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The Association of Consumption of Fruits/Vegetables with Decreased Risk of Glaucoma among Older African American Women in the Study of Osteoporotic Fractures

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Abstract

Purpose—To explore the association between consumption of fruits and vegetables and the presence of glaucoma in older African American women.

Design—Cross-sectional study.

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D. Statement about Conformity with Author Information: The Institutional Review Board for Human Subjects Research (IRB) approvals were obtained for the continuation of all research activities, including data analysis, for the ongoing prospective cohort study, including sites from UCLA; UCSF; the University of Maryland; the University of Minnesota; Kaiser Permanente Center for Health Research Northwest; and the University of Pittsburgh prior to the study. The study was HIPPA compliant, and complied with the tenets of the Declaration of Helsinki related to the treatment of human subjects.

Methods—Disc photographs and suprathreshold visual fields were obtained from the 662 African American participants in the Study of Osteoporotic Fractures. Masked, trained readers graded all discs, and two glaucoma specialists reviewed photos and visual fields. The Block Food Frequency Questionnaire assessed food consumption. Relationships between selected fruit/vegetable/nutrient consumption and glaucoma were evaluated using logistic regression models after adjusting for potential confounders.

Results—After excluding women missing Food Frequency Questionnaire and disc data, 584 African American women (88.2% of total African American cohort) were included. Glaucoma was diagnosed in at least one eye in 77 subjects (13%). Women who ate 3 or more servings/day of fruits/fruit juices were 79% (odds ratio [OR]=0.21; 95% confidence interval [CI]: 0.08–0.60) less likely to have glaucoma than women who ate less than one serving/day. Women who consumed more than 2 servings/week of fresh oranges (OR=0.18; 95%CI: 0.06–0.51) and peaches (OR=0.30; 95%CI: 0.13–0.67) had a decreased odds of glaucoma compared to those consuming less than one serving/week. For vegetables, >1 serving/week compared to ≤1 serving/month of collard-greens/kale decreased the odds of glaucoma by 57% (OR=0.43; 95%CI: 0.21–0.85). There was a protective trend against glaucoma in those consuming more fruit/fruit juices (p=0.023), fresh oranges (p=0.002), fresh peaches (p=0.002), and collard greens/kale (p=0.014). Higher consumption of carrots (p=0.061) and spinach (p=0.094) also showed some associations. Individual nutrient intake from food sources found protective trends with higher intakes of vitamin A (p=0.011), vitamin C (p=0.018), and α-carotene (p=0.021), and close to statistically significant trends with β-carotene (p=0.052), folate (p=0.056), and lutein/zeaxanthin (p=0.077).

Conclusion—Higher intake of certain fruits and vegetables high in Vitamins A and C and carotenoids may be associated with a decreased likelihood of glaucoma in older African American women. Randomized controlled trials are needed to determine whether the intake of specific nutrients changes the risk of glaucoma.

Introduction

Presently, the only treatment shown to prevent progression of glaucoma is lowering of intraocular pressure (IOP), although it does not prevent progression and/or onset in all patients.[1,2] A primary prevention strategy for glaucoma is highly desirable. Epidemiologic studies on antioxidants, ingested through diet and supplements, have suggested benefit on the risk of multiple diseases, including late age-related macular degeneration, [3] cataract [4], cardiovascular disease, [5,6,7,8] cancers, [9,10,11] although data is still needed from randomized controlled trials for cataracts, cardiovascular disease and cancer. *In vitro* evidence suggests that oxidative stress may contribute to the etiology and progression of glaucoma via apoptosis and extracellular matrix remodeling of the trabecular meshwork and lamina cribosa. [12,13,14,15] It is biologically feasible that antioxidants found in the diet through fruits and vegetables may modify the risk of glaucoma development and/or progression.

We previously investigated associations between diet and glaucoma in a random sample of women from the Study of Osteoporotic Fractures. [16] Some associations, such as that between green leafy vegetables and glaucoma appeared stronger in the African American subgroup, however, the number of African American women in the sample was very small (n=144, 12.5% of study population). In this study, we further investigated a possible association between glaucoma and the consumption of fruits and vegetables in the entire cohort of African American women aged 65 and older (n=662) participating in the Study of Osteoporotic Fractures. The association between the antioxidant constituents of fruits and vegetables and glaucoma was also examined.

