A DASH dietary pattern and the risk of colorectal cancer in Canadian adults

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Abstract

Introduction: Colorectal cancer (CRC) is a high incidence cancer affecting many Canadian adults each year. Diet is important in the etiology of CRC with many dietary components identified as potential risk factors. The Dietary Approaches to Stop Hypertension (DASH) diet is a well-established pattern to characterize overall eating. The purpose of this study was to characterize a DASH pattern within the Canadian context and to assess its relationship to the risk of CRC in Canadian adults.

Methods: Unconditional multiple logistic regression with control for confounding variables was performed using data from the National Enhanced Cancer Surveillance Study. Dietary intake was captured for this case-control study through a food frequency questionnaire (FFQ) and categorized into a DASH score ranging from 0 to 10 representing a poor to a strong DASH pattern respectively.

Results: Consuming a strong DASH pattern of eating (score $\geq$ 8) was not common in the 3161 cases and 3097 controls. Overall, only 10.8 % of men and 13.6 % of women had a strong DASH pattern. Multivariate analysis demonstrated a trend for decreasing risk of CRC in men with increasing DASH scores (p value for trend = .007). Men with a strong DASH score had a 33% reduction in risk of CRC compared to those with a low DASH score. There were no significant trends for women for CRC or for colon or rectal cancers separately.

Conclusion: Our findings are similar to other researchers suggesting a benefit with a strong DASH pattern associated with a decreased risk of CRC, especially in men. Research should further investigate our gender-based differences.

Keywords: *diet, colorectal neoplasms, primary prevention*

Introduction

Colorectal cancer (CRC) is the second leading cause of cancer deaths in Canada, with 5000 males and 4200 females forecast to die from the disease in 2013.[1] Risk factors for CRC include family history, certain genetic syndromes (e.g. familial adenomatous polyposis), medical conditions (e.g. inflammatory diseases), medications, as well as lifestyle behaviours associated with excess body weight (e.g. low physical activity level) and diet.[2] Modifiable dietary factors are believed to be crucial in the etiology of CRC.[3]

The relationships between diet and complex chronic diseases such as CRC can be examined by investigating dietary patterns. Chronic diseases are likely mediated by the culmination of multiple dietary components interacting synergistically or antagonistically over time. Examining dietary patterns by capturing combinations of specific foods or dietary components and expressing these as a summary exposure measure may accurately and comprehensively describe dietary exposure. Common dietary patterns include the Western, the Prudent and the Mediterranean dietary patterns, but the list continues to grow.[4]

One established dietary pattern is the Dietary Approaches to Stop Hypertension (DASH) diet, which is rich in fruit, vegetables, whole grains, low-fat dairy products and legumes/seeds but low in saturated fat, sodium and added sugars.[5] Initially designed and evaluated for reducing blood pressure,[6] the DASH diet has now been studied in relation to outcomes such as cardiovascular disease, kidney function, metabolic syndrome and gestational diabetes.[7-9]

Few studies have looked at the DASH diet in relation to risk of CRC despite that many of the foods or nutrients the DASH diet recommends are associated with a lessened risk of CRC.[10] Studies by Dixon et al.[11] and Fung et al.,[12] as well as one on eating frequency using the DASH diet[13] used different methodologies to characterize a DASH pattern. Recognizing possible differences across countries with respect to food choices, we set out to establish a DASH pattern within the Canadian context and to determine if adherence to this pattern is associated with a decreased risk of CRC. We hypothesized that with increasing DASH pattern scores, the risk of CRC in Canadian adults would decrease.

Despite the availability of other dietary patterns or indices, we chose to focus on the DASH pattern because many Canadians may already be following this diet to prevent

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or treat hypertension. In Canada, the prevalence of hypertension is high; in 2010, 17.1% of all Canadians aged 12 years or older were diagnosed with high blood pressure, with those aged 65 years or older having a significantly higher prevalence (i.e. 40%).[14]

Methods

Between 1994 and 1997, the National Enhanced Cancer Surveillance Study (NECSS) collected data from a population-based sample that included people with 19 types of cancer. Cases as well as controls lived in the Canadian provinces of British Columbia, Alberta, Saskatchewan, Manitoba, Prince Edward Island, Nova Scotia and Newfoundland and Labrador. Ontario provided controls but no cases and, as a result, was excluded from our current analyses.

