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Original Article

Adherence to Baltic Sea Diet and Healthy Nordic Food Index and Risk of Age-Related Cataract: A Case-Control Study from Iran

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ABSTRACT

Background and Objectives: Age-related cataract (ARC) is a multifactorial progressive disease that causes blindness globally. Dietary antioxidants such as vitamins and carotenoids have been reported to attenuate oxidative stress as the major cause of ARC. However, associations between adherence to healthy dietary patterns and ARC must be understood. Up to date, adherence to the Nordic diet style assessed by two indices, including the healthy Nordic food index and Baltic Sea dietary score, have been associated with chronic diseases. This study aimed to investigate associations between the healthy Nordic food index and Baltic Sea dietary score and the odds of ARC in a case-control study, in Iran.

Materials and Methods: This hospital-based case-control study was carried out on 98 patients with ARC and 198 healthy controls were selected based on the inclusion criteria. A valid 168-item food frequency questionnaire was used to assess dietary intake over the last year. To investigate associations between the healthy Nordic food index and Baltic Sea dietary score and the risk of ARC, logistic regression tests were used.

Results: Adherence to the Baltic Sea dietary score was associated with lower risks of ARC in crude and adjusted models. After adjustment for potential confounders, participants in the highest quartile of Baltic Sea dietary score (compared to the lowest) had 75% lower age-related cataract risks (OR = 0.25; 95% CI = 0.11–0.56). The current results support previous results on the protective effects of dietary patterns rich in antioxidants on ARC.

Conclusions: Adherence to the Nordic eating style, including fruits and vegetables, whole grains, low-fat milk, fish, and healthy fats, assessed by the Baltic Sea dietary score may decrease risks of age-related ARC.

Keywords: Age-related cataract, Healthy Nordic food index, Antioxidants, Baltic Sea dietary score

Highlights

- Age ralated cataract is the major cause of blindness worldwide.
- Dietary patterns rich in antioxidants are likely to decrease risk of age ralated cataract.
- Healthy Nordic food index (HNFI) or Baltic Sea diet score (BSDS) assessing adherence to traditional and local foods, which are rich in complex carbohydrates, sea foods, vegetables, and healthy source of fats, have been suggested to include health beneficial effects against age ralated cataract.
- Adherence to Nordic eating style, consisting of fruits and vegetables, whole grains, low fat milk, fish, and healthy fats, assessed by Baltic Sea diet score may decrease risks of age-related cataract.

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Introduction

Oxidative stress, defined as an imbalance between antioxidants and free radicals, is widely known to be involved in the etiology of age-related diseases such as age-related cataract (ARC) (1). ARC or senile cataract is a vision acuity impairment, which is reported as the largest cause of blindness worldwide (2). Based on the World Health Organization (WHO) estimation, the number of cataract blinds will increase to 40 million in 2025 with increasing populations and higher life expectancies (3). In Asians, a higher prevalence of ARC has been reported and the onset of ARC in Asians was ten years earlier than that in Europeans (4). A recent study has been reported that nearly two-thirds of the geriatric population in Iran affected by ARC with equal distribution between women and men (5), which was significantly greater than in previous times (6). Although surgery and lens replacement are the most usual treatments for cataract, the results of cataract surgery can vary significantly and result in adverse visual outcomes (7). Of lifestyle-related risk factors for ARC such as hypertension, diabetes, smoking, alcohol, ultraviolet radiation, and overweight (8), dietary patterns have recently been popular (9). Since the high quantity of antioxidants, including ascorbate, vitamin E, retinol, and lutein/zeaxanthin, has been detected in the healthy eye lens (10, 11), a complex network containing endogenous antioxidants (enzymatic and non-enzymatic molecules) and dietary antioxidants may promote the eye defense against oxidative stress and its consequence ARC. In this context, most observational epidemiological studies have shown inverse associations between the diets rich in antioxidants such as plant-based and anti-inflammatory diets and the odds of cataract (12–14).

