Cataract risk had a positive association with metabolic syndrome and negative with a traditional balanced diet in middle-aged adults

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Research

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Abstract

Background

The prevalence of cataracts is steadily increasing among middle-aged and elderly Asians. We hypothesized that adults aged 40–77 years with cataracts would show an association with metabolic syndrome and its components and have different dietary patterns and lifestyles.

Methods

The study was performed using the Korean genome and epidemiology study (KoGES; a large-scale hospital-based cohort study) data collected during 2004–2013. Subjects were classified as cases (945 cataract patients) and controls (27,454 healthy controls) based on responses to the question "have you ever been diagnosed to have a cataract?".

Results

The presence of metabolic syndrome had a significant positive association with cataract risk after adjusting for age, sex, resistance area, BMI and energy intake (model 1; by 1.23-fold) and socioeconomic parameters (model 2; 1.15-fold). Plasma glucose and HbA1c concentrations also exhibited a higher cataract risk by 1.92- and 2.07-fold, respectively. For the analysis we used four dietary patterns to represent Korean food intake, that is, a traditional balanced diet, a meat and fish diet, a bread and cookie diet, and a grain-based diet. High traditional balanced diet consumption had a negative association with cataract risk (OR = 0.84), but high grain-based diet consumption exhibited a positive association with cataract risk (OR = 1.41). Systolic blood pressure and high carbohydrate intake (OR = 1.42) were also associated with cataract risk in model 1, but high fat and protein intake showed negative associations (OR = 0.74 and 0.74, respectively).

Conclusions

The risk of cataract development was found to be positively associated with metabolic syndrome, high systolic blood pressure, and hyperglycemia and negatively associated with a traditional balanced diet.

Background

Cataracts are a leading cause of visual impairment and cause lens clouding in one or both eyes and result in vision impairments such as double vision and difficulties with bright lights and night vision [1]. Furthermore, cataracts make reading, driving, and recognizing faces difficult and increase the risks of falling and depression. Age-related cataracts are classified as nuclear sclerotic, cortical, or posterior subcapsular. Nuclear cataracts are the most common, in which dense nuclear sclerosis occurs at the center of the lens, which becomes sclerotic due to the intra-lens deposition of brown pigmentation [2]. Cortical cataracts cause opacity at lens cortices due to changes in fluid contents at lens peripheries, whereas posterior subcapsular cataracts develop as a cloud at the back of the lens adjacent to the lens capsule [3]. Although types of cataracts differ, they all result in lens opacity and may have similar risk factors [4].

The overall prevalence of cataracts is 42.3% (95% CI, 40.67–43.89) in Koreans aged ≥ 40 years [3], 69.5% in Asian adults aged 60–69 years, and 33% in Europeans aged 60–69 years [2]. Thus, the prevalence of cataract in Asians is much higher than that in Europeans, which suggests cataract incidence is higher in developing countries [5]. Since life expectancy has been globally extended and over 80% of elderly aged over 70 years have a cataract, the prevalence cataract will undoubtedly increase [1]. The common causes of cataract are aging, gender, trauma, and radiation exposure. Some of these factors such as age and gender are not modifiable but others are accessible. In European countries, men have a higher incidence of cataracts than women [6], but the Korea National Health Nutrition Examination Survey 2008–2010 found no gender predilection [7]. Furthermore, cataract prevalence has been reported to be inversely associated with socioeconomic factors, education level, and income, and with a residence in a rural area [8].

Cataracts can be prevented by altering modifiable risk factors. Environmental risk factors include hyperglycemia, smoking, long-term exposure to sunlight, and heavy alcohol consumption [9–11], though reports on relations between alcohol consumption and smoking and cataract have been somewhat inconsistent. Lipid profiles have also been reported to affect cataract incidence but the relationship remains controversial. Since cataract formation is known to be associated with oxidative stress, the influence of vitamin C on cataract development has attracted attention [12], but its effects are not obvious. Furthermore, these risk factors have been largely studied in Western countries, and studies on Asians are relatively recent. However, relations between dietary intakes (e.g., nutrient intakes and dietary patterns) and cataract risk have not been studied in Asians. Koreans have 5 distinct dietary patterns, that is, a traditional balanced diet, a bread-based diet,

a rice-based diet, a noodle-based diet, and an alcohol-based diet. We hypothesized that middle-aged adults with cataracts display associations with metabolic syndrome and its components and dietary patterns and lifestyles. The present study was performed using data obtained during the Korean Genome and Epidemiology Study (KoGES; a large, annual, hospital-based cohort study) for the period 2004–2013.

Methods

Subject characteristics and biochemical results

A total of 28,342 Korean adults aged 40–77 years participated from 2004–2013 in the KoGES, which was organized by the Korean Center for Disease and Control [13]. This study was approved by the Institutional Review Board of the Korean National Institute of Health for the Korean Genome and Epidemiology Study (KoGES; KBP-2015-055) and Hoseo University (1041231-150811-HR-034-01). All that participated in KoGES provided written informed consent.

General characteristics, including socioeconomic factors, were acquired using survey responses [14]. Anthropometric, biochemical, and dietary parameters were assessed. Weight, height, and waist and hip circumferences were measured and body mass indices were calculated, as previously described [15]. Serum and plasma were separated from blood collected after an overnight-fast [16]. Serum glucose and plasma total and HDL cholesterol and triglyceride concentrations in a fasting state were measured using a Hitachi 7600 Automatic Analyzer (Hitachi, Tokyo, Japan), and plasma LDL concentrations were calculated using the Friedewald Equation (plasma LDL concentration = plasma total cholesterol concentration – plasma HDL concentration – plasma triglyceride concentration/5). Blood HbA1c contents were determined using a ZEUS 9.9 automatic analyzer (Takeda, Tokyo, Japan).