Details of the NECSS and diet-based analyses are available elsewhere.[15-17]

Cases

Participating provincial cancer registries ascertained 5112 (2227 women and 2885 men) histologically confirmed incident cases of CRC aged 20 to 76 years. Of these, 325 people (6.4 %; 111 women and 214 men) had died by the time of physician contact, and 341 (6.7%; 177 women and 164 men) were not contacted because the attending physician refused consent (generally because the patient was too ill). Of 4446 questionnaires sent by provincial cancer registries, 3174 were completed, a response rate of 62.1% of cases ascertained or 71.4% of patients contacted. Cases were confirmed using definitions from the current International Classification of Diseases for Oncology (ICD-O-2)[18] and resulted in 1 male and 2 female cases being excluded due to missing ICD-O codes. Our study analysed the resulting sample of 1816 male and 1355 female cases.

Controls

We selected people without cancer from a random sample within each participating province, with an age/sex distribution similar to that of all cancer cases in the NECSS. The selection of controls made sure that at least one sex-specific control was chosen for each case within a 5-year age group and for each type of cancer. The sampling strategy for population-based controls was determined for each province based on research experience with specific databases, access to data and data quality as well as database confidentiality conditions. As such, the sampling strategy for selecting controls varied by province. Data from provincial health insurance plans were used in British Columbia, Saskatchewan, Manitoba, Prince Edward Island and Nova Scotia. The Ontario Ministry of Finance Property Assessment Database provided Ontario's controls. Random digit dialling provided controls for Alberta and Newfoundland and Labrador. Controls were also collected over the whole calendar year to ensure an even distribution of responses that may be influenced by seasonality (e.g. on questions of diet and physical activity). A nominal financial incentive was tried in Ontario to improve response rates.

Of 5119 questionnaires sent to potential controls, 81 were returned because they were incorrectly addressed; of the remainder, 3097 (1635 men and 1462 women) were completed, yielding a response rate of 61.5% of controls contacted.[19-20]

Data collection

The provincial cancer registries identified most cases within 1 to 3 months of diagnosis through pathology reports. After obtaining physician consent, the registries mailed questionnaires to potential participants (cases and controls). If a completed questionnaire was not returned, a reminder postcard was sent out after 14 days, and a second copy of the questionnaire at 4 weeks. After 6 weeks, recipients who had not yet completed the questionnaire were reminded to do so by telephone. Information was collected from controls using the same protocol as for cases.

Information was collected on socio-economic status, self-reported height and weight, smoking history, alcohol consumption, physical activity, menstrual and reproductive history and diet.

For self-reported weight, participants were asked to recall their weight 2 years before the study to calculate body mass index (BMI, in kg/m^2).[21]

We defined ''ever smokers'' as those who had smoked at least 100 cigarettes in their entire life and ''current smokers'' as those who were still smoking during the year before the interview.

Information on recreational physical activity was obtained by asking about the time spent doing both moderate and strenuous activities 2 years prior to the study.

We derived dietary information from a semi-quantitative food frequency questionnaire (FFQ) based on 2 validated instruments: the short Block questionnaire[22] and the Willett questionnaire.[23] The FFQ was used to determine usual dietary intake 2 years before participants' enrollment in the study. The FFQ included 69 specific foods/beverages that were categorized into 8 food groups: (a) breads and cereals; (b) meat, poultry, fish, eggs and cheese; (c) vegetables; (d) fruit; (e) sweets; (f) miscellaneous foods such as peanut butter and nuts; (g) beverages made with water such as coffee, tea and juices/drinks; (h) other beverages such as soft drinks, milk and alcohol. For each food item, participants were asked to describe how often (per day, per week, per month) they consumed, on average, the specified serving size. We used a nutrient database based on the Canadian Nutrient File to estimate nutrient and total energy intake according to the nutrient profile of foods at that time.[24]

We derived a 10-point score to describe participants' DASH pattern intake (see Table 1), rather than use a 9-point scoring system as reported in some studies.[11,25] We based our scoring system on the foods or food groups in the DASH Eating Plan from the Dietary Guidelines for Americans[26] and from a related publication[11] to capture intake of whole grains, vegetables, fruit, low-fat dairy, red and processed meats, sweets, alcohol, saturated fat, and nuts, legumes and seeds. We modified our scale by including a tenth item, sodium intake, as other researchers have done.[12]