Since, dietary scores include the advantages of taking into account the complex interactions and cumulative effects of a variety of foods and nutrients within the diets, using these scores may reveal comprehensive health effects of multiple food items. Recently, modern styles of eating such as the Healthy Nordic Food Index (HNFI) or Baltic Sea Diet Score (BSDS) and Mediterranean diet assessing adherence to traditional and local foods that are rich in complex carbohydrates, seafood, vegetables, and healthy sources of fats have been suggested to include health beneficial effects (15–17). The most difference between the Nordic diet pattern and the Mediterranean diet score includes the source of added fats, which is rapeseed oil or canola oil in the Nordic diet instead of olive oil in the Mediterranean diet. The HNFI was created by Olsen et al. (18) and includes only six foods with the health benefits of a traditional Nordic diet, including whole-grain bread, apples and pears, cabbages, fish, barley, and root vegetables. In contrast, BSDS was designed to demonstrate adherence to the healthy Nordic diet based on foods commonly cultivated in the Nordic counties and includes fruits and berries, vegetables, low-fat milk, cereals, meat products, alcohol, and total fat and fat ratio (19). Although no studies have investigated associations between BSDS and HNFI and risks of various types of ARC, significant negative associations between adherence to Nordic dietary patterns and risks of diabetes (20) and abdominal obesity (21) as the potential risk factors of ARC (8, 22) have been seen in recent studies. Based on the high quantity of antioxidant-rich foods in the Nordic diet pattern and the easy availability of these food items in Iran, this study was carried out to clarify whether adherence to HNFI and BSDS might decrease the risk of ARC. The aim of this case-control study was to assess associations between HNFI and BSDS and the risk of ARC in Iranian people over 40 years.

Materials and Methods

Study design and subjects

This hospital-based case-control study was carried out in Farabi Hospital of Tehran, the capital city of Iran, 2014–2015. Briefly, 101 newly diagnosed patients aged above 40 years were selected to participate in this study using convenience sampling methods. ARC defined as the presence of any type of cataract at least in one eye and visual acuity less than 0.6 using slit lamps. Participants in the case and control groups had the ophthalmologists check their eyes for ARC. In general, 202 healthy controls were selected from individuals, who referred to the hospital with causes of non-chronic diseases such as trauma, orthopedic conditions, disk disorders, and acute surgical conditions. Individuals in the case group were patients aged over 40, who were not affected by serious eye diseases in the two eyes except ARC with no more than a month since they were diagnosed with ARC. Inclusion criteria for the control group were the age of 40 years or greater, no history of medical conditions linked to ARC causing any eye problems, and verified visual acuity of more than 0.6 by the ophthalmologists. To eliminate confounding effects, the control group was matched with cases regarding gender and age with 5-y intervals. Furthermore, three cases and four controls with a daily calorie intake of less than 702 kcal or more than 5016 (less or more than the "mean ±3 SD" for $\log_e$ transformed energy) kcal were excluded regarding possibly exhibiting carelessness in completing dietary questionnaires. In general, 97 cases and 198 controls were finally included in the analysis. This study was carried out based on the criteria outlined in the Helsinki Declaration and the National Nutrition and Food Technology Research Institute of Iran approved all procedures involving human subjects (ethic code 051525,12.10.2013). Before participation, all patients submitted a signed consent form. A socioeconomic questionnaire was designed to achieve relative information on age, family history of ARC, hypertension (defined as systolic blood pressure above 160 mm Hg or diastolic blood pressure above 100 mm Hg, or use of antihypertensive medication), heart diseases, hyperlipidemia, diabetes, physical activities, smoking, and alcohol consumption through face-to-face interviews.

Dietary assessment

All participants were asked about their dietary intakes during the last year using face-to-face interviews and validated 168-item food frequency questionnaires (23). The frequency of daily, weekly, monthly, and yearly consumption of each food item was recorded through interviews. Energy intake was assessed using the United States Drug Agency (USDA) food composition table. The Iranian food composition table was used to calculate the nutritional values of traditional Iranian dishes that were not included in the USDA database.

