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Dietary Habits and Nutrient Intake in Patients with Inflammatory Bowel Disease

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Abstract

Patients with inflammatory bowel diseases (IBD) are often affected by nutrient deficiencies. Besides a limited nutrient intake by disease-related side effects and malabsorption, the influence of diets and dietary changes is much discussed. However, data about food patterns are mostly based on subjective declarations. Therefore, this study aimed to achieve a detailed and objective analysis of nutrient intake and individual food habits in IBD, a prerequisite for an appropriate nutritional intervention in risk patients. One hundred IBD patients (n=70 Crohn's disease (CD), n=30 ulcerative colitis (UC)) and 30 healthy controls (HC) were included in the study. All participants filled in a disease-related and food frequency questionnaire. Fifteen healthy controls and 71 IBD patients additionally completed a questionnaire for self-imposed food restrictions. Most IBD patients and healthy controls showed a normal body mass index. However, within the IBD group, UC patients were more often overweight than CD patients ($p=0.007$). Food restrictions were common in all participants, but significantly more IBD patients restricted their consumption of fast food ($p=0.037$), fruits and vegetables ($p=0.019$). Especially CD patients with acute relapse consumed less fruits and vegetables ($p=0.035$). Contrary to subjective assessment, an objective survey of dietary intake revealed a significantly higher sugar intake of IBD patients compared to healthy controls ($p<0.001$) with an increased ingestion of sugar/confectionery ($p=0.041$), soft/isotonic drinks ($p<0.001$) and fruit/vegetable juices ($p=0.022$). Additionally, IBD patients ingested higher amounts of salt than healthy controls ($p=0.005$). Both groups showed an insufficient ingestion of folate, vitamin D and pantothenic acid.

In conclusion, self-managed food restrictions appear to be common in IBD patients. The huge discrepancy between the subjective view of dietary habits and objective evaluation of nutrient intake indicates that nutrient assessment should be based on objective tools. A repetitive professional nutritional counseling is recommended to prevent and treat nutritional deficiencies.

Keywords: Inflammatory bowel disease; Crohn's disease; Ulcerative colitis; Nutrient intake; Nutrient deficiencies

Abbreviations: IBD: Inflammatory Bowel Disease; CD: Crohn's Disease; UC: Ulcerative Colitis; -R: In remission; -A: With Active Disease; HC: Healthy Controls; FFQ: Food Frequency Questionnaire; CRP: C-Reactive Protein; BMI: Body Mass Index; BW: Body Weight; BH: Body Height; SD: Standard Deviation; ANOVA: Analysis Of Variances; DACH: German Nutrition Society (DGE), Austrian Nutrition Society (ÖGE) and Swiss Society for Nutritional Research (SGE); TE: Total Energy; FODMAP: fermentable oligo-, di-, monosaccharides and polyols; LA: Linolic Acid; ALA: α-Linoleic Acid; FA: Fatty Acid; EPA: Eicosapentaenoic Acid; DHA: Docosahexaenoic Acid

Introduction

The prevalence of inflammatory bowel diseases (IBD), especially Crohn's disease (CD) and ulcerative colitis (UC), has risen over the past years in the Western and developing countries [1,2]. Even though many advances in investigating IBD were achieved, the disease pathogenesis remains in part unclear. Genetics, microbiota and especially the "Western style diet" might have a major influence on disease onset and progress [3-5].

Patients with inflammatory bowel disease are commonly associated with a low body weight linked to the risk for malnutrition and nutrient deficiencies [6-8]. Disease-induced changes of the small intestinal function, e.g. malabsorption and maldigestion can interfere with nutrient uptake and nutrition. In particular, patients with active disease status may suffer from a nutrient deficiency [9-14]. Malnutrition can also be caused by a reduced food intake, e.g. as a result of gastrointestinal discomfort, food intolerance or restrictive dietary advices, which further enhance the disease pathology [9,10].

IBD patients not only have an increased risk of malnutrition, but the diet itself seems to play a significant role in the course of the disease. Food intolerances can intensify the patients' symptoms and promote inflammation of the intestinal tract. That is why patients tend to avoid foods which they associate with intolerance. Interestingly, Zallot et al. showed that about 67% of IBD patients restrict the consumption of certain foods to avoid a disease relapse [11]. Fiber-rich foods, fruits and vegetables, dairy, alcohol or processed meat were often suspected by patients with IBD to worsen their symptoms [11,12].

Although IBD patients show an increased prevalence of food intolerances and allergies, the detection is very difficult due to limited diagnostic possibilities. Thus, the patients themselves often remove probable unfavorable foods from their diet. However, the avoidance of many nutrient-rich foods has some negative effects on patient health caused by an inadequate intake of important nutrients and a diminished quality of life [11,13-15].

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A long-lasting restriction or even exclusion of these food groups enhances the risk for nutrient deficiencies. Especially the omission of certain fruits, vegetables or dairy without professional dietary advice can contribute to an insufficient intake of vitamins and minerals. Since patients with IBD often present with various micronutrient deficiencies, particularly for iron, calcium, zinc or vitamin B12, folate and vitamin D, an inadequate nutrition might further impair the progression of the disease [16]. In consequence, complications of micronutrient deficiencies, including anemia and osteoporosis, are often diagnosed and are associated with a poor disease outcome, growth retardation in children, longer hospitalization time and increased morbidity [17].

Interestingly, a preference for certain foods is assumed in IBD patients. Particularly the consumption of sugary foods is suspected to be increased [18,19]. However, intake of other food components such as fat and protein and fast foods also seem to influence the onset and course of IBD [20-23].

Consequently, an adequate nutrient supply in accordance with the patient's nutritional preferences is important for the recovery and for preventing or at least alleviating disease relapses in IBD patients. So far, some studies examined the consumption of different foods and beverages based on subjective patient description, but data with accurate amounts of nutrient supply are still missing.

The aim of this study was to provide a detailed, objective and valid analysis of the regular intake of food and beverages in IBD patients in order to obtain reliable data about existing intolerances, preferred or restricted foods, nutritional quality and the influence of the disease status on nutrient intake. Based on this knowledge, a professional nutritional counseling can be adapted most effectively and nutritional disorders might be prevented.

Materials and Methods

Patients and study design

The cross-sectional study was conducted on patients with IBD, including Crohn´s disease (CD) and ulcerative colitis (UC), who attended to the outpatient clinic for IBD of the Department of Internal Medicine, University Hospital Erlangen, between October 2013 and January 2016. One hundred patients with IBD (70 CD patients and 30 UC patients) and 30 healthy controls (HC) were included in the study. Age-matched healthy controls were randomly recruited from the circle of friends or colleagues.

Every IBD patient was asked to complete questionnaires about demographic features, disease activity, medical therapy and nutritional status. In addition, the nutrient intake of all study participants was recorded by a self-administered food frequency questionnaire (FFQ). A supplementary questionnaire of self-introduced food restrictions was used in a subgroup of all participants, who were willing to complete this questionnaire.

All participants were informed by a medical doctor about the purpose and procedure of the study and gave their informed written consent prior to study inclusion.

Disease status

To assess the impact of disease status with nutrient uptake, the disease activity was determined with the Harvey-Bradshaw index (HBI-Score) [24] for Crohn´s disease and the Mayo Score [25], including clinical and endoscopic subscores, for ulcerative colitis. A HBI-or Mayo score over five were considered as active disease, scores below as remission.

C-reactive protein (CRP) was measured for evaluation of systemic inflammation.

Dietary assessment

For dietary assessment a self-administered FFQ designed and established for the German part of the European Prospective Investigation into Cancer and Nutrition (EPIC) study was applied. This FFQ provides a validated tool for the retro-perspective acquisition of food frequencies from the past twelve months. Foods are represented by 158 items categorized in 16 food groups and illustrated pictures demonstrating the portion size [26]. The filled in forms were sent to the German Institute of Nutritional Research Potsdam-Rehbrücke for optical scan and evaluation. A computer-assisted analysis (EPIC-Soft program) calculated the levels of 16 food groups as well as the mean uptake of calories and 135 nutrients based on the data of the German Food Code [27]. They include the general macronutrients (i.a. carbohydrates, fat, protein, fibers, minerals and alcohol), fatty acids, amino acids, special carbohydrates, trace elements, vitamins and dietary fibers. Additionally, self-imposed food restrictions in the last 12 months were recorded and categorized in main food groups (dairy products, fast food, fruits and vegetables, meat and meat products, pastries and pasta, soft drinks, sweets and snacks).

Nutritional status

The body weight (BW) and height (BH) were measured to determine the nutritional status. The body mass index (BMI) was calculated according to: BMI [kg/m²]=BW [kg]/(BH × BH [m²]). According to the BMI-classification of the World Health Organization (WHO), a BMI less than 18.5 kg/m² was considered as underweight, between 18.5 kg/m² to 25.0 kg/m² as normal weight, between 25.0 kg/m² to 30.0 kg/m² as overweight (pre-obese) and over 30.0 kg/m² as obese [28-45].

Two questions about the percentage of weight loss and reduced food intake in the past three months intended to identify the risk for malnutrition.

Statistical analysis

For statistical analysis, IBM® SPSS® Statistics Version 21.0 and GraphPad Prism 7 (GraphPad Software, Inc.) was used. All data are described as means ± standard deviation (SD) or in number (n) and percent (%). The data were checked by Kolmogorov-Smirnov-test for normal distribution. Differences between IBD patients and healthy controls were determined using the Mann-Whitney-U-Test for non-parametric and the unpaired t-test for parametric data. The Chi-square test was used for frequencies comparisons of study groups. Multiple comparisons between different IBD subtypes (CD and UC) or disease statuses (active disease and remission) and healthy controls were carried out by analyses of variances (ANOVA) or Kruskal-Wallis-test. Post-hoc analyses of multiple comparisons were corrected by Bonferroni and Dunn-Bonferroni method.

A p-value of $p<0.05$ was considered as significant.

Results

Characteristics

The study comprises a total of 100 patients with IBD (39.5 ± 14.6 years, 39 men and 61 women). 70 patients were diagnosed with Crohn`s disease and 30 patients suffered from ulcerative colitis. Additionally, 30 age- and gender-matched healthy controls (43.0 ± 19.2 years, 11 men and 19 women) were included in the study. The characteristics of the study participants are

listed in (Table 1). Both study groups showed no significant differences in age or gender, with women predominating in each group.