We controlled for total energy intake by establishing quartiles based on the energy distribution in controls. For each of the

TABLE 1
DASH-Pattern scoring scheme

Dietary component	Examples of FFQ items (or nutrient calculation)	Excluding
POSITIVE	1 point for intakes ≥ median; 0 points for intakes < median	
Whole grains	Bran, granola cereals, shredded wheat, cooked cereals, dark and whole grain bread	White bread, rice, macaroni
Vegetables	Tomatoes, carrots, broccoli, cabbage, cauliflower, Brussels sprouts, spinach or other greens, winter squash, sweet potatoes, any other vegetable including green beans, corn, peas	French fries, soups with vegetables or tomato, vegetable juice
Fruit	Apples, pears, oranges, bananas, cantaloupe, other fruit, fresh or canned, orange or grapefruit juice	Items with added sugar such as drinks from frozen concentrate, crystals
Low-fat dairy products	2% milk, 1% milk, skim milk	Whole milk, regular cheese, ice cream
Nuts/seeds/legumes	Nuts, tofu, soybeans, baked beans or lentils	High fat peanut butter
NEGATIVE	1 point for intakes ≤ median; 0 points for intakes > median	
Meat (red, processed)	Beef, pork, lamb as a main or mixed dish, hamburger, sausage, hotdog, smoked or corned beef, luncheon meats, liver	Fish, poultry, eggs
SFAs	Total dietary SFA intake from all foods in the FFQ, as defined by: % = Saturated Fat (g) x 9 (kcal) / Total energy of the diet (kcal)	
Sodium	Total dietary sodium intake from all foods of FFQ	
Alcohol	Beer, wine, liquor	
Sweets	Cake, cookies, doughnuts, pastry, pies, ice cream, chocolate, soft drinks, drinks from powdered drink crystals, etc.	

Abbreviations: DASH, Dietary Approaches to Stop Hypertension; FFQ, Food Frequency Questionnaire; SFA, saturated fat.

quartiles, we calculated specific median intakes for all 10 dietary components using the intake of controls, stratified by sex. Our energy quartiles were 1458 kcal/day or less, 1459 to 1843 kcal/day, 1844 to 2284 kcal/day and 2285 kcal/day or more. Study participants received a point for intakes at or above the energy sex-specific median for the following ''positive'' dietary components: whole grains, vegetables, fruit, low-fat dairy and legumes/nuts/seeds. Intakes below the median for these components were scored a zero. Alternatively, a point was given to each intake at or below the median for ''negative'' dietary components: red and processed meat; saturated fat; alcohol; and sweets. For these, a zero was assigned to intakes above the median.

We assigned foods from the FFQ into the appropriate food groups and calculated the number of servings of each food based on existing DASH pattern methodology.[5,11,26] When information was lacking, we supplemented this approach by examining common nutrients across foods within a food group to ensure nutrient equivalency. This was especially important for groups that contained heterogeneous food items such as the sweets group. Because the Canadian Nutrient File[24] is limited in reporting the sugar content of foods, we assessed foods in the sweets group according to calories. As such, one cookie was equivalent to 1 serving (54 kcal) and one glass of soft drink to 2 servings (98 kcal). For saturated fat and sodium intakes, we did not rely on consumption of specific FFQ items as with the other food groups; rather, we scored people based on their total intakes of these nutrients across all foods captured in relation to the median total intakes across the energy quartiles.

The DASH score could range from 0 to 10. In this study, DASH scores represent a DASH-like pattern as they are based on estimates over or under the sex- and energy-specific medians. As such, a DASH score of 8 or higher is a strong DASH pattern of eating while a score of 2 or less is a poor DASH pattern.

Statistical analysis

We used unconditional logistic regression, stratified by sex, to estimate odds ratios (OR) and the corresponding 95% confidence intervals (CI), including terms for age groups (20–49, 50–59, 60–69, ≥ 70 years), province, education (≤ 8, 9–13, ≥ 14 years), BMI (< 25.0, 25.0–29.9, ≥ 30.0 kg/m^2), pack-years of smoking, income, moderate and strenuous leisure-time physical activity, calcium supplementation and age at first pregnancy. Confounding variables, except for age group, province, BMI and sex, were treated as continuous variables in the models. Tests for trend were assessed for each study variable by substituting the variable in the model in continuous form.