Dietary indices

In this study, BSDS was developed using techniques described by Kanerva et al. (19) and included the following nine components: 1) fruits and berries (berries, apples, and pears); 2) vegetables (tomato, cucumber, cabbage, roots, peas, and lettuce); 3) cereals (rye, oat, and barley); 4) fish; 5) meat (processed and unprocessed meats); 6) milk (low-fat and fat-free milk); 7) ratio of PUFAs to SFAs and trans fatty acids (fat ratio); 8) alcohol (since alcohol was not permitted in Iran, it was excluded from BSDS); and 9) total fat (total fat as a proportion of total energy). Each component of BSDS was categorized into sex-specific quartiles (Q1–Q4), based on the intakes of the participants. Quartiles Q1 to Q4 were respectively assigned 1, 2, 3, and 4 scores, whereas the scores were reversed for unhealthy items (meat and total fat). A higher BSDS score indicated adherence to the Baltic Sea diet, resulting in a score ranging from 4–32 points. According to Olsen et al. (18), HNFI was calculated using six initial foods (1) fish, (2) cabbage, (3) whole grains, (4) oatmeal, (5) apple, pear, and (6) root vegetables. To calculate the index, each food item received a score of 0 or 1 depending on whether it was located inside or outside of the sex-specific median intakes of the participants. Higher HNFI scores indicated higher adherence and adherence ranged from 0–6.

Statistical analysis

Statistical analysis was carried out using SPSS v.26 and significant results were defined as two-sided $p < 0.05$. Independent sample t-test and Chi-square test were used to assess the distribution of study participants between the cases and the controls. Additionally, an independent sample t-test was used to compare dietary intakes of cases and controls. Based on the scores of the control group on BSDS and HNFI, participants were classified into quartiles. Analysis of multivariable logistic regression was used to assess relationships between the BSDS and HNFI scores and ARC. The fully adjusted model included age, gender, total energy intake, body mass index (BMI), education, diabetes, hypertension, family history of cataract, physical activity, and smoking.

Results

In this study, 295 participants collaborated; from which, 198 participants were healthy as controls and 97 participants were recently ARC diagnosed (< 1 month) as cases. Major characteristics of the case and control participants are shown in Table 1. The mean age of the participants was 57.8 y ±9.3 in the case group and 57.4 y ±9.1 in the control group (57.5 y ±9.2 in the two groups). In total, 66.1% of the participants were female (66% in case and 66.2% in control groups). In the control group, 40.9% of the participants had a family history of ARC. This was 54.6% in controls. The mean daily calorie intake was 2790.80 ±568.35 in controls and 2814.78 ±721.04 in cases groups. The control group had higher vitamin A (P value= 0.02), vitamin D (P value= 0.04), and Vitamin C (P value= 0.01) intakes than those cases had. Table 2 shows the distribution of macro and micronutrient intakes within quartiles of BSDS and HNFI. The mean total calorie intakes and dietary intakes of total protein, total carbohydrate, vitamin A, vitamin D, vitamin C, selenium, magnesium, zinc, and calcium significantly increased within the quartiles of HNFI (all $p < 0.01$). Furthermore, no statistically significant differences were observed in dietary intakes of saturated fatty acids (SFA) ($p = 0.63$), total fat ($p = 0.62$), and vitamin E ($p = 0.67$) within the quartiles of HNFI.

No statistically significant variations were observed in the distribution of total carbohydrate intakes and SFA within the quartiles of BSDS with corresponding p values of 0.09 and 0.37, respectively. However, the average dietary intake of total calories, total protein, total fat, vitamin A, vitamin D, vitamin E, vitamin C, selenium, magnesium, zinc, and calcium showed increases within the quartiles of BSDS (all $p < 0.05$). Table 3 provides the mean ±SD daily intake of dietary components based on the quartiles of the BSDS and HNFI. The mean food items of fish, cabbage, root vegetables, whole cereals, and oatmeal increased significantly within all the quartiles of HNFI (all $p < 0.05$). However, no significant differences were seen within the quartiles of BSDS for fat ratio and total fat. In addition, the mean dietary food item intakes of fruits and berries, vegetables, cereals, fish, meat products, and low-fat milk significantly increased within the quartiles of BSDS. However, no significant differences were detected in the mean dietary intake of fat ratio and total fat within the quartiles of BSDS.

