC) among the many different population groups living in the United States of America,[6] in Spanish Mediterranean, and in Indians among others. Other studies have shown that no such relationship exists

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and show instead that high serum vitamin C levels are associated with ARC.[8,9] Whether this is the same for population groups among black Africans, particularly in this demographical region is yet to be determined. The relationship between the serum vitamin C levels and the age of onset, the type and grade of cataract has, to the best of our knowledge not been documented in our geographical region, the North-Central part of Nigeria.

This study investigates the relationship between serum vitamin C and ARC.

Methods

Ethical clearance (FCT/UATH/HREC/PR/C59) for this comparative cross-sectional study was obtained from our institutional health research ethics committee and the study was conducted in accordance with the declaration of Helsinki. Written informed consent was obtained from all participants before enrolment.

Adult patients aged between 45 and 65 years with ARC who visited outpatient eye clinic at University of Abuja Teaching Hospital, Gwagwalada within the study period and gave written informed consent were recruited and matched with patients without cataract based on age, gender, and socioeconomic background. The study was conducted from January 1, 2018 to April 30, 2018.

Patients with cataract that was not age related, any corneal lesions or opacification, patients with acute or chronic ocular inflammations, patients with a history of acute illnesses requiring medications in the past 2 weeks, patients with shallow anterior chamber on anterior segment examination that would have increased the risk of angle closure when dilated, any ocular pathology that would prevent a proper dilated eye examination or any systemic pathology that could affect serum vitamin C levels and/or be a cause of cataract, patients with glaucoma, and age-related macular degeneration were all excluded from the study.

A sample size of 180 was estimated with 90 participants in each group using the formula for comparing means:

$$n = \left(\frac{r+1}{r}\right)\frac{\sigma^2\left(Z_\beta + Z_{\alpha/2}\right)^2}{(\text{difference})^2}$$

$$n = \left(\frac{1+1}{1}\right)\frac{(20.02)^2(0.84+1.96)^2}{10^2}$$

Attrition rate of 10% was included and minimum sample size was determined.

A structured pretested interviewer-administered questionnaire was used to obtain information about the demographics of the participants. The questionnaire was administered by a single ophthalmologist.

The participants had a complete anterior segment examination carried out and the findings recorded in a proforma. Lens opacities were graded after full dilation based on the modified World Health Organization grading system[10] as outlined

All types are graded 0 to 3 then 9. Grade 9 indicates a full cataract.

(1) Cortical cataract (grade 0: <1/8 of lens diameter; grade 1: >1/8 to <1/4 of lens diameter; grade 2: 1/4 to < 1/2; grade 3: >1/2; grade 9: full cataract)
(2) Posterior subcapsular cataract (grade 0: <1 mm diameter; grade 1: ≥1.0 mm but <2.0; grade 2: ≥2.0 mm but <3.0 mm; grade 3: ≥3 mm; grade 9: full cataract)

Nuclear cataract is graded based on clarity of the central nuclear part of the lens using standard photographs (grades: 0–3).

Grade 0: < the standard 1 photograph, has a clear well delineated central zone

(1) Grade 1: ≥ the standard one photograph but < than the standard 2 photograph, where the central zone is more uniformly opaque
(2) Grade 2: ≥ the standard 2 photograph but < the standard 3 photograph, where the central zone is densely opaque
(3) Grade 3: ≥ the standard 3 photograph
(4) Grade 9: full cataract[10]

All the examinations and grading of lens opacities were carried out by one ophthalmologist.

The pupils were dilated to at least 6.5 mm in diameter using Appamide plus (Appasamy Ocular Devices Pvt Ltd, Chennai, India), a topical mydriatic that is a combination of phenylephrine and tropicamide 5% and 8%, respectively.