All analyses were carried out using statistical package SAS version 9.01 (SAS Institute Inc., Cary, NC, US).[27]

Results

Study participants included 3171 cases and 3097 controls, with 23% more men (n = 3451) than women (n = 2817). The majority of participants had a high school education or higher, had middle- to high-level family incomes and were ever and current smokers. Cases tended to be older and have a higher BMI, and women with CRC tended have been over the age of 20 years when they had a child. Of those reporting family income, there was no statistical difference between cases and controls (Table 2).

TABLE 2
Distribution of colorectal cancer cases (n = 3171) and population-based controls (n = 3097) based on selected covariates, NECSS, Canada, 1994–1997

	Cases		Controls		*p* value for Chi-Square
	n	%	n	%	
Sex					
Men	1816	57.2	1635	52.8	
Women	1355	42.8	1462	47.2	
Age, years					
20–49	378	11.9	838	27.1	< .0001
50–59	645	20.4	605	19.5	
60–69	1342	42.3	1043	33.7	
≥ 70	806	25.4	611	19.7	
Education, years					
≤ 8	577	18.2	471	15.2	< .0001
9–13	1818	57.3	1689	54.5	
≥ 14	711	22.4	900	29.1	
Missing values	65	2.1	37	1.2	
Family income[a]					
Low	584	18.4	584	18.9	0.32
Lower-middle	570	18.0	585	18.9	
Upper-middle	758	23.9	779	25.2	
High	474	14.9	440	14.2	
Missing values	785	24.8	709	22.9	
Pack-year smoking					
Never smokers	995	31.4	1123	36.5	< .0001
≤ 10	626	19.7	705	23.0	
11–20	525	16.6	470	15.3	
21–30	377	11.9	302	9.8	
> 30	592	18.7	447	14.5	
Missing values	56	1.8	50	1.6	
BMI, kg/m^2					
< 25.0	1175	37.1	1461	47.2	< .0001
25.0–29.9	1345	42.4	1176	38.0	
≥ 30.0	637	20.1	447	14.4	
Missing values	14	0.2	13	0.4	
Moderate physical activity, hour/month					
≤ 4.22	598	18.9	638	20.6	< .0019
4.23–11.57	645	20.3	702	22.7	
11.58–24.44	720	22.7	725	23.4	
≥ 24.45	730	23.0	636	20.5	
Missing values	478	15.1	396	12.8	

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Median intakes of foods or nutrients tended to increase with increasing energy intake. The exception was alcohol, which appeared relatively stable for women across the energy quartiles (Table 3). Saturated fat intake was similar for men and women at between 1.5% and 1.7% of total energy intake, across all energy quartiles.

Consuming foods largely to a DASH pattern (i.e. a score of ≥ 8) was not common in study participants (Table 4). Overall, only 10.8 % of all men (374/3451) and 13.6 % of all women (382/2817) scored 8 or higher (Table 4). Similarly, only a small percentage of participants had a low DASH score (≤ 2) representing a poor DASH pattern of eating; 10.1% of men (349/3451) and 10.2% of women (286/2817) scored 2 or less. Approximately 50% of study participants had DASH scores in the mid-range of 4 to 6.

Our analyses showed a significant trend towards decreased risk of CRC with increasing DASH scores (p value for trend = .007) in men. After adjusting for confounders, men who scored ≥ 8 on the DASH scale had a 33% reduced risk of CRC compared to men with lower DASH scores. Men showed a decreasing trend for risk of rectal cancer (p = .003), but not colon cancer (p = .09), with increasing DASH scores, although a similar pattern was evident. For women, trends with increasing DASH scores for either colon or rectal cancers or both cancers combined were not significant.

We stratified analyses according to BMI (Table 5) and found no interaction between DASH scores and risk of CRC. The trend for rectal cancer (p = .01) was significant and the trend for CRC (p = .05) was borderline significant in men who were not overweight/obese (BMI < 25.0 kg/m^2). Men had a 50% and 36% risk reduction for rectal cancer and CRC respectively with a strong DASH pattern. In men who were overweight/obese (BMI ≥ 25.0 kg/m^2), CRC was reduced by 35% in those with a strong DASH pattern though this was borderline significant (p = .05). Although not statistically significant (p = .07), there seemed to be a decreasing risk of rectal cancer in overweight/obese men with increasing DASH scores.

