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Increased Dietary Inflammatory Index (DII) Is Associated With Increased Risk of Prostate Cancer in Jamaican Men

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Abstract

Purpose—Prostate cancer is the most common non-skin malignancy; and it accounts for the most cancer deaths among Jamaican males. Diet has been implicated in the etiology of prostate cancer, including through its effects on inflammation.

Method—We examined the association between a newly developed dietary inflammatory index (DII) and prostate cancer in a case-control study of 40–80 year-old Jamaican males. A total of 229 incident cases and 250 controls attended the same urology out-patient clinics at 2 major hospitals and private practitioners in the Kingston, Jamaica Metropolitan area between March 2005 and July 2007. The DII was computed based on dietary intake assessed using a previously validated food frequency questionnaire (FFQ) that was expanded to assess diet and cancer in this Jamaican population. Multivariable logistic regression was used to estimate odds ratios, with DII as continuous and expressed as quartiles. Logistic regression analysis adjusted for age, total energy intake, education, body mass index (BMI), smoking status, physical activity and family history of prostate cancer.

Results—Men in the highest quartile of the DII were at higher risk of prostate cancer [odds ratio (OR) = 2.39; 95% confidence interval (CI) = 1.14–5.04 ($P_{\text{trend}} = 0.08$)] compared to men in the lowest DII quartile.

Conclusion—These data suggest a pro-inflammatory diet, as indicated by increasing DII score, may be a risk factor for prostate cancer in Jamaican men.

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Keywords

DII; diet; inflammation; prostate cancer; case-control design; Jamaica

Introduction

Prostate cancer is the leading non-skin cancer (age-standardized incidence rate = 78.1 per 100,000 per year) and the principal cause of cancer mortality among Jamaican males [1]. The Jamaican population is predominantly (91.6%) of African origin [2] and black men, compared to white and Asian men, have a higher incidence and mortality from the disease [3].

Chronic inflammation contributes to cancer development [4,5] and considerable evidence is accumulating on the role of chronic inflammation in prostate cancer [6-8]. While inflammation typically occurs as part of the body's response to tissue insult/injury [5,9] chronic inflammation is a persistent condition in which tissue destruction and repair occur simultaneously [10,11] and involves continuous recruitment of pro-inflammatory cytokines (associated with increased blood flow to the injured tissue, due to histamine released by damaged mast cells) [5].

Consistent with this chronic inflammation hypothesis, a case-control study showed that levels of CRP were higher in men with prostate cancer compared to those with benign prostatic hypertrophy [12]. Innate immunity and inflammation play a modest role in the development of prostate cancer [13] and in the Melbourne Collaborative Cohort Study higher levels of IL-6, a pro-inflammatory cytokine, was seen among malignant prostate cancer cases compared to those with benign disease [14].

Research into the role of diet-related inflammation and prostate cancer suggests that diet represents a complicated set of exposures that often interact, and whose cumulative effect modifies both inflammatory responses and health outcomes. A search of the literature using the National Library of Medicine, Medline® database, indicates that there are very few articles that include all four components on which we are focusing our attention; i.e. diet, inflammation, obesity, and cancer. The paucity of research is likely due to logistic issues resulting from limited funding and methodological complexity involved in linking diet, obesity, inflammation and cancers in the same study. In an effort to fill the obvious methodological, and related information, gap researchers at the University of South Carolina's Cancer Prevention and Control Program developed the Dietary Inflammatory Index (DII), which can be used in diverse populations in order to predict levels of inflammatory markers and related health outcomes [15,16]. The DII is based on reviewing and scoring the scientific literature on diet and inflammation, and obtaining nutritional surveillance data sets from around the world to which individuals' dietary intakes could be compared. A higher DII score indicates a pro-inflammatory dietary milieu and a lower DII score indicates that diet is more anti-inflammatory [15]. In a case-control study conducted among Italian men, higher DII score was associated with increased risk of prostate cancer [17]. Thus far, the DII has been found to be associated with C-reactive protein [16,18], interleukin-6 [19-21], and homocysteine [19]. Additionally, DII has been shown to be

