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Serum nutrients and habitual dietary intake in colectomized FAP patients in Norway

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Abstract *Background* Patients with familial adenomatous polyposis (FAP) are colectomized in young age in order to avoid development of colorectal cancer. Because colectomy radically changes gastrointestinal physiology, and food avoidance may be present, colectomized patients may be at risk for nutritional deficiency. *Aim of the study* to evaluate: (1) serum biochemical levels as compared to reference; (2) dietary intake as compared to the recommendations. *Methods* Blood samples, interviews and food frequency questionnaire were collected from 38 colectomized FAP patients with duodenal adenomas (mean age 40 years, range: 24–70). They were recruited from the Norwegian database on FAP. *Results* Serum albumin was significantly higher ($P \leq 0.0001$), and Mg ($P = 0.02$), ferritin ($P \leq 0.001$), and cholesterol ($P = 0.03$) significantly lower, than reference levels. Compared to recommendations, a low intake was seen for folate and fiber (<50%), iron, thiamin, riboflavin (<25%), and omega-3 fatty acids (8%). Sugar intake exceeded the recommendation, mainly due to a high intake of soft drinks. Food avoidance was reported by 53%. *Conclusions* We would suggest that the nutrient intake among FAP patients should at least meet the recommendations for healthy subjects. Their risk of metachronous cancers should also cause special attention to dietary factors that may prevent nutritional deficiency and carcinogenesis.

Key words familial adenomatous polyposis – ileostomy – colectomy – diet – nutritional status

Introduction

Familial adenomatous polyposis (FAP) is a rare autosomal dominantly inherited disorder caused by germline mutations in the APC gene [23]. Patients with FAP are colectomized in young age in order to avoid development of colorectal cancer [35]. In spite of colectomy, these patients remain at an increased cancer risk at other sites.

Colectomy radically changes gastrointestinal physiology. Low serum levels of albumin, calcium, B_{12}, vitamin A and vitamin D have been observed in patients with intestinal resection [24, 26, 29]. Because these problems may exist in patients with a continent pouch [7, 12], increased loss of nutrients may occur also in colectomized FAP patients. Additionally, they may have symptoms due to difficulties with digestion of certain foods [4, 7, 13, 19, 32]. Avoidance of such food items may induce lower nutritional quality. No specific food recommendations exist for long standing ileostomy or ileoanal pouch patients, regardless of underlying disease.

Many agents are potential suppressors of tumour formation or small intestinal growth in an Apc(Min/+) mouse model [14], such as selenium, celecoxib, aspirin, omega-3 fatty acids, calcium, folic acid, vegetables, and vitamin C. Many dietary substances may decrease the risk of sporadic cancers by several mechanisms [18]. It is not known, however, whether specific diets or micronutrients may help to prevent the development of cancer in FAP patients, either alone or in combination with drugs [11, 16].

The objectives of the present study on colectomized FAP patients were to evaluate: (1) serum biochemical levels as compared to reference; and (2) dietary intake, to see if the patients meet the dietary recommendations, in an attempt to improve the health care and life expectancy for these patients.

Subjects and methods

Patients

Subjects were recruited from a Norwegian data base on FAP. They had all been colectomized and duodenal adenomas had been verified by endoscopy and histology. Rikshospitalet University Hospital is a highly specialized university hospital with national responsibilities within complicated treatments, such as follow ups on the Norwegian FAP patients. All patients were included in a randomized double-blind placebo-controlled intervention study with a cyclooxygenase -2 inhibitor (data in preparation). This paper presents nutritional data at baseline. Inclusion criteria were verified FAP, colectomy, 18–70 years of age and documented duodenal adenomas graded as Spigelman I, II or III and the largest adenoma <10 mm. Exclusion criteria were indications for surgical treatment, suspected or documented intestinal obstruction or stenosis, patients with pacemakers and other implanted electro medical devices, patients unwilling or unable to adhere to protocol, known cardiac failure requiring medical treatment, and pregnancy. The inclusion period lasted from winter 2003 until spring 2004. All patients were on a free diet. They did not receive any dietary advice, or advice concerning additional use of dietary supplements, as part of the study.