Trends for increasing DASH scores and risk of any cancers for women in either weight status group were not statistically significant.

We also assessed parity in women, for potential confounding, but found no sta-

TABLE 2 (continued)
Distribution of colorectal cancer cases (n = 3171) and population-based controls (n = 3097) based on selected covariates, NECSS, Canada, 1994–1997

	Cases		Controls		*p* value for Chi-Square
	n	%	n	%	
Strenuous physical activity, hour/month					
Never	1324	41.8	1146	37.0	< .0006
≤ 0.19	174	5.5	162	5.2	
0.20–3.68	565	17.8	644	20.8	
≥ 3.69	597	18.8	647	20.9	
Missing values	511	16.1	498	16.1	
Calcium supplementation					
Never	1944	61.3	1849	59.7	< .0001
Not regularly	603	19.0	649	20.9	
Regularly	369	11.6	430	13.9	
Missing values	255	8.0	169	5.5	
Age at first pregnancy, years					
≤ 20	270	19.9	358	24.5	< .01
21–23	343	25.3	343	23.5	
24–26	238	17.6	239	16.4	
> 26	302	22.3	283	19.4	
Missing values	202	14.9	239	16.4	

Abbreviations: BMI, body mass index; NECSS, National Enhanced Cancer Surveillance Study.

[a] Family income was indicated as a categorical variable with the following values: low:< $20 000 with ≤ 3 people or $30 000 with ≥ 4 people; lower-middle: $20 000–$30 000 with ≤ 3 people or $30 000–$50 000 with ≥ 4 people; upper-middle: < $50 000 with ≤ 3 people or $50 000–$100 000 with ≥ 4 people; high: ≥ 50 000 for ≤ 3 people or ≥ 100 000 for ≥ 4 people.

tistical difference between cases and controls (data not shown).

Discussion

This is the first published Canadian study to investigate the DASH pattern in relation to risk of CRC.

Our results parallel other studies that showed an inverse relationship between a strong DASH pattern and risk of CRC with some variability across sex.[11-13,28] Fung et al.[12] reported a protective association for proximal colon cancer in women, but not men, who followed a DASH or Mediterranean type of diet. In our study, adherence to a DASH dietary pattern was protective for men but not for women. Our findings agree with those of Dixon et al.[11] who demonstrated a significant trend for increased DASH scores with lower risk of distal CRC adenomas in men regardless of other factors such as body weight or smoking status. Other studies have also shown inverse relationships between strong DASH patterns or other healthy diet indices in men, but not women,[13,29] with some researchers explaining these differences as being due to the differences in the etiology of CRC between men and women.[29]

Some researchers strongly suggest that men and women respond differently to dietary

TABLE 3
Median intakes of foods or nutrients by sex and energy levels, NECSS, Canada, 1994–1997

Food Components[a] (servings/day)	Energy Level (Kcal/day)							
	≤ 1458		1459–1843		1844–2284		≥ 2285	
	Men	Women	Men	Women	Men	Women	Men	Women
Whole grains	0.71	0.79	1.29	1.64	1.99	2.14	2.13	2.43
Vegetables	0.86	1.20	1.28	1.71	1.42	1.85	1.78	2.21
Fruit	0.23	1.23	1.42	1.88	1.67	2.12	2.15	2.76
Low-fat dairy products	0.14	0.17	0.79	0.79	1.00	1.00	1.00	1.00
Nuts/seeds/legumes	0.07	0.07	0.10	0.07	0.10	0.10	0.11	0.14
Meat	0.79	0.70	1.11	1.05	1.43	1.24	1.93	1.71
Sweets	1.35	1.10	2.26	2.18	3.14	2.66	4.57	4.60
Sodium (mg/day)	1408.54	1451.54	2043.39	2025.40	2458.56	2491.16	3388.26	3198.28
Saturated fats (% of total energy)	0.016	0.015	0.016	0.015	0.017	0.016	0.016	0.016
Alcohol	0.13	0.00	0.35	0.07	0.50	0.07	0.56	0.07

Abbreviations: CI, confidence interval; DASH, Dietary Approaches to Stop Hypertension; OR, odds ratio; NECSS, National Enhanced Cancer Surveillance Study.