The patients' characteristics of the IBD subtypes (CD and UC) are shown in (Table 2). Although there were more male patients with UC (50% vs. 34.3%) in comparison to patients with CD, these data reached no significance (p=0.140). No differences in alcohol and nicotine abuse could be found. The mean disease duration (p=0.246) and the CRP level (p=0.441) showed no significant differences. 51.4% of the CD patients had intestinal fistulae and 60.0% already underwent a bowel resection, whereas only two patients with UC reported a bowel resection. Concerning the use of medication, there were no differences within the IBD group, except for the anti-inflammatory drug 5-aminosalicylic acid (mesalazine), which was used by significantly more patients with UC than with CD (p<0.001).

Parameter	HC (n=30)	Total IBD (n=100)	p-value
Age [years]	43.0 ± 19.2	39.5 ± 14.6	0.36
Male [n (%)]	11 (36.7)	39 (39.0)	0.818
Female [n (%)]	19 (63.3)	61 (61.0)	0.818
Body weight [kg]	70.11 ± 11.00	68.22 ± 14.09	0.501
Height [m]	1.72 ± 0.08	1.71 ± 0.09	0.501
BMI [kg/m²]	23.56 ± 2.95	23.20 ± 3.78	0.637

Data are presented as mean ± standard deviation or number (percent). Group differences were calculated by Mann-Whitney-U-test or Chi-square-test.
Abbreviations: BMI: Body Mass Index; HC: Healthy Controls; IBD: Inflammatory Bowel Disease; n: Number

Table 1: Characteristics of the study participants.

Parameter	CD (n=70)	UC (n=30)	p-value
Age [years]	39.7 ± 14.9	39.0 ± 14.32	0.83
Male	24 (34.3)	15 (50.0)	0.14
Female	46 (65.7)	15 (50.0)	0.14
Body weight [kg]	**66.0 ± 13.6**	**73.5 ± 14.0**	**0.014**
Body height [m]	1.71 ± 0.09	1.72 ± 0.09	0.48
BMI [kg/m²]	**22.55 ± 3.68**	**24.73 ± 3.63**	**0.008**
Alcohol consumption	58 (82.9)	22 (73.3)	0.275
Smoking	10 (14.3)	6 (20.0)	0.475
Disease characteristics			
Disease duration [years]	15.8 ± 14.6	9.4 ± 6.7	0.246
Disease state [active/remission]	20 (43.5) / 26 (56.5)	8 (33.3) / 16 (66.7)	0.411
Harvey-Bradshaw-Index (HBI)	5.7 ± 4.6	-	-
Mayo-score	-	3.9 ± 3.7	-
Clinical subscore	-	1.4 ± 1.9	-
Endoscopic subscore	-	1.4 ± 1.0	-
CRP [mg/dl]	6.27 ± 9.78	13.31 ± 35.38	0.441
Disease affected regions			
Colon	**52 (74.3)**	**30 (100.0)**	**0.002**
Small intestine	**55 (78.6)**	**0 (0.0)**	**<0.001**
Colon and small intestine	**35 (50.0)**	**0 (0.0)**	**<0.001**
Disease complications			
Fistulae	**36 (51.4)**	**0 (0.0)**	**<0.001**
Bowel resection	**42 (60.0)**	**2 (6.7)**	**<0.001**
Medication	66 (94.3)	29 (96.7)	0.617
Cortisone	15 (21.4)	5 (16.7)	0.585
Dosage [mg]	8.46 ± 4.91	20.00 ± 20.41	0.342
Mesalazine	**6 (8.6)**	**14 (46.7)**	**<0.001**
Methotrexate	2 (2.9)	0 (0.0)	0.35
Azathioprine	11 (15.7)	1 (3.3)	0.081
TNF-α-Antibodies	43 (64.1)	23 (76.7)	0.14
Nutritional status			
Weight loss in the past 3 months?	22 (31.4)	6 (20.0)	0.243
Reduced food intake in the past 3 months?	9 (12.9)	4 (13.3)	0.948
Loss of appetite	16 (22.9)	3 (10.0)	0.133

Data are presented as mean ± standard deviation or number (percent). Group differences were calculated by Mann-Whitney-U-test or Chi-square-test.
Abbreviations: BMI: Body Mass Index; CD: Crohn's Disease; CRP: C-Reactive Protein; HBI: Harvey-Bradshaw-Index; IBD: Inflammatory Bowel Disease; n: number; TNF-α: Tumor Necrosis Factor Alpha; UC: Ulcerative Colitis

Table 2: Demographic and disease characteristics of the IBD patients.

Patients were also asked for weight loss or a reduced nutritional intake during the last three months. In total, 28% of the IBD patients lost more than 5% of their body weight in the past 3 months. A reduced food intake and loss of appetite were mentioned by 13% and 19% of the IBD patients, respectively. However, no significant differences were observed between the two IBD groups (Table 2).

Concerning all study participants, the mean BMI did not differ between the entire group of patients with IBD and the control group (p=0.637). However, patients with CD presented significantly more often with a BMI ≤ 18.5 compared to HC (12.9% vs. 0%) and significantly less UC patients had a normal weight (46.7% vs. 73.3%)

Within the IBD group, the BMI of CD patients was significantly lower compared to UC patients (p=0.008) and about 13% of the CD patients were underweight (Tables 2 and 3). 50% of UC patients showed an increased BMI>25.0 and 40% presented with pre-obesity (BMI>25-30), which was significantly elevated in comparison to CD patients (p=0.007). IBD patients with bowel resection showed a significantly lower BMI compared to those without surgical intervention (22.3 ± 3.6 vs. 23.9 ± 3.8 kg/m^2; p=0.027), but there were no differences relating to active or remission status and BMI in IBD patients (data not shown).

Dietary habits-Nutrition survey (FFQ)

The nutrition survey revealed that both IBD patients and healthy controls preferred a mixed diet including meat, fish and other animal-derived foods. Two healthy controls and one IBD patient were vegetarian and one IBD patient was vegan.

More patients with IBD than healthy controls changed their dietary habits in the past (38.0% vs. 16.7%; p=0.068), reaching significance between CD patients and HC (p=0.021). The main reasons for dietary changes were gastrointestinal afflictions like stomach pain, intestinal complaints and indigestions (e.g. bloating, flatulence or abdominal distension). Other reasons for dietary modifications were food intolerances or allergies, weight gain and metabolic disorders like glucose intolerance and diabetes mellitus, hyperlipidemia or hypertension (Table 4).

IBD patients used dietary supplements more often than HC. One-third of the HC and almost half (47%) of the IBD patients took some kind of supplements in addition to their normal diet (Table 4).

Self-imposed food restrictions

We further determined the self-imposed restriction of foods and beverages. Fifteen healthy controls and 71 IBD patients completed the corresponding questionnaire and were included for analysis. The items are listed in Table 5. Interestingly, significantly more HC avoided the consumption of biscuits (p=0.030) in comparison to the IBD group and especially patients with UC rarely eliminated biscuits from their food list (p=0.025) (Table 5). A lot of participants in both groups (HC vs. IBD) avoided sweets (46.7 vs. 40.8%), chocolate (40.0 vs. 39.4%), chips (26.7 vs. 39.4%) and soft drinks like lemonade, cola or ice tea (20.0 vs. 36.6%).

After classifying the foods and beverages to food groups, a high proportion of the IBD group ate less fast food (p=0.029) (Table 6) and mainly patients with CD often strictly limited themselves to the consumption of hamburger (p=0.047), kebab (0.037) and pizza (p=0.047) compared to HC (Table 5). In regard to the information given by the patients, a significantly increased number of patients with UC minimized white bread compared to the CD patients (p=0.003) (Table 5).

IBD patients also indicated to eat less fruits and vegetables than HC (p=0.019). In terms, 14.1% of IBD patients avoided the consumption of apples, 7.0% of banana, 4.2% of strawberries, 11.3% of broccoli, 8.5% green or raw vegetable salad and 5.6% did not eat carrots. In comparison, only one healthy control eliminated apples from the diet (6.7%). Apart from fast food and fruits or vegetables, no differences in the self-imposed restrictions of the other food groups were observed between the HC and IBD group (Table 6).

Interestingly, IBD patients and especially the patients with CD, tried twice as often to restrict certain foodstuff than healthy persons (2.8 ± 2.1 vs. 1.5 ± 1.8 attempts; p=0.002) (Table 5). Regarding the disease status, there were also significant food-related differences within the IBD group (Figure 1 and supplementary tables 1 and 2). The self-imposed restriction of fruits and vegetables was significantly higher in IBD patients with active disease (IBD-A, n=22) compared to remission status (IBD-R, n=22) with 63.6 vs. 31.8% (p=0.035). Especially CD patients in active status (CD-A, n=17) of the disease compared to patients in remission (CD-R, n=17) claimed to reduce the ingestion of items of the fruit and vegetable food group (70.6 vs. 29.4%; p=0.016) (Supplementary Table 1). Thereby, CD-A patients significantly restricted the consumption of green and raw vegetable salad (31.2 vs. 0.0%; p=0.012), but also limited the eating of apple (29.4 vs. 5.9%; p=0.072) and banana (17.6 vs. 0.0%; p=0.070) (Supplementary Table 2). In contrast, more CD-R patients minimized the intake of ice cream (29.4 vs. 0.0%; p=0.019) and hamburgers (35.3 vs. 5.9%; p=0.015) compared to CD-A patients. Interestingly, there were no differences between disease status and the self-imposed restriction of foods or beverages in the UC group.

Valid and differentiated analysis of the daily intake of nutrients

The total and relative amounts of 16 food groups were analysed in order to monitor differences in the food composition between the study

BMI range [kg/m²]	Definition	HC	Total	IBD	
			IBD	CD	UC
BMI ≤ 18.5	underweight	**0 (0.0)**$^+$	10 (10.0)	**9 (12.9)**$^+$	1 (3.3)
BMI 18.5-25.0	normal weight	**22 (73.3)**$^+$	59 (59.0)	45 (64.3)	**14 (46.7)**$^+$
BMI>25.0	overweight	8 (26.7)	31 (31.0)	**16 (22.9)**$^{\#\#}$	**15 (50.0)**$^{\#\#}$
BMI>25.0-30.0	*pre-obesity*	8 (26.7)	24 (24.0)	**12 (17.1)**$^{\#}$	**12 (40.0)**$^{\#}$
BMI>30.0	*obesity*	0 (0.0)	7 (7.0)	4 (5.7)	3 (10.0)

Data are presented as number (percent). Group differences were calculated by Chi-square-test.
Abbreviations: BMI: Body Mass Index; CD: Crohn's Disease; HC: Healthy Controls; IBD: Inflammatory Bowel Disease; UC: Ulcerative Colitis
Significances:
$^+$p<0.05 comparison healthy controls and CD or UC patients
$^{\#}$ p<0.05 comparison CD and UC patients; $^{\#\#}$ p<0.01 comparison CD and UC patients

Table 3: BMI classification HC and IBD.