associated with glucose intolerance and dyslipidemia components of the metabolic syndrome [22,23], anthropometric measurements in Spain [24], asthma in Australia [25] respiratory conditions in Italy [26], bone mineral density among postmenopausal women in Iran [21], colorectal cancer in two case-control studies in Spain and Italy [27,28] and three cohort studies in the USA [29-31], and pancreatic cancer in an Italian case-control study [32]. The purpose of this study is to examine the association between the DII and prostate cancer in a case-control study of 40-80 year-old Jamaican men. Our working hypothesis is that higher DII scores (indicating pro-inflammatory diet) increases risk of prostate cancer. Previous research in this case-control study has revealed a strong positive association between a carbohydrate- rich dietary pattern and prostate cancer [33], which would be broadly consistent with this hypothesis.

Methods

Full details regarding the case-control design have been published elsewhere [33]. In brief, cases and controls were men attending urology clinics at the two main tertiary hospitals and private practitioners in the Kingston Metropolitan area in Jamaica. Data were collected between March 2005 and July 2007. Cases were men 40 to 80 years old, with newly diagnosed, and histologically confirmed prostate cancer. Controls were men with a normal digital rectal examination and total prostate specific antigen (PSA) < 4.0 $\mu\text{g/L}$ or total free PSA > 0.15.

Dietary intakes were assessed using a validated semi-quantitative food frequency questionnaire designed to assess diet and cancer in the Jamaican population [34]. Data were collected on the frequency of consumption for each food item, as well as the amount of food consumed using food models, commonly used household utensils, measuring cups, and a measuring tape. The FFQ was interviewer-administered. FFQ-derived dietary data were used to calculate DII scores for all participants. The DII is based on literature published through 2010 linking diet to inflammation. Individuals' intakes of food parameters on which the DII is based are then compared to a world standard database. A complete description of the DII is available elsewhere [15]. A description of validation work, including both dietary recalls and a structured questionnaire similar to an FFQ, is also available [16]. Briefly, to calculate DII for the participants of this study, the dietary data were first linked to the regionally representative world database that provided a robust estimate of a mean and standard deviation for each parameter. These then become the multipliers to express an individual's exposure relative to the "standard global mean" as a z-score. This is achieved by subtracting the "standard global mean" from the amount reported and dividing this value by the standard deviation. To minimize the effect of "right skewing" (a common occurrence with dietary data), this value is then converted to a centered percentile score. The centered percentile score for each food parameter for each individual was then multiplied by the respective food parameter effect score, which is derived from the literature review, in order to obtain a food parameter-specific DII score for an individual. All of the food parameter-specific DII scores are then summed to create the overall DII score for every participant in the study [15]. A total of 21 food parameters were available from the FFQ and therefore could be used to calculate DII (energy, carbohydrate, protein, total fat, alcohol, fiber, cholesterol, saturated fat, mono-unsaturated fat, poly unsaturated fat, omega-3, omega-6,

vitamin B12, iron, zinc, vitamin A, vitamin C, vitamin D, vitamin E, folic acid, beta carotene.)

The DII was analyzed both as a continuous variable and categorized by quartiles of exposure. DII (as quartiles) was examined across the following characteristics: age, education, physical activity level, body mass index (BMI), smoking and family history of prostate cancer, food groups and nutrients using ANOVA-test or χ^2 test for continuous and categorical variables, respectively. BMI was calculated and the World Health Organization's classification of BMI was used to determine overweight (BMI 25.0 kg/m²- 29.9 kg/m²) and obesity (BMI $\geq$ 30.0 kg/m²) [35]. Odds ratio and 95% confidence intervals (OR; 95% CI) were estimated using multivariable logistic regression models, adjusting only for age in the crude model and then fitting a model with additional adjustment for BMI, smoking status, physical activity, family history of prostate cancer, education and total energy intake. The covariates were chosen *a priori* as they were shown to be risk factors for prostate cancer. Tests for trend were carried out by calculating the median values for each of the quartiles of DII and including the median value in the model. Statistical tests were performed using SAS® 9.3 (SAS Institute Inc., Cary, NC); all p values were based on two-sided tests.