Blood samples were collected in a dimly lit room shaded from direct sunlight. Three milliliters of blood were taken from each participant using a 5-mL syringe in plain blood specimen bottles appropriately labeled and allowed to clot at room temperature for 30 minutes and allowed to clot at room temperature for 30 minutes, it was then centrifuged at 2500*g* for 20 minutes and supernatant separated, the serum was transported in an ice box to the laboratory and stored in the deep freezer at −40°C till enough samples had been pooled. Analysis was carried out using Cell Biolabs' Oxiselect™ ascorbic acid assay kit (FRASC) Catalogue Number: STA-860 (Cell Biolabs Inc. 7758, Arjons Drive, San Diego, CA, USA).

In assessing status of vitamin C, serum vitamin C levels <0.2 mg/dL (11.35 μmol/L) indicate deficiency, 0.2 to 0.39 mg/dL (11.35–22.14 μmol/L) indicate low levels, 0.4 to 0.99 mg/dL (22.71–56.21 μmol/L) indicate normal levels, and levels ≥1.0 mg/dL (56.78 μmol/L) indicate saturation.[11]

The questionnaires were manually checked by the principal investigator for errors, completeness and consistency, and data extracted. Statistical analysis was carried out using

commercial software, IBM SPSS version 21 (International Business Machines, Statistical Package for Social Sciences version 21) (IBM Corp., Armonk, NY, USA). A confidence intervals of 95% and *P*-value of <0.05 was considered statistically significant.

Results

A total of 180 participants were recruited for the study. Ninety persons were in the cataract (ARC) group, whereas 90 persons were in the no-cataract group. Participants were between 45 and 65 years of age, frequency matched on sex and age. Age frequency matching was carried out in 5-year age groups intervals. One hundred and seventy-eight samples were analyzed, giving a response rate for the study of 98.9%.

The sociodemographic and lifestyle characteristics of the cataract and no-cataract groups revealed that the two groups were comparable on the two matching variables with a similar gender proportion, as 43 (47.8%) were males in the cataract group, and 47 (52.2%) in the no-cataract group. They also had a similar age distribution with the median age being 57.50 years for the cataract group and 58 years for the no-cataract group.

Thirty-six (40%) of the ARC group were unskilled workers, whereas 45 (50%) of the no-cataract group were skilled workers. This observed difference was statistically significant ($\chi^2 = 16.78$, $P = 0.001$).

Sixteen (17.8%) of the ARC group had no formal education, whereas a higher proportion 58 (64.4%) of the no-cataract group had tertiary education. This observed difference was also statistically significant ($\chi^2 = 10.02$, $P = 0.02$) [Table 1].

Of the 180 participants in the study, 178 (98.8%) had their serum vitamin C levels assayed. Although none of the participants were observed to have been deficient in vitamin C, 158 (88.8%) had low levels. Only 20 (11.2%) participants had normal levels and none had attained levels of saturation [Figure 1].

The cataract group had a higher number of participants with low levels of serum vitamin C 83 (94.3%) as against 75 (83.3%) in the no-cataract group with low levels ($P = 0.020$). As participants with normal levels of serum vitamin C were higher in the no cataract group with 15 (16.7%) compared to the 5 (5.7%) who had normal levels in the cataract group ($P = 0.020$).

Table 1: Sociodemographic characteristics of participants among the cataract and no cataract groups

Variables	Cataract (n = 90)*N* (%)	No cataract (n = 90)*N* (%)	χ^2	*P*-value
Gender			0.356	0.551
Male	43 (47.8)	47 (52.2)		
Female	47 (52.2)	43(47.8)		
Total	90 (100)	90 (100)		
Religion			0.408	0.648
Islam	28 (31.1)	23 (25.6)		
Christianity	62 (68.9)	67 (74.4)		
Total	90 (100)	90 (100)		
Occupation			16.781	0.001*
Skilled	21 (23.3)	45 (50)		
Semiskilled	33 (36.7)	14 (15.6)		
Unskilled	36 (40.0)	31 (34.4)		
Total	90 (100)	90 (100)		
Level of education			10.018	0.018*
Primary	18 (20)	11 (12.2)		
Secondary	11 (12.2)	16 (17.7)		
Tertiary	45 (50)	58 (64.4)		
Others	16 (17.8)	5 (5.6)		
Total	90 (100)	90 (100)		
Age			32.098	0.16
45–49	8 (8.9)	25 (27.8)		
50–54	25 (27.8)	8 (8.9)		
55–59	19 (21.8)	37 (41.1)		
60–64	25 (27.8)	8 (8.9)		
65–69	13 (14.4)	12 (13.3)		
Total	90 (100)	90 (100)		
Mean ± SD	57.08 ± 5.80	55.82 ± 6.07		0.158

SD, standard deviation. *Significant $P < 0.05$.