Education status was classified as less than high school, high school, and college or higher and smoking status as current-smokers, past-smoker, and non-smoker. Alcohol beverage types, intake amounts, and frequencies during the previous year were obtained from KoGES data and daily alcohol intakes were calculated by multiplying frequencies of alcohol drinking by the average amount of alcohol consumed daily. Participants were classified as light drinkers (< 0.3 g/day), moderate drinkers (0.3–2 g/day), or heavy drinkers (> 2 g/day). Daily coffee intake was assessed in the same manner and participants were categorized into three groups using daily coffee intake tertiles. Daily physical activity was estimated by summing physical activities and daily physical activity levels were classified as light, moderate, or heavy using tertiles.

Cataract Diagnosis

In the KoGES survey, subjects were asked the question "Have you ever been diagnosed with a cataract?" Those that answered "yes" were assigned to the case group and the others were included in the control group.

Definition Of Metabolic Syndrome

Metabolic syndrome was defined as the presence of a cluster of ≥ 3 of the following: 1) abdominal obesity (waist circumference ≥ 90 cm for men and ≥ 85 cm for women); 2) elevated blood pressure (average systolic blood pressure ≥ 130 mmHg or diastolic blood pressure ≥ 85 mmHg); 3) low HDL-cholesterol level (< 40 mg/dl for men and < 50 mg/dl for women); 4) elevated serum triglyceride level (≥ 150 mg/dl); and 5) elevated fasting blood glucose level (≥ 110 mg/dl). [17] Participants taking medication for dyslipidemia, hyperglycemia, or hypertension were included in the metabolic syndrome group.

Dietary Assessment And Dietary Patterns

Food intakes were calculated using responses to a semi-quantitative food frequency questionnaire (SQFFQ) composed of 106 food items that Koreans mainly consume. Frequencies and average serving sizes were checked for the 106 food items. Usual serving sizes of individual food items were rated as 0.5, 1, or 2-fold those of displayed reference serving sizes. The midpoint of each food frequency category was used for the frequencies of each food item. The average intake of each food item was calculated by multiplying average daily intake frequency by average selected serving size. The quality of the SQFFQ was validated using 3-day food records conducted by subjects [18]. SQFFQ data on dietary patterns of subjects were classified using principal component analysis (PCA). Daily intakes of energy and nutrients (e.g., protein, carbohydrate, and fat) were calculated using Can-Pro 2.0 nutrient assessment software developed by the Korean Nutrition Society [17].

Statistical analysis

Statistical analysis was performed using SAS version 9.4 (SAS Institute, Cary, NC, USA). The 106 food items in SQFFQ were categorized into 30 predefined food groups (Supplemental Table 1) and were used as variables for factor analysis, which was performed using the FACTOR procedure. The number of factors in PCA was selected to retain eigenvalues of > 1.5 [19]. The orthogonal rotation procedure (varimax) and post-rotated factor loadings were used with PCA. The selected factors described distinct dietary patterns comprised of specific foods and major contributory foods were indicated by factor-loading values of ≥ 0.40 [20]. Factor scores for each pattern were determined by summing the intakes of all food groups weighted by factor loading. Factor scores of each dietary pattern were categorized into tertiles to compare lifestyle factors and nutrient intakes.

Frequency distributions of classification variables were calculated using the chi-squared test, and the two-sample t-test was used to determine the means and standard deviations of continuous variables, which included body mass index (BMI) and serum lipid profiles, in the case and control groups. The significance of intergroup differences was determined by one-way analysis of variance (ANOVA) with adjustments for covariates. Intergroup multiple comparisons were performed using the Tukey test.

Results

General characteristics of the study population according to the presence of cataracts

The demographic characteristics of subjects with and without cataracts are summarized in Table 1. For subjects aged ≥ 45 years, 945 (3.3%) had a cataract and 27,454 (96.7%) did not. The mean age in the cataract group (54.7 years) was higher than in the control group (53.3 years). Women (57.6%) had much more cataract than men (42.4%). The prevalence of cataract was four times as high in those with a lower income (<\$4,000) than in those with a higher-income ($\geq$ \$4,000), was greater in subjects educated to middle school than in those educated to a higher level, and was greater in subjects with high activity levels than in those with low activity levels. Cataract prevalence was also higher in subjects aged > 60 years, in those that smoked, and in heavy alcohol consumers. Intakes of coffee, energy, and macronutrients were not significantly different in the cataract and non-cataract groups.

Table 1
Distribution of prevalence of cataract over key variables

	Non-cataract (n = 27,454)	Cataract (n = 945)	P value
Age (years)	53.3 ± 8.0	54.7 ± 7.6	< 0.0001
Sex (Number, male %)	9842(35.9)	401(42.4)	< 0.0001
Income (dollar/month)	5147 (20.0)	322 (36.7)	< 0.0001
<\$1500	13924 (54.0)	408 (46.5)	
\$1500–4000	6725 (26.1)	148 (16.9)	
≥\$4000			
Education	7863 (30.5)	399 (45.4)	< 0.0001
< high school	10440 (40.1)	257 (29.4)	
High school	7493 (29.1)	222 (25.4)	
≥Undergraduate			
Total activity (Number, %)	12139(46.2)	393(43.4)	0.0006
Little 10 min	6714(25.5)	204 (22.5)	
Moderate 90–210 min	7448(28.3)	309(34.1)	
Heavy			
Smoking status at < 60 yrs (Number, %)	15203(74.9)	184(60.0)	< 0.0001
Non-smoking	2753(12.4)	61 (20.7)	
Past	2445(12.7)	46 (19.3)	
Smoking			
Alcohol intake at < 60 yrs (Number, %)	11706(57.6)	168(54.9)	0.0012
Little	3461(17.0)	29 (10.0)	0.0644
Moderate 15	5149 (25.3)	93 (32.1)	
Heavy			
Coffee intake (Number, %)	8949 (32.6)	337 (35.7)	
Little			
Moderate	7824 (28.5)	273 (28.9)	
Many	10681 (38.9)	335 (35.5)	
Energy intake (kcal/day)	88.6 ± 27.7	89.2 ± 27.4	0.5235
Carbohydrate intake (En%)	72.0 ± 6.8	72.0 ± 6.8	0.4575
Protein intake (En%)	13.4 ± 2.6	13.3 ± 2.6	0.2248
Fat intake (En%)	13.4 ± 5.2	13.3 ± 5.2	0.2248
Ca intake (mg/day)	449 ± 258	440 ± 261	0.1746
Na intake (mg/day)	2502 ± 1425	2442 ± 1423	0.1376
Vitamin C (mg/day)	108 ± 66.9	112 ± 68.9	0.0934
Vitamin A (RE/day)	481 ± 344	490 ± 340	0.4793
β-carotene (ug/day)	2400 ± 1849	2420 ± 1843	0.7311
Results are means ± standard deviation or number (%).			