Of the 47 patients initially considered for participation, five patients did not meet the inclusion criteria and four patients refused to participate. Thus, data are presented for 38 FAP patients (50% men). Eleven patients had been operated with conventional and 2 with a continent ileostomy, 20 patients with ileal-pouch-anal anastomosis (IPAA), three patients with ileoanal anastomosis (IAA) and two patients with ileorectal anastomosis (IRA).

Dietary and anthropometrical assessment

Dietary intake was assessed by a validated food frequency questionnaire [3], designed to cover as much of the total diet as possible. Questions were related to habitual frequency of consumption and the amount of foods eaten. Dietary supplements, such as cod liver oil, fish oil capsules and vitamin and mineral supplements were included. The food frequency questionnaire was mailed to the patients and filled in at home. All subjects were given individual appointments with a nutritionist at the hospital, in which each food frequency questionnaire was checked. Patients were asked to indicate their intake in the 1-year period prior to inclusion. They were asked to identify their habitual choices of edible fats by pointing at specially prepared pictures, in order to increase the validity of the estimate of dietary fat. These pictures contained all types of margarine/butter/butter-based margarine that were commercially available at that time. Omega-3 fatty acid supplements were included in the dietary analysis. Data on dietary intake were entered by scanning, with the Teleform program, version 6.0 (Datascan, Oslo, Norway). Daily intakes of foods, energy, and nutrients were computed by use of a food database and software system developed at the Department of Nutrition, University of Oslo [2]. The food database is based mainly on the official food composition table 16, which is continuously supplemented with data on new food items and nutrients.

All patients were also asked if they avoided foods, or ate in a modified way, for instance in small portions, primarily due to intestinal symptoms. The use of this open question aimed to support or show discrepancies between which foods they reported to avoid and which foods they recalled in the food frequency questionnaire.

Weight and height were measured at the hospital according to standard procedures. The body mass index was computed as weight (kg) divided by squared height (m^2). Patients were classified as underweight if body mass index was <18.5 kg/m^2, normal weight if body mass index was 18.5–24.9 kg/m^2, overweight if body mass index was 25.0–29.9 kg/m^2 and obese if body mass index was ≥30 kg/m^2.

Blood sampling and analyses

Fasting blood samples were obtained from an antecubital vein and centrifuged within 30 min. Serum and serum samples were transferred to 1.8 ml screw capped vials, and kept at +4°C for 2–6 h before storage at −80°C. Serum levels (day-to-day coefficients of variation in parenthesis) of magnesium (3.5%), calcium (2.6%), albumin (2.7%), iron (4.0%), transferrin (4.8%), total cholesterol (2.9%), HDL cholesterol (<1.0 mmol/l: 6.0%; >1.0 mmol/l: 3.0%), LDL cholesterol (4.9%) were measured on a Roche Modular-P automatic analyzer, ferritin (<20 μg/l: 12,2%; >20 μg/l: 7,5%) on a Roche Modular-E automatic analyzer, and serum levels of vitamin B12 (10%) and folate (10%) on the Immulite 2000 analyzer. All the laboratory methods were accredited to the ISO/IEC 17025 standard. Reference values were taken from a Clinical laboratory handbook, Rikshospitalet University Hospital HF. Analyses of fatty acid profile in serum phospholipids were performed as described elsewhere [1].

Ethics approval

The study was performed in accordance with the Helsinki Declaration. Patients were informed by a physician, and in addition thoroughly written information that was given to all patients. The protocol was explained to the subjects that had to give their consent before inclusion. No honorarium was offered. The patients were informed specifically of the option to withdraw at any stage of the study with no need for an explanation. The study protocol (RH01/01) was approved by the Norwegian health authorities and the Regional Committee of Medical Ethics 20/06/2002 (reference: S-02127).