There was a weak positive correlation between age and serum vitamin C with a correlation coefficient of 0.042 and *P*-value of 0.577, which was not statistically significant [Table 2].

In the cataract group, 17 participants had primary school level of education, 11 had secondary school level, and 44 had tertiary level of education, whereas 15 participants had informal education. Eighty-three (94.3%) of the participants had low levels of serum vitamin C, whereas 5 (5.7%) had normal levels. This showed that educational level was not a statistically significant variable [Fischer exact test (FET) = 2.886 and P = value of 0.395; Table 3].

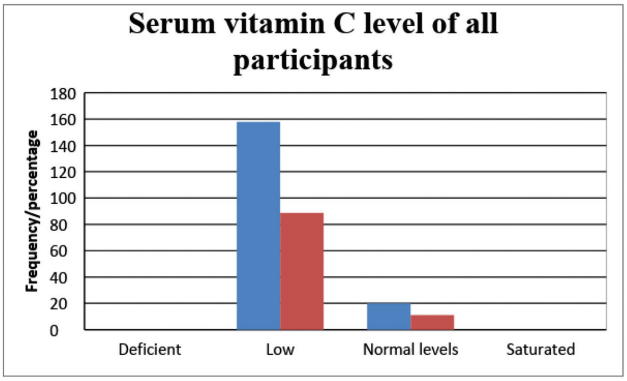

Figure 1: Serum vitamin C levels among all participants.

In the no-cataract group, 11 participants had primary school level of education, 15 had secondary school level of education, and 58 had tertiary level of education, whereas 5 had informal education. Seventy-five (83.3%) had low levels of serum vitamin C, whereas 15 (16.7%) had normal levels. The FET value = 2.201 and $P = 0.530$ was not statistically significant [Table 3].

There is an odd ratio > 1, which is a positive value. It indicates a positive relationship between low levels of serum vitamin C and cataract, and participants with low levels were 3.32 times more likely to develop ARC [Table 4].

Table 2: Serum vitamin C concentrations across gender among cataract and no cataract groups

Variables	Cataract			No cataract		
	Male(mean ± SD)	Female(mean ± SD)	*P*-value	Male(mean ± SD)	Female(mean ± SD)	*P*-value
Serum vitamin C	0.312 ± 0.041	0.302 ± 0.055	0.004*	0.357 ± 0.138	0.332 ± 0.074	0.004*

SD, standard deviation. *Significant $P < 0.05$.

Table 3: Relationship between serum vitamin C levels, cataract, educational levels, and occupation

Variables	Cataract			No cataract		
	Low levels	Normal levels	FET,*P*-value	Low levels	Normal levels	FET,*P*-value
Educational level						
Primary	15	2	1.847,	9	2	2.201,
Secondary	11	0	0.582	15	1	0.530
Tertiary	42	2		46	12	
Others	15	1		5	0	
Occupation						
Skilled	20	1	0.962,	38	7	1.827,
Semiskilled	31	1	0.842	10	4	0.437
Unskilled	32	3		27	4	

Total FET across the groups = 2.886, *P*-value (educational levels) = 0.395. Total FET across the groups = 0.140, *P*-value (occupation) = 0.959. FET, Fischer exact test. *Fischer exact test.

Table 4: Vitamin C grading and cataract cross tabulation

		Cataract		Total
		Have cataract	No cataract	
Vitamin C grading	Low levels	83	75	158
	Normal levels	5	15	20
		88	90	178

$$OR = \frac{\text{Exposed cases} \times \text{Unexposed control}}{\text{Exposed control} \times \text{Unexposed cases}}$$

$$OR = \frac{83 \times 15}{75 \times 5}$$

$$OR = 3.32$$

.OR, odds ratio.