Adjusted Means Of Metabolic Parameters Related To Metabolic Syndrome

The frequencies of metabolic syndrome and obesity were significantly higher in the cataract group (32.2 and 37.3%, respectively) than in the non-cataract group (21.9 and 32.7%, respectively) ($P < 0.0001$; Table 2). However, mean BMIs and waist and hip circumferences were not significantly different in these two groups. Fasting plasma glucose concentrations and blood HbA1c levels were much higher in the cataract group (97.5 vs 94.3 mg/dL and 5.86 vs 5.71%, respectively; $P < 0.0001$; Table 2), but serum total cholesterol and LDL cholesterol levels were lower in the cataract group (Table 2). Serum HDL and triglyceride concentrations and systolic blood pressure and diastolic blood pressure were similar in the two groups, but group serum C-reactive peptide levels (an index of inflammation) were not significantly different (Table 2).

Table 2
Adjusted means and 95% confidence intervals of metabolic parameters according to cataract status

	Non-cataract (n = 27,454)	Cataract (n = 945)	P value
Metabolic syndrome (Number, %)	6012 (21.9)	304 (32.2)	< 0.0001
Obesity ¹ (Number, %)	8922 (32.5)	309 (37.7)	0.0013
BMI ² (kg/m ²)	23.9 ± 2.6	24.0 ± 2.8	0.6871
Waist circumference (cm)	80.8 ± 8.1	80.9 ± 7.4	0.5841
Hip circumference (cm)	94.4 ± 5.4	94.2 ± 5.7	0.2235
Serum glucose (mg/dl)	94.3 ± 14.8	97.5 ± 27.4	< 0.0001
HbA1c (%)	5.71 ± 0.54	5.86 ± 0.99	< 0.0001
Serum total cholesterol (mg/dL)	197 ± 35.1	192 ± 37.7	< 0.0001
Serum LDL (mg/dL)	119 ± 32.3	114 ± 34.2	< 0.0001
Serum HDL (mg/dL)	52.8 ± 12.7	52.4 ± 12.5	0.2383
Serum triglyceride (mg/dL)	126 ± 86.6	128 ± 87.3	0.4825
SBP (mmHg)	122 ± 15	122 ± 14	0.6860
DBP (mmHg)	75.9 ± 9.6	75.3 ± 9.3	0.1082
Serum C-reactive protein (mg/L)	0.14 ± 0.38	0.14 ± 0.25	0.7601
¹ Body mass index (BMI) ≥ 25 kg/m ² for both sexes			
² Statistical analysis by GLM with adjusted for age, sex, residence area, and body mass index in continuous variables were			
HbA1c, hemoglobin A1c; SBP, systolic blood pressure; DBP, diastolic blood pressure;			

Associations Between Cataract Risk And Socioeconomic And Metabolic Parameters

The adjusted ORs and 95% CIs of cataract risk were exhibited in models 1 and 2 according to the binary groups of socioeconomic and metabolic parameters after adjusting covariates (Table 3). The covariates used in model 1 were age, sex, residence area, and body mass index and model 2 included model 1 covariates plus family income, education, smoking, physical activity, menopause, and energy, fat, protein, carbohydrate, alcohol, coffee, and cholesterol intakes. Subjects ≥ 55 years old had a 6.7- and 5.6-fold higher risk of cataract than subjects < 55 years old in models 1 and 2, respectively (Table 3). Sex was not significantly associated with cataract risk. Subjects educated to high school or more and with a monthly income of ≥ \$1500 dollars had a lower cataract risk than those that had received less education and were earning less (Table 3).

Table 3
Adjusted odds ratio and 95% confidence intervals of key parameters to affect cataract risk