Statistics

Since the study was performed without a matched control group, each measured blood component was evaluated with respect to the distribution of the reference population where reference limits had been calculated. Except for S-folate and S-vitamin B12, the reference population consisted of a presumably healthy Nordic population (The NORIP project) and is well described by Rustad et al. [30]. For S-folate and S-vitamin B_{12} in-house reference limits were used, essentially based on similar inclusion criteria. For the components that were normally distributed (magnesium, calcium, albumin, iron, transferrin, total cholesterol, and LDL cholesterol) the arithmetic average of the reference limits was taken as a good estimate for the median. Components that were not normally distributed were transformed to make them approximately normally distributed (log-transform for triglycerides, HDL cholesterol, vitamin B12, and folate, and square root transform for ferritin). A two-sided Wilcoxon signed-rank test was then applied for the difference = patient value—reference median to look for statistical significant level differences ($P < 0.05$). For components that had to be transformed to obtain a normal distribution, the median was estimated as the retransformed value of the mean of transformed reference limits. The international consensus for reference interval is the central 95% confidence interval of the population, i.e. from the 2.5th to the 97.5th percentile. For the dietary variables, non-parametrical statistical methods were chosen, as some of the variables were skewed and the number of observations limited. Median values with quartiles are presented unless otherwise stated. Relations between dietary components and concentrations of serum values were investigated by using Spearman's correlation coefficients (ρ). In order to evaluate the nutritional adequacy, we compared the intake of nutrients to the Nordic Nutrient Recommendations [6]. Low and high intake values are defined as values below and above the lower/upper recommended limits. All statistical analyses were performed with the SPSS 12.0 and Excel software for Windows.

Results

Background characteristics of the FAP patients are given in Table 1. Age ($P = 0.001$), age at diagnosis of FAP ($P = 0.03$), age at diagnosis of duodenal polyposis ($P = 0.003$) and presence of colorectal cancer at colectomy ($P = 0.002$) differed between patients with ileostomy and IPAA.

Nearly half of the patients reported using omega-3 fatty acids supplements (42%), whereas 24% did not report to use any type of dietary supplementation. The frequency of patients taking vitamin/mineral supplements was 43%. Several types of supplements were taken (data not shown).

Serum values of nutrients and habitual dietary intake

Table 2 shows the biochemical measurements for the FAP patients compared to the reference population. The measurements did not vary according to time

Table 1 Characteristics of colectomized patients, due to familial adenomatos polyposis (FAP) and duodenal adenomas

	Total FAP group (n = 38)	FAP patients with ileostomy (n = 13)[a]	FAP patients with IPAA (n = 20)[a]	FAP patients with IAA (n = 3)	FAP patients with IRA (n = 2)
Body mass index (kg/m^2)	26.2 (17.2, 35.2)	26.6 (19.8, 35.2)	25.5 (17.2, 30.8)	26.4 (25.0, 28.2)	26.7 (23.9, 29.4)
Age at inclusion (years)	40 (24, 70)	51 (36, 70)	36 (24, 61)	47 (35, 53)	31 (25, 36)
Age at FAP diagnosis (years)	20 (6, 47)	26 (15, 47)	19 (6, 45)	15 (14, 25)	16 (14, 17)
Age at colectomy (years)	22 (10, 48)	28 (19, 48)	21 (10, 45)	20 (15, 26)	18 (16, 20)
Age at duodenal polyposis diagnosis (years)	25 (10, 57)	36 (20, 57)	21 (10, 45)	29 (15, 38)	20 (16, 24)

Values are shown as medians and (range)
P_{25} lower percentile, P_{75} upper percentile, *IAA* ileoanal anastomosis, *IPAA* patients with ileal-pouch-anal anastomosis, *IRA* ileorectal anastomosis
[a]Age (P = 0.001), age at FAP diagnosis (P = 0.03), age at duodenal polyposis diagnosis (P = 0.003) and presence of colorectal cancer at colectomy (P = 0.002) differed between FAP patients with ileostomy and FAP patients with IPAA

Table 2 Biochemical measurements among colectomized patients with familial adenomatous polyposis (FAP) and duodenal adenomas

