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Dietary fibre and the risk of colorectal cancer

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Abstract

The relationship between various types of fibre and colorectal cancer risk was investigated using data from a case–control study conducted in the Swiss Canton of Vaud between January 1992 and December 2000. The study included 286 cases of incident, histologically-confirmed colorectal cancers (149 colon and 137 rectal cancers) admitted to the University Hospital of Lausanne, and 550 controls whose admission diagnosis was of acute, non-neoplastic diseases. Dietary habits were investigated using a validated food frequency questionnaire (FFQ). Odds ratios (ORs) were computed after allowance for age, sex, education, physical activity and energy intake. Fibre was analysed both as a continuous variable and in tertiles. There was a significant inverse relationship of total fibre intake (determined by the Englyst method as non-starch polysaccharides) and of its components with the risk of colorectal cancer. ORs for a difference in intake of one standard deviation from the mean fibre intake of the control distribution was 0.57 for total fibres, 0.55 for soluble non-cellulose polysaccharides (NCPs), 0.58 for total insoluble fibres, 0.57 for cellulose, 0.62 for insoluble NCP and 0.62 for lignin. When fibre was classified according to its source, the OR was 0.60 for vegetables, 0.78 for fruit and 0.74 for grain fibre. The ORs were similar for colon and rectal cancer and consistent across the strata of the major covariates and of several types of fibres.

Keywords: Case–control study; Colorectal cancr; Diet; Dietary fibre; Epidemiology; Humans; Neoplasms; Risk factors; Switzerland

1. Introduction

A favourable role of fibres on colorectal carcinogenesis was hypothesised by Burkitt on the basis of the observation that colorectal cancer rates were low in Africa, where fibre intake has traditionally been high [1]. An ecological analysis from the Seven Countries Study also showed a consistent inverse association between fibre intake and colorectal cancer mortality [2].

Several case–control studies have reported a protective effect of fibre on colon and rectal cancer cases. A combined analysis of 13 case–control studies reported a relative risk (RR) of colorectal cancer of 0.53 for the highest quintiles of fibre intake [3]. A case–control study of over 2000 colon cancer cases from California, Utah and Minnesota also showed an inverse relationship [4]. In another case–control study of almost 2000 cases from Italy, when the difference was set between the 80th and the 20th percentile, the RRs of colorectal cancer were 0.68 for total fibre, 0.67 for soluble fibres, 0.71 for insoluble ones, 0.67 for cellulose and 0.88 for lignin [5]. The protection was stronger for vegetable fibres than for grain ones. Likewise, in a study conducted in Hawaii on approximately 1200 cases, the protective effect was limited to fibres from vegetables, while no clear relationship emerged for fibre from bread and cereals [6].

The results from prospective studies have, however, been essentially negative. The American Cancer Society—Cancer Prevention Study II found some inverse relationship between selected fibre-rich fruits and colon cancer mortality [7]. However, no consistent trend in risk for colorectal cancer or adenoma was observed for women in the Nurses' Health Study [8], for men in the Health Professionals' Study [9], nor in the Iowa's Women's Health Study [10], in a cohort study from The Netherlands [11], or in the Finnish Alpha-Tocopherol, Beta-Carotene Cancer Prevention Study [12]. Furthermore, fibre supplementation to prevent colorectal adenoma recurrence has been largely disappointing [13,14].

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To provide further information on the issue, we have therefore considered data from a case–control study conducted in Switzerland, where information was available on different types of fibre and major covariates of interest.

2. Patients and methods

The data for the present analysis were derived from a case–control study of colorectal cancer conducted between January 1992 and December 2000 in the Swiss Canton of Vaud [15].

Cases were 286 patients (174 males, 112 females) with incident, histologically-confirmed colon (ICD-O-9: 153.0–153.9; $n=149$) or rectal (ICD-O-9: 154.0–154.1; $n=137$) cancer (age range: 26–74 years; median age 65 years) who had been admitted to the University Hospital of Lausanne, Switzerland.

Controls were subjects residing in the same geographical area, whose admission diagnosis was of acute, non-neoplastic diseases other than chronic digestive tract disorders, and unrelated to long-term modification of diet. A total of 550 subjects (269 males, 281 females) aged <75 years (range: 27–74 years; median age 59 years) were interviewed. They were admitted to the University Hospital of Lausanne for a wide spectrum of acute conditions, including traumas (33%, mostly sprains and fractures), non-traumatic orthopaedic conditions (31%, mostly low back pain and disc disorders), surgical conditions (19%, mostly abdominal, such as acute appendicitis, kidney stones or strangulated hernia), and miscellaneous other disorders (17%, including acute medical, eye, nose and throat, and skin diseases).