	Model 1 ¹			Model 2 ²	
	No cataract	Cataract	P value	Cataract	P value
Age (≥ 55 years) ³	1 ⁴	6.682 (5.550–8.045)	<0.0001	5.614 (4.482–6.878)	<0.0001
Sex (Male)	1	0.961 (0.839–1.101)	0.5689	1.099 (0.881–1.370)	0.4037
Education ($\geq$ high school graduation or more)	1	0.522 (0.453–0.602)	<0.0001	0.751 (0.637–0.884)	<0.0001
Family income ($\geq$ \$1500/mon)	1	0.447 (0.387–0.517)	<0.0001	0.543 (0.461–0.640)	<0.0001
Metabolic syndrome	1	1.230 (1.046–1.447)	0.0122	1.153 (1.001–1.392)	0.0498
BMI (≥ 25 kg/m ²)	1	1.017 (0.886–1.168)	0.8091	1.071 (0.923–1.243)	0.3663
Waist circumferences (Men ≥ 90 , Women ≥ 85 cm)	1	0.931 (0.777–1.115)	0.4355	0.940(0.775–1.140)	0.5281
Plasma glucose (≥ 126 mg/dL)	1	1.939 (1.627–2.311)	<0.0001	1.920 (1.586–2.325)	<0.0001
HbA1c ($\geq 6.5\%$)	1	2.084 (1.750–2.481)	<0.0001	2.071 (1.718–2.497)	<0.0001
SBP (≥ 140 mmHg)	1	1.159 (1.001–1.338)	0.0495	1.132 (0.969–1.321)	0.1178
DBP (≥ 90 mmHg)	1	1.132 (0.968–1.323)	0.1951	1.073 (0.914–1.259)	0.3876
Hypertension	1	1.163 (0.991–1.365)	0.0643	1.117 (0.945–1.319)	0.1938
Serum total cholesterol (≥ 250 mg/dL)	1	0.983 (0.758–1.275)	0.8961	0.998 (0.763–1.305)	0.9873
Serum LDL cholesterol (≥ 160 mg/dL)	1	0.835 (0.660–1.057)	0.1347	0.847 (0.664–1.081)	0.1826
Serum HDL (Men ≥ 40 , Women ≥ 50 mg/dL)	1	1.050 (0.909–1.214)	0.5051	1.062 (0.875–1.289)	0.5409
Serum TG (≥ 200 mg/dL)	1	1.179 (0.968–1.428)	0.1027	1.158 (0.949–1.413)	0.1485
Serum C-reactive protein (≥ 1 mg/L)	1	0.974 (0.527–1.801)	0.9339	1.028 (0.555–1.904)	0.9294
¹ Model 1: adjusted for age, sex, residence area, and body mass index					
² Model 2: adjusted for model 1 plus family income, education, smoke, physical activity, menopause, and intake of energy, alcohol, coffee, fat, protein, carbohydrate, and cholesterol					
³ The criteria for the high group when the values were dichotomized into two groups with the cutoff point.					
⁴ The no-cataract group was the reference.					

Subjects with metabolic syndrome were found to have 1.23- and 1.15-fold higher risks of cataract than those without, by models 1 and 2, respectively (Table 3). BMI and waist circumference were not associated with cataract risk, but fasting plasma glucose and HbA1c levels were significantly higher in those with a cataract than in those without by model 2 (OR = 1.920, 95% CI = 1.586–2.325 and OR = 2.071, 95% CI = 1.718–2.497; $P < 0.0001$). Interestingly, systolic blood pressure (≥ 140 mmHg), but not diastolic blood pressure (≥ 90 mmHg), was significantly associated with a 1.16-fold increase in cataract risk by model 1 ($P = 0.0495$) (Table 3). Serum concentrations of total cholesterol, LDL, HDL, and triglyceride and serum C-reactive peptide were not associated with cataract risk by model 1 or 2 (Table 3).

Cataract incidence, nutrient intake, and lifestyles according to dietary pattern tertiles

Based on food frequency results, dietary intakes of subjects were divided into four dietary patterns using PCA (Table 4). The five dietary patterns were; a traditional balanced diet (TB), a meat and fish diet (MF), a bread and cookie diet (BC), a grain-based diet (GB), and a coffee and alcohol diet (CA). Adjusted means of energy and nutrient intake are presented according to dietary pattern tertiles (T1, T2, and T3) in Table 3, after adjusting for age, sex, residence area, and BMI (Table 4). Cataract incidences were not significantly different between TB tertiles. Daily energy intakes were slightly but significantly higher in tertile 3 (T3) than in T1. Carbohydrate intake was lower and protein, fat, Ca, and coffee intakes were higher in T3 than T1 (Table 4). For TB, the prevalence of non-smokers and those with high physical activity

levels were higher in T3 than in T1. Alcohol intake was not significantly different among the tertiles. For the MF diet, cataract incidence was lower in T3 than in T1. CHO, fat, and Ca intakes were lower but protein and alcohol intakes were higher in T3 than in T1, but daily energy intakes were not significantly different among tertiles (Table 4). The prevalence of smoking was greater in T3 than in T1. For the BC diet, the prevalence of cataracts was lower in T3 than in T1. Carbohydrate and fat intakes were higher, but protein, Ca, coffee, and alcohol intakes were lower in T3 than in T1. No significant difference between smoking prevalence was observed among the tertiles. For the GB diet, the prevalence of cataract was higher in T3 than in T1 (Table 4). A high intake GB diet was lower in CHO, protein, fat, and coffee and higher in Ca and alcohol, and CHO, fat, protein, and coffee intakes were lower but Na and alcohol intake were higher in T3 than in T1. No significant difference was observed between the GB tertile groups in terms of V-C, V-A, or β -carotene intakes (Data not shown).

Table 4
Adjusted means of nutrient intake and lifestyles according to dietary patterns