Table 1. The case and control characteristics. [a]

Characteristic	Controls (n = 198)	Cases (n = 97)	P Value [b]
Age	57.4 ± 9.1	57.8±9.3	0.68
Age groups			
≤ 55	93 (67.9)	44 (32.1)	
55-65	62 (66.0)	32 (34.0)	0.95
+66	43 (67.2)	21 (32.8)	
BMI [c]	26.25± 4.82	28.02± 4.59	0.01
Gender			
Female	131 (67.2)	64 (32.8)	0.97
Male	67 (67.0)	33 (33.0)	
Smoking			
Never	178 (68.7)	81 (31.3)	
Before	3 (60.0)	2 (40.0)	0.28
Current	17 (54.8)	14 (45.2)	
Physical activity (Yes)	58 (80.6)	14 (19.4)	0.52
Diabetes (Yes)	23 (46.0)	27 (54.0)	0.01
Hypertension (Yes)	81 (60.4)	53 (39.6)	0.02
Family history of cataract (Yes)	81 (60.4)	53 (39.6)	0.02
Total calories (kcal/day)	2790.80±568.35	2814.78±721.04	0.77
Total protein intake (g/day)	92.67±23.06	91.79±29.53	0.79
Total carbohydrate intake (g/day)	371.49±92.50	388.51±118.94	0.21
Total fat intake (g/day)	111.39±38.47	105.88±31.13	0.18
Vitamin A (RAE/day)	822.99±348.51	686.46±359.09	0.02
Vitamin D (ug/day)	2.04±1.46	1.69±1.28	0.04
Vitamin E (mg/day)	21.07±6.82	20.52±5.97	0.47
Vitamin C (mg/day)	196.66±88.83	148.32±79.42	0.01
Selenium (mg/day)	128.96±49.36	138.49±53.13	0.13

a) Data are presented as n (%) or mean ± SD.
b) independent samples t-test for continuous variables and Chi-square test for categorical variables.
c) Body Mass Index

Table 2. Macro and micronutrient intake distributions within the quartiles of Baltic Sea Diet Score and Healthy Nordic Food Index.

Characteristics	Quartiles of Healthy Nordic Food Index				P-value
	Q1 (n=106)	Q2 (n=45)	Q3 (n=120)	Q4 (n=24)	
Total calories (kcal/day)	2622.7± 615.2	2990.5 ± 745.1	2856.3 ± 555.3	2928.3 ± 550.6	<0.01
Total protein intake (g/day)	80.1± 21.7	100.8 ± 28.3	97.4 ± 22.8	105.2 ± 25.9	<0.01
Total carbohydrate intake (g/day)	335.5 ± 99.5	425.4 ± 121.3	388.6 ± 84.9	412.7 ± 89.2	<0.01
Total fat intake (g/day)	112.7±40.9	106.4 ± 30.6	109.1 ± 36.1	103.8 ± 22.2	0.62
SFA e(g/day)	30.8 ± 10.7	30.7 ± 8.8	32.5 ± 12.0	30.9 ± 8.2	0.63
Vitamin A (RAE/day)	586.6 ± 231.0	801.9 ± 411.3	911.9 ± 353.4	911.2 ± 367.5	<0.01
Vitamin D (ug/day)	1.5 ± 1.1	1.9 ± 1.4	2.2 ± 1.5	2.3 ± 1.5	<0.01
Vitamin E (mg/day)	21.3 ± 6.7	21.5 ± 5.8	20.4 ± 6.9	20.4 ± 5.6	0.67
Vitamin C (mg/day)	139.1 ± 59.7	198.2 ± 107.6	206 ± 93.9	205.6 ± 62.8	<0.01
Selenium(mg/day)	118.6 ± 48.3	145.9 ± 61.3	133.9 ± 43.9	156.5 ± 56.8	<0.01
Magnesium (ug/day)	402.2 ± 117.4	504.4 ± 139.4	496.8 ± 108.6	537.5 ± 125.9	<0.01
Zinc (mg/day)	11.1 ± 3.1	14.2 ± 4.1	13.6 ± 2.9	14.9 ± 4.3	<0.01
Calcium (mg/day)	1042.2 ± 321.5	1369.3 ± 460.7	1334.4 ± 335.9	1319.4 ± 304.7	<0.01
Characteristics	**Quartiles of Baltic Sea Diet Score**				**P-value**
	Q1 (n=90)	Q2 (n=73)	Q3 (n=70)	Q4 (n=62)	
Total calories (kcal/day)	2608.9 ± 734.7	2808.0 ± 583.2	2917.1 ± 550.0	2929.5 ± 494.0	<0.01
Total protein intake (g/day)	81.8 ± 25.6	92.3 ± 23.6	98.0 ± 24.5	101.3 ± 22.7	<0.001
Total carbohydrate intake (g/day)	354.4 ± 119.6	386.6 ± 105.2	387.3 ± 89.4	387.1 ± 78.3	0.09
Total fat intake (g/day)	102.1 ± 37.1	106.6 ± 36.3	116.4 ± 35.5	116.2 ± 34.0	0.03
SFA e(g/day)	30.3 ± 11.4	30.9 ± 9.8	33.2 ± 10.8	32.0 ± 10.9	0.37
Vitamin A (RAE/day)	632.6 ± 346.6	816.7 ± 399.9	792.2 ± 244.7	927.8 ± 356.7	<0.01
Vitamin D (ug/day)	1.5 ± 1.2	1.7 ± 1.2	2.2 ± 1.4	2.4 ± 1.6	<0.01
Vitamin E (mg/day)	19.8 ± 6.8	20.5 ± 6.3	20.9 ± 6.9	22.9 ± 5.6	0.03
Vitamin C (mg/day)	153.1 ± 91.1	183.6 ± 68.6	194.8 ± 110.1	201.8 ± 68.7	<0.01
Selenium(mg/day)	120.0 ± 50.7	137.3 ± 56.4	138.3 ± 45.8	136.3 ± 47.0	<0.01
Magnesium (ug/day)	411.4 ± 132.4	473.3 ± 119.3	498.6 ± 122.0	506.1 ± 110.6	<0.01