Results

A summary of the characteristics of prostate cancer cases and controls is presented in Table 1. Compared with controls, cases were older and less likely to report secondary or higher education and more likely to be physically active. A similar proportion of cases and controls were current smokers (cases, 14.8%; controls, 15.9%). Examination of anthropometric characteristics showed that, with the exception of cases being significantly shorter (cases, 169.5 $\pm$ 6.6 cm; controls, 171.6 $\pm$ 7.1 cm), both groups were similar on other factors including weight, BMI, waist and hip circumference and waist-hip ratio.

Following exclusions due to missing information, the final analytic sample consisted of 479 men (229 cases and 250 controls) and had a mean DII value of -1.05 (SD= $\pm$ 1.11). Participant characteristics by quartiles of DII are provided in Table 2. There were few differences in sociodemographic and health behavior characteristics by DII quartiles. Men in quartile 3 were less likely to have completed post-secondary education, more likely to be current smokers, less likely to be obese, more likely to be younger and less active, and to have higher CRP levels. Men in the highest quartile of DII scores had higher rate of obesity (24.6% for quartile 4 vs.23.1% for quartile 1). Table 3 shows the distribution of food groups across quartiles of DII. Men in quartile 4 had lower seafood, total fruit, total vegetables, and whole grains consumption compared to men in quartile 1. The food groups that showed the greatest reduction ($\geq$ 10%) from quartile 1 to quartile 4 were total fruits (82%), fruit juice (68%), cereals (62%), beans and legumes (57%), starches (47%), dairy (43%), seafood (37%), whole grains (33%), eggs (23%) and poultry (12%). The food groups that showed greatest increase ($\geq$ 10%) were red meat (10%), rice and pasta (16%), total meat (47%). The nutrients which showed the greatest reduction across DII quartiles were zinc (95%), linoleic acid (86%), vitamin B12 (76%) and folate (74%).

Odds ratios (OR) and 95% confidence intervals (CI) for the risk of prostate cancer according to quartiles of DII are shown in Table 4. Results obtained from modeling DII as a continuous variable in relation to risk of prostate cancer suggested a positive association after adjustment for covariates in analysis (OR=1.27 CI=0.98-1.50). When analysis was carried out with DII expressed as quartiles, and adjusting for age, no significant association was observed; although results were in the expected direction, with men in the highest quartile of DII having an apparent elevation in risk of total prostate cancer (OR = 1.27; CI = 0.73–2.19). However, in the model adjusting for family history of prostate cancer, education, BMI, smoking, physical activity and total energy intake men in the highest quartile of DII had increased odds for prostate cancer (quartile 4: OR=2.39; CI=1.14-5.04; $P_{\text{trend}}=0.08$).

Discussion

In this case-control study of Jamaican males aged 40-80 years, consuming a more pro-inflammatory diet, as reflected in higher DII scores, was associated with increased risk of prostate cancer. We found no association between DII and CRP, although there was a suggestion of a positive association. Our data showed that men with a high DII score had higher intakes of pro-inflammatory foods, including total meat, and red meat in particular. They also reported lower consumption of anti-inflammatory food groups such as fruits, fruit juice, vegetables, whole grains and sea food. Men in quartile 4 were observed to consume less food in general, and to report consuming foods that tend to be pro-inflammatory, such as sugar-sweetened soft drinks, and red meat. Men in quartile 4 also consumed very low amount of key nutrients such as zinc and folate, which have been shown to have a protective role in prostate carcinogenesis [36,37]. This result is consistent with what we have found in other developing country populations where higher-income, more educated individuals tend to be more likely to eat a westernized diet that is lower in anti-inflammatory foods and richer in pro-inflammatory foods than traditional fare [38,39]. However, it also must be kept in mind that comparatively few men in this study reported higher education.