		CA	Energy intake	CHO percent	Fat percent	Protein percent	Ca intake (mg/day)	Alcohol intake	Coffee intake	Smoker	No activity
Traditional balanced diet	T1 (9747)	316 (3.45)	88.5 $\pm$ 24.6 ^b	72.3 $\pm$ 6.9 ^a	12.7 $\pm$ 8.1 ^c	12.8 $\pm$ 2.2 ^c	408 $\pm$ 160 ^c	10.8 $\pm$ 19.7	3.7 $\pm$ 4.4 ^b	1093 (11.3)	4748 (50.8)
	T2 (9489)	304 (3.42)	88.6 $\pm$ 22.3 ^b	71.9 $\pm$ 6.2	13.4 $\pm$ 8.0 ^b	13.4 $\pm$ 2.2 ^b	429 $\pm$ 160 ^b	10.7 $\pm$ 21.2	4.7 $\pm$ 4.8 ^a	1132 (12.0)	4165 (45.8)
	T3 (9209)	258 (2.99)	88.8 $\pm$ 29.8 ^{a***}	71.4 $\pm$ 6.7 ^{c***}	14.1 $\pm$ 7.8 ^{a***}	14.1 $\pm$ 2.6 ^{a***}	505 $\pm$ 296 ^{a***}	10.8 $\pm$ 42.5	4.7 $\pm$ 5.0 ^{a***}	950 (10.3)***	3626 (41.3)***
Meat/fish diet	T1 (9742)	330 (3.65)	88.6 $\pm$ 24.4	72.0 $\pm$ 5.9 ^a	13.8 $\pm$ 8.1 ^a	13.4 $\pm$ 12.5 ^b	475 $\pm$ 232 ^a	10.3 $\pm$ 21.6 ^a	5.1 $\pm$ 5.1 ^a	1078 (11.4)	4411 (47.1)
	T2 (9494)	300 (3.36)	88.7 $\pm$ 22.9	71.9 $\pm$ 5.6 ^b	13.7 $\pm$ 7.9 ^b	13.3 $\pm$ 2.1 ^c	451 $\pm$ 205 ^b	10.4 $\pm$ 18.8 ^a	4.2 $\pm$ 4.5 ^b	945 (10.0)	4252 (46.6)
	T3 (9209)	248 (2.85)*	88.6 $\pm$ 30.9	71.7 $\pm$ 6.9 ^{c***}	13.6 $\pm$ 7.8 ^{c***}	13.5 $\pm$ 2.7 ^{a***}	412 $\pm$ 297 ^{c***}	11.6 $\pm$ 29.7 ^{b*}	3.9 $\pm$ 4.7 ^{c***}	1152 (12.6)***	3876 (44.4)**
Bread/cookies diet	T1 (9737)	382 (4.23)	88.6 $\pm$ 23.5	71.7 $\pm$ 7.0 ^c	13.3 $\pm$ 7.6 ^a	13.6 $\pm$ 1.6 ^a	461 $\pm$ 268 ^a	13.4 $\pm$ 42.5 ^a	4.5 $\pm$ 4.4 ^a	1095 (11.3)	4480 (48.0)
	T2 (9499)	289 (3.22)	88.6 $\pm$ 21.4	71.8 $\pm$ 6.0 ^b	13.7 $\pm$ 7.9 ^b	13.3 $\pm$ 4.5 ^b	447 $\pm$ 209 ^b	10.8 $\pm$ 20.5 ^a	4.7 $\pm$ 4.8 ^a	1077 (11.4)	4154 (45.7)
	T3 (9209)	207 (2.39)***	88.7 $\pm$ 30.9	72.1 $\pm$ 6.4 ^{a***}	14.1 $\pm$ 7.9 ^{c***}	13.2 $\pm$ 4.9 ^{c***}	432 $\pm$ 272 ^{c***}	8.3 $\pm$ 19.4 ^{b*}	4.0 $\pm$ 5.0 ^{c***}	1003 (10.9)	3905 (44.4)***
Grain-main diet	T1 (9745)	259 (2.82)	88.5 $\pm$ 27.8 ^b	71.9 $\pm$ 7.4 ^b	13.8 $\pm$ 8.1 ^a	13.5 $\pm$ 2.9 ^a	409 $\pm$ 290 ^b	10.1 $\pm$ 22.0 ^b	4.7 $\pm$ 4.9 ^a	1248 (12.9)	4706 (50.3)
	T2 (9485)	299 (3.36)	88.8 $\pm$ 28.0 ^a	72.0 $\pm$ 6.3 ^a	13.8 $\pm$ 7.8 ^a	13.5 $\pm$ 2.4 ^a	473 $\pm$ 261 ^a	10.0 $\pm$ 38.2 ^b	4.6 $\pm$ 4.9 ^a	797 (8.4)	3897 (43.0)
	T3 (9215)	320 (3.72)**	88.6 $\pm$ 25.2 ^{b***}	71.7 $\pm$ 5.9 ^{c***}	13.5 $\pm$ 8.0 ^{b***}	13.2 $\pm$ 2.2 ^{b***}	458 $\pm$ 206 ^{c***}	12.1 $\pm$ 25.7 ^{a***}	3.8 $\pm$ 4.5 ^{b***}	1130 (12.3)***	3936 (44.8)***
CA, cataract incidence;											
Adjusted with family income, education, smoke, physical activity, menopause, and intake of energy, alcohol, coffee, fat, protein, carbohydrate, and cholesterol.											

Association Between Cataract Risk And Dietary Patterns

Those who frequently consumed a TB diet (a high-intake group) had significantly lower ORs (0.839; 95% CI = 0.700-0.999; $P < 0.05$) for cataracts than those that consumed a TB diet infrequently (reference group; a low-intake group) in model 1, but not in model 2 (Table 5). On the other hand, those with a high intake GB diet had higher ORs for cataracts than those with a low intake GB diet by model 1 (OR = 1.289) and model 2 (OR = 1.291). MF and BC diet patterns did not exhibit an association with cataract risk (Table 5).

Table 5
Adjusted odds ratio and 95% confidence intervals of dietary patterns and lifestyles for cataract risk