	HC	Total IBD	IBD	
			CD	UC
Nutrition [n (%)]				
Mixed	28 (93.3)	98 (98.0)	69 (98.6)	29 (96.7)
Vegetarian	2 (6.7)	1 (1.0)	1 (1.4)	0 (0.0)
Vegan	0 (0.0)	1 (1.0)	0 (0.0)	1 (3.3)
Dietary change	**5 (16.7)$^{+}$**	38 (38.0)	**31 (44.3)$^{+}$**	7 (25.9)
Partly	5 (16.7)	31 (31.0)	24 (34.3)	7 (23.3)
Completely	0 (0.0)	7 (7.0)	7 (10.0)	0 (0.0)
Reasons				
Gastrointestinal symptoms	1 (20.0)$^{**/+}$	30 (78.9)**	24 (77.4)$^{+}$	6 (85.7)$^{+}$
Indigestions	1 (20.0)	16 (42.1)	14 (45.2)	2 (28.6)
Intestinal complaints	**0 (0.0)$^{**/++}$**	**28 (73.1)****	**22 (71.0)$^{++}$**	**6 (85.7)$^{++}$**
Stomach trouble	1 (20.0)	8 (21.1)	8 (25.8)	0 (0.0)
Food intolerance or allergy	2 (40.0)	12 (31.6)	10 (32.3)	2 (28.6)
Weight related	1 (20.0)	15 (39.5)	11 (35.5)	4 (57.1)
Weight gain	1 (20.0)	9 (23.7)	8 (25,8)	1 (14.3)
Overweight	0 (0.0)	7 (18.4)	4 (12.9)	3 (42.9)
Hypertension	0 (0.0)	3 (7.9)	3 (9.7)	0 (0.0)
Hyperlipidemia	0 (0.0)	1 (2.6)	1 (3.2)	0 (0.0)
Use of dietary supplements	10 (33.3)	47 (47.0)	36 (51.4)	11 (36.7)
Vitamins	2 (6.7)	6 (6.0)	4 (5.7)	2 (6.7)
Minerals	1 (3.3)	4 (4.0)	4 (5.7)	0 (0.0)
Vitamins and minerals	1 (3.3)	15 (15.0)	11 (15.7)	4 (13.3)
Bran, linseed	1 (3.3)	4 (4.0)	4 (5.7)	0 (0.0)
Cranberry extracts	0 (0.0)	2 (2.0)	2 (2.9)	0 (0.0)
St. John's wort	0 (0.0)	1 (1.0)	1 (1.4)	0 (0.0)
Fish oil	1 (3.3)	3 (3.0)	1 (1.4)	2 (6.7)
Other supplements	0 (0.0)	6 (6.0)	4 (5.7)	2 (6.7)

Data are presented as number (percent). Group differences were calculated by Chi-square-test.
Abbreviations: CD: Crohn's Disease; HC: Healthy Controls; IBD: Inflammatory Bowel Disease; n: Number; UC: Ulcerative Colitis
Significances:
** p<0.001 comparison healthy controls and IBD patients
$^{+}$p<0.05 comparison healthy controls and CD or UC patients; $^{++}$p<0.001 comparison healthy controls and CD or UC patients

Table 4: Nutrition survey.

groups (Table 7). All study participants consumed similar amounts of non-alcoholic beverages including water, coffee and tea, soft drinks and juices, whereas alcoholic beverages like wine, beer or liquors were predominantly consumed by healthy controls (p<0.001). Of particular interest was the significantly increased daily amount of sugar and confectionary by IBD patients compared to healthy controls (p=0.041). The intake amount of items of the other food groups including dairy, cereal products, meat, fruits and vegetables, did not differ between HC and IBD patients.

Macronutrients

The amounts of macronutrient intake was similar in all study groups (Table 8), but the daily energy intake was increased in IBD patients compared to healthy controls (p=0.120). After correlation of the calorie intake with the body weight (BW), significant differences became obvious (p=0.016) (Table 8).

No major differences were observed in fat and protein intake, but the total carbohydrate intake was significantly pronounced in the IBD group compared to HC (p<0.001) (Table 8). Nevertheless, the percentage of the daily carbohydrate intake did not reach the recommendations of the German Nutrition Society (DGE), Austrian Nutrition Society (ÖGE) and Swiss Society for Nutritional Research (SGE), abbreviated as DACH, with 50%-55% carbohydrates, whereas all groups consumed more fat than the recommended amount, which is 30% referred to the daily total food intake (see Figure 2). Compared to DACH reference values of 30 g fibers per day, the fiber intake was reduced in both study groups.

No differences were noticed in water consumption, but the total alcohol intake was significantly reduced in IBD patients compared to HC (p=0.004). Especially CD patients showed a significantly diminished alcohol intake compared to HC group (p=0.012) (Table 7). Noteworthy, especially patients with IBD-R and UC-R consumed increased amounts of organic acids (e.g. fruit acids) compared to HC (p=0.002 and p=0.003, respectively) (Supplementary Tables 3, 4 and 5).

Carbohydrates and sugar-containing foods

Compared to healthy controls, IBD patients consumed more carbohydrates (p<0.001), which was mainly reflected by a significant higher daily intake of mono-and disaccharides (Table 9). This includes a higher amount of glucose (p=0.001), fructose (p=0.001) and sucrose (p<0.001). Even the intake of the polysaccharide starch was increased in the IBD group (p=0.032) and IBD patients ingested more sugar polyols, especially sorbitol, compared to the healthy controls (p=0.016). The eating of other carbohydrates, like absorbable or non-absorbable oligosaccharides and fibers, did not differ between IBD patients and HC (Table 9).

Food or beverage	HC	Total IBD	IBD	
	(n=15)	(n=71)	CD (n=55)	UC (n=16)
Apples	1 (6.7)	10 (14.1)	8 (14.5)	2 (12.5)
Banana	0 (0.0)	5 (7.0)	4 (7.3)	1 (6.2)
Biscuits	**6 (40.0)**$^{*/+}$	**11 (15.5)***	10 (18.2)	**1 (6.2)**$^{+}$
Broccoli	0 (0.0)	8 (11.3)	7 (12.7)	1 (6.2)
Buns	2 (13.3)	17 (23.9)	13 (23.6)	4 (25.0)
Cake	3 (20.0)	15 (21.1)	12 (21.8)	3 (18.8)
Carrots	0 (0.0)	4 (5.6)	4 (7.3)	0 (0.0)
Chips	4 (26.7)	28 (39.4)	21 (38.2)	7 (43.8)
Chocolate	6 (40.0)	28 (39.4)	21 (38.2)	7 (43.8)
Crackers	3 (20.0)	8 (11.3)	7 (12.7)	1 (6.2)
Deli-style salad	0 (0.0)	11 (15.5)	10 (18.2)	1 (6.2)
French fries	1 (6.7)	19 (26.8)	16 (29.1)	3 (18.8)
Green salad, raw vegetable salad	0 (0.0)	6 (8.5)	6 (10.9)	0 (0.0)
Hamburger	**0 (0.0)**$^{+}$	14 (19.7)	**12 (21.8)**$^{+}$	2 (12.5)
Ice cream	1 (6.7)	14 (19.7)	10 (18.2)	4 (25.0)
Kebab	**0 (0.0)**$^{*/+}$	**17 (23.9)***	**13 (23.6)**$^{+}$	**4 (25.0)**$^{+}$
Lemonade, cola and ice tea	3 (20.0)	26 (36.6)	20 (36.4)	6 (37.5)
Meat	1 (6.7)	7 (9.9)	6 (10.9)	1 (6.2)
Pasta	1 (6.7)	4 (5.6)	4 (7.3)	0 (0.0)
Pizza	**0 (0.0)**$^{+}$	15 (21.1)	**12 (21.8)**$^{+}$	3 (18.8)
Rice	0 (0.0)	1 (1.4)	1 (1.8)	0 (0.0)
Salt sticks	2 (13.3)	3 (4.2)	3 (5.5)	0 (0.0)
Sausage	2 (13.3)	14 (19.7)	10 (18.2)	4 (25.0)
Strawberries	0 (0.0)	3 (4.2)	1 (1.8)	2 (12.5)
Sweets	7 (46.7)	29 (40.8)	23 (41.8)	6 (37.5)
White bread	2 (13.3)	13 (18.3)	**6 (10.9)**$^{\#\#}$	**7 (43.8)**$^{\#\#}$
Others	4 (26.7)	18 (25.4)	13 (23.6)	5 (31.3)
(e.g. Butter, dairy, nuts, wheat flour, potatoes, sugar, pork, oranges, peppers, Sauerkraut, energy drinks)				
Number of attempts to restrict foods or beverages?	**1.5 ± 1.8****	**2.8 ± 2.1****	**3.0 ± 2.0**$^{\#}$	**2.1 ± 2.1**$^{\#}$

Data are presented as number (percent). Group differences were calculated by Chi-square-test.
Abbreviations: CD: Crohn's Disease; HC: Healthy Controls; IBD: Inflammatory Bowel Disease; n: Number; UC: Ulcerative Colitis
Significances:
* p<0.05 comparison healthy controls and IBD patients; **p<0.01 comparison healthy controls and IBD patients
$^{\#}$ p<0.05 comparison CD and UC patients; $^{\#\#}$ p<0.01 comparison CD and UC patients

Table 5: Self-restricted foods and beverages of the study participants.

With regard to disease activity, patients with IBD in remission (IBD-R; n=42) and IBD in active status (IBD-A; n=28) consumed significantly more carbohydrates than HC (p=0.008). The group of patients with IBD-R ingested more monosaccharides than HC (p=0.010), with high amounts especially consumed by patients with UC-R. Intriguingly, both groups (IBD-R and IBD-A) consumed significantly more disaccharides than the HC (p=0.015). All patient groups (CD-R, CD-A, UC-R and UC-A) showed increased intake of sucrose (for more detailed analysis Supplementary Tables 3, 4 and 5).