Component (unit)	Patient median (P_{25}, P_{75})	Reference interval[a, b] ($P_{2.5}$–$P_{97.5}$)	Median in reference interval	Median difference (95% CI)[b]	*P*-value
Calcium (mmol/l)	2.36 (2.30, 2.43)	2.15–2.55	2.35	0.01 (−0.02–0.04)	0.49
Albumin (g/l)	46 (42, 47)	18–39 years: 36–48	42.0	4.4 (3.7–5.3)	≤0.0001
		40–69 years: 36–45	40.5		
Magnesium (mmol/l)	0.79 (0.75, 0.84)	0.71–0.94	0.83	−0.03 (−0.05– −0.01)	0.02
Iron (μmol/l)	23 (16, 28)	9–34	21.5	1.5 (−1.5–4.0)	0.35
Transferrin (g/l)	2.8 (2.6, 3.2)	2.2–3.9	3.05	−0.25 (−0.4–0)	0.07
Transferrin saturation	0.32 (0.24, 0.40)	Women 18–49 years: 0.10–0.50	0.30	0.00 (−0.045–0.04)	0.99
		Women ≥50 years: 0.15–0.50	0.325		
		Men ≥18 years: 0.15–0.57	0.36		
Ferritin (μg/l)	71 (24, 111)	Women: 10–167	40.9	34.6 (13.6–61.6)	≤0.001
		Men: 29–383	105.4		
Vitamin B_{12} (pmol/l)	290 (243, 422)	160–710	337	−14.5 (−62.1–43.0)	0.61
Folat (nmol/l)	15.3 (11.3, 21.6)	7.1–27.0	13.8	1.4 (−0.2–6.3)	0.07
Total-cholesterol (mmol/l)	4.8 (4.3, 5.6)	18–29 years: 2.9–6.1	4.5	0.4 (0.1–0.7)	0.03
		30–49 years: 3.3–6.9	5.1		
		50–79 years: 3.9–7.8	5.9		
Triglycerids (mmol/l)	1.1 (0.8, 1.4)	0.5–2.6	1.1	0.0 (−0.2–0.2)	0.67
HDL-cholesterol (mmol/l)	1.6 (1.3, 1.9)	Women: 1.0–2.7	1.6	0.0 (−0.1–0.2)	0.97
		Men: 0.8–2.1	1.3		
LDL-cholesterol (mmol/l)	3.1 (2.5, 3.7)	18–29 years: 1.5–4.2	2.9	0.3 (−0.1–0.6)	0.19
		30–49 years: 1.9–4.8	3.4		
		50–79 years: 2.1–4.9	3.5		

Patient data are presented as medians and (P_{25}, P_{75})
P_{25} lower quartile, P_{75} upper quartile
[a]From clinical laboratory handbook, Department of Medical Biochemistry, Rikshospitalet-Radiumhospitalet HF [30]
[b]For the components that were normally distributed (magnesium, calcium, albumin, iron, transferrin, total -, and LDL cholesterol) the arithmetic average of the reference limits was taken as a good estimate for the median. For components that had to be transformed to obtain a normal distribution, the median was estimated as the retransformed value of the mean of transformed reference limits (log-transform for triglycerides, HDL cholesterol, vitamin B_{12}, and folate, and square root transform for ferritin). A two-sided Wilcoxon signed-rank test was then applied for the difference = patient value–reference median, likewise for transformed values, to look for statistical significant level differences ($P < 0.05$). The international consensus for reference interval is the central 95% confidence interval of the population, i.e. from the 2.5th to the 97.5th percentile

since diagnosis of FAP, time since colectomy, or according to type of intestinal reconstruction (data not shown). The serum albumin levels were significantly higher among the FAP patients than among the reference population ($P \leq 0.0001$). The median difference was 4.4 g/l and the corresponding 95% CI = 3.7–5.3. Serum levels of Mg, ferritin and total cholesterol were reduced as compared to the reference ($P = 0.02$, $P \leq 0.001$ and $P = 0.03$, respectively). One man and one woman had serum Mg levels below 0.66 mmol/l. Standard daily supplementation with multivitamins was used by these two patients. The levels of ferritin were lower than 10 μg/l in 8% of the patients. These patients reported using dietary supplements, but not iron supplements specially. Those who reported to use iron supplementation (8%), had normalized ferritin levels. Serum levels of vitamin B_{12} did not differ between the reference population and the FAP patients. One woman had serum B_{12} levels equal to 1,425 Pmol/l, due to a recent B_{12} injection. We did not exclude her from analyses, although the 95% CI would have been narrowed as a consequence.