	Model 1 ¹			Model 2 ²	
	Low intake ³	Medium intake	High intake	Medium intake	High intake
Traditionally balanced diet	1	0.984 (0.831–1.165)	0.839 (0.700–0.999)*	1.014 (0.843–1.220)	0.917 (0.726–1.157)
Meat/fish diet	1	1.051 (0.891–1.240)	1.032 (0.859–1.239)	1.082 (0.910–1.286)	1.192 (0.966–1.470)
Bread/cookie diet	1	0.943 (0.801–1.109)	0.871 (0.719–1.055)	0.978 (0.819–1.167)	0.963 (0.764–1.215)
Grain-main diet	1	1.289 (1.078–1.541)	1.406 (1.175–1.682)**	1.268 (1.052–1.530)	1.291 (1.057–1.577)*
Energy intake (EER %)	1	0.923 (0.784–1.087)	0.931 (0.782–1.108)	0.986 (0.831–1.169)	1.056 (0.874–1.275)
Carbohydrate intake (En%)	1	1.228 (1.016–1.485)	1.415 (1.176–1.702)***	1.225 (0.737–2.036)	1.205 (0.630–2.306)
Fat intake (En%)	1	0.859 (0.729–1.011)	0.743 (0.617–0.895)**	1.001 (0.712–1.406)	1.217 (0.705–2.103)
Protein intake (En%)	1	0.800 (0.683–0.937)**	0.740 (0.629–0.871)***	0.815 (0.638–1.040)	0.880 (0.620–1.250)
Ca (mg/day)	1	0.804 (0.681–0.949)	0.730 (0.614–0.867)***	0.992 (0.804–1.224)	1.012 (0.773–1.325)
Na (mg/day)	1	0.861 (0.725–1.024)	0.890 (0.735–1.078)	0.907 (0.749–1.098)	0.999 (0.792–1.261)
Coffee (cups/day)	1	1.041 (0.874–1.240)	0.901 (0.760–1.068)	1.021 (0.852–1.224)	0.900 (0.753–1.076)
Alcohol (g/day)	1	0.802 (0.670–0.960)*	0.609 (0.221–1.675)	0.763 (0.631–0.922)**	0.571 (0.204–1.598)
Physical activity (h/day)	1	0.927 (0.772–1.114)	1.007 (0.855–1.185)	0.929 (0.772–1.118)	1.021 (0.866–1.204)
Smoking status	1	1.303 (1.032–1.644)*	1.124 (0.844–1.498)	1.352 (1.065–1.716)*	1.207 (0.896–1.627)
¹ Model 1: age, sex, residence area, body mass index and daily energy intake.					
² Model 2: model 1 plus income, education, smoke, physical activity, menopause, and intake of alcohol, coffee, fat, protein, carbohydrate, and cholesterol.					
³ The cut-off points of the low-, medium-, and high-intake groups were assigned by the tertiles.					
Significantly different from major allele in logistic regression analysis at * P < 0.05, ** P < 0.01, *** P < 0.001.					

Daily energy intake was not associated with cataract risk by model 1 or 2. However, the percentage of macronutrient intake influenced cataract risk. A high carbohydrate intake (energy %) had a 1.42 higher risk of cataract by model 1 but was not found to present a higher risk by model 2 (Table 5). High intakes of fat, protein, and Ca were associated with lower cataract risks by 0.74-, 0.74-, and 0.73-fold by model 1 but no association was indicated by model 2. However, no significant association was observed between cataract risk and physical activity or Na or coffee intake by model 1 or 2 (Table 5). Moderate alcohol intake, but not heavy alcohol intake, lowered cataract risk by 0.80 fold as compared with low alcohol intake by model 1 (P < 0.05) and 2 (P < 0.001). Interestingly, former smokers had a higher risk of cataract than non-smokers by models 1 and 2 (Table 5).

Discussion

The prevalence of cataracts among the elderly has increased worldwide, and cataract surgery is the main therapeutic method used to prevent vision loss. In the present study, we found that metabolic syndrome was positively associated with cataract prevalence after adjusting for confounding factors. Furthermore, cataract prevalence was positively associated with grain-based dietary patterns and negatively associated with a traditional balanced diet. High carbohydrate intake was associated with a 1.4-fold increase in cataract risk and high fat, protein, and Ca intake was in association with a 0.74-fold decrease in model 1. These results suggest that a balanced diet containing sufficient protein and Ca protect against cataract development in middle-aged adults.

Previous studies have reported that obesity [21, 22], diabetes [23, 24], dyslipidemia [25, 26], and hypertension [27] are associated with cataract incidence. Our study supports these previous results. However, further analysis of results showed that relations between cataract prevalence and the components of metabolic syndrome differed from previous findings. For example, in the present study, BMI, waist circumferences, systolic and diastolic blood pressures, hypertension, lipid profiles (LDL, HDL, and triglyceride) were not significantly associated with cataract prevalence. Total cholesterol and LDL levels were significantly lower in the cataract group than in the non-cataract group, although this association disappeared after adjusting for confounding factors in logistic regression analysis. Although the exact reason is unclear, one possible explanation for this observation is that patients with cataract might have taken cholesterol-lowering drugs (e.g., statins), given that patients with a cataract may also have dyslipidemia. However, the pathogenic and protective effects of statins on cataracts are poorly documented and widely debated [28, 29]. It was recently reported that the prolonged use of statins may predispose cataract development [30], but others failed to identify an association [31]. Unfortunately, the administration of cholesterol-lowering drugs was not included in the analysis in the present study. Further studies are needed to determine whether cholesterol-lowering drugs might be associated with cataractogenesis.

BMI and abdominal obesity (as determined by waist circumference) have been suggested to be risk factors of cataract development. Cheung and Wond have reported that obesity was positively associated with the presence of cataract [32], but other studies disagreed. In a study conducted in Singapore obesity was found to be positively related to the prevalence of cortical cataracts but negatively related to that of nuclear cataracts [21]. Another study based on the Korean National Health and Nutritional Examination Survey data showed that overweight was significantly associated with a lower risk of cataract development [22]. However, we found no association between obesity and cataract prevalence.

The present study revealed significant associations between cataract prevalence serum glucose levels and hemoglobin A1c levels, which is consistent with previous findings [33, 34]. In particular, we observed linear associations between hemoglobin A1c and fasting serum glucose levels and the presence of cataracts using generalized linear models, which suggests high fasting glucose levels and diabetes are risk factors of cataract development. It has also been suggested that advanced glycation of lens fiber proteins [35], hyperosmotic pressure, and the sorbitol pathway are possible mechanisms of cataract formation [36].