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Methods

Setting and Subjects

The subjects and setting of the Study of Osteoporotic Fractures have been previously described. [16] Institutional Review Board approvals were obtained from the participating institutions prior to this study in order to review de-identified data that had been collected as part of the Study of Osteoporotic Fractures. The characteristics of the entire study population have been described in earlier reports. [17,18]

Glaucoma (outcome measurement) ascertainment

The ascertainment of glaucoma has been previously described.[16] In brief, optic nerve images were obtained with a Canon non-mydriatic camera (Canon CR – 45UAF 45 degree auto-focus non-mydriatic camera, Canon Inc, Kanagawaken, Japan) through a pharmacologically dilated pupil. Visual field testing was performed on each eye using the Humphrey Field Analyzer suprathreshold 76-point 30° visual field test (Carl Zeiss Meditec, Dublin, CA). Photographs were graded by two masked, trained photo graders. The visual fields and photographs of all women with a cup-to-disc ratio of 0.6 or greater (n=118), asymmetry between vertical cup-to-disc ratios of 0.2 or greater (n=93), discrepancy greater than 0.1 between photo graders on the grading of cup-to-disc ratios (n=161), and/or discrepancy in notation of focal thinning/notching of the neuroretinal rim between photo graders (n=62), along with a 5% random sample of the women with cup-to-disc ratios less than 0.6 (n=36) were evaluated by a masked, trained glaucoma specialist [JG]. The optic nerves were diagnosed as glaucomatous based on diffuse or localized thinning of the neuroretinal rim and loss of retinal nerve fiber layer. Visual field loss was defined as the presence of at least one missing point on the suprathreshold test. A second glaucoma specialist [AC] reviewed all optic nerves diagnosed with glaucoma and glaucoma suspect, along with the 5% random sample for confirmation of the diagnosis.

Measurement of fruit/vegetable consumption and antioxidant intake

Consumption of fruits and vegetables was assessed using the 1995 Block Food Frequency Questionnaire.[19,20] The Block questionnaire is a validated, self-administered diet questionnaire developed from the National Health and Nutrition Survey III (or NHANES III) that asks for average frequency of food intake over the last year. Participants completed the questionnaire just before their clinical visit. Block Dietary Data Systems (Berkeley, CA) calculated nutrition summary variables based on questionnaire responses, including daily intake of vitamins, fat, protein, carbohydrates, and nutrients obtained from all food sources (not including intake from supplements).[21]

Statistical Analysis

Excluded from the analysis were women with incomplete questionnaires or unknown glaucoma status, due to ungradeable or absent photographs. The distribution of selected fruit and vegetable item was examined in the total study population. In the analysis, consumption of individual items was categorized into frequency categories reflective of their different frequency distributions on the questionnaires filled out by participants. The number of participants consuming a certain item may not add up to the total study population due to incomplete responses for the item. For further details see reference 16.

Because it is presumably the constituents (vitamins, minerals, etc) of fruits and vegetables that confer a protective effect, the major nutrient components of fruits and vegetables were determined.[22] The total intake of calories, fat, protein, and carbohydrate were also calculated based on the consumption of all food.. The relationships of both food items and nutrients to the risk of glaucoma were examined individually using logistic regression models, adjusted for potential confounders. The potential confounders were chosen based on their clinical relevance and evidence from the literature [15,16], and are seen in Table 1. Due to the skewed distribution of antioxidant intake, intakes were categorized into either tertiles or quartiles, depending on where easily recognized cut-offs were seen. The lowest tertile or quartile of intake formed the reference category. Trend p-values were determined from the multiple logistic regression models of the odds of glaucoma adjusting for the potential confounders listed above. Trend p-values indicate whether a dose-response effect exists when consuming a higher amount of food items or nutrients.

A power calculation was performed at the start of this study, based on the results of previous analysis of 1,155 the Study of Osteoporotic Fractures participants that only included 144 African American participants.[16] Drawing on the results of that study where some relationships appeared stronger in the African American cohort, one of the key distinctions anticipated to occur was between subjects reporting less than 1 serving of spinach per week and those reporting at least 1 serving per week. With assumed alternate prevalence rates for glaucoma between 10% and 12% and intake of less than one serving per week or between prevalence rates of 2 to 3% with more than one serving per week, study power was calculated to lie between 95% and 99.9% assuming at least 500 patients with gradable photos. All statistical analyses were performed using SAS version 9.1 statistical software (SAS institute, Cary, NC).

Results

Study Population

Among the 662 African American women in the cohort, glaucoma status could not be determined in 68 women due to missing or ungradeable disc photos (10.3%--47 with unknown status bilaterally and 21 with unknown status unilaterally with a normal fellow eye). Additionally, there were 13 (1.9%) women for whom we did not have Food Frequency Questionnaire data, 3 of them also had unknown glaucoma status. Thus, the final study population consisted of 584 women (88.2% of original African American cohort). There were no statistically significant differences in baseline characteristics among the 78 women excluded from analyses (data not shown).

The characteristics of the study population are described in Table 1.

Prevalence of Glaucoma

Among the 584 women in the analysis, 77 (13.2%) were diagnosed with glaucoma in at least one eye. Glaucoma was bilateral in 32 women, unilateral in 39, and there were 6 women with glaucoma in one eye but unknown status in the fellow eye.