Table 3 Habitual intake of energy and nutrients among colectomized patients with familial adenomatous polyposis (FAP) and duodenal adenomas

Dietary variable	FAP patients (n = 38)	Nordic Nutrition recommendations[a,b]
Energy (MJ)	10.4 (7.9, 11.7)	–
Vitamin D (μg)	5.5 (3.9, 11.1)	8.3
Calcium (mg)	786 (578, 996)	933
Iron (mg)	10.7 (9.6, 14.0)	12
Folat (μg)	221 (181, 292)	252
Retinol eq. (μg)	1,300 (815, 1700)	785
Vitamin E (μ-TE)	10 (9, 15)	13
Thiamin (mg)	1.3 (1.0, 1.6)	1,4
Riboflavin (mg)	1.6 (1.2, 2.0)	1,8
Vitamin C (mg)	120 (86, 201)	147
Magnesium (mg)	325 (286, 415)	361
Fiber (g)	22 (16, 26)	30
Cholesterol (mg)	273 (216, 336)	–
Total fatty acids	31 (29, 37)	25–30
Saturates	12 (11, 14)	<10
Monounsaturates	10 (9, 12)	10–15
Polyunsaturates	7 (5, 9)	5–10
Omega-3	1.0 (0.8, 1.4)	0.5[c]
Omega-6	6.1 (4.5, 7.2)	
Protein	15 (13, 17)	10–20
Carbohydrates	50 (44, 56)	50–60
Sugar	10 (5, 16)	<10
Alcohol	1 (0, 3)	–

Data are presented as medians and (P_{25}, P_{75}) per day
P_{25} lower percentile, P_{75} upper percentile
[a]Nordic nutrition recommendations [6]
[b]Female/male recommendation
[c]Essential polyunsaturated omega-6 and omega-3 fatty acids should provide at least 3% of energy, including at least 0.5% of energy from omega-3 fatty acids

The recommended intake of fiber was reached by less than 3/4 of the patients (Table 3). The intake of omega-3 fatty acids was lower than the minimum recommendation of 0.5 % of energy in three patients (8%) not taking omega-3 supplements. Those who reported using omega-3 supplements (42%) had a higher energy intake from omega-3 fatty acids, vitamin D and vitamin E (all $P \leq 0.001$) as compared to those who did not. The concentration of omega-3 fatty acids in serum phospholipids was higher in patients taking omega-3 fatty acids supplements as compared to those who did not ($P = 0.03$).

The serum levels of folate were low in two patients (5%). None of them reached the dietary recommendations for folate, and none of them reported to use dietary supplements. Serum folate correlated to relative intake of dietary iron ($r = 0.5$, $P = 0.005$), magnesium ($r = 0.4$, $P = 0.02$), vitamin E ($r = 0.4$, $P = 0.002$), folate ($r = 0.5$, $P = 0.004$) (pr 10 MJ), and fresh vegetables ($r = 0.5$, $P = 0.001$). Serum magnesium correlated to relative intakes of dietary magnesium ($r = -0.4$, $P = 0.04$) and folate ($r = 0.4$, $P = 0.02$). No correlations were found between intake of iron, calcium, vitamin C, milk and meat and the biochemical indicators for iron status.

The energy intake from sugar was higher than recommended among 50% of the patients and 25% had more than 16% of their energy intake from sugar. Most of the added sugar came from soft drinks (66%).

Food intake was similar between the ileostomists and the IPAA-patients, with exception for fish intake ($P = 0.001$) (Table 4). With the exception of coffee ($P = 0.02$), consumption of foods, nutrients and meal pattern did not vary according to time since colectomy or time since FAP diagnosis (data not shown).

Elimination of foods

Fifty-three percent of the patients reported some type of dietary restrictions. Of the remaining 47%, four

Table 4 Habitual food intake (g/10 MJ) among colectomized patients with familial adenomatous polyposis (FAP) and duodenal adenomas

Dietary items	Total FAP group (n = 38)	FAP patients with:	
		Ileostomy (n = 13)	IPAA (n = 20)
Bread	159 (52, 302)	153 (55, 302)	170 (64, 286)
Potatoes	77 (1, 258)	65 (3, 258)	80 (1, 247)
Vegetables	177 (19, 914)	172 (25, 914)	205 (19, 430)
Fresh	166 (7, 896)	151 (23, 896)	191 (7, 425)
Fruit and berries	218 (6, 499)	274 (6, 434)	218 (13, 499)
Meat and meat products	155 (19, 287)	142 (53, 268)	164 (19, 287)
Fish and fish products	58 (0, 227)	90 (34, 227)	45 (0, 98)[a]
Eggs	11 (0, 88)	13 (4, 27)	10 (0, 45)
Milk and milk products	310 (0, 1355)	252 (22, 1355)	333 (0, 889)
Edible fats	41 (0, 94)	29 (5, 94)	42 (0, 76)
Drinks total	1,515 (646, 4,840)	1,499 (806, 3,697)	1,813 (646, 4,840)
Soft drinks (with sugar)	177 (0, 3,246)	166 (0, 3,246)	196 (0, 2,202)
Drinking water	399 (0, 4,240)	464 (0, 886)	424 (6, 4,240)
Coffee	210 (0, 1,716)	374 (0, 1,716)	210 (0, 1.282)