[a] The food components are the same as in Table 1.

TABLE 4
Odds ratios[a] and 95% confidence intervals of colorectal cancer according to median score by sex, NECSS, Canada, 1994–1997

Cancer site	DASH score							*p* value for trend
	≤ 2	3	4	5	6	7	≥ 8	
Colon								
Men								
Cases	93	124	169	174	177	130	89	
Controls	181	226	272	279	242	217	216	
OR (95% CI)	Ref.	0.98 (0.68–1.41)	1.07 (0.76–1.51)	1.06 (0.75–1.50)	1.20 (0.85–1.70)	0.92 (0.63–1.33)	0.65 (0.44–0.97)	.09
Women								
Cases	71	89	135	149	111	99	108	
Controls	152	173	259	251	225	202	196	
OR (95% CI)	Ref.	1.04 (0.69–1.57)	1.12 (0.76–1.64)	1.06 (0.72–1.55)	1.01 (0.67–1.51)	1.00 (0.66–1.51)	1.15 (0.76–1.74)	.81
Rectum								
Men								
Cases	75	128	173	158	143	110	69	
Controls	181	226	272	279	242	217	216	
OR (95% CI)	Ref.	1.32 (0.91–1.93)	1.57 (1.10–2.25)	1.27 (0.88–1.83)	1.26 (0.87–1.83)	1.01 (0.68–1.50)	0.64 (0.42–0.98)	.003
Women								
Cases	63	67	79	112	108	82	78	
Controls	152	173	259	251	225	202	196	
OR (95% CI)	Ref.	1.02 (0.66–1.57)	0.79 (0.52–1.19)	0.98 (0.65–1.47)	1.23 (0.81–1.97)	0.92 (0.59–1.42)	1.03 (0.66–1.60)	.58
Colorectum								
Men								
Cases	168	252	342	332	320	240	158	
Controls	181	226	272	279	242	217	216	
OR (95% CI)	Ref.	1.13 (0.84–1.53)	1.31 (0.98–1.75)	1.17 (0.88–1.57)	1.25 (0.93–1.68)	0.97 (0.71–1.32)	0.66 (0.47–0.92)	0.007
Women								
Cases	134	156	214	261	219	181	186	
Controls	152	173	259	251	225	202	196	
OR (95% CI)	Ref.	1.05 (0.74–1.48)	0.96 (0.70–1.33)	1.04 (0.75–1.42)	1.10 (0.79–1.53)	0.96 (0.68–1.35)	1.09 (0.77–1.54)	.70

Abbreviations: CI, confidence interval; DASH, Dietary Approaches to Stop Hypertension; OR, odds ratio; NECSS, National Enhanced Cancer Surveillance Study; Ref., reference.

Note: Totals may vary due to missing values.

[a] Adjusted for 10-year age group (20–49, 50–59, 60–69, 70–76 years), province, education, body mass index (< 25.0, 25.0–29.9, ≥ 30.0), pack-year smoking, moderate and strenuous activity, calcium supplementation and age at first pregnancy for women.

interventions.[30,31] In one Canadian study, men were found to have better two-hour post-load insulin concentrations than women after both stayed on a Mediterranean diet.[30] In addition, only the male participants experienced a statistically significant reduction in BMI with the Mediterranean diet. Both findings were attributed to improved insulin sensitivity and homeostasis in males.[30]

In another group of adults, adherence to a Mediterranean diet was associated with greater insulin sensitivity in young men but not in pre-menopausal women.[31] Although these sex-specific findings were not assessed with regard to CRC or any other cancer, insulin response has important implications for colorectal cancer risk. Insulin and insulin-like growth factor 1 together can promote CRC by activating several signalling pathways associated with an elevated risk of oncogenesis.[32] That insulin may play a role in the development of CRC is supported by the association between type 2 diabetes and an elevated risk of cancer including CRC.[33,34] Since the Mediterranean and DASH diets are very similar (e.g. emphasis on whole grains, nuts and legumes, limited sweets) and highly correlated,[12] it is possible that our findings in men may only be related to metabolic processes involving insulin sensitivity.