The DII is different from other dietary indices, virtually all of which fall into three main categories: 1. Those derived from specific dietary prescriptions based on some external standard [e.g., Healthy Eating Index] [40,41], which was derived from adherence to the US Dietary guidelines [42]; 2. Those derived from findings within particular study populations (e.g., computing a pattern using principal component analysis [33]) or 3. Those that link to particular cultural patterns of dietary intake (e.g., the Mediterranean diet [43]). Previously, studies have been conducted to examine various dietary patterns and such indices and their association with prostate cancer in men [33,44]. In this Jamaican case-control study, analyses were conducted looking at dietary patterns and prostate cancer risk and it was observed that refined carbohydrate intake was associated with increased prostate cancer risk [33]. In a study conducted on the NIH-AARP study, authors tested the Healthy Eating Index-2005 (HEI-2005), Alternate Healthy Eating Index-2010 (AHEI-2010), and alternate Mediterranean diet score (aMED) in relation to prostate cancer risk and observed significant inverse associations between HEI-2005 and AHEI-2010 and prostate cancer risk [44]. Typically, the healthiest consumers within each of these patterns demonstrate a style of eating which most individuals would recognize as “nutritious.” For example, someone

relationships observed still cannot be determined. Notwithstanding the limitations of case-control studies in general, we believe that our findings of a positive association between the DII and prostate cancer are plausible and could point to a link to immune and hormonal factors [54,55,53].

The observed association between DII and prostate cancer was independent of socioeconomic status and other lifestyle characteristics. Obesity is known to be associated with inflammation; however, in this study we observed only a small difference in rates of obesity between quartile 4 and quartile 1 (24.6 % in quartile 4 vs 23.1 % in quartile 1). This may explain differences between socioeconomic status-associated patterns of obesity in Jamaica versus other places that have generally higher rates of both obesity and prostate cancer, such as the US.

A major debate has raged concerning the tension between over-treating indolent prostate cancers and under-treating virulent prostate cancers [56-58]. Indeed this forms the basis of the 2008 United States Preventive Services Task Force recommendation to avoid population-based screening [59,60]. Although this is less of a problem than it would be in a heavily screened population, there is some concern with not being able to distinguish indolent cancers from others. Future studies are needed to gain insight into the relationship between DII and the risk of prostate cancer aggressiveness; this would deepen understanding about the role of diet in determining extent and virulence of prostate cancer. The results from the current study are restricted to men, so using DII in studies with women would help to discern the generalizability of DII across genders.

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Table 1
Characteristics of prostate cancer cases and controls, Jamaican Prostate Case-Control Study, 2005-7

Characteristics	Cases	Controls
	<i>N</i> =229	<i>N</i> =250
Age, (years): mean $\pm$ sd	67.8 $\pm$ 7.8 ^a	62.0 $\pm$ 10.5
Waist, cm: mean $\pm$ sd	88.6 $\pm$ 11.8	88.1 $\pm$ 12.5
Hip circumference, cm: mean $\pm$ sd	97.8 $\pm$ 8.5	98.7 $\pm$ 10.0
Weight, kg: mean $\pm$ sd	72.3 $\pm$ 14.1	74.4 $\pm$ 14.5
Height, cm: mean $\pm$ sd	169.5 $\pm$ 6.6 ^a	171.6 $\pm$ 7.1
Waist-to-Hip Ratio: mean $\pm$ sd	0.90 $\pm$ 0.08	0.89 $\pm$ 0.08
BMI, kg/m ² : mean $\pm$ sd	25.1 $\pm$ 4.4	25.2 $\pm$ 4.6
Categorical variables:		
Education (%)		
Primary or less	90.4 ^a	80.5
Secondary	5.7	13.9
Tertiary (i.e., Post-Secondary)	3.9	5.6
Physical activity (%)		
Inactive	18.7 ^a	20.3
Moderately inactive	20.9	28.7
Moderately active	39.6	41.0
Active	20.8	10.0
Smoking (%)		
Nonsmoker	21.3	24.7
Ex-smoker	63.9	59.4
Current smoker	14.8	15.9
Overweight (%)	33.0	36.6
Obese (%)	12.6	13.1