Results are presented as medians and (range)
IPAA ileal-pouch-anal anastomosis
[a]The ileostomists as compared to the IPAA-patients ($P = 0.001$)

patients reported to have a "reduced intake" of certain items. The most frequently avoided food items were oranges ($n = 9$), nuts ($n = 7$), corn ($n = 6$), apples ($n = 6$), carrot ($n = 3$), milk ($n = 3$), and asparagus ($n = 2$). Six patients avoided or had a low intake of raw vegetables. Many patients avoided more than one specific food type.

Food avoidance did not vary between IPAA and ileostomy patients, and not according to time since colectomy. No significant differences were observed in the calculated intake of energy, nutrients and foods, nor time since colectomy, among those with and without reported elimination of certain food items. Except for lower levels of serum calcium ($P = 0.03$) and serum albumin ($P = 0.001$), no differences were observed in blood levels (vitamins, minerals, lipids) among the food avoiders and the rest of the patients. We found no discrepancies between which foods the patients reported to eat in the food frequency questionnaire and reports of avoidance (data not shown).

Smoking status

Of the FAP patients, 45% reported to be never smokers, 34% ex-smokers and 21% current smokers. A positive association with smoking status was observed for coffee ($P = 0.01$) and negative associations were found for fresh fruits ($P = 0.04$), and to a lesser extent also fiber ($P = 0.08$). Serum folate was lower among smokers ($P = 0.05$) (data not shown).

Discussion

The patients were recruited from the Norwegian data base on FAP. They had all been colectomized and duodenal adenomas had been verified by endoscopy and histology. The present number of patients is close to the maximum possible number of eligible Norwegian FAP patients.

We did not include a control group for several reasons. Rikshospitalet University Hospital HF is a highly specialized university hospital with national responsibilities within complicated treatments. This group of patients is very rare, and few of them lived in our hospital catchment area. It would be practically impossible to recruit representative age- and sex matched controls from the geographic areas corresponding to the addresses of the FAP patients. However, each measured blood component was evaluated with respect to the distribution of the reference population where reference limits had been calculated. We were thus able to apply a two-sided Wilcoxon signed-rank test for the difference = patient value—reference median, to look for statistical significant level differences.

Almost 50% of the FAP patients had had a very low dietary intake of folate, but serum levels of folate were not significantly different from that of the reference population. A low dietary intake of folate is also found in other Norwegian studies [10]. The implications of a positive association between serum folat and DHA in serum phospholipids remains to be elucidated [34]. Notably, the serum levels of folate were lower in FAP patients who reported to be current smokers. Folate has been a focus of intense interest because folate deficiency may be involved in colorectal cancer carcinogenesis through increased chromosome instability, gene mutations, and aberrant DNA methylation [22]. We suggest that the underlying mechanisms should be further studied, and also that smoking habit should be taken into consideration [33].

Notably, the current smokers had a lower intake of antioxidant containing foods as compared to the nonsmokers. Current smokers reported a less healthy diet than the others, and they also had lower serum levels of folate. Since low levels of ascorbate and tocopherol previously have been found in FAP patients [9, 31], we may suggest that the combination of FAP diagnosis, tobacco and a low intake of antioxidants, should be avoided. Smoking has been recognized as an initiator and possibly also as a promotor for many cancers [8, 18]. As the FAP patients already have a mutation in the APC gene, the risk of another cancer may be even higher in the smokers. To prevent this, such patients should be recommended an antioxidant rich diet, in addition to no smoking.

Loss of the absorptive function of the colon, is associated with salt and water depletion [12, 26, 28]. Presently, soft drinks were the major contributor of added sugar (66%). The patients should instead be recommended non-sugar containing drinks or oral rehydration solutions. One may speculate that the increased levels of serum albumin may be due to dehydration since the different surgical techniques may influence the excretion of water and electrolytes. We may suggest that future studies looks into this finding in more in details.