Zinc (mg/day)	11.3 ± 3.5	12.9 ± 3.4	13.9 ± 3.5	14.2 ± 3.3	<0.01
Calcium (mg/day)	1120.8 ± 395.1	1197.3 ± 361.3	1298.1 ± 348.8	1366.9 ± 351.6	<0.01

Table 3. Daily intakes of dietary components based on the quartiles of the Baltic Sea Diet Score and Healthy Nordic Food Index.

Food items	Quartiles of Healthy Nordic Food Index				P-value
	Q1	Q2	Q3	Q4	
Fish (g/day)	9.4 ± 19.3	11.7 ± 15.3	15.1 ± 17.5	19.0 ± 18.9	0.03
Cabbages (g/day)	5.6 ± 9.1	11.1 ± 14.2	15.9 ± 18.1	19.4 ± 15.8	<0.001
Fruits (g/day)	30.8 ± 29.4	64.3 ± 47.9	81.7 ± 52.6	102.4 ± 26.7	<0.001
Root vegetables (g/day)	47.0 ± 25.5	61.6 ± 25.0	83.9 ± 44.5	114.0 ± 51.6	<0.001
Whole grain (g/day)	19.5 ± 31.4	50.11 ± 50.7	75.8 ± 61.4	121.3 ± 68.6	<0.001
Oatmeal (g/day)	4.8 ± 8.1	5.4 ± 11.0	9.4 ± 11.8	16.0 ± 11.7	<0.001
Food items	**Quartiles of Baltic Sea Diet Score**				
	Q1	Q2	Q3	Q4	
Fruits and berries (g/day)	43.9 ± 37.8	64.9 ± 49.7	85.5 ± 61.8	106.7 ± 48.4	<0.001
Vegetables (g/day)	317.3 ± 129.5	427.2 ± 126.9	452.6 ± 163.0	503.0 ± 138.6	<0.001
Cereal (g/day)	4.9 ± 9.1	7.1 ± 11.5	9.7 ± 12.6	10.2 ± 9.8	<0.01
Fish (g/day)	32.4 ± 70.9	64.5 ± 92.4	89.9 ± 118.1	154.8 ± 147.2	<0.001
Meat products (g/day)	4.5 ± 6.6	11.0 ± 18.0	16.6 ± 20.7	23.0 ± 20.7	<0.001
Low-fat milk (g/day)	18.6 ± 13.8	26.1 ± 21.5	36.9 ± 34.2	34.0 ± 16.7	<0.001
Fat ratio	0.35 ± 0.08	0.34 ± 0.09	0.35 ± 0.08	0.35 ± 0.07	0.69
Total fat (% of energy)	0.80 ± 0.27	0.79. ±0.24	0.81 ± 0.23	0.88 ± 0.32	0.21

The odds ratio for ARC in the highest quartile of the BSDS was significant, compared to the lowest quartile in crude, age-gender-adjusted and fully-adjusted models (OR = 0.27, 95%CI = 0.13–0.58), (OR = 0.27, 95%CI = 0.13–0.57) and (OR = 0.25, 95%CI = 0.11–0.56), respectively (Table 4). In HNFI, compared to the lowest category of HNFI, the highest category showed no significant associations with the odds of cataract in crude (OR = 0.37, 95%CI: 0.13–1.06) or age and gender-adjusted (OR = 0.36, 95%CI: 0.12–1.00) or fully-adjusted models (OR = 0.3, 95%CI: 0.12–1.23).