Relationship between Fruit/Vegetable Intake and Glaucoma: Adjusted Analyses

Fruit and vegetable consumption varied among study participants with a somewhat even spread across the various frequency categories. (Table 2) In analyses adjusted for potential confounders (Table 2), the odds of having glaucoma were decreased by 79% [odds ratio (OR)=0.21; 95% confidence interval (CI)=0.08–0.60] in women who consumed 3 or more servings per day of all fruits and fruit juices compared to those who consumed less than 1 serving per day (trend p=0.023). Compared to the reference group (<1 serving per day of fruit), those women consuming 2 servings per day and at least 1 serving per day had a 37% (OR=0.63; 95% CI=0.32–1.24) and 65% (OR=0.35; 95% CI=0.18–0.70) decreased odds of glaucoma, respectively. Of the individual fruits analyzed, women consuming greater amounts of fresh oranges [OR=0.18; CI=0.06–0.51; p=0.002] and fresh peaches [OR=0.30; CI=0.13–0.67; p=0.002] were 82% and 70% less likely to have glaucoma, respectively. The frequencies compared for these fruits were more than 2 servings per week compared to less than 1 serving per week. Consumption of apples/applesauce, bananas, orange juice, or canned/dried peaches did not show any statistically significant benefits or harms with relation to glaucoma and there were no significant trends with higher consumption.

The odds of having glaucoma were not affected by consumption of 3 or more servings of vegetables per day compared to less than 1 serving (OR=0.97; CI=0.37–2.54; trend p=0.965). However, consumption of more than 1 serving per week of green collards/kale decreased the odds of having glaucoma by 57% [OR=0.43; CI=0.21–0.85] compared to consuming less than 1 serving per month (trend p=0.014). Eating greater amounts of spinach and fresh carrots came close to showing a statistically significant protective trend (trend p=0.094 and 0.061, respectively). Higher green salad consumption showed no protective or harmful trend.

Relationship between Individual Nutrient Intake and Glaucoma

After adjusting for potential confounders, the highest quartiles or tertiles of intake of the following nutrients were associated with decreased odds of having glaucoma: vitamin C 70% less likely (trend p=0.018), vitamin A 63% less likely (trend p=0.011), and α-carotene 54% less likely (p=0.021). (Table 3) The trend results for higher dietary intake of β-carotene (trend p=0.052), folate (trend p=0.056), and lutein/zeathanxine (trend p=0.077) were very close to being statistically significant. Higher intake levels of vitamins B1, B2, B3, B6, D, E, lycopene, and potassium were not associated with statistically significant increased or decreased odds of having glaucoma. Intake of increasing calories per day, total carbohydrate, total protein (Table 3) and total fat (Table 4) also showed no trend or affect on the odds of glaucoma.

Discussion

Our results suggest that higher daily consumption of fruit and dark green leafy vegetables may decrease the likelihood of having glaucoma in older African American women. Fruits and vegetables are rich with antioxidants, and in epidemiologic studies diets high in fruits/vegetables have been associated with decreased risk of coronary heart disease,[5,6,7,8] ischemic stroke, [23] cancer, [9,10,11] late AMD,[3] and cataract [4]. However, randomized controlled trials using high-dose supplements have not demonstrated a beneficial effect on the incidence of certain cancers and cardiovascular disease, and some have even shown harmful effects. [24,25] Antioxidants found in fruits and vegetables include vitamins A, C, E, provitamin A carotenoids that the body converts to vitamin A (α- and β-carotene, β-cryptoxanthin), and other carotenoids without vitamin A activity (lycopene, lutein, zeaxanthin). In our study population, higher dietary intakes of vitamins C and A and the provitamin carotenoids through the entire diet were significantly associated with reduced odds of glaucoma diagnosis, while higher intake of lutein/zeaxanthin and folate showed a near significant trend toward reduced odds of glaucoma diagnosis. Foods rich in vitamin A include eggs, meat, liver, dairy, and certain fish. Those rich in carotenoids include collards, kale, spinach, carrots, pumpkin, tomatoes, and oranges, among many others. Vitamin C rich food sources are citrus fruits/juices, strawberries, tomato, red pepper, broccoli, and potatoes.

There are multiple mechanisms by which the antioxidant constituents of fruits and vegetables may have a beneficial effect on glaucoma. Effects may be mediated directly on the trabecular meshwork, [26,27,28] on individual retinal ganglion cells,[13,29,30] on the vascular system nourishing the optic nerve, [31] by a combined mechanism, or by mechanisms not yet understood. While vitamin A and carotenoids were identified as having a statistically significant association with reduced glaucoma risk in our population, it is premature to recommend supplements of these nutrients. For example, observational studies have linked higher dietary intakes of beta-carotene to reduced risk of lung cancer,[9,10] but subsequent large, prospective randomized controlled trials of beta-carotene supplementation showed an increased risk of lung cancer.[32,33] Also, it is not yet clear whether the beneficial health effects of diets high in antioxidants are a direct result of the antioxidants or due to other factors associated with diets high in antioxidant-rich foods (for example, other life-style choices, such as regular exercise or choosing not to smoke). [34] However, in our study these and other potential confounders were controlled for and they did not negate the associations we observed.