Foodstuffs	HC	Total IBD	IBD	
	(n=15)	(n=71)	CD (n=55)	UC (n=16)
Dairy products	2 (13.3)	3 (4.2)	2 (3.6)	1 (6.2)
Fast food	**1 (6.7)**$^{*+}$	**25 (35.2)***	**21 (38.2)**$^{+}$	4 (25.0)
Fruits and vegetables	**1 (6.7)***	**27 (38.0)***	22 (40.0)	5 (31.2)
Meat and meat products	4 (26.7)	14 (19.7)	11 (20.0)	3 (18.8)
Pastries and pasta	7 (46.7)	34 (47.9)	26 (47.3)	8 (50.0)
Soft drinks	3 (20.0)	27 (38.0)	21 (38.2)	6 (37.5)
Sweets and snacks	8 (53.3)	51 (71.8)	40 (72.7)	11 (68.8)

Data are presented as number (percent). Group differences were calculated by Chi-square-test.
Abbreviations: CD: Crohn's Disease; HC: Healthy Controls; IBD: Inflammatory Bowel Disease; n: Number; UC: Ulcerative Colitis
Significances:
* p<0.05 comparison healthy controls and IBD patients
$^{+}$p<0.05 comparison healthy controls and CD patients

Table 6: Restriction of food groups.

Since the sugar consumption was strikingly increased in patients with IBS compared to HC, it was of interest to identify the main sugar sources (see Figure 3).

Remarkably, IBD patients consumed significantly more soft or isotonic drinks than HC (268.2 ± 486.0 vs. 50.3 ± 137.8 g/d; p<0.001), fruit and vegetable juices (174.4 ± 300.4 vs. 94.0 ± 93.6 g/d; p=0.022) and sugar and confectionery (8.1 ± 13.5 vs. 6.12 ± 10.71 g/d; p=0.043). This resulted in a significant increase in mono-and disaccharide intake caused by soft and isotonic drinks (13.3 ± 26.5 vs. 2.9 ± 8.1 g/d; p=0.002 and 5.5 ± 11.0 vs. 1.2 ± 3.4 g/d; p=0.002), fruit and vegetable juices (10.4 ± 19.3 vs. 4.6 ± 4.3 g/d; p=0.006 and 8.6 ± 16.0 vs. 3.8 ± 3.9 g/d; p=0.007) and sugar and confectionery (disaccharides: 3.8 ± 7.3 vs. 2.6 ± 4.8 g/d; p=0.015) compared to HC.

Fat, lipids and proteins

The evaluation of lipid and fat revealed no significant difference in the intake of cholesterol, glycerol or total fatty acid between the HC and IBD group (Supplementary Table 6). However, cholesterol intake was increased in all participants (by about 25%) compared to DACH recommendations of 300 mg per day. Furthermore, the ratio of the essential omega-6 (n-6) and omega-3 (n-3) fatty acids linolic (LA) and α-linolenic acid (ALA) of 7:1, was higher than the recommended ratio of 5:1 (LA:ALA).

The total protein intake was similar in both study groups, but IBD patients ingested more proteins from vegetables than the healthy controls (p=0.013) (Supplementary Table 7).

Vitamins, minerals and other trace elements

The intake of fat-and water-soluble vitamins was almost equal in IBD patients and healthy controls and no significant differences were observed (Table 10). The study participants reached most of the vitamin levels recommended by DACH. A very high intake of vitamin K was noticed in all groups, with a fourfold higher amount than the advised value (60-70 µg). However, daily intake of Vitamin D, Vitamin B3 (pantothenic acid) and folate did not reach the recommendations of 20 µg, 6 mg and 300 µg per day, respectively.

There were differences in the daily intake of minerals and other trace elements between IBD patients and healthy controls (Table

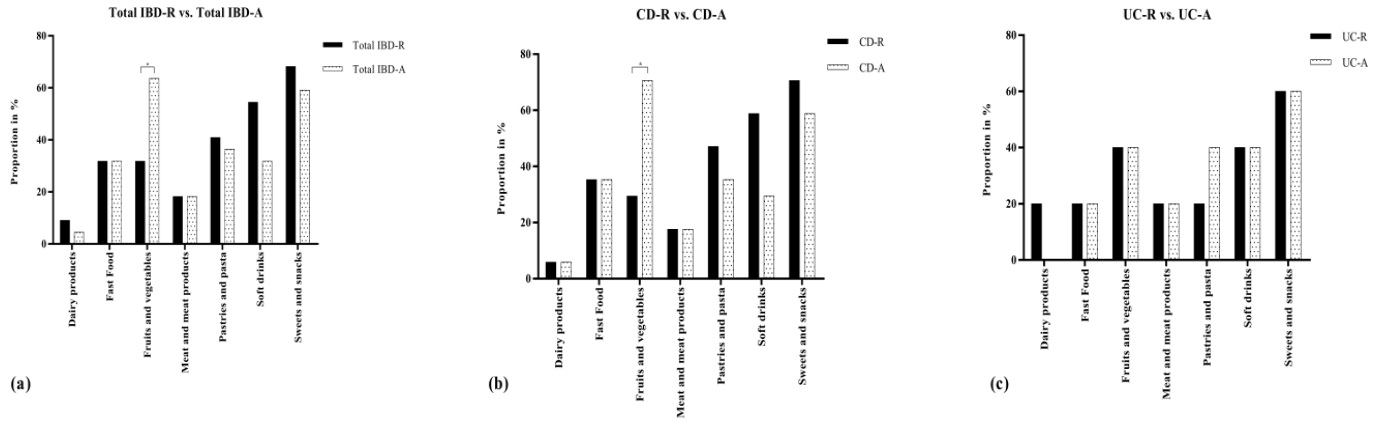

Figure 1: Restriction of food groups and disease status: Comparison of the self-imposed restriction of different foods groups with disease status in IBD patients. Figure (a) shows the proportions of food restrictions in the total IBD group. Restriction of fruits and vegetables is significantly higher in the IBD-A than in the IBD-R group (*p=0.035). Figure (b) shows proportions of food restrictions between CD disease statuses. Restriction of fruits and vegetables is significantly higher in CD-A group compared to the CD-R (*p=0.016). Figure (c) shows no significant difference in the proportions of food restrictions between the different UC groups.

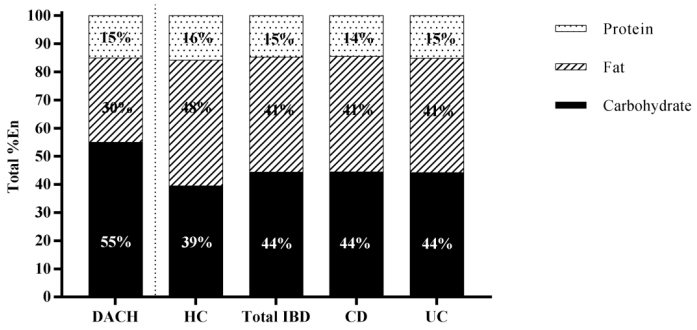

Figure 2: Macronutrients energy distribution: The bars show percentages of carbohydrates referred to the total daily energy intake (TE). The first bar presents the DACH reference values of total energy percent. No differences between study groups were observed. The carbohydrate percentage was lower in all study groups compared to the recommended values of the DACH with about 55% of TE. Fat percentage was higher than DACH recommendations of max. 30% TE. Protein percentage with about 15% TE was adequate in all study groups. Abbreviations: %En: Energy Percent; TE: Total Energy

11). Patients with IBD ingested more copper (p=0.049). There was also a significantly increased consumption of common salt (sodium chloride) in the IBD group compared to healthy controls (p=0.005) and specifically patients with UC showed a significant higher intake of salt compared to the HC group (p=0.026).

With regard to disease status, IBD patients in remission consumed distinctly more salt compared to healthy controls (p=0.046) (Supplementary Table 3) and especially patients with CD-R and CD-A showed a significant higher salt intake than HC (p=0.044) (Supplementary Table 4).

Discussion

To our knowledge, this study provides the first differentiated and detailed objective analysis of nutrient uptake including dietary habits and disease status of patients with inflammatory bowel disease compared to healthy controls.

The majority of our IBD patients showed a normal BMI indicating that malnutrition, especially underweight, is not as common as described in former studies with up to 85% in IBD patients [29]. Whereas the prevalence of malnutrition and underweight has decreased over the past years [30], patients with IBD are more often overweight or obese now, probably as a result of improved therapeutic options and prolonged remission status [31,32]. Our study data confirmed this trend. Regarding the body mass index, about 24% of the IBD patients were overweight and 7% obese. Especially the UC patients showed an increased BMI, which is potentially a consequence of a lower disease activity. The elevated calorie intake accompanied by an increased sugar consumption of the IBD patients, which was much higher than in healthy controls, might explain the elevated number of overweight patients in this study. Even though patients with CD also showed an increased calorie and sugar intake, fewer CD patients were overweight. In contrast, the proportion of underweight patients with Crohn's disease was higher than in healthy controls and UC patients. This might be caused by more intestinal resections, complications or ileac disease in CD patients, which reduce the intestinal absorption capacity and increase the energy requirement and make them more vulnerable for undernourishment despite higher calorie intake.

Whereas reduced body weight in IBD patients seems to be less common nowadays, deficiencies in vitamins and minerals are more frequent. An unbalanced nutrition due to the (self-imposed) restriction of certain foods or food groups can contribute to this.

Many patients with IBD suppose that the diet influences the course of their disease or even cause a relapse [11,33]. Therefore, patients often start dietary changes and avoid "trigger foods" which might worsen