All interviews were conducted in hospital during the admission diagnosis. 16% of subjects (16% cases; 15% controls) approached for interview refused. The structured questionnaire included information on sociodemographic characteristics and lifestyle habits (e.g. smoking, alcohol consumption and physical exercise), and anthropometric factors. A problem-oriented medical history was also included. An interviewer-administered food-frequency questionnaire (FFQ) [16,17], was used to assess subjects' habitual diet. Information was elicited on average weekly frequency of consumption of specific foods, as well as complex recipes (including the most common ones in the Swiss diet) during the 2 years prior to cancer diagnosis or hospital admission (for controls). The FFQ included 79 foods, food groups or recipes.

To compute energy and nutrient intake, standardised portion sizes and food-composition databases were used for approximately 80% of food items. These sources had to be integrated with data on traditional food products, as well as information from manufacturers.

Dietary fibre intake was derived using the Englyst procedure [18], which measures fibre as non-starch polysaccharides. A value was obtained for total fibre and for soluble and insoluble fibre. A modification of the method allows cellulose to be measured separately from insoluble non-cellulose polysaccharides (NCPs). Values for lignin, a minor component of the human diet, were provided separately. We did not include resistant starch in the computation of total fibre because the amount depends on how each food is processed and consumed [19], and valid food composition tables, which include processing-related changes, were not available. Furthermore, it is known that the definition and quantification of 'resistant starch' is fraught with difficulty [20]. Fibre intake was also divided according to the food from which it originated (i.e. vegetable, fruit or grain).

2.1. Data analysis

Odds ratios (OR) and the corresponding 95% confidence intervals (CI) were computed, using unconditional multiple logistic regression models. Various types of fibre were entered in the models both as tertiles of the distribution of controls and continuously. In the latter case, the standard deviation of mean intake was used as a measurement unit. Several models were fitted to the data, all of which included terms for age, sex, education, physical activity, alcohol and energy intake, or separately fat, protein and carbohydrate intakes. Models allowing for total energy according to the residual model [21], or for its components (fat, protein and carbohydrates) yielded similar results, and the first ones were chosen for presentation.

3. Results

Table 1 gives the distribution of colon and rectal cancer cases according to sex, age, education, body mass index, physical activity, energy intake and family history of colorectal cancer. Cases were older, more often males, more educated and reported lower physical activity and more frequent history of colorectal cancer in first-degree relatives. Allowance for these factors was consequently made in all analyses.

Table 2 gives the correlation matrix between various types of fibres considered. Most coefficients were positive, and several of them were above 0.5, indicating a substantial co-linearity between various sources of fibres. Comparatively lower correlations were observed between the various sources of fibres, i.e. vegetable, fruit or grain fibres.

Table 3 gives the energy-adjusted distribution of cases and controls in subsequent intake tertiles of types or sources of fibre. The corresponding upper cutpoints and

Table 1
Distribution of 286 colorectal cancer cases and 550 controls according to selected covariates, Vaud, Switzerland, 1992–2000

Characteristic	Cases	Controls
	n (%)	*n* (%)
Sex		
Male	174 (60.8)	269 (48.9)
Female	112 (39.2)	281 (51.1)
Age (years)		
<45	17 (5.9)	81 (14.7)
45–54	40 (14.0)	124 (22.5)
55–64	80 (28.0)	166 (30.2)
65–74	149 (52.1)	179 (32.5)
Education (years)		
<9	30 (10.5)	72 (13.1)
9–12	166 (58.0)	315 (57.3)
⩾13	90 (31.5)	163 (29.6)
Body mass index (kg/m^2)		
<25	126 (44.1)	277 (50.4)
25–29	113 (39.5)	213 (38.7)
⩾30	47 (16.4)	60 (10.9)
Physical activity[a]		
Low	140 (49.5)	234 (42.7)
Medium	102 (36.0)	211 (38.5)
High	41 (14.5)	103 (18.8)
Family history of colorectal cancer		
No	268 (93.7)	538 (97.8)
Yes	18 (6.3)	12 (2.2)

[a] The sum does not add up to the total due to a few missing values.

OR of colorectal cancer are given in Table 4, both in tertiles and continuously. There was a significant inverse relationship of total fibre intake and of its components with the risk of colorectal cancer. The ORs for a difference in intake of one standard deviation from the mean fibre intake of the control distribution was 0.57 for total fibres, 0.55 for soluble NCP, 0.58 for total insoluble fibres, 0.57 for cellulose, 0.62 for insoluble NCP and 0.62 for lignin. With reference to the source of fibres, the OR was 0.60 for vegetable, 0.78 for fruit and 0.74 for grain fibre.