We stratified study participants according to BMI since dietary patterns may influence the risk of CRC only in those at high risk of insulin resistance (i.e. with a high BMI).[35] However, we did not observe the influence of a protective DASH pattern in only the overweight or the obese. We observed a protective effect of a strong DASH pattern for rectal cancer in normal weight men and a protective effect that was borderline significant for CRC in normal, overweight and obese males. We found no statistical trends for rectal, colon or combined cancers for women.

To further help understand this protective association with men but not women, we

TABLE 5
Odds ratios[a] and 95% confidence intervals of colorectal cancer according to median DASH score stratified by body mass index and sex, NECSS, Canada, 1994–1997

Cancer site	DASH Score							*p* value for trend
	≤2	3	4	5	6	7	≥8	
BMI < 25.0 kg/m²								
Colon (n = 629)								
Men (n = 274)	Ref.	1.30 (0.68–2.51)	0.84 (0.45–1.60)	0.86 (0.45–1.63)	1.39 (0.74–2.62)	0.94 (0.48–1.85)	0.69 (0.34–1.40)	.40
Women (n = 355)	Ref.	1.53 (0.79–2.96)	1.49 (0.81–2.73)	1.53 (0.82–2.84)	2.09 (1.13–3.89)	1.60 (0.84–3.05)	1.65 (0.86–3.17)	.16
Rectum (n = 546)								
Men (n = 268)	Ref.	1.55 (0.80–3.01)	1.34 (0.72–2.51)	0.89 (0.46–1.72)	1.25 (0.64–2.43)	0.91 (0.45–1.83)	0.50 (0.24–1.07)	.01
Women (n = 278)	Ref.	0.97 (0.51–1.84)	0.77 (1.43–1.39)	0.88 (0.48–1.60)	0.91 (0.49–1.69)	0.74 (0.39–1.40)	1.04 (0.56–1.95)	.96
Colorectum (n = 1175)								
Men (n = 542)	Ref.	1.48 (0.87–2.52)	1.18 (0.71–1.95)	0.92 (0.55–1.55)	1.40 (0.83–2.36)	0.98 (0.57–1.70)	0.64 (0.36–1.14)	.05
Women (n = 633)	Ref.	1.32 (0.79–2.20)	1.10 (0.69–1.76)	1.17 (0.72–1.89)	1.43 (0.88–2.32)	1.13 (0.68–1.87)	1.32 (0.80–2.19)	.41
BMI ≥ 25.0 kg/m²								
Colon (n = 1084)								
Men (n = 681)	Ref.	0.85 (0.55–1.32)	1.13 (0.75–1.72)	1.14 (0.75–1.72)	1.13 (0.74–1.72)	0.88 (0.56–1.38)	0.61 (0.38–0.99)	.15
Women (n = 403)	Ref.	0.74 (0.44–1.24)	1.03 (0.63–1.69)	0.74 (0.45–1.21)	0.73 (0.42–1.25)	0.75 (0.44–1.30)	0.78 (0.42–1.45)	.30
Rectum (n = 891)								
Men (n = 586)	Ref.	1.21 (0.77–1.91)	1.64 (1.05–2.56)	1.45 (0.93–2.26)	1.24 (0.79–1.96)	1.06 (0.66–1.71)	0.70 (0.41–1.17)	.07
Women (n = 305)	Ref.	1.02 (0.56–1.86)	0.75 (0.41–1.38)	1.10 (0.63–1.92)	1.58 (0.90–2.80)	1.06 (0.58–1.93)	0.65 (0.50–1.82)	.47
Colorectum (n = 1974)								
Men (n = 1267)	Ref.	0.99 (0.68–1.43)	1.35 (0.95–1.94)	1.29 (0.91–1.84)	1.18 (0.82–1.70)	0.95 (0.65–1.39)	0.65 (0.43–0.98)	.05
Women (n = 707)	Ref.	0.85 (0.53–1.36)	0.88 (0.56–1.38)	0.96 (0.62–1.48)	0.85 (0.54–1.35)	0.83 (0.52–1.33)	0.93 (0.57–1.52)	.78

Abbreviations: BMI, body mass index; DASH, Dietary Approaches to Stop Hypertension; CI, confidence interval; OR, odds ratio; NECSS, National Enhanced Cancer Surveillance Study.

Note: Totals may vary due to missing values.