Sub-group analysis of the associations between the BSDS and HNFI with ARC is provided in Table 5. The subgroup analysis showed that the odds ratio for ARC in the highest quartile of BSDS was still significant in older participants (older than 55 years old), women, and individuals with hypertension, compared to the lowest quartile. Moreover, the odds ratio of ARC was significantly lower in men in the highest quartile of the HNFI, compared to the lowest quartile.

Table 4. Odds ratios (ORs) and 95% confidence intervals (CIs) for the age-related cataract based on quartiles of the Baltic Sea Diet Score and Healthy Nordic Food Index.

	Quartiles of Baltic Sea Diet Score				
	Q1	Q2	Q3	Q4	P-value for trend
Control/Case (Median score)	46/44 (15.5)	53/20 (19)	50/20 (21)	49/13 (23.5)	
Crude	Ref	0.39 (0.20-0.76)	0.41 (0.21-0.81)	0.27 (0.13-0.58)	<0.001
Model 1[a]	Ref	0.38 (0.20-0.75)	0.41 (0.21-0.80)	0.27 (0.13-0.57)	<0.001
Model 2[b]	Ref	0.42 (0.19-0.89)	0.42 (0.20-0.90)	0.25 (0.11-0.56)	<0.001
	Quartiles of Healthy Nordic Food Index				
	Q1	Q2	Q3	Q4	P-value for trend
Control/Case (Median score)	62/42 (8)	24/21 (9)	69/51 (10)	19/5 (12)	
Crude	Ref	1.23 (0.61-2.48)	0.40 (0.23-0.72)	0.37 (0.13-1.06)	0.01
Model 1[a]	Ref	1.24 (0.61-2.50)	0.40 (0.22-0.72)	0.36 (0.12-1.00)	0.01
Model 2[b]	Ref	1.57 (0.71-3.48)	0.49 (0.25-0.94)	0.39 (0.12-1.23)	<0.01

a) Adjusted for age and gender.
b) Adjusted for age, gender, total calorie intake, body mass index, education, diabetes, hypertension, family history of age-raleted cataract, physical activity, and smoking.

Table 5. Odds ratios (ORs) and 95% confidence intervals (CIs) for the age-related cataract based on quartiles of Baltic Sea Diet Score and Healthy Nordic Food Index between the subgroups