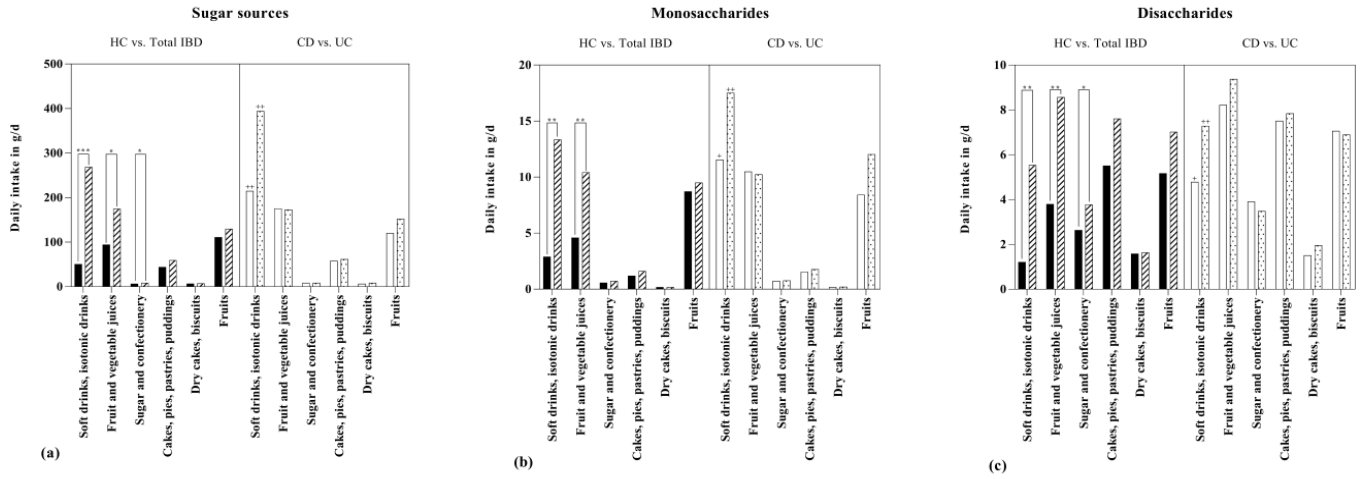

Figure 3: Sugar sources: Bars show the sugar intake and amounts of mono- and disaccharides in foods and beverages consumed by the study groups (black: HC, striped: Total IBD, white: CD, dotted: UC). Figure (a) shows the daily intake in gram of the main sugar sources. Intake of soft and isotonic drinks ($p<0.001$), fruit and vegetable juices ($p=0.022$), and sugar and confectionery ($p=0.043$) was significantly higher in IBD patients compared to HC. The daily intake of soft and isotonic drinks was significant higher for the CD ($p=0.009$) and the UC ($p=0.002$) group compared to HC. Figure (b) shows daily intake of monosaccharides in gram. Intake of monosaccharides from soft and isotonic drinks ($p=0.002$), and fruits and vegetable juices ($p=0.006$) was significantly higher in the IBD group compared to the HC group. CD ($p=0.034$) and UC patients ($p=0.004$) consumed significantly more monosaccharides from soft and isotonic drinks than HC. Figure (c) shows the daily intake of disaccharides in gram. Intake of soft and isotonic drinks ($p=0.002$), fruit and vegetable juices ($p=0.007$), as well as sugar and confectionery ($p=0.015$) was significantly higher in the IBD group compared to HC. CD ($p=0.034$) and UC patients ($p=0.004$) consumed significantly more disaccharides from soft and isotonic drinks than HC.

Food group	HC	Total IBD	IBD	
(intake in [g/d])			CD	UC
Non-alcoholic beverages	1911.50 ± 517.79	1930.48 ± 859.11	1859.37 ± 822.21	2096.40 ± 932.99
Alcoholic beverages	**288.40 ± 431.15**$^{***/+++}$	**146.49 ± 316.97*****	**135.46 ± 304.52**$^{+++}$	**172.23 ± 348.40**$^{+++}$
Dairy products	227.60 ± 132.78	203.38 ± 129.56	199.07 ± 124.8	213.43 ± 141.76
Cereals / cereal products	189.60 ± 88.48	223.57 ± 106.46	224.34 ± 96.09	221.77 ± 129.29
Meat / meat products	133.93 ± 89.36	142.78 ± 111.44	129.17 ± 95.53	174.53 ± 138.53
Vegetables	123.97 ± 37.99	120.86 ± 55.71	115.06 ± 55.12	134.40 ± 55.64
Fruits	119.07 ± 86.46	136.28 ± 113.72	125.60 ± 76.09	161.20 ± 171.62
Condiment and sauces	74.23 ± 22.42	72.30 ± 32.02	70.86 ± 34.28	75.67 ± 26.24
Soups and bouillon	66.40 ± 62.24	72.44 ± 65.58	73.41 ± 68.94	70.17 ± 58.03
Potatoes and other tuber	55.10 ± 39.89	63.57 ± 41.85	62.01 ± 3.84	67.20 ± 46.72
Cakes	49.90 ± 32.78	65.64 ± 47.16	64.03 ± 43.56	69.40 ± 55.30
Sugar and confectionary	**36.47 ± 25.80***	**48.28 ± 29.99***	48.64 ± 27.57	47.43 ± 35.52
Fat	25.67 ± 11.75	30.72 ± 17.43	31.27 ± 17.60	29.43 ± 17.26
Fish and shellfish	16.33 ± 13.21	18.69 ± 13.50	18.24 ± 13.08	19.73 ± 14.63
Egg and egg products	13.73 ± 9.35	11.64 ± 8.54	11.09 ± 8.26	12.93 ± 9.18
Legumes	4.00 ± 3.64	2.70 ± 2.96	2.70 ± 3.11	2.70 ± 2.64

Data are presented as mean ± standard deviation. Group differences were calculated by t-test (HC vs. IBD) or ANOVA.
Abbreviations: CD: Crohn's Disease; HC: Healthy Controls; IBD: Inflammatory Bowel Disease; UC: Ulcerative Colitis
Significances:
* $p<0.05$ comparison healthy controls and IBD patients; ** $p<0.01$ comparison healthy controls and IBD patients; *** $p<0.001$ comparison healthy controls and IBD patients
$^{+++}p<0.001$ comparison healthy controls and CD or UC patients

Table 7: Consumption of different food groups in gram per day.

their symptoms. In our study, 38% of the IBD patients claimed to have changed their diet, mostly because of gastrointestinal afflictions including indigestions, bowel complaints or stomach pain. This percentage is much lower compared to a recent study of Vidarsdottir et al., where 87% of the IBD patients were convinced that the food affects their gastrointestinal tract; 72% of these patients changed their diet during the course of the disease [34]. This discrepancy with our data may be caused by the fact that we asked for dietary changes only within in the past twelve months, but the actual disease duration of our IBD patients ranged from six months up to 54 years.

Other groups also investigated the dietary behavior and food restrictions of patients with IBD. Often leafy or non-leafy vegetables, fruits, dairy, alcohol, red meat or fast food were avoided [12,33]. This is in accordance with our data, since 35% of our patients with IBD stated to have reduced the consumption of fast food compared to only 7% in the healthy control group. Different studies showed that deep-fried and high-fat foods worsen symptoms in 40%-44% of IBD patients [33,34], a fact that might explain the high restriction rate in our IBD patients.

Interestingly, in our study, 60%-70% of all study participants indicated that they avoid sugars and snacks. This high proportion in

Macronutrients [g/d]	HC	Total IBD	IBD	
			CD	UC
Food intake	3344.1 ± 876.2	3296.5 ± 1048.1	3177.5 ± 998.8	3574.1 ± 1124.1
Energy intake [kcal/d]	2079.9 ± 718.4	2333.9 ± 936.4	2267.4 ± 787.5	2489.2 ± 1217.4
[kcal/kg BW]	**29.6 ± 8.6**$^{*/+}$	**34.6 ± 12.6***	**34.7 ± 11.2**$^{+}$	34.3 ± 15.6
Carbohydrates	**192.2 ± 66.5**$^{***/+/++}$	**251.1 ± 103.2*****	**244.6 ± 85.7**$^{+}$	**266.11 ± 136.2**$^{++}$
Fat	96.2 ± 31.3	102.3 ± 45.3	99.9 ± 40.2	108.2 ± 55.8
Protein	77.0 ± 29.0	83.0 ± 36.2	79.5 ± 30.8	91.2 ± 46.0
Fiber	17.3 ± 4.5	19.00 ± 6.8	18.6 ± 5.8	19.8 ± 8.7
Water	2920.3 ± 788.3	2807.5 ± 947.3	2702.7 ± 916.4	3052.0 ± 988.4
Alcohol	**17.5 ± 22.8**$^{**/+}$	**7.6 ± 13.5****	**7.2 ± 13.0**$^{+}$	8.5 ± 14.6
Minerals	16.7 ± 4.1	17.4 ± 5.4	16.9 ± 4.6	18.5 ± 6.7
Organic acids	**4.9 ± 2.1**$^{**/+}$	**6.8 ± 4.3****	6.3 ± 3.9	**7.9 ± 5.1**$^{+}$

Data are presented as mean ± standard deviation. Group differences were calculated by t-test (HC vs. IBD) or ANOVA.
Abbreviations: BW: Body Weight; CD: Crohn's Disease; HC: Healthy Controls; IBD: Inflammatory Bowel Disease; n: Number; UC: Ulcerative Colitis
Significances:
* p<0.05 comparison healthy controls and IBD patients; ** p<0.01 comparison healthy controls and IBD patients; *** p<0.001 comparison healthy controls and IBD patients
$^{+}$p<0.05 comparison healthy controls and CD and UC patients; $^{++}$p<0.05 comparison healthy controls and UC patients

Table 8: Daily macronutrient intake.

Carbohydrates [g/d]	HC	Total IBD	IBD	
			CD	UC
Monosaccharides	**30.9 ± 15.5**$^{***/+}$	**47.3 ± 37.5*****	43.96 ± 35.71	**55.15 ± 40.81**$^{+}$
Glucose	**13.5 ± 7.2**$^{***/+}$	**21.3 ± 17.5*****	19.85 ± 16.26	**24.7 ± 20.08**$^{+}$
Fructose	**16.8 ± 8.3**$^{***/+}$	**25.6 ± 20.7*****	23.74 ± 20.48	**29.92 ± 20.97**$^{+}$
Galactose	0.3 ± 0.3	0.3 ± 0.5	0.30 ± 0.24	0.42 ± 0.76
Disaccharides	**53.4 ± 25.0**$^{***/+}$	74.1 ± 38.7***	**72.31 ± 35.06**	78.35 ± 46.38^{+}
Sucrose	**41.3 ± 21.0**$^{***/+}$	**61.8 ± 35.1*****	**60.35 ± 31.88**$^{+}$	**65.04 ± 42.15**$^{+}$
Lactose	10.5 ± 6.1	9.4 ± 5.6	9.25 ± 5.66	9.64 ± 5.48
Maltose	1.62 ± 1.8	3.0 ± 5.6	2.71 ± 5.23	3.67 ± 6.29
Oligosaccharides, non-absorbable	0.4 ± 0.4	0.3 ± 0.3	0.35 ± 0.38	0.28 ± 0.15
Oligosaccharides, absorbable	4.9 ± 9.0	4.2 ± 9.2	3.40 ± 8.07	5.96 ± 11.51
Polysaccharides	**102.0 ± 39.8***	**124.0 ± 50.9***	123.61 ± 43.24	124.99 ± 66.30
Glycogen	0.3 ± 0.1	0.2 ± 0.1	0.21 ± 0.12	0.27 ± 0.14
Starch	**101.0 ± 39.7***	**122.8 ± 50.6***	122.5 ± 43.03	123.59 ± 65.80
Polyols	**1.01 ± 0.59***	**1.42 ± 1.32***	1.32 ± 1.41	1.66 ± 1.07
Mannitol	0.05 ± 0.02	0.05 ± 0.02	0.05 ± 0.02	0.05 ± 0.02
Sorbitol	0.94 ± 0.58	1.35 ± 1.32	1.26 ± 1.41	1.59 ± 1.07
Xylitol	0.0 ± 0.0	0.00 ± 0.00	0.00 ± 0.00	0.00 ± 0.00
Fibers	17.3 ± 4.5	19.0 ± 6.8	18.64 ± 5.8	19.79 ± 8.73
Cellulose	3.7 ± 1.0	3.9 ± 1.3	3.74 ± 1.10	4.13 ±1.73
Polyhexoses	5.9 ± 1.8	6.8 ± 2.5	6.74 ± 2.18	6.79 ± 3.25
Lignin	1.1 ± 0.4	1.2 ± 0.6	1.20 ± 0.57	1.22 ± 0.69
Fibers, water-insoluble	11.7 ± 3.0	12.7 ± 4.5	12.37 ± 3.74	13.34 ± 5.95
Polypentoses	4.0 ± 1.1	4.4 ± 1.9	4.38 ± 1.76	4.47 ± 2.10
Polyuronic acids	2.6 ± 0.9	2.8 ± 1.2	**2.59 ± 0.75**$^{\#}$	**3.19 ± 1.87**$^{\#}$
Fibers, water-soluble	5.7 ± 1.5	6.3 ± 2.4	6.27 ± 2.12	6.44 ± 2.88