Tryptophan/selenium imbalance and calcium, vitamin C, vitamin A, and excessive energy intakes are generally considered to be cataract risk factors [37]. However, we found vitamin C, vitamin A, and carotene intakes were not associated and that calcium intake was negatively associated with cataract risk. The average intake of vitamins A and C and carotene was higher than DRI in both case and control groups. However, the average intake of calcium intake (~ 449 mg/day) in our subjects was ~ 50% of DRI and calcium intakes were too low to enhance cataract risk [38]. Furthermore, in the present study, macronutrient intake was observed to be associated with cataract risk that is consistent with metabolic syndrome risk [39, 40]. A high carbohydrate diet (> 70 energy %) and a low-fat diet (< 15 energy %) were found to be associated with metabolic syndrome in a previous using KNHANES data.[40, 41] The present study showed a consistent result in cataract risk. Metabolic syndrome is known to be associated with cataract risk [42] and macronutrient nutrient intake showed similar patterns for the risk of both diseases. The present study shows that high CHO, low fat, and low protein diets increased the risk of cataract in middle-aged adults.

The present study has several limitations. First, the presence of cataracts was evaluated based on self-reports and not on clinical examinations, which may have caused bias. Second, KoGES data did not include details of current cataract status or information on the cataract severity or subtype. Third, the data obtained could not be used to determine causalities because of the cross-sectional design of KoGES. Forth, nutrient intakes and life-styles were determined using self-reported questionnaires, and thus, were prone to subjective errors. However, it should be added that the semi-quantitative food questionnaire used contained 106 commonly consumed 106 food items and was validated using 3 day-food records over 4 seasons.

Conclusion

Summarizing, the present study shows an association exists between metabolic syndrome and the presence of cataract in a large hospital-based cohort, and that fasting serum glucose was a strong and independent risk factor of cataract, whereas other components of metabolic

syndrome (i.e., obesity, lipid profiles, and hypertension) were not. Furthermore, the study shows strict glucose control is more important terms for preventing cataract formation than blood pressure or dyslipidemia control.

Abbreviations

KoGES: Korean Genome and Epidemiology Study; SQFFQ: semi-quantitative food frequency questionnaire; PCA: principal component analysis; BMI: body mass index; ANOVA: analysis of variance; TB: a traditional balanced diet; MF: a meat and fish diet; BC: a bread and cookie diet; GB: a grain-based diet; CA: a coffee and alcohol diet.

Declarations

Acknowledgements

Not applicable.

Authors' contributions

SP contributed to the study's conception and design. SP and JDH contributed to drafting of the manuscript. SP and JDH performed data analysis and interpretation. The final draft was read and approved by all the authors.

Availability of data and materials

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

Ethics approval

This study was approved by the Institutional Review Board of the Korean National Institute of Health for the KoGES (KBP-2015-055) and Hoseo University (1041231-150811-HR-034-01).

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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References

1. Lee CM, Afshari NA. The global state of cataract blindness. *Curr Opin Ophthalmol*. 2017;28:98–103.
2. Prokofyeva E, Wegener A, Zrenner E. Cataract prevalence and prevention in Europe: a literature review. *Acta Ophthalmol*. 2013;91:395–405.
3. Rim TH, Kim MH, Kim WC, Kim TI, Kim EK. Cataract subtype risk factors identified from the Korea National Health and Nutrition Examination survey 2008–2010. *BMC Ophthalmol*. 2014;14::4.
4. Beebe DC, Holekamp NM, Shui YB. Oxidative damage and the prevention of age-related cataracts. *Ophthalmic Res*. 2010; 44:155 – 65.
5. Liang YB, Friedman DS, Wong TY, Zhan SY, Sun LP, Wang JJ, et al. Prevalence and causes of low vision and blindness in a rural chinese adult population: the Handan Eye Study. *Ophthalmology*. 2008;115::1965–72.
6. Mundy KM, Nichols E, Lindsey J. Socioeconomic Disparities in Cataract Prevalence, Characteristics, and Management. *Semin Ophthalmol*. 2016; 31:358 – 63.
7. Nam GE, Han K, Ha SG, Han BD, Kim DH, Kim YH, et al. Relationship between socioeconomic and lifestyle factors and cataracts in Koreans: the Korea National Health and Nutrition Examination Survey 2008–2011. *Eye (Lond)*. 2015; 29:913 – 20.