The serum levels of ferritin and Mg were lower than expected from the reference population. Similar findings were found in a relevant study on patients with ulcerative colitis and FAP, after restorative proctocotomy [25]. Speculations concerning the present data should be avoided, but hypomagnesaemia is frequently reported in steatorrhea and in malabsorption. Hypo ferric anemia is reported in chronic pouchitis and bleeding, but may also be due to low dietary iron intake, impaired absorption and increased requirements.

Low dietary intakes were also found for iron, fiber, thiamin and riboflavin. The intake of vitamin C and food groups seems similar to the general Norwegian population [20]. The intake of omega-3 fatty acids was, however, below the recommendations among 8% of these FAP patients. Omega-3 fatty acids are important for many biological functions, and they are the precursors of prostaglandins and other eicosanoids and can modulate immune responses through modulation of the cyclooxygenase pathway [5]. FAP patients are also at an increased risk of metachronous cancers, thus maintaining a healthy dietary profile, including dietary substances that may decrease cancer risk, may be essential. Because FAP is a disease that is present from birth, the impact of nutrition may be significant for their health condition later in life. A clarification of this awaits further investigations in the future. However, as the optimal nutrient intake for colectomized FAP patients is unknown, we suggest that the nutrient intake should at least meet the official recommendations for healthy subjects [6].

Regarding the foods most frequently avoided, our results are comparable to other studies [4, 7, 13, 19, 32]. One initial concern was that fruits, berries, nuts, vegetables etc. were avoided by these patients, and that the intake of vitamins, minerals, fiber, isothiocyanates, terpenes, etc. was unfortunately low. Such substances may decrease cancer risk by several mechanisms [15]. The nutrient density did, however, not vary between those who reported to avoid some food items compared to those who did not. Although serum calcium and albumin levels were lower among the food avoiders, the median levels among the avoiders were still above the lower reference value.

These colectomized FAP patients reported a meal pattern that was similar to that of the Norwegian population [20]. This is in contrast to an older study in which ileostomy patients took more of their energy in the morning in order to minimize ileal flow at night when it could disturb sleep [7].

Colectomized patients may have an increased need of energy since the absorption of short-chain fatty acids in the large bowel does not occur. This has been calculated to contribute to 6–9% of total daily energy requirement [26]. The present energy intake seemed higher than the levels estimated from healthy subjects in other studies using the same food frequency questionnaire [2, 10, 21]. The levels of body mass index were comparable to levels of body mass index reported by other studies on colectomized patients [17, 24].

The present low levels of total cholesterol in serum are in accordance with studies on patients with different types of intestinal reconstructions [27]. This favorable serum lipid profile may be due to enhanced fecal loss of sterols, as cholesterol and bile acids, despite abnormally high cholesterol synthesis.

Studies have shown that colectomized patients have a reduced life quality [13]. For ethical reasons, we did not want to burden these patients with extensive dietary assessment methods, and we only scheduled one appointment for data collection for the present study. Although FFQ is an unreliable method to assess dietary intake at the individual level, this method was chosen for the present purpose. The FFQ aims to cover habitual long time dietary exposure. A general tendency of over reporting healthy dietary items and underreporting unhealthy dietary items cannot be excluded. The validity of dietary intake data can always be questioned. However, FFQ was not used as a self-administrated method. In order to increase the quality of the dietary data, the subjects were given individual appointments with a nutritionist at the hospital, in which each FFQ was checked in order to check for misunderstandings, missing data, etc. Moreover, they were asked to identify their habitual choices of edible fats by pointing at specially prepared pictures, in order to increase the quality of the estimate of the intake of dietary fat.

In conclusion, we found that the serum albumin levels were significantly higher, and the serum Mg, ferritin and cholesterol levels significantly lower, as compared to the reference population. Low dietary intakes were observed to some extent for several micronutrients and omega-3 fatty acids. Approximately 50% reported food avoidance to some extent. The intake of sugar was too high, mainly due to consumption of soft drinks. Their optimal nutrient intake is unknown, but we may suggest that the intake should at least meet the official recommendations for healthy subjects. Nevertheless, due to the young age of FAP patients with a hopefully long life expectancy, their risk of metachronous cancers should cause special attention to dietary factors that may prevent nutritional deficiency and inhibit or prevent carcinogenesis.

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