Data are presented as mean ± standard deviation. Group differences were calculated by t-test (HC vs. IBD) or ANOVA.
Abbreviations: CD: Crohn's Disease; HC: Healthy Controls; IBD: Inflammatory Bowel Disease; n: Number; UC: Ulcerative Colitis
Significances
* p<0.05 comparison healthy controls and IBD patients; *** p<0.001 comparison healthy controls and IBD patients
$^{+}$p<0.05 comparison healthy controls CD or UC patients
$^{\#}$p<0.05 comparison CD and UC patients

Table 9: Daily intake of specific carbohydrates.

both study groups is rather caused by the motivation for a healthy life style and to avoid weight gain than by disease or gastrointestinal complaints.

Fruits and vegetables are often blamed to influence symptoms in IBD patients. However, several studies showed different effects in patients with IBD on disease course [34], depending on disease type and status [12]. The avoidance of raw fruits and vegetables to reduce gastrointestinal afflictions varied between 8% and 71% [11,33]. About 38% of the IBD patients in our study stated to restrict the consumption of some fruits and vegetables. Particularly patients with CD with active relapse (71%) avoided this food group. This is in line with findings

Fat-soluble vitamins [mg/d]	HC	Total IBD	IBD	
			CD	UC
Vitamin A (retinol equivalent)	1.30 ± 0.42	1.26 ± 0.46	1.23 ± 0.41	1.34 ± 0.56
Vitamin D (calciferol)	0.004 ± 0.002	0.004 ± 0.002	0.004 ± 0.002	0.004 ± 0.002
Vitamin E (tocopherol equivalent)	11.96 ± 3.30	13.32 ± 5.29	13.23 ± 5.31	13.51 ± 5.34
Vitamin K (phylloquinone)	0.27 ± 0.06	0.28 ± 0.08	0.28 ± 0.08	0.29 ± 0.10
Water-soluble vitamins [mg/d]				
Vitamin C (ascorbic acid)	91.38 ± 38.61	100.99 ± 48.42	96.87 ± 48.69	110.59 ± 47.20
Vitamin B1 (thiamin)	1.17 ± 0.45	1.30 ± 0.61	1.24 ± 0.51	1.45 ± 0.79
Vitamin B12 (cobalamin)	0.006 ± 0.002	0.005 ± 0.003	0.005 ± 0.003	0.006 ± 0.003
Vitamin B2 (riboflavin)	1.40 ± 0.49	1.40 ± 0.54	1.35 ± 0.48	1.53 ± 0.64
Vitamin B3 (niacin equivalent)	28.37 ± 11.45	29.80 ± 12.96	28.41 ± 10.96	33.03 ± 16.50
Vitamin B5 (pantothenic acid)	4.45 ± 1.46	4.39 ± 1.53	4.27 ± 1.34	4.67 ± 1.90
Vitamin B6 (pyridoxine)	1.47 ± 0.53	1.60 ± 0.64	1.54 ± 0.54	1.74 ± 0.83
Vitamin B7 (biotin)	0.04 ± 0.01	0.04 ± 0.01	0.04 ± 0.01	0.04 ± 0.02
Vitamin B9 (free folate equivalent)	0.10 ± 0.03	0.09 ± 0.03	0.09 ± 0.03	0.10 ± 0.04

Data are presented as mean ± standard deviation. Group differences were calculated by t-test (HC vs. IBD) or ANOVA.
Abbreviations: CD: Crohn's Disease; HC: Healthy Controls; IBD: Inflammatory Bowel Disease; n: Number; UC: Ulcerative Colitis

Table 10: Daily intake of vitamins.

Minerals and trace elements	HC	Total IBD	IBD	
			CD	UC
Calcium [g/d]	1.11 ± 0.29	1.01 ± 0.31	0.99 ± 0.30	1.04 ± 0.32
Chlorine [g/d]	**3.11 ± 0.90**$^{*/+}$	**3.71 ± 1.39***	3.60 ± 1.18	3.97 ± 1.80^{+}
Copper [mg/d]	**1.85 ± 0.42***	**2.06 ± 0.72***	2.00 ± 0.63	2.20 ± 0.89
Fluorine [mg/d]	0.97 ± 0.30	0.98 ± 0.45	0.97 ± 0.44	0.99 ± 0.48
Iron [mg/d]	12.11 ± 3.16	13.22 ± 4.82	12.80 ± 4.09	14.20 ± 6.18
Iodine [mg/d]	0.10 ± 0.03	0.10 ± 0.03	0.10 ± 0.03	0.10 ± 0.03
Potassium [g/d]	2.61 ± 0.77	2.77 ± 0.94	2.68 ± 0.84	2.96 ± 1.15
Magnesium [g/d]	0.42 ± 0.10	0.40 ± 0.12	0.39 ± 0.11	0.42 ± 0.15
Manganese [mg/d]	4.48 ± 1.47	4.84 ± 2.60	4.81 ± 2.59	4.91 ± 2.69
Sodium [g/d]	**1.98 ± 0.56**$^{**/+}$	**2.36 ± 0.89****	2.28 ± 0.75	**2.54 ± 1.16**$^{+}$
Phosphor [g/d]	1.22 ± 0.41	1.24 ± 0.44	1.21 ± 0.38	1.32 ± 0.56
Sulphur [g/d]	0.84 ± 0.30	0.87 ± 0.34	0.83 ± 0.29	0.95 ± 0.44
Zinc [mg/d]	10.83 ± 3.20	11.06 ± 4.14	10.74 ± 3.56	11.82 ± 5.24
Common salt [g/d]	**4.53 ± 1.32**$^{**/+}$	**5.46 ± 2.12****	5.29 ± 1.78	**5.88 ± 2.73**$^{+}$

Data are presented as mean ± standard deviation. Group differences were calculated by t-test (HC vs. IBD) or ANOVA.
Abbreviations: CD: Crohn's Disease; HC: Healthy Controls; IBD: Inflammatory Bowel Disease; n: Number; UC: Ulcerative Colitis
Significances:
* p<0.05 comparison healthy controls and IBD patients; ** p<0.01 comparison healthy controls and IBD patients
$^{+}$p<0.05 comparison healthy controls and UC patients

Table 11: Daily intake of minerals and other trace elements.

from other studies, showing that more patients do not eat fruits and/or vegetables when being in active disease [33]. Main reasons for the limitation of fruit and vegetable consumption is the fear of unwanted side effects like bloating, abdominal discomfort or diarrhea, caused by food components (e.g. fibers, fructose, sorbitol and fruit acids). A study of Zallot et al. revealed that almost half of their patients with IBD believed that raw fruits (44%) and raw vegetables (48%) can influence the course of the disease and cause a relapse [11]. However, only 11% of these patients excluded fruits and 16% eliminated vegetables from their diet [11]. We noticed the same phenomenon in our study. IBD patients claimed to restrict fruits and vegetables, but after differentiated nutritional analysis, the daily amount of both food groups were equal compared to the healthy controls, indicating that the belief and the actual behavior of IBD patients may diverge strongly.

Additionally, patients with IBD are often affected by food intolerances and allergies [35,36]. Many fruits, especially pome and stone fruits, contain high amounts of fructose or sorbitol. Barrett et al. described that 42% of their UC and 61% of their CD patients had a fructose malabsorption confirmed with breath testing [35], which may be responsible for gastrointestinal symptoms. Fructose and sorbitol belong to the so called "FODMAPs", an acronym for "Fermentable Oligo-, Di-, Monosaccharides and Polyols". These short-chain carbohydrates are hardly absorbed in the small intestine which is caused by e.g. reduced enzymatic digestion or impaired transport mechanisms (GLUT-2 or-5 transporters in fructose malabsorption) [37]. Their fermentation by colonic gut microbiota and their osmotic effect can induce gastrointestinal complaints, expressed by diarrhea, flatulence, bloating and/or abdominal pain. Because the ileum is often affected in Crohn's disease, patients frequently show a reduced ability for the digestion of short-chain carbohydrates in the active disease stage [38].

However, a reduction of FODMAP-containing foods seems to have positive effects on gastrointestinal symptoms in all IBD patients [39, 40]. Recent studies with IBD patients with gastrointestinal symptoms

showed a significant symptom relief under low FODMAP diet [39, 41]. The evaluation of the daily sugar consumption revealed higher amounts in our IBD patients compared to healthy controls providing a potential explanation for gastrointestinal symptoms in some of these patients. Therefore, the effect of a low FODMAP diet in IBD patients with gastrointestinal symptoms should be evaluated in the future.

Different studies reported the avoidance of milk and dairy products in up to 65% of patients with IBD [12,42,43]. However, in our study the total daily intake did not differ between both groups and the frequency to avoid these products was rather low. The reasons for this are still unclear, but might be in part explained by use of lactose supplements or lactose-free dairy.

Since milk and dairy products are important sources of calcium and vitamin D, a long-term restriction can cause deficiency or complications like osteoporosis in IBD patients [44]. Although most vitamin D is supplied by synthesis in the skin, the oral intake is very important. Our study showed that the daily vitamin D supply was insufficient in all participants with only 4 µg per day. For some medication regimens in IBD therapy, especially cortisone administration [45], an increased vitamin D and calcium supply is recommended to avoid demineralizing effects on bones. Studies showed a lower risk for clinical relapse as well as a decreased necessity for surgery in patients with Crohn's disease under treatment with Vitamin D [46,47]. Thus, a regular monitoring of vitamin D levels, especially in IBD patients with cortisone therapy, is important to prevent secondary diseases and to improve disease outcome.