There are only two previous studies examining the association between dietary intake and glaucoma. Both study populations are predominantly Caucasian. In analyses of over 110,000 men and women from the prospective Health Professionals Follow-up and Nurses' Health studies that identified 474 cases of self-reported glaucoma, no association was found between risk of glaucoma and six food groups, including green leafy vegetables, all fruits combined, and all vegetables combined. [15] Kang et al. concluded that there were no strong associations with higher intakes of the various antioxidants, although there were some reductions in risk that were close to reaching statistical significance. In their paper on dietary fat, they found a higher ratio of omega-3 to omega-6 was associated with higher risk of primary open angle glaucoma, a finding that was not duplicated in our study. [35] Of note, these studies used the Willet food frequency questionnaire, which is known to estimate nutrient intake differently than the Block questionnaire.[36] Besides lacking African American subjects (<10%), Kang's study population also significantly differed from ours in that it was mixed gender and younger by 2–3 decades, so that the prevalence of glaucoma would be expected to be lower. The Kang subjects also had healthier eating habits (median consumption of antioxidants among women in the Study of Osteoporotic Fractures falls within the first two quintiles of the Nurses' Health Study and Health Professional Follow-up Study populations). Finally, cases of glaucoma were identified by case report and then confirmed by chart review, and there was no random sample of the controls to confirm lack of glaucoma. Knowing that population-based studies found 50% of patients with glaucoma are unaware of having the disease, there may be many missed cases of glaucoma in their 100,000 plus controls.[37,38]

In a previous study by us in a predominantly Caucasian sample of the Study of Osteoporotic Fractures cohort with identical methods of glaucoma identification and nutrient assessment, [16] the odds of glaucoma risk were decreased by higher consumption of green collards/ kale, carrots, and canned/dried peaches (foods found to be associated with decreased odds of glaucoma in this African American cohort), and of vitamin B2 (riboflavin). Vitamin A and α-carotene showed decreased risk coming close to reaching statistical significance. Higher intake of orange juice, spinach, and cryptoxanthin increased the odds of glaucoma. Possible reasons why different nutrients showed statistical significance in the predominantly Caucasian population compared to the African American population include: differences in eating habits, food preparation methods, and absorption and metabolism, which may be related to hormonal and genetic differences [39]. For example, high vitamin A intake doesn't necessarily equate to high blood levels of retinol--age, gender, hormones, and genetics can influence this relationship. [40] Also, carotenoid absorption depends on the presence of fat in a meal. Chopping, pureeing, and cooking carotenoid-containing vegetables in oil generally increases bioavailability because these preparation methods help release the carotenoids from their associated proteins within the plant matrix. [41,42] Perhaps the African American subjects tended to eat carrots raw, limiting the beneficial nutrients derived from this vegetable, while they chopped and prepared collard greens with oil, making the nutrients more bioavailable. Why spinach, orange juice, and cryptoxanthin, a nutrient found in high quantities within orange juice, were associated with increased odds of glaucoma in the Caucasian but not in the African American group may also be related to differences in diet preparation, genetics and metabolism. Of course, there is also the possibility that some of our findings in either study are due to chance and do not represent a true association.

Specific limitations of our study include residual confounding by unmeasured variables, such as intraocular pressure, family history of glaucoma, and certain lifestyle factors. In terms of family history, it is unlikely that diet would vary with family history since there is little to no information in the public suggesting that diet affects glaucoma. Secondly, gonioscopy was not performed, so the exact type of glaucomatous optic nerve damage diagnosed is unknown (this may be an issue because diet would not be expected to have an etiologic effect on acute angle closure glaucoma). Thirdly, we did not measure plasma nutrient levels. However, plasma and diet levels are not expected to highly correlate due to many factors other than diet that influence the plasma levels. [40] Nonetheless, studies are published that validate the Block Food Frequency Questionnaire against dietary records and plasma nutrient values.[19,20] Another limitation may be that our Food Frequency Questionnaires were conducted at the same time as the eye exam, and thus they may have missed the etiologically relevant diet exposure, if one assumes that diets change with age and time and that it is past diet that affects glaucoma development. At the present time, the relevant diet exposure (in childhood, young or middle adulthood) is unknown. There is also the issue of multiple comparisons of fruits/vegetables and antioxidants, which is a general limitation of all such studies and may lead to statistically significant findings by chance. Lastly, the cross-sectional design does not allow causality to be established.