Discussion

The age of the participants ranged from 45 to 65 years with a mean age of 56.45 ± 5.8. The cataract group had a median age of 57.50 years, whereas the no-cataract group had a median age of 58 years. Although participants in the two groups (cataract and no cataract) were gender and age matched, the men in the study were found to have higher levels of education and employed in skilled and semi-skilled type occupation when compared with the women.

In our study, we found that the serum vitamin C levels were significantly lower among the cataract group than the no-cataract group with means of 0.307 mg/dL ± 0.049 and 0.345 mg/dL ± 0.112, respectively. Thus, serum vitamin C was inversely associated with ARC. This finding agrees with studies carried out among similarly low-income Indian populations.[12,13] In a South Indian tertiary hospital-based study, serum vitamin C levels were significantly lower in groups with significant lens opacity than in those with minimal or no lens opacity.[14] This was also an inverse relationship, similar to what was found in a hospital-based case–control study in India[15] and another carried out in the Mediterranean.[16] In an Iranian study, on the other hand, by Abbaszadeh *et al*. on patients with age-related nuclear cataract alone, they found no inverse relationship between serum vitamin C and cataract.[17]

Indian studies found the population to be generally vitamin deficient or had substandard levels of vitamin C which is similar to what we observed in our study.[12,13] We found serum vitamin C to be low in 158 (88%) participants with levels ≤0.39 mg/dL (22.14 μmol/L), none were however found to be deficient, a finding somewhat similar to what was found with 90% of the population having substandard or deficiency of vitamin C in the North Indian population and 74% of the population in the South of India.[18] The serum vitamin C levels being low in our result may be an indication of a low serum vitamin C level in the population probably as a result of poor intake. A population-based study will however be required to prove this fact.Our results showed that patients in the cataract group with lower serum vitamin C were mostly unskilled laborers ($P = 0.001$). Participants with tertiary level of education were significantly more in the no-cataract group ($P = 0.018$). This was similar to the Indian study where people with cataract were more likely to be illiterate and had lower serum vitamin C levels.[12] Another Indian study showed significant difference between the serum vitamin C levels among the low- and high-income patients in the cataract group.[17] The Mediterranean population was characterized by high intakes of fruits and vegetables as against ours but they still allow the plausibility that lower educational levels might lead to poorer diets with lower antioxidant levels.[16] The literacy level of a population may directly influence their socioeconomic levels, how conscious they are of the value of good nutritious foods to health and their ability to afford them. Although the quantity of oral vitamin C intake was not calculated, the 24-hour dietary recalls for most of the study participants was a reflection of their normal diets. This study indicates that in the population studied, the risk of developing ARC was 3.32 times higher in participants with low levels of serum vitamin C than in those with normal levels. Multicenter longitudinal studies or even population-based studies could be carried out, Nigeria has the unique advantage of being populous, geographically, ethnically, and culturally diverse, thus results from Nigerian studies could be a reflection of Africa as a continent.

This study was limited in that being hospital based, it may not convey the true picture of the Nigerian population. The sampling technique used may also be considered a limitation. Nonprobability samplings mean some patients have no chance at all of being selected leading to having a sample that is not a representative sample of the population making the results difficult to generalize.

Conclusion

This study reveals there was a statistically significant inverse relationship between serum vitamin C levels and ARC in the study population. Although aging by itself has long been established as the most important risk factor for cataract formation, other factors such as oxidative stress due to free radicals may play an important role. Our study unequivocally shows how deficient our sample population is in vitamin C levels even with a diet that is seemingly high in fruits and vegetables. This could be a pointer to general poor nutritional status of the population group and our people. The results from our study could however mean that increasing intake of serum vitamin C may have a role to play in the management of ARC.

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Conflicts of interest

There are no conflicts of interest.

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