In addition, patients with IBD often show reduced levels of folic acid [48] and medications or disease complications have a major influence on folate deficiency. Sulfasalazine and methotrexate, that are common therapeutics in IBD, alleviate the folate absorption in the small intestine and are responsible for deficiency [48]. The same as for vitamin B12 [49], especially patients with Crohn's disease, ileal resection and active disease are prone for reduced folate serum levels [48, 50]. Our patients with IBD showed a decreased dietary folic intake. Compared to the recommendations of the DACH with 300 µg per day, the daily intake of free folate equivalents was lower in IBD patients, but also the healthy controls did not reach the recommended daily intake level. Folic acid is primarily found in eggs, cereal germs, green vegetables and legumes. These foods are largely blamed for symptom worsening in IBD patients [12] and a low intake due to dietary restrictions may contribute to a reduced folate intake. Therefore, folate levels should be monitored constantly [50] and already manifested deficiencies should be supplemented adequately.

Even the daily intake of pantothenic acid did not reach the DACH recommendations of 6 mg per day in cohorts, the IBD patients and the healthy controls. However, the impact of this reduced oral intake is unclear, since pantothenic acid is also synthesized intestinal by gut bacteria [51].

IBD patients are also susceptible to different deficiencies in minerals and other trace elements including iron, calcium and zinc. A lack of iron is present in 30% to 90% of anemic IBD patients [16] and zinc deficiency is associated with a poor disease outcome and a higher risk for disease-related complications [52]. The daily intake of these minerals, as well as of potassium and magnesium, was in accordance with the recommendations of DACH in all our study participants. Hence, a deficiency of these minerals in patients with IBD might rather be the consequence of an altered intestinal absorption or loss through bleedings and diarrhea, than of an insufficient oral intake.

In our study, 47% of the patients with IBD took dietary supplements, especially multivitamins and minerals. The use of other alternative supplements like fish oil, cranberry extracts or St. John's wort was scarce. A recent study showed a similar prevalence for the use of vitamin and mineral supplements [34], with 27% of IBD patients consuming multivitamins compounds. Summarizing the use of vitamins (6%), minerals (4%) and combinations (15%) of the IBD patients in our study the prevalence was 25% and confirmed former results. Since micronutrients deficiencies were described in over 50% of IBD patients [16], it is highly recommended to monitor the vitamin and micronutrient status and apply dietary supplementation to prevent or treat deficiencies.

Our detailed analysis of the total nutrient uptake revealed an increased consumption of fat but a too low amount of ingested carbohydrates, compared to the recommendations of the DACH, in all our study participants. However, the absolute amount of carbohydrates was significantly higher in all IBD patients, particular in CD patients with active disease, compared to healthy controls; this result is in accordance with a former study [53]. The increased sugar consumption, mainly mono-and disaccharides, of our IBD patients is highly remarkable. This phenomenon was already observed in previous studies [18,19] and raises the suspicion that high amounts of refined sugars may contribute to the etiology of IBD [38,40]. However, data about the influence of sugar intake and the onset of IBD are contradictory. The increased sugar intake of IBD patients in our study is the consequence of a higher total consumption of sugar containing foods and beverages, especially in form of soft and isotonic drinks and fruit and vegetable juices. This is in line with recent findings in a Canadian cohort, that revealed an increased intake of sugar containing beverages and particularly patients with CD or UC in active disease status consumed proportionally more drinks that were sweetened with simple sugars [33]. The increased sugar consumption in German as well as Canadian patients with IBD arouses the suspicion that this habit is not only related to geographically specific habits but rather represents a more disease-dependent phenomenon. Indeed, a former study of us observed significantly elevated taste thresholds for the flavors sweet, salty, sour and bitter, in patients with CD compared to healthy controls, independent of disease severity and status [53]. Steinbach et al. confirmed the taste disturbance in IBD patients and further detected an irritation in smelling. Interestingly, most of their IBD patients were not aware of this altered sensory perception, which might explain the more excessive intake of sweetened foods [54].

Moreover, the IBD patients of our study ate significantly more sugar and confectionery, including honey, jam, chocolate, candy bars, syrup and ice cream, all sources of simple sugars. These findings contradict the statements of IBD patients to restrict sugar-containing food groups from their diet (72% soft drinks; 38%, sugar and confectionery). Therefore, the self-assessment and self-reported data differ substantially from their actual habits. This discrepancy may be caused by a lack of knowledge about the sugar and calorie content of foods or beverages like soft drinks and thus require an intensive dietary education of these patients.

Our patients with IBD also consumed a significantly higher amount of common salt compared to healthy controls. Again, this may be provoked by an altered taste threshold for salt [53] and/or might represent an unconscious physiological reaction to compensate the electrolyte loss caused by diarrhea, vomiting or a damaged intestinal mucosa [55]. However, we did not observe an elevated salt intake in patients with active disease. Since animal studies showed a negative

effect of sodium chloride on inflammation markers in experimental colitis [56], IBD patients should be informed about an adequate salt consumption to prevent additional negative effects.

Dietary advices also include a reduced fiber intake in patients with IBD, especially during disease flare-ups. There are varying recommendations concerning the fiber intake in IBD ranging from reducing fiber consumption during active disease status, through the ingestion of soluble fibers only with a total restriction of insoluble fibers [57]. Anyway, these recommendations may explain the insufficient fiber intake in our IBD patients (advised: 30 gram fibers/day). Dietary fibers and starches were not digested in the small intestine and their fermentation by colonic bacteria to short chain fatty acids, e.g. acetate, propionate and butyrate, provides an important energy source for enterocytes and shows anti-inflammatory effects in animal models of colitis [58]. Several studies described that fibers and fiber-rich foods are avoided by IBD patients to prevent relapses or undesired side effects like bloating and abdominal pain [11,12]. However, in the absence of strong evidence showing negative effects of insoluble fibers in IBD, fibers should not be restricted from the diet, except in case of stenosis or persistent abdominal afflictions. Because of prevailing health benefits, the IBD patients should rather be encouraged to increase the fiber intake especially in remission phase [58].

Furthermore, our study groups showed an unfavorable ratio of essential fatty acids (FA) compared to the recent guidelines. Whereas the ratio of the n-6 fatty acid linolic acid (LA) to the n-3 fatty acid α-linolenic acid (ALA) should be 5:1, the actual ratio was about 7:1 in all participants. The unbalanced ratio of these two fatty acids is characteristic of the modern Western style diet and seems to contribute to pro-thrombotic and pro-inflammatory reactions promoting cardiovascular diseases, cancer, inflammatory and autoimmune disorders [59]. A higher proportion of LA, as a precursor of arachidonic acid, promotes the synthesis of pro-inflammatory substances [21] and a high intake of n-6 fatty acids is associated with an increased incidence for ulcerative colitis [21,58]. In contrast, n-3 fatty acids, like ALA from plant sources or eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) from animal sources, have anti-inflammatory effects and showed protective features in animal colitis models, but the benefit for IBD patients remains still unclear [60]. However, patients should be encouraged to reduce the intake of n-6-fatty acid-rich foods and increase the intake of foods enriched with n-3-fatty acids, including plant oils and fatty fish to receive a more favorable fatty acid ratio.

Conclusion

In summary, our study revealed differences in the nutrient intake of IBD patients in comparison to healthy controls. We noticed a remarkable increased sugar and salt consumption of IBD patients, which is probably a consequence of an altered taste perception or caused by the lack of knowledge about food contents. In contrast to former studies, today's IBD patients seem to be well-nourished with a tendency to overweight, maybe induced by the increased calorie and sugar intake.

Food restrictions are common in IBD patients and might be responsible for micronutrient deficiencies. Therefore, a reduced intake of certain food groups, which are sources of important vitamins and minerals, should be monitored and adequately substituted.The discrepancies between patients' indications about food restrictions and the actual nutrient intake according to the detailed analysis of the FFQ revealed an altered self-perception. A professional nutritional counselling for food choices and nutrient replacement in the case of food restrictions is highly recommended to prevent nutrient deficiencies and a more negative disease outcome in IBD patients.

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References

1. Kaplan GG (2015) The global burden of IBD: From 2015 to 2025. Nat Rev Gastroenterol Hepatol 12: 720-727.
2. Molodecky NA, Soon IS, Rabi DM, Ghali WA, Ferris M, et al. (2012) Increasing incidence and prevalence of the inflammatory bowel diseases with time, based on systematic review. Gastroenterology 142: 46-54 e42; quiz e30.
3. Kostic AD, Xavier RJ, Gevers D (2014) The microbiome in inflammatory bowel disease: Current status and the future ahead. Gastroenterology 146: 1489-1499.
4. Marion-Letellier R, Savoye G, Ghosh S (2016) IBD: In Food We Trust. J Crohns Colitis 10: 1351-1361.
5. Graham DB, Xavier RJ (2013) From genetics of inflammatory bowel disease towards mechanistic insights. Trends Immunol 34: 371-378.
6. Both H, Torp-Pedersen K, Kreiner S, Hendriksen C, Binder V (1983) Clinical appearance at diagnosis of ulcerative colitis and Crohn's disease in a regional patient group. Scand J Gastroenterol 18: 987-991.
7. Ferguson A, Sedgwick DM (1994) Juvenile onset inflammatory bowel disease: Height and body mass index in adult life. BMJ 308: 1259-1263.
8. Mijac DD, Jankovic GL, Jorga J, Krstic MN (2010) Nutritional status in patients with active inflammatory bowel disease: Prevalence of malnutrition and methods for routine nutritional assessment. Eur J Intern Med 21: 315-319.
9. Vavricka SR, Rogler G (2012) Intestinal absorption and vitamin levels: Is a new focus needed? Dig Dis 30 Suppl 3: 73-80.
10. Dworzanski T, Celinski K (2016) Advances in Nutrition of Patients with Inflammatory Bowel Diseases. J Nutr Food Sci 6: 1-8.
11. Zallot C, Quilliot D, Chevaux JB, Peyrin-Biroulet C, Gueant-Rodriguez RM, et al. (2013) Dietary beliefs and behavior among inflammatory bowel disease patients. Inflamm Bowel Dis 19: 66-72.
12. Cohen AB, Lee D, Long MD, Kappelman MD, Martin CF, et al. (2013) Dietary patterns and self-reported associations of diet with symptoms of inflammatory bowel disease. Dig Dis Sci 58: 1322-1328.
13. Hughes LD, King L, Morgan M, Ayis S, Direkze N, et al. (2016) Food-related Quality of Life in Inflammatory Bowel Disease: Development and Validation of a Questionnaire. J Crohns Colitis 10: 194-201.
14. Fletcher PC, Schneider MA (2006) Is there any food I can eat? Living with inflammatory bowel disease and/or irritable bowel syndrome. Clin Nurse Spec 20: 241-247.
15. Hall NJ, Rubin GP, Dougall A, Hungin AP, Neely J (2005) The fight for 'health-related normality': A qualitative study of the experiences of individuals living with established inflammatory bowel disease (ibd). J Health Psychol 10: 443-455.
16. Weisshof R, Chermesh I (2015) Micronutrient deficiencies in inflammatory bowel disease. Curr Opin Clin Nutr Metab Care 18: 576-581.
17. O'Sullivan M, O'Morain C (2006) Nutrition in inflammatory bowel disease. Best Pract Res Clin Gastroenterol 20: 561-573.
18. Martini GA, Brandes JW (1976) Increased consumption of refined carbohydrates in patients with Crohn's disease. Klin Wochenschr 54: 367-371.
19. Mayberry JF, Rhodes J, Allan R, Newcombe RG, Regan GM, et al. (1981) Diet in Crohn's disease two studies of current and previous habits in newly diagnosed patients. Dig Dis Sci 26: 444-448.
20. Burisch J, Pedersen N, Cukovic-Cavka S, Turk N, Kaimakliotis I, et al. (2014) Environmental factors in a population-based inception cohort of inflammatory bowel disease patients in Europe: An ECCO-EpiCom study. J Crohns Colitis 8: 607-616.