Strengths of our study are that the African American women we studied appear to be representative of other African American populations studied. The prevalence of glaucoma reported here, 13.2%, falls within the prevalence confidence interval of a recent meta-analysis of the literature on open-angle glaucoma that specifically included black populations. [43] The prevalence of self-reported diabetes and hypertension in our older African American population is also consistent with the prevalence rates reported by the National Health and Nutrition Examination Surveys. [44,45]

In summary, using data from the African American participants of the Study of Osteoporotic Fractures, we found evidence that higher intake of vitamin A, vitamin C, dietary carotenoids, fruits and dark green leafy vegetables were associated with a lower likelihood of having glaucoma. It remains to be asked whether a randomized controlled trial is warranted if these findings can be confirmed by prospective studies. Any single constituent of fruits and vegetables may not fully explain the apparent beneficial association observed in this study, as such, it may be better to recommend increased overall intake of fruits and vegetables at this time, rather than supplements.

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Table 1

Characteristics of African American women who had known glaucoma status and completed Block Food Frequency Questionnaire in the Study of Osteoporotic Fractures year-10 clinic visit (N=584).

Characteristics	All Women N (%) or Mean±SD N=584	Women with Glaucoma N (%) or Mean±SD N=77	Women without Glaucoma N (%) or Mean±SD N=507	P-value
Study sites				0.543[a]
Baltimore	137 (23.5%)	15 (19.5%)	122 (24.1%)	
Minneapolis	146 (25.0%)	18 (23.4%)	128 (25.3%)	
Pittsburgh	157 (26.9%)	20 (26.0%)	137 (27.0%)	
Portland	144 (24.7%)	24 (31.2%)	120 (23.7%)	
Age (years)				
Mean±SD	75.3 ± 5.1	77.0 ± 5.5	75.1 ± 5.0	0.003[b]
65–74	295 (50.5%)	30 (39.0%)	265 (52.3%)	0.065[a]
75–79	172 (29.5%)	25 (32.5%)	147 (29.0%)	
80–84	84 (14.4%)	14 (18.2%)	70 (13.8%)	
85–94	33 (5.7%)	8 (10.4%)	25 (4.9%)	
Education (years)				
Mean±SD	12.1 ± 3.2	12.1 ± 3.5	12.1 ± 3.1	0.939[b]
< 12 years	192 (33.2%)	23 (29.9%)	169 (33.7%)	0.675[a]
12 years	187 (32.3%)	24 (31.2%)	163 (32.5%)	
> 12 years	200 (34.5%)	30 (39.0%)	170 (33.9%)	
Current smoker	48 (8.3%)	6 (7.9%)	42 (8.3%)	1.00[a]
At least one alcoholic drink in past 30 days	154 (26.4%)	19 (24.7%)	135 (26.7%)	0.782[a]
Walking for exercise	212 (36.5%)	19 (25.0%)	193 (38.2%)	0.030[a]
Body mass index (kg/m^2)				
Mean±SD	30.2 ± 6.0	31.2 ± 6.2	30.0 ± 6.0	0.098[b]
Self-rated health status				0.414[a]
Good or excellent	419 (71.9%)	52 (67.5%)	367 (72.5%)	
Fair or poor	164 (28.1%)	25 (32.5%)	139 (27.5%)	
Self-report of diabetes	101 (17.3%)	12 (15.6%)	89 (17.6%)	0.748[a]
Self-report of hypertension	370 (63.5%)	43 (55.8%)	327 (64.6%)	0.162[a]

SD = Standard Deviation.

[a]Fisher exact test.

[b]T test.

Table 2

Associations between selected fruits and vegetable consumptions and glaucoma among African American women who had known glaucoma status and completed Block Food Frequency Questionnaire in the Study of Osteoporotic Fractures year-10 clinic visit (N=584).