^aCases significantly different from controls (p-value <0.05)

Table 2
Participant characteristics across quartiles of dietary inflammatory index (DII), Jamaican Prostate case-control study, 2005-7

Characteristics	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Age (years): mean $\pm$ sd	65.03 $\pm$ 9.7	65.09 $\pm$ 8.9	63.39 $\pm$ 10.9	65.13 $\pm$ 9.7
Body mass Index (kg/m ²): mean $\pm$ sd	24.87 $\pm$ 4.5	25.08 $\pm$ 4.4	25.55 $\pm$ 4.6	25.44 $\pm$ 4.6
Overweight (% 25<BMI 30 kg/m ²)	28.3	22.5	27.8	21.4
Obese (% BMI>30 kg/m ²)	23.1	29.2	23.1	24.6
C-Reactive Protein (mg/l): mean $\pm$ sd	2.62 $\pm$ 2.2	2.93 $\pm$ 2.7	3.39 $\pm$ 4.6	3.00 $\pm$ 2.7
Physical activity (%):				
Inactive	23.0	29.0	24.0	24.0
Moderately inactive	20.8	24.8	27.2	27.2
Moderately active	29.7	25.2	28.2	16.8
Active	30.7	25.3	18.7	25.3
Smoking (%)				
Non-smoker	25.0	29.3	27.6	18.1
Ex-smoker	26.7	23.8	24.4	25.1
Current smoker	25.3	26.7	30.7	17.3
Education (%)				
Primary	113 (85.6)	113 (88.3)	109 (84.5)	91 (82.7)
Secondary	12 (9.1)	10 (7.8)	17 (13.2)	10 (9.1)
Tertiary	7 (5.3)	5 (3.9)	3 (2.3)	9 (8.2)

* This represents the change in moving from the mean of quartile 1 to the mean of quartile 4.

Table 3
Distribution of food groups intake across quartiles of DII, Jamaican Prostate case-control study, 2005-7