21. Investigators IBDiES, Tjonneland A, Overvad K, Bergmann MM, Nagel G, et al. (2009) Linoleic acid, a dietary n-6 polyunsaturated fatty acid and the aetiology of ulcerative colitis: A nested case-control study within a European prospective cohort study. Gut 58: 1606-1611.

22. Jantchou P, Morois S, Clavel-Chapelon F, Boutron-Ruault MC, Carbonnel F (2010) Animal protein intake and risk of inflammatory bowel disease: The E3N prospective study. Am J Gastroenterol 105: 2195-2201.

23. Spooren CE, Pierik MJ, Zeegers MP, Feskens EJ, Masclee AA, et al. (2013) Review article: The association of diet with onset and relapse in patients with inflammatory bowel disease. Aliment Pharmacol Ther 38: 1172-1187.

24. Harvey R, Bradshaw J (1980) A simple index of Crohn's-disease activity. Lancet 1: 514.

25. Lewis JD, Chuai S, Nessel L, Lichtenstein GR, Aberra FN, et al. (2008) Use of the noninvasive components of the Mayo score to assess clinical response in ulcerative colitis. Inflamm Bowel Dis 14: 1660-1666.

26. Nöthlings UHK, Bergmann MM, Boeing, H (2007) Fitting portion sizes in a self-administered food frequency questionnaire. J Nutr 137: 2781278-2781276.

27. Dehne LI, Klemm C, Henseler G, Hermann-Kunz E (1999) The German Food Code and Nutrient Data Base (BLS II.2). Eur J Epidemiol 15: 355-359.

28. World Health Organization (WHO). Global Database on Body Mass Index. BMI Classification.

29. Lomer MC (2011) Dietary and nutritional considerations for inflammatory bowel disease. Proc Nutr Soc 70: 329-335.

30. Moran GW, Dubeau MF, Kaplan GG, Panaccione R, Ghosh S (2013) The increasing weight of Crohn's disease subjects in clinical trials: A hypothesis-generatings time-trend analysis. Inflamm Bowel Dis 19: 2949-2956.

31. Flores A, Burstein E, Cipher DJ, Feagins LA (2015) Obesity in inflammatory bowel disease: A Marker of less severe disease. Dig Dis Sci 60: 2436-2445.

32. Long MD, Crandall WV, Leibowitz IH, Duffy L, del Rosario F, et al. (2011) Prevalence and epidemiology of overweight and obesity in children with inflammatory bowel disease. Inflamm Bowel Dis 17: 2162-2168.

33. Vagianos K, Clara I, Carr R, Graff LA, Walker JR, et al. (2016) What are adults with inflammatory bowel disease (IBD) eating? a closer look at the dietary habits of a population-based Canadian IBD cohort. JPEN J Parenter Enteral Nutr 40: 405-411.

34. Vidarsdottir JB, Johannsdottir SE, Thorsdottir I, Bjornsson E, Ramel A (2016) A cross-sectional study on nutrient intake and -status in inflammatory bowel disease patients. Nutr J 15: 61.

35. Barrett JS, Irving PM, Shepherd SJ, Muir JG, Gibson PR (2009) Comparison of the prevalence of fructose and lactose malabsorption across chronic intestinal disorders. Aliment Pharmacol Ther 30: 165-174.

36. Cai C, Shen J, Zhao D, Qiao Y, Xu A, et al. (2014) Serological investigation of food specific immunoglobulin G antibodies in patients with inflammatory bowel diseases. PLoS One 9: e112154.

37. Gibson PR, Shepherd SJ (2010) Evidence-based dietary management of functional gastrointestinal symptoms: The FODMAP approach. J Gastroenterol Hepatol 25: 252-258.

38. Gibson PR, Shepherd SJ (2005) Personal view: Food for thought--western lifestyle and susceptibility to Crohn's disease. The FODMAP hypothesis. Aliment Pharmacol Ther 21: 1399-1409.

39. Prince AC, Myers CE, Joyce T, Irving P, Lomer M, et al. (2016) Fermentable Carbohydrate Restriction (Low FODMAP Diet) in Clinical Practice Improves Functional Gastrointestinal Symptoms in Patients with Inflammatory Bowel Disease. Inflamm Bowel Dis 22: 1129-1136.

40. Ruemmele FM (2016) Role of Diet in Inflammatory Bowel Disease. Ann Nutr Metab 68 Suppl 1: 33-41.

41. Maagaard L, Ankersen DV, Vegh Z, Burisch J, Jensen L, et al. (2016) Follow-up of patients with functional bowel symptoms treated with a low FODMAP diet. World J Gastroenterol 22: 4009-4019.

42. Brasil Lopes M, Rocha R, Castro Lyra A, Rosa Oliveira V, Gomes Coqueiro F, et al. (2014) Restriction of dairy products: A reality in inflammatory bowel disease patients. Nutr Hosp 29: 575-581.

43. Vagianos KBS, McConnell J, Bernstein CN (2007) Nutrition assessment of patients with Inflammatory bowel disease. Journal of Parenteral and Enteral Nutrition 31: 311-319.

44. Lim H, Kim HJ, Hong SJ, Kim S (2014) Nutrient intake and bone mineral density by nutritional status in patients with inflammatory bowel disease. J Bone Metab 21: 195-203.

45. De Nijs RN (2008) Glucocorticoid-induced osteoporosis: A review on pathophysiology and treatment options. Minerva Med 99: 23-43.

46. Jorgensen SP, Agnholt J, Glerup H, Lyhne S, Villadsen GE, et al. (2010) Clinical trial: Vitamin D3 treatment in Crohn's disease: A randomized double-blind placebo-controlled study. Aliment Pharmacol Ther 32: 377-383.

47. Ananthakrishnan AN, Cagan A, Gainer VS, Cai T, Cheng SC, et al. (2013) Normalization of plasma 25-hydroxy vitamin D is associated with reduced risk of surgery in Crohn's disease. Inflamm Bowel Dis 19: 1921-1927.

48. Yakut M, Ustun Y, Kabacam G, Soykan I (2010) Serum vitamin B12 and folate status in patients with inflammatory bowel diseases. Eur J Intern Med 21: 320-323.

49. Battat R, Kopylov U, Szilagyi A, Saxena A, Rosenblatt DS, et al. (2014) Vitamin B12 deficiency in inflammatory bowel disease: Prevalence, risk factors, evaluation and management. Inflamm Bowel Dis 20: 1120-1128.

50. Bermejo F, Algaba A, Guerra I, Chaparro M, De-La-Poza G, et al. (2013) Should we monitor vitamin B12 and folate levels in Crohn's disease patients? Scand J Gastroenterol 48: 1272-1277.

51. Said HM (2011) Intestinal absorption of water-soluble vitamins in health and disease. Biochem J 437: 357-372.

52. Siva S, Rubin DT, Gulotta G, Wroblewski K, Pekow J (2017) Zinc deficiency is associated with poor clinical outcomes in patients with inflammatory bowel disease. Inflamm Bowel Dis 23: 152-157.

53. Zopf Y, Rabe C, Kollmann S, Hahn EG, Thurauf N, et al. (2009) Alterations of taste perception in Crohn's disease and their dependency on disease activity and nutritional behavior. J Clin Gastroenterol 43: 617-621.

54. Steinbach S, Reindl W, Dempfle A, Schuster A, Wolf P, et al. (2013) Smell and taste in inflammatory bowel disease. PLoS One 8: e73454.

55. Barkas F, Liberopoulos E, Kei a, Elisaf M (2013) Electrolyte and acid-base disorders in inflammatory bowel disease. Ann Gastroenterol 26: 23-28.

56. Monteleone I, Marafini I, Dinallo V, Di Fusco D, Troncone E, et al. (2016) Sodium chloride-enriched diet enhanced inflammatory cytokine production and exacerbated experimental colitis in mice. J Crohns Colitis.

57. Lucendo AJ (2009) Importance of nutrition in inflammatory bowel disease. World Journal of Gastroenterology 15: 2081.

58. Lewis JD, Abreu MT (2016) Diet as a Trigger or Therapy for Inflammatory Bowel Diseases. Gastroenterology.

59. Simopoulos AP (2008) The importance of the omega-6/omega-3 fatty acid ratio in cardiovascular disease and other chronic diseases. Exp Biol Med (Maywood) 233: 674-688.

60. Bischoff S, Koletzko B, Lochs H, Meier R (2014) S3-Leitlinie der Deutschen Gesellschaft für Ernährungsmedizin (DGEM) in Zusammenarbeit mit der Gesellschaft für klinische Ernährung der Schweiz (GESKES), der Österreichischen Arbeitsgemeinschaft für klinische Ernährung (AKE) und der Deutsche Gesellschaft für Gastroenterologie, Verdauungs- und Stoffwechselkrankheiten (DGVS). Aktuelle Ernährungsmedizin 39: e72-e98.

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