Table 3
Energy-adjusted distribution of cases and controls according to intake tertile of various types/sources of fibre, Vaud, Switzerland, 1992–2000

	1st tertile	2nd tertile	3rd tertile
Type/source of fibre	Cases:Controls	Cases:Controls	Cases:Controls
Total (Englyst) fibre	172:181	67:182	47:187
Soluble NCP	168:182	63:181	55:187
Total insoluble fibre	169:181	69:182	48:187
Cellulose	162:181	70:182	54:187
Insoluble NCP	145:182	96:181	45:187
Lignin	166:181	70:182	50:187
Vegetable fibre	145:181	93:182	48:187
Fruit fibre	140:181	67:183	79:186
Grain fibre	127:181	105:182	54:187

NCP, non-cellulose polysaccharides.

Table 5 considers the relationship between total fibre intake and colorectal cancer risk in separate strata of subsite and covariates. The continuous OR was similar for colon (OR = 0.58) and rectal cancer (OR = 0.51), and consistent across strata of sex, age, education, physical activity, family history of colorectal cancer and energy intakes. All the ORs were below unity, in the absence of significant heterogeneity across the strata.

4. Discussion

The present findings, based on a comprehensive FFQ and estimates of intake for various types of fibres, further suggest that there is an inverse relationship between fibre consumption and colorectal cancer risk. The inverse association was observed across strata of subsites (colon and rectum) and major covariates, and of several types of fibres, including soluble, insoluble fibre or cellulose. This may well reflect the positive correlation between various types of fibres, as well as the inverse relationship between selected foods, including raw and cooked vegetable, and colorectal cancer risk in this and other populations [22].

Table 2
Pearson correlation coefficients between various types/sources of fibres consumed by 550 controls, Vaud, Switzerland, 1992–2000

Type/source of fibre	Total (Englyst)	Soluble NCP	Total insoluble	Cellulose	Insoluble NCP	Lignin	Vegetable fibre	Fruit fibre	Grain fibre
Total (Englyst)	1.000								
Soluble NCP	0.975	1.000							
Total insoluble	0.987	0.927	1.000						
Cellulose	0.967	0.970	0.937	1.000					
Insoluble NCP	0.918	0.817	0.964	0.810	1.000				
Lignin	0.904	0.874	0.899	0.817	0.885	1.000			
Vegetable fibre	0.651	0.683	0.611	0.701	0.490	0.566	1.000		
Fruit fibre	0.671	0.741	0.600	0.775	0.415	0.467	0.240	1.000	
Grain fibre	0.719	0.590	0.790	0.534	0.919	0.801	0.305	0.082	1.000

NCP, non-cellulose polysaccharides.

Table 4
Odds ratios (OR),[a] and corresponding 95% confidence intervals (CI), of 286 colorectal cancer cases and 550 controls according to the intake of various types/sources of fibre, Vaud, Switzerland, 1992–2000

Type/source of fibre	Upper cutpoints at 1st:2nd tertile (g)	OR (95% CI) according to tertile[b] of intake		X^2_1 (trend)	Continuous OR (95% CI)
		2nd	3rd		1 S.D. unit[c,d]
Total (Englyst) fibre	11.4:16.6	0.50 (0.34–0.73)	0.36 (9.24–0.54)	28.0[e]	0.57 (0.47-0.68)
Soluble NCP[f]	5.3:7.5	0.46 (0.32–0.68)	0.40 (0.27–0.59)	27.9[e]	0.55 (0.45-0.67)
Total insoluble fibre	6.0:9.1	0.55 (0.48–0.70)	0.35 (0.23–0.52)	28.9[e]	0.58 (0.48–0.70)
Cellulose	2.9:4.2	0.53 (0.36–0.77)	0.35 (0.24–0.52)	27.9[e]	0.57 (0.47-0.68)
Insoluble NCP[f]	3.1:4.9	0.77 (0.55–1.09)	0.33 (0.22–0.49)	27.4[e]	0.62 (0.52–0.75)
Lignin	1.1:1.5	0.58 (0.40–0.84)	0.42 (0.52-0.74)	21.7[e]	0.62 (0.29–0.61)
Vegetable fibre	3.9:5.4	0.50 (0.35–0.72)	0.36 (0.50–0.73)	29.0[e]	0.60 (0.24-0.53)
Fruit fibre	2.8:5.1	0.58 90.39–0.84)	0.58 (0.39–0.85)	8.0[e]	0.78 (0.66–0.92)
Grain fibre	3.6:6.7	1.07 (0.76–1.51)	0.49 (0.33–0.73)	11.0[e]	0.74 (0.62–0.88)