8. Guo C, Wang Z, He P, Chen G, Zheng X. Prevalence, Causes and Social Factors of Visual Impairment among Chinese Adults: Based on a National Survey. *Int J Environ Res Public Health*. 2017; 14.
9. Lindblad BE, Hakansson N, Philipson B, Wolk A. Alcohol consumption and risk of cataract extraction: a prospective cohort study of women. *Ophthalmology*. 2007;114:680–5.
10. Lu ZQ, Sun WH, Yan J, Jiang TX, Zhai SN, Li Y. Cigarette smoking, body mass index associated with the risks of age-related cataract in male patients in northeast China. *Int J Ophthalmol*. 2012;5:317–22.
11. Lindblad BE, Hakansson N, Wolk A. Smoking cessation and the risk of cataract: a prospective cohort study of cataract extraction among men. *JAMA Ophthalmol*. 2014;132:253–7.
12. Zheng Selin J, Rautiainen S, Lindblad BE, Morgenstern R, Wolk A. High-dose supplements of vitamins C and E, low-dose multivitamins, and the risk of age-related cataract: a population-based prospective cohort study of men. *Am J Epidemiol*. 2013; 177:548 – 55.
13. Kim Y, Han BG. Cohort Profile: The Korean Genome and Epidemiology Study (KoGES) Consortium. *Int J Epidemiol*. 2017; 46:e20.
14. Lim S, Jang H, Lee H, Kimm K, Park C, Cho N. A rural-urban comparison of the characteristics of the metabolic syndrome by gender in Korea: the Korean Health and Genome Study (KHGS). *Journal of endocrinological investigation*. 2006; 29:313.
15. Liu M, Jin HS, Park S. Protein and fat intake interacts with the haplotype of PTPN11_rs11066325, RPH3A_rs886477, and OAS3_rs2072134 to modulate serum HDL concentrations in middle-aged people. *Clin Nutr*. 2019.
16. Kim Y, Han B-G, group K. Cohort profile: the Korean genome and epidemiology study (KoGES) consortium. *International journal of epidemiology*. 2016; 46:e20-e.
17. Park S, Ham JO, Lee BK. Effects of total vitamin A, vitamin C, and fruit intake on risk for metabolic syndrome in Korean women and men. *Nutrition*. 2015;31:111–8.
18. Park S, Daily JW, Zhang X, Jin HS, Lee HJ, Lee YH. Interactions with the MC4R rs17782313 variant, mental stress and energy intake and the risk of obesity in Genome Epidemiology Study. *Nutr Metab (Lond)*. 2016; 13:38.
19. Steel RG, Torrie JH, Dickey DA. *Principles and Procedures of Statistics: A Biological Approach*. McGraw-Hill; 1997.
20. Kim JO, Mueller CW. Factor Analysis. Statistical Methods and Practical Issues. Thousand Oaks: Sage publications; 1978.
21. Sabanayagam C, Wang JJ, Mitchell P, Tan AG, Tai ES, Aung T, et al. Metabolic syndrome components and age-related cataract: the Singapore Malay eye study. *Invest Ophthalmol Vis Sci*. 2011;52:2397–404.
22. Park S, Kim T, Cho SI, Lee EH. Association between cataract and the degree of obesity. *Optom Vis Sci*. 2013;90:1019–27.
23. Pizzol D, Veronese N, Quaglio G, Di Gennaro F, Deganello D, Stubbs B, et al. The association between diabetes and cataract among 42,469 community-dwelling adults in six low- and middle-income countries. *Diabetes Res Clin Pract*. 2019; 147:102 – 10.
24. Becker C, Schneider C, Aballea S, Bailey C, Bourne R, Jick S, et al. Cataract in patients with diabetes mellitus-incidence rates in the UK and risk factors. *Eye (Lond)*. 2018;32:1028–35.
25. Heydari B, Kazemi T, Zarban A, Ghahramani S. Correlation of cataract with serum lipids, glucose and antioxidant activities: a case-control study. *West Indian Med J*. 2012;61:230–4.
26. Li S, Li D, Zhang Y, Teng J, Shao M, Cao W. Association between serum lipids concentration and patients with age-related cataract in China: a cross-sectional, case-control study. *BMJ Open*. 2018; 8:e021496.
27. Yu X, Lyu D, Dong X, He J, Yao K. Hypertension and risk of cataract: a meta-analysis. *PLoS One*. 2014;9:e114012.
28. de Vries AC, Vermeer MA, Bloemendal H, Cohen LH. Pravastatin and simvastatin differently inhibit cholesterol biosynthesis in human lens. *Invest Ophthalmol Vis Sci*. 1993; 34:377–84.
29. Stoll LL, McCormick ML, Denning GM, Weintraub NL. Antioxidant effects of statins. *Drugs Today (Barc)*. 2004; 40:975 – 90.
30. Hippisley-Cox J, Coupland C. Unintended effects of statins in men and women in England and Wales: population based cohort study using the QResearch database. *Bmj*. 2010;340:c2197.
31. Hermans MP, Ahn SA, Rousseau MF. Statin therapy and cataract in type 2 diabetes. *Diabetes Metab*. 2011; 37:139 – 43.
32. Cheung N, Wong TY. Obesity and eye diseases. *Surv Ophthalmol*. 2007; 52:180 – 95.
33. Tan JS, Wang JJ, Mitchell P. Influence of diabetes and cardiovascular disease on the long-term incidence of cataract: the Blue Mountains eye study. *Ophthalmic Epidemiol*. 2008; 15:317 – 27.
34. Ghaem Maralani H, Tai BC, Wong TY, Tai ES, Li J, Wang JJ, et al. Metabolic syndrome and risk of age-related cataract over time: an analysis of interval-censored data using a random-effects model. *Invest Ophthalmol Vis Sci*. 2013;54:641–6.
35. Stevens VJ, Rouzer CA, Monnier VM, Cerami A. Diabetic cataract formation: potential role of glycosylation of lens crystallins. *Proc Natl Acad Sci U S A*. 1978;75:2918–22.
36. Pollreisz A, Schmidt-Erfurth U. Diabetic cataract-pathogenesis, epidemiology and treatment. *J Ophthalmol*. 2010; 2010:608751.

37. Bunce GE, Kinoshita J, Horwitz J. Nutritional factors in cataract. *Annu Rev Nutr.* 1990; 10:233–54.
38. Sedaghat F, Ghanavati M, Nezhad Hajian P, Hajishirazi S, Ehteshami M, Rashidkhani B. Nutrient patterns and risk of cataract: a case-control study. *Int J Ophthalmol.* 2017;10:586–92.
39. Ahn J, Kim NS, Lee BK, Park S. Carbohydrate Intake Exhibited a Positive Association with the Risk of Metabolic Syndrome in Both Semi-Quantitative Food Frequency Questionnaires and 24-Hour Recall in Women. *J Korean Med Sci.* 2017;32:1474–83.
40. Park S, Ahn J, Lee BK. Very-low-fat diets may be associated with increased risk of metabolic syndrome in the adult population. *Clin Nutr.* 2016;35:1159–67.
41. Park S, Ahn J, Kim NS, Lee BK. High carbohydrate diets are positively associated with the risk of metabolic syndrome irrespective to fatty acid composition in women: the KNHANES 2007–2014. *Int J Food Sci Nutr.* 2017; 68:479–87.
42. Park S, Lee EH. Association between metabolic syndrome and age-related cataract. *Int J Ophthalmol.* 2015; 8:804–11.

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