Average intake of fruits/vegetables	**N (%)**	**OR (95% CI)[a]**
All fruits and fruit juices		
<1 serving per day	121(21%)	1.00 (referent)
1 serving per day	216 (37%)	0.35 (0.18–0.70)
2 servings per day	157 (27%)	0.63 (0.32–1.24)
≥3 servings per day	90 (15%)	0.21 (0.08–0.60)
Trend p-value		0.023
All vegetables		
<1 serving per day	62 (11%)	1.00 (referent)
1 serving per day	202 (35%)	0.95 (0.39–2.28)
2 servings per day	178 (30%)	1.02 (0.41–2.53)
≥3 servings per day	142 (24%)	0.97 (0.37–2.54)
Trend p-value		0.965
Fresh apple		
<1 serving per week	171 (34%)	1.00 (referent)
1 serving per week	57 (11%)	0.32 (0.10–1.02)
2 servings per week	99 (20%)	0.84 (0.40–1.77)
>2 servings per week	171 (34%)	0.52 (0.26–1.05)
Trend p-value		0.137
Fresh banana		
<1 serving per week	95 (17%)	1.00 (referent)
1–2 servings per week	117 (21%)	0.73 (0.31–1.75)
3–6 servings per week	228 (41%)	1.02 (0.48–2.15)
≥1 serving per day	112 (20%)	1.05 (0.44–2.48)
Trend p-value		0.661
Fresh orange		
<1 serving per week	153 (39%)	1.00 (referent)
1 serving per week	42 (11%)	0.83 (0.28–2.48)
2 servings per week	85 (22%)	0.70 (0.30–1.61)
>2 servings per week	111 (28%)	0.18 (0.06–0.51)
Trend p-value		0.002
Orange juice		
≤1 serving per week	191 (33%)	1.00 (referent)
3 servings per week to <1 serving per day	185 (32%)	0.77 (0.41–1.44)
≥1 serving per day	205 (35%)	0.79 (0.42–1.47)
Trend p-value		0.448

Average intake of fruits/vegetables	N (%)	OR (95% CI)[a]
Fresh peach		
<1 serving per week	156 (36%)	1.00 (referent)
1 serving per week	60 (14%)	0.86 (0.38–1.98)
2 servings per week	84 (19%)	0.42 (0.17–1.02)
>2 servings per week	134 (31%)	0.30 (0.13–0.67)
Trend p-value		0.002
Canned/dried peach		
<1 serving per month	239 (41%)	1.00 (referent)
1 serving per month to <1 serving per week	183 (32%)	1.07 (0.60–1.91)
≥1 serving per week	157 (27%)	0.65 (0.33–1.28)
Trend p-value		0.258
Fresh carrot		
≤1 serving per month	85 (16%)	1.00 (referent)
>1 serving per month to <1 serving per week	136 (26%)	1.23 (0.54–2.83)
1 serving per week	105 (20%)	0.81 (0.32–2.05)
>1 serving per week	190 (37%)	0.57 (0.24–1.34)
Trend p-value		0.061
Spinach (cooked or raw)		
≤1 serving per month	129 (29%)	1.00 (referent)
>1 serving per month to <1 serving per week	125 (28%)	1.19 (0.57–2.46)
1 serving per week	96 (22%)	0.62 (0.26–1.45)
>1 serving per week	96 (22%)	0.54 (0.22–1.35)
Trend p-value		0.094
Green salad		
<1 serving per week	141 (27%)	1.00 (referent)
1 serving per week	86 (17%)	1.43 (0.62–3.30)
2 servings per week	84 (16%)	1.28 (0.52–3.14)
>2 servings per week	210 (40%)	1.02 (0.48–2.17)
Trend p-value		0.909
Green collards/kale		
≤1 serving per month	178 (30%)	1.00 (referent)
>1 serving per month to <1 serving per week	162 (28%)	0.45 (0.24–0.88)
1 serving per week	85 (15%)	0.48 (0.22–1.09)
>1 serving per week	159 (27%)	0.43 (0.21–0.85)
Trend p-value		0.014

CI=Confidence Interval; OR=Odds Ratio.

[a]Based on multiple logistic regression models of the odds of glaucoma adjusting for potential confounders including study sites, age, education, smoking status, alcohol consumption, walking for exercise, body mass index, self-rated health status, presence of self-reported diabetes, and presence of self-reported hypertension.

Table 3

Associations between selected intake of nutrients from food consumptions and glaucoma among African American women who had known glaucoma status and completed Block Food Frequency Questionnaire in the Study of Osteoporotic Fractures year-10 clinic visit (N=584).

Average daily intake of nutrients from food	N (%)	OR (95% CI)[a]
Vitamin A (RE)		
<800	155 (27%)	1.00 (referent)
800–1099	135 (23%)	1.35 (0.69–2.65)
1100–1499	146 (25%)	0.93 (0.47–1.86)
≥1500	148 (25%)	0.37 (0.15–0.90)
Trend p-value		0.011
Vitamin B (Folate) (μg)		
<180	163 (28%)	1.00 (referent)
180–229	136 (23%)	0.61 (0.30–1.22)
230–299	128 (22%)	0.70 (0.35–1.40)
≥300	157 (27%)	0.47 (0.22–0.96)
Trend p-value		0.056
Vitamin B1 (Thiamin) (mg)		
<1	238 (41%)	1.00 (referent)
1–1.4	243 (42%)	0.65 (0.37–1.14)
≥1.5	103 (18%)	0.84 (0.41–1.72)
Trend p-value		0.455
Vitamin B2 (Riboflavin) (mg)		
<1	129 (22%)	1.00 (referent)
1–1.3	160 (27%)	0.77 (0.38–1.57)
1.4–1.8	162 (28%)	0.73 (0.35–1.50)
≥1.9	133 (23%)	0.75 (0.35–1.62)
Trend p-value		0.529
Vitamin B3 (Niacin) (mg)		
<11	135 (23%)	1.00 (referent)
11–14	166 (28%)	0.71 (0.36–1.40)
15–18	153 (26%)	0.61 (0.29–1.26)
≥19	130 (22%)	0.64 (0.30–1.38)
Trend p-value		0.251
Vitamin B6 (mg)		
<1.1	152 (26%)	1.00 (referent)
1.1–1.3	159 (27%)	0.72 (0.37–1.43)
1.4–1.6	112 (19%)	0.88 (0.43–1.83)
≥1.7	161 (28%)	0.65 (0.32–1.32)
Trend p-value		0.299