[a] Adjusted for 10-year age group (20–49, 50–59, 60–69, 70–76 years), province, education, smoking, strenuous and moderate activity, calcium supplementation and age at first pregnancy for women.

considered reproductive health factors. We were able to assess parity, a factor that may be associated with decreasing risk of CRC,[36-38] but the difference between female cases and controls was not statistically significant. We did not collect data on the use of hormone replacement therapy (HRT) and of oral contraceptives (OC), although these variables are related to CRC risk. HRT is inversely associated with risk of CRC in most studies including the Women's Health Initiative, which showed a 36% decreased risk of CRC with use of HRT.[39-41] The predominant age group for HRT use is 50 to 69 years. In our study, 63% of the cases and 53% of the controls were in that age range. During this study period, usage of HRT was peaking at almost 40% in Canadian women aged 50 to 59 years and approaching 20% for those aged 60 to 69 years.[42] Thus HRT could have been a protective factor for a high percentage of the female participants. Nonetheless, another study that controlled for HRT in the logistic modelling did not report significant findings with a DASH diet in women, even though findings in men were significant.[11] In younger women, the use of OC may have attenuated the effect of a low DASH-type of diet as some studies[43,44] have shown an inverse relationship between OC use and risk of CRC in past or current OC users. Yet we suspect the potential influence of OC use on risk of CRC to be negligible.

Our finding that adhering to a strong DASH pattern was associated with a reduced risk of CRC in men is consistent with evidence for the link of certain dietary factors with CRC. A global assessment of diet and prevention of cancer[10] identified all of our score's food components or their dominant nutrients—with the exception of sodium—as potentially contributing to risk for CRC, with varying strengths of association. Specifically, these components include fibre-containing foods (e.g. legumes), vegetables, fruit, meat, milk and vitamin D/calcium-rich foods, sugar, alcohol, saturated fat and selenium-rich foods such as nuts, seeds and whole grains. This global assessment of diet and reference to specific foods offers a scientific basis from which to explore the DASH pattern to study the risk of CRC and offers biological plausibility to support our finding of an inverse association between a high score and a lower risk of CRC in men.

Differences between cases and controls in intakes of some DASH components varied by sex. Some components may have been more influential than others. For males, higher consumption of saturated fat, alcohol and sweets (negative nutrients) was reported in the cases. This pattern of greater negative nutrients was not evident in females. For females, greater consumption of fruit and whole grains (positive nutrients) were reported in cases, suggesting the

presence of other factors that negate the positive effects of these dietary components. These findings align with reports from other researchers that high alcohol intakes (along with high intakes of meat and refined grains) increased the risk of CRC—a risk that was attenuated with increased intakes of fruit, vegetables and whole grains.[4]

Limitations

The case-control design of this study inherently imparts weaknesses associated with recall bias. This may be particularly relevant to having to recall diet from 2 years before.

Applying dietary patterns involves some degree of subjectivity.[4,11,45] This is true also for how authors define and determine adherence to a DASH diet.[28,46-48] In our study, we relied on available information to define food groups and to add relevant foods to each group, including assigning equivalent serving sizes. In this regard, we may have misclassified some foods, thereby possibly misclassifying participants into an adjacent DASH score and possibly over-populating mid-range DASH scores. Mid-range scores are difficult to interpret as they may represent a lack of positive attributes, a presence of many negative attributes or a combination of both. Our finding that few study participants achieved a high DASH score is an observation reported in another similar study.[11] Further, the FFQ used in this study was a shortened version of the Block and Willett questionnaires and included only 69 items. Compared with other FFQs,[11,12] ours may have been too limiting to capture all foods contributing to the DASH pattern.

All 10 food groups were given equal weight for a final DASH score. However, the effect on CRC of some dietary components probably differ.[29] For example, red and processed meats are convincingly associated with increased risk of CRC while saturated fats are less convincingly linked.[10] The sex differences we observed may further point to the importance of weighting some foods differently, especially between sexes. For example, alcohol is convincingly associated with CRC in men but only of probable risk for women.[10]

Conclusion

Our findings suggest that a DASH pattern of eating may be associated with a lower risk of CRC, especially in men. Further research could investigate the gender differences we observed and assess the potential importance of a DASH pattern beyond prevention of CRC.

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