	Quartiles of Baltic Sea Diet Score				
	Q1	Q2	Q3	Q4	P-value for trend
Sex[1]					
Men	Ref	1.80 (0.44-7.44)	0.42 (0.09-2.06)	0.21 (0.03-1.56)	0.04
Women	Ref	0.19 (0.07-0.53)	0.45 (0.18-1.12)	0.29 (0.18-0.72)	0.01
Age[2]					
<55	Ref	0.35 (0.10-1.13)	0.54 (0.16-1.81)	0.29 (0.07-1.07)	0.08
≥55	Ref	0.67 (0.22-1.98)	0.51 (0.17-1.49)	0.32 (0.10-0.99)	0.04
Diabetes[3]					
Yes	Ref	1.19 (0.05-29.93)	0.20 (0.01-2.35)	0.05 (0.01-0.79)	0.02
No	Ref	0.43 (0.19-0.96)	0.48 (0.21-1.10)	0.36 (0.15-0.88)	0.02
Hypertension[4]					
Yes	Ref	0.46 (0.16-1.34)	0.30 (0.09-0.98)	0.11 (0.02-0.45)	0.01
No	Ref	0.29 (0.08-1.07)	0.49 (0.18-1.38)	0.40 (0.14-1.23)	0.08
Family history of cataract[5]					
Yes	Ref	0.39 (0.14-1.13)	0.40 (0.13-1.22)	0.26 (0.09-0.80)	0.02
No	Ref	0.39 (0.12-1.28)	0.42 (0.14-1.27)	0.22 (0.06-0.77)	0.02
Body mass index Status[6]					
Normal	Ref	0.89 (0.23-3.38)	0.23 (0.05-1.10)	0.23 (0.05-1.10)	0.02
Overweight	Ref	0.19 (0.04-0.92)	0.39 (0.10-1.55)	0.31 (0.07-1.44)	0.11
Obese	Ref	0.39 (0.08-1.93)	1.16 (0.22-5.99)	0.50 (0.09-2.77)	0.73
	Quartiles of Healthy Nordic Food Index				
	Q1	Q2	Q3	Q4	P-value for trend
Sex[1]					
Men	Ref	1.74 (0.33-9.12)	0.46 (0.11-1.85)	0.13 (0.01-0.98)	0.02
Women	Ref	1.86 (0.26-1.25)	0.58 (0.26-1.25)	0.62 (0.14-2.80)	0.13
Age[2]					
<55	Ref	1.01 (0.27-3.74)	0.22 (0.08-0.64)	0.20 (0.01-2.44)	<0.01
≥55	Ref	2.26 (0.73-7.02)	1.11 (0.43-2.91)	0.68 (0.15-3.06)	0.64
Diabetes[3]					
Yes	Ref	2.30 (0.10-52.87)	0.27 (0.01-5.89)	0.02 (0.01-1.30)	0.04
No	Ref	1.59 (0.67-3.75)	0.52 (0.25-1.05)	0.53 (0.14-1.89)	0.04
Hypertension[4]					
Yes	Ref	2.25 (0.65-7.75)	0.79 (0.28-2.17)	0.37 (0.07-1.87)	0.17
No	Ref	1.27 (0.42-3.84)	0.38 (0.15-0.95)	0.36 (0.06-2.05)	0.03
Family history of cataract[5]					
Yes	Ref	1.11 (0.34-3.67)	0.56 (0.24-1.33)	0.64 (0.09-4.34)	0.19
No	Ref	2.43 (0.77-7.67)	0.41 (0.13-1.21)	0.25 (0.05-1.20)	0.01
Body mass index Status[6]					
Normal	Ref	0.84 (0.20-3.45)	0.41 (0.13-1.30)	-	0.01
Overweight	Ref	0.85 (0.13-5.39)	0.27 (0.07-0.96)	0.77 (0.11-5.14)	0.15
Obese	Ref	3.56 (0.69-18.24)	1.21 (0.25-5.90)	0.50 (0.03-7.81)	0.72

[1]Adjusted for age, total calorie intake, body mass index, education, diabetes, hypertension, family history of age-related cataract, physical activity, and smoking.
[2]Adjusted for gender, total calorie intake, body mass index, education, diabetes, hypertension, family history of age-related cataract, physical activity, and smoking.
[3]Adjusted for age, gender, total calorie intake, body mass index, education, hypertension, family history of age-related cataract, physical activity, and smoking.
[4]Adjusted for age, gender, total calorie intake, body mass index, education, diabetes, family history of age-related cataract, physical activity, and smoking.
[5]Adjusted for age, gender, total calorie intake, body mass index, education, diabetes, hypertension, physical activity, and smoking.
[6]Adjusted for age, gender, total calorie intake, education, diabetes, hypertension, family history of age-related cataract, physical activity, and smoking.

Discussion

Findings from the current study showed that greater adherence to BSDS was negatively associated with the odds of ARC in crude or adjusted models, while HNFI was not significantly associated with the odds of ARC. The subgroup analysis showed that the inverse association between the BSDS and ARC was still significant in older participants (older than 55 years old), women, and individuals with hypertension. However, no significant differences were reported in other subgroups. Furthermore, a significant association was recorded between adherence to HNFI and risks of ARC in men. Of the BSDS components, daily intakes of fruits and berries, vegetables, fish, cereals, meat products, and low-fat milk significantly varied within the BSDS quartiles. This study represented the first assessment of relationships between the adherence to BSDS and HNFI and the odds of ARC. Although higher adherence to BSDS and HNFI have been reported to modify the risk of non-communicable inflammatory-related diseases, including diabetes (24, 25), cancers (16, 26), and cardiovascular diseases (CVDs) (27, 28), unequivocal epidemiological evidence on relationships between BSDS and HNFI or their components and odds of ARC is elusive. Previously observational studies have shown that receiving higher BSDS scores is associated with further life satisfaction in older adults (29), lesser circulating inflammatory markers such as hs-CRP (30) and abdominal obesity (31), while higher compliances with a modified Nordic diet have been suggested to improve low-grade inflammation (32), weight management (33) and hypo-metabolic state in overweight and obese women (34).