Average daily intake of nutrients from food	**N (%)**	**OR (95% CI)[a]**
Vitamin C (mg)		
<60	128 (22%)	1.00 (referent)
60–99	179 (31%)	0.37 (0.18–0.76)
100–139	147 (25%)	0.58 (0.29–1.14)
≥140	130 (22%)	0.30 (0.13–0.70)
Trend p-value		0.018
Vitamin D (IU)		
<70	138 (24%)	1.00 (referent)
70–119	153 (26%)	0.76 (0.38–1.53)
120–179	151 (26%)	0.61 (0.29–1.30)
≥180	142 (24%)	0.91 (0.45–1.83)
Trend p-value		0.915
Vitamin E (A-TE)		
<5	135 (23%)	1.00 (referent)
5–6.9	163 (28%)	1.22 (0.61–2.44)
7–8.9	140 (24%)	1.00 (0.47–2.12)
≥9	146 (25%)	0.76 (0.35–1.66)
Trend p-value		0.327
Alpha-carotene (µg)		
<200	226 (39%)	1.00 (referent)
200–399	176 (30%)	0.69 (0.38–1.26)
≥400	182 (31%)	0.45 (0.23–0.88)
Trend p-value		0.021
Beta-carotene (µg)		
<2000	157 (27%)	1.00 (referent)
2000–3199	144 (25%)	0.61 (0.31–1.20)
3200–4799	137 (23%)	0.54 (0.27–1.11)
≥4800	146 (25%)	0.46 (0.22–0.95)
Trend p-value		0.052
Cryptoxanthin (µg)		
<60	163 (28%)	1.00 (referent)
60–99	134 (23%)	1.26 (0.63–2.51)
100–149	157 (27%)	0.98 (0.50–1.94)
≥150	130 (22%)	0.62 (0.28–1.36)
Trend p-value		0.171
Lutein/zeaxanthin (µg)		
<1400	152 (26%)	1.00 (referent)
1400–2199	130 (22%)	0.44 (0.21–0.90)
2200–3999	160 (27%)	0.42 (0.21–0.84)

Average daily intake of nutrients from food	N (%)	OR (95% CI)[a]
≥4000	142 (24%)	0.43 (0.21–0.88)
Trend p-value		0.077
Lycopene (μg)		
<400	158 (27%)	1.00 (referent)
400–799	150 (26%)	0.70 (0.35–1.43)
800–1199	124 (21%)	0.69 (0.32–1.48)
≥1200	152 (26%)	0.94 (0.47–1.87)
Trend p-value		0.917
Potassium (mg)		
<1700	154 (26%)	1.00 (referent)
1700–2099	132 (23%)	0.75 (0.36–1.55)
2100–2699	146 (25%)	0.70 (0.34–1.44)
≥2700	152 (26%)	0.83 (0.41–1.70)
Trend p-value		0.670
Total calories (Kcal)		
<1100	172 (29%)	1.00 (referent)
1100–1399	133 (23%)	0.72 (0.35–1.51)
1400–1799	161 (28%)	0.87 (0.44–1.71)
≥1800	118 (20%)	1.06 (0.51–2.18)
Trend p-value		0.786
Total protein (g)		
<40	130 (22%)	1.00 (referent)
40–54	157 (27%)	0.47 (0.22–0.99)
55–69	142 (24%)	0.77 (0.38–1.58)
≥70	155 (27%)	0.65 (0.32–1.34)
Trend p-value		0.460
Total carbohydrate (g)		
<120	126 (22%)	1.00 (referent)
120–159	167 (29%)	0.69 (0.34–1.40)
160–209	154 (26%)	0.72 (0.35–1.48)
≥210	137 (23%)	0.75 (0.35–1.59)
Trend p-value		0.613

CI=Confidence Interval; OR=Odds Ratio.