[a] Estimates from multiple logistic regression models including terms for sex, age, education, physical activity and energy intake.
[b] Tertiles are computed on the distribution of controls. The reference category is the first (lowest) tertile.
[c] S.D. = standard deviation of the mean fibre intake.
[d] Units in g: 4.9 for total fibre; 2.1 for soluble NCP; 3.1 for total insoluble fibre; 1.4 for cellulose; 1.9 for insoluble NCP; 0.4 for lignin; 2.0 for vegetable fibre; 3.3 for fruit fibre; 3.0 for grain fibre.
[e] $P < 0.01$.
[f] Non-cellulose polysaccharides.

The association, as previously observed [5], was somewhat stronger for vegetable than for fruit or grain fibres. In this population, the cereals consumed include a substantial proportion of refined grains, leading to a high ratio between starch and fibre intake. Consequently, a potential promotional effect of starch [23] and sugar in fruit [24] may at least in part counteract a protective action of the fibres.

Fibres, in fact, and particularly soluble fibres, may reduce glycaemic load [25] and improve insulin resistance, favourably influencing insulin-like growth factor 1 (IGF-1), which is a promoter of the process of colorectal carcinogenesis [26]. Along this line, a clinical history of diabetes mellitus was related to colorectal cancer risk [27], and an inverse relationship was observed between whole grain foods and upper aero-digestive tract neoplasms [28]. The association was stronger, though non-significant, in older subjects and in those in the highest category of physical activity, which showed an independent protection on colorectal cancer risk in this population [29]. This suggests that it is probably not diet alone, but the entire lifestyle that is associated with an improved insulin resistance which may be associated with reduced risk [30]. Furthermore, more fibre may modify the bacterial microflora, influence bowel transit time and fermentation, but none of these mechanisms has been shown to definitely influence the process of colorectal carcinogenesis.

Plant foods contain various types of fibre, and this makes it difficult to distinguish between their separate effects and the use of food composition tables to estimate and quantify various types of fibres remains open to discussion. It is, moreover, unclear whether the apparent inverse relationship between fibre and colorectal cancer reflects other aspects of diet composition, which are difficult to completely allow for in the analysis. For instance, high fibre diets tend to also have a high content of antioxidant vitamins and flavonoids [31], and are generally a rich source of vegetables, fruit

Table 5
Odds ratios (ORs)[a] and 95% confidence intervals (CIs) of colorectal cancer, according to total fibre intake, in strata of selected covariates, Vaud, Switzerland, 1992–2000

Stratum	Continuous OR (95% CI)
Colon	0.58 (0.46–0.74)
Rectum	0.51 (0.40–0.66)
Men	0.54 (0.42–0.69)
Women	0.59 (0.45–0.77)
Age (years)	
<60	0.76 (0.57–0.99)
60–69	0.54 (0.39–0.74)
⩾70	0.46 (0.31–0.70)
Education	
<11 years	0.48 (0.35–0.65)
⩾11 years	0.64 (0.51–0.80)
Physical activity	
Low	0.69 (0.52–0.92)
Medium	0.55 (0.41–0.74)
High	0.49 (0.31–0.79)
Family history of colorectal cancer	
No	0.58 (0.48–0.69)
Yes	0.31 (0.08–1.28)
Energy intake	
I (lowest)	0.55 (0.39–0.78)
II	0.35 (0.24–0.53)
III (highest)	0.67 (0.51–0.88)

[a] Estimates from multiple logistic regression models including terms for sex, age, education, physical activity and energy intake. The unit for fibre intake is one standard deviation of the mean fibre intake of the controls.

and the related wide spectrum of substances with a potentially favourable influence on the process of carcinogenesis.

Dietary habits of hospital controls may differ from those of the general population, but we excluded from the comparison group all diagnoses that may have involved long-term diet modification. Among other strengths of this study, are the satisfactory reproducibility and validity of the FFQ, with an adjusted correlation coefficient for total fibres of 0.58 [16,17], the comparable catchment area of cases and controls, the high participation rate, and the possibility of allowance for several relevant covariates, including total energy, in the analysis. Still, since diet history was focused on the two years preceding diagnosis/interview, a potential role of recall bias following disease-related dietary changes is conceivable, and could in principle, at least in part, explain the differences observed with prospective studies.

Although this study contributes to the general evidence from case–control studies indicating that fibres are inversely related to colorectal cancer risk, the inconclusive results of most cohort studies [8–12] and intervention trials [13,14] leave the issue of a causal inference—and of any time–risk relationship—open to discussion and further investigation.

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