As far as the authors know, this is the first study to assess associations between HNFI and BSDS and the risk of ARC. Components of HNFI such as fruits and vegetables, whole grains, and fish are rich in vitamins with antioxidant characteristics, polyphenols, dietary fibers, and healthy fatty acids that can attenuate age-induced oxidative stresses (35). The current findings are similar to those of a cohort study by Chiu et al.; in which, a vegetarian diet characterized by high intakes of soy products, vegetables, nuts, whole grains, dietary fibers, vitamin C, folate, and vitamin A equivalents protected 20% against cataract, especially in overweight participants (36). Furthermore, a 10-year cohort study has revealed an inverse association between dietary vitamin C consumption and ARC formation (37). In a meta-analysis of 12 cohort studies, Jiang et al. declared that with every increase in daily vitamin C and vitamin A consumption by 500 and 5 mg, the risk of ARC decreased by 18 and 6%, respectively (38). In another study, lower intakes of vitamin A and vitamin C than the estimated average requirement intakes, based on the dietary reference intakes for Koreans, increased the odds of ARC (1.89 and 2.06, respectively) in crude (not adjusted) models (39). Theodoropoulou and colleagues detected negative associations between the intakes of fish, vegetables, fruits, potatoes, carotene, vitamin C, and vitamin E unlike meat, total fat and cholesterol, and risk of ARC (40). As a result, lower adherence to BSDS and HNFI in the ARC group is likely associated with lower daily intake of vitamin D, vitamin C, vitamin A, zinc, and calcium. Another cohort study reported that high meat eaters (≥ 100 g meat and meat products per day), low meat eaters (<50 g meat per day), fish eaters (not meat), vegetarians, and vegans had approximately 15, 20, 30 and 40% lower risks of cataract, respectively (14). Townend et al. reported that the 5-y incidence of nuclear cataract was 40% lower in the highest quintile of dietary omega-3 intake, compared to those in the lowest quintile (41). In a case-control study, Amini et al. showed that dairy products and vegetable dietary patterns protected against ARC (42). However, Camacho et al. reported no significant associations between the total dairy products, whole and skimmed milk intakes, and ARC risks (43). In the present study, the median consumption of milk and whole grains was not significantly different between the ARC group and normal controls. Tan et al. reported no associations between the regular intakes of whole grains and the 5-y incidence of any type of cataract (44). However, decreasing dietary glycemic and insulin load through replacing carbohydrates with a high glycemic index by whole grains, fruits and vegetables might decrease the ARC incidence (45). Accumulation of free radicals in eye lens have been implicated in development of ARC through disturbing normal function and structural integrity of the site. Plant-based foods rich in bioactive phytochemicals and anti-oxidative vitamins scavenge UV exposure-induced excessive free radicals, therefore these functional foods lessen the oxidative damage and morphological changes of eye lens (13, 38, 39, 46). Moreover, high contents of omega-3 in fish may attenuate inflammatory responses by modulating prostaglandin metabolism (47). The current study revealed that in participants with hypertension and those older than 55 years as well as women, associations between the adherence to BSDS and ARC were stronger, verifying adverse roles of hypertension, age and gender in etiology of ARC.

In this novel study, incident cases (< 1-month diagnosis) of ARC were used and validated FFQ by trained interviewers for the cases, and controls in similar conditions were used to decrease information bias. Using a convenience sampling method and lack of sub-analysis based on the type of cataract, limitations about the celerity of data were reported. There are challenges to the generalizability of the present data, especially on items such as whole grains and oatmeal based on various regional food tables. Due to the small number of observational studies that assessed the risk of ARC linked to diet-based micronutrients, the possibility of data interpretation was limited.

Conclusion: This study has supported the anti-cataractogenesis roles of adherence to BSDS against ARC. From the BSDS components, daily intakes of fruits and berries, vegetables, fish, cereals, meat products, and low-fat milk significantly varied between the BSDS quartiles, which suggested that anti-cataractogenesis of BSDS in this study might be attributed to these components in Nordic-style patterns. Future studies with wide populations are needed to extend the present understanding of the preventive effects of the Nordic-diet eating style and its components on risks of ARC.

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