[a]Based on multiple logistic regression models of the odds of glaucoma adjusting for potential confounders including study sites, age, education, smoking status, alcohol consumption, walking for exercise, body mass index, self-rated health status, presence of self-reported diabetes, and presence of self-reported hypertension.

Table 4

Associations between selected fat intake from food consumptions and glaucoma among African American women who had known glaucoma status and completed Block Food Frequency Questionnaire in the Study of Osteoporotic Fractures year-10 clinic visit (N=584).

Average daily intake of fats from food	N (%)	OR (95% CI)[a]
Total fat (g)		
<40	167 (29%)	1.00 (referent)
40–54	147 (25%)	0.46 (0.21–0.99)
55–69	113 (19%)	0.86 (0.41–1.79)
≥70	157 (27%)	0.90 (0.46–1.77)
Trend p-value		0.821
Saturated fat (g)		
<12	144 (25%)	1.00 (referent)
12–16	146 (25%)	0.84 (0.40–1.79)
17–23	145 (25%)	0.93 (0.44–1.95)
≥24	149 (26%)	1.18 (0.57–2.45)
Trend p-value		0.511
Omega-3 PUFA (g)		
<0.09	140 (24%)	1.00 (referent)
0.09–0.15	143 (24%)	1.40 (0.67–2.93)
0.16–0.27	154 (26%)	1.24 (0.58–2.64)
≥0.28	147 (25%)	1.24 (0.57–2.68)
Trend p-value		0.821
Omega-6 PUFA (g)		
<7.5	139 (24%)	1.00 (referent)
7.5–9.9	141 (24%)	0.91 (0.44–1.89)
10–13.4	153 (26%)	0.99 (0.48–2.07)
≥13.5	151 (26%)	1.02 (0.49–2.11)
Trend p-value		0.890
Ratio of omega-3 PUFA to omega-6 PUFA		
<0.01	157 (27%)	1.00 (referent)
0.01–0.014	137 (23%)	1.11 (0.54–2.31)
0.015–0.024	129 (22%)	1.27 (0.61–2.65)
≥0.025	161 (28%)	1.13 (0.54–2.34)
Trend p-value		0.791
Omega-3 PUFA: EPA (20:5) (g)		
<0.03	207 (35%)	1.00 (referent)
0.03–0.05	209 (35%)	1.17 (0.65–2.08)
≥0.06	168 (29%)	0.68 (0.34–1.36)
Trend p-value		0.214

Average daily intake of fats from food	N (%)	OR (95% CI)[a]
Omega-3 PUFA: DPA (22:5) (g)		
<0.02	273 (47%)	1.00 (referent)
0.02	168 (29%)	0.80 (0.43–1.47)
≥0.03	143 (24%)	0.75 (0.39–1.46)
Trend p-value		0.401
Omega-3 PUFA: DHA (22:6) (g)		
<0.05	165 (28%)	1.00 (referent)
0.05–0.07	133 (23%)	1.01 (0.49–2.08)
0.08–0.11	140 (24%)	1.07 (0.53–2.16)
≥0.12	146 (25%)	0.94 (0.45–1.94)
Trend p-value		0.854
Linoleic acid (18:2) (g)		
<7.5	138 (24%)	1.00 (referent)
7.5–9.9	142 (24%)	0.91 (0.44–1.89)
10–13.4	154 (26%)	1.03 (0.50–2.14)
≥13.5	150 (26%)	0.96 (0.46–1.99)
Trend p-value		0.969
Linolenicacid (18:3) (g)		
<1	155 (27%)	1.00 (referent)
1–1.29	135 (23%)	0.90 (0.43–1.88)
1.3–1.69	141 (24%)	1.51 (0.75–3.04)
≥1.7	153 (26%)	0.83 (0.40–1.75)
Trend p-value		0.663
Dietary fatty acid (18:4) (g)		
0	275 (47%)	1.00 (referent)
0.01	225 (39%)	1.13 (0.65–1.95)
≥0.02	84 (14%)	0.65 (0.27–1.56)
Trend p-value		0.467
Arachidonic acid (20:4) (g)		
<0.07	141 (24%)	1.00 (referent)
0.07–0.099	138 (24%)	1.34 (0.66–2.70)
0.10–0.129	160 (27%)	0.50 (0.23–1.09)
≥0.13	145 (25%)	0.84 (0.40–1.77)
Trend p-value		0.341

CI=Confidence Interval; OR=Odds Ratio; PUFA=Polyunsaturated fatty acid; EPA=Eicosapentaenoic acid; DPA=Docosapentaenoic acid; DHA=Docosahexaenoic acid.

[a]Based on multiple logistic regression models of the odds of glaucoma adjusting for potential confounders including study sites, age, education, smoking status, alcohol consumption, walking for exercise, body mass index, self-rated health status, presence of self-reported diabetes, and presence of self-reported hypertension.