Food groups g/week (mean $\pm$ SD)	% Change (Quartile 1-4)*	Quartile 1	Quartile 2	Quartile 3	Quartile 4
Total fruits	-82	1059.9 $\pm$ 592.4	986.6 $\pm$ 550.4	614 $\pm$ 456.8	187.7 $\pm$ 153.6
Fruit juice	-68	242.5 $\pm$ 233.0	259.4 $\pm$ 248.1	221.0 $\pm$ 262.4	76.9 $\pm$ 95.0
Cereals	-62	4.2 $\pm$ 9.6	3.9 $\pm$ 10.0	3.0 $\pm$ 8.2	1.6 $\pm$ 5.8
Total vegetables	-60	554.1 $\pm$ 372.6	541 $\pm$ 412.3	411.7 $\pm$ 340.2	222.1 $\pm$ 215.7
Beans and legumes	-57	132.1 $\pm$ 144.5	125.5 $\pm$ 137.9	92.9 $\pm$ 77.2	56.9 $\pm$ 65.5
Starches	-47	318.9 $\pm$ 151.7	287.7 $\pm$ 198.8	265.1 $\pm$ 165.6	169.2 $\pm$ 110.6
Dairy	-43	76.6 $\pm$ 119.1	70.8 $\pm$ 104.9	52.6 $\pm$ 86.7	44.0 $\pm$ 86.1
Seafood	-37	70.2 $\pm$ 44.6	64.4 $\pm$ 48.1	46.6 $\pm$ 39.0	44.2 $\pm$ 42.7
Whole grains	-33	109.6 $\pm$ 116.3	153.6 $\pm$ 199.3	93.7 $\pm$ 146.2	73.5 $\pm$ 125.4
Eggs	-23	14.0 $\pm$ 15.4	12.5 $\pm$ 15.9	13.8 $\pm$ 16.4	10.7 $\pm$ 15.0
Poultry	-12	70.1 $\pm$ 55.9	75.5 $\pm$ 53.6	74.9 $\pm$ 50.6	61.9 $\pm$ 55.7
Sugary foods	-4	15.7 $\pm$ 17.1	16.5 $\pm$ 19.1	15.4 $\pm$ 16.6	15.1 $\pm$ 23.0
Non diet (i.e., sugar-sweetened) soft drinks	+1	211.5 $\pm$ 239.8	208.6 $\pm$ 281.8	193.5 $\pm$ 231.5	213.2 $\pm$ 268.9
Red Meat	+10	19.6 $\pm$ 26.2	23.2 $\pm$ 27.9	17.5 $\pm$ 21.0	21.5 $\pm$ 25.4
Rice and pasta	+16	244.4 $\pm$ 181.6	237.4 $\pm$ 190.3	308.1 $\pm$ 224.0	284.4 $\pm$ 209.0
Total meat	+47	12.9 $\pm$ 21.1	18.5 $\pm$ 29.5	19.8 $\pm$ 27.2	19.0 $\pm$ 25.9
Nutrients (units/d)					
Energy (kcal/day)	-38	3825.0 $\pm$ 1426.8	3553.5 $\pm$ 992.3	3066.3 $\pm$ 902.3	2373.7 $\pm$ 1005.6
Carbohydrates (g/day)	-43	684.7 $\pm$ 270.2	627.8 $\pm$ 200.2	523.8 $\pm$ 170.8	389.6 $\pm$ 182.5
Proteins (g/day)	-33	140.8 $\pm$ 62.0	131.4 $\pm$ 48.8	116.3 $\pm$ 45.0	93.7 $\pm$ 40.2
Fat (g/day)	-30	90.6 $\pm$ 41.9	90.0 $\pm$ 32.5	79.3 $\pm$ 28.9	63.5 $\pm$ 29.9
Linoleic acid (g/d)	-86	11.8 $\pm$ 14.2	8.6 $\pm$ 9.3	5.4 $\pm$ 5.0	1.6 $\pm$ 2.8
Vitamin B12 (ug/d)	-76	22.9 $\pm$ 16.3	19.6 $\pm$ 14.5	14.0 $\pm$ 12.1	5.5 $\pm$ 8.6
Zinc (mg/d)	-95	162.1 $\pm$ 428.2	139.9 $\pm$ 358.2	54.1 $\pm$ 119.6	8.7 $\pm$ 19.4
Folate (ug/d)	-74	963.9 $\pm$ 357.6	848.5 $\pm$ 285.9	789.3 $\pm$ 279.9	248.6 $\pm$ 291.5

* This represents the change in moving from the mean of quartile 1 to the mean of quartile 4.

Table 4
Odds ratios and confidence intervals for quartiles of DII associated with total prostate cancer, Jamaican Prostate case-control study, 2005-7

	Quartiles of Dietary Inflammatory Index OR (95% CI)				<i>P_{trend}</i>	DII (Continuous) OR (95% CI)
	1	2	3	4		
DII	-1.96	-1.97 to -1.42	-1.43 to -0.96	-0.97		
Cases / controls	65/67	64/68	50/82	64/55		
Age-adjusted	1 (ref.)	0.85 (0.51, 1.42)	0.65 (0.38, 1.09)	1.27 (0.73, 2.19)	0.48	1.07 (0.90, 1.26)
Multivariate-adjusted ^a	1 (ref.)	0.96 (0.56, 1.66)	0.80 (0.46, 1.40)	2.39 (1.14, 5.04)	0.08	1.27 (0.98, 1.50)

^a Adjusted for age, BMI, smoking status, education, physical activity, energy intake, family history of prostate cancer.