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ORIGINAL ARTICLE

Nutritional status and food intake in pediatric patients with inflammatory bowel disease at diagnosis significantly differs from healthy controls

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Abstract

Nutritional status and dietary intake in pediatric-onset inflammatory bowel disease are complex and need to be further explored. Therefore, we have assessed anthropometric measures, body composition, and dietary intake of newly diagnosed pediatric patients, and compared them with healthy controls. This was a prospective cross-sectional study including newly diagnosed patients with inflammatory bowel disease ($n = 89$) and healthy controls ($n = 159$). Mean energy intake was significantly lower in healthy controls compared to patients with ulcerative colitis, but not in patients with Crohn's disease. Intake of all macronutrients, dietary fiber, and calcium was significantly lower in patients with ulcerative colitis, whereas the only intake of animal protein, fruit, and calcium differed significantly in patients with Crohn's disease. There were no significant differences in the body fat percentage between patients with ulcerative colitis or Crohn's disease vs. controls; however, lean mass-for-age z-scores were significantly lower in patients with both diseases in comparison to controls.

Conclusion: Food intake of newly diagnosed pediatric patients with inflammatory bowel disease significantly differed from healthy controls. Altered anthropometry and body composition are present already at the time of diagnosis.

What is Known:
- *Children with inflammatory bowel disease suffer from malnutrition, especially children with Crohn's disease in whom linear growth failure often precedes gastrointestinal symptoms.*

What is New:
- *This study showed significantly lower intake of energy, macronutrients, and various micronutrients in patients with ulcerative colitis compared to healthy controls, while patients with Crohn's disease have a lower intake of fruits, calcium, and animal protein at diagnosis.*
- *Altered body composition is present in both groups of patients at the time of diagnosis.*

Keywords Inflammatory bowel disease · Children · Adolescents · Diet · Anthropometry

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Abbreviations

CD	Crohn's disease
IBD	Inflammatory bowel disease
UC	Ulcerative colitis
PCDAI	Pediatric Crohn's disease activity index
PUCAI	Pediatric ulcerative colitis activity index

Introduction

Inflammatory bowel disease (IBD) is a group of chronic relapsing and remitting inflammatory diseases of the alimentary tract, consisting of Crohn's disease (CD), ulcerative colitis (UC) and, if undistinguishable, IBD-unclassified (IBD-U). Approximately, a quarter of patients with IBD present in childhood [1] and, according to a recent systematic survey, the incidence and prevalence of pediatric-onset IBD are on the rise while the overall incidence of IBD has stabilized [2]. The exact etiology of IBD has yet to be elucidated. Continued progress has been made in identifying potential genetic risk factors. However, the genetic contribution seems to be low (with the exception of monogenic IBD) compared to environmental risk factors, among which dietary factors are receiving considerable attention [3]. Dietary factors play a key role in the child's growth and development, but they may also have an important role in altering gut microbiota, metabolome, host barrier function, and innate immunity, thus contributing to the disease development [4].

In IBD malnutrition is a well-recognized condition, especially in children with CD in whom linear growth failure often precedes gastrointestinal symptoms [5] and around two-thirds of them are underweight at the time of diagnosis [1]. Malnutrition is not only found in the acute phases of CD [6] but has also been documented during clinical remission [7]. Symptoms of IBD include, but are not limited to, abdominal pain, change in bowel habits, impaired general well-being, and malnutrition. The latter is often caused by suboptimal energy and nutrient intake, malabsorption, and increased energy requirements [8]. Even so, children with IBD are affected by current population trends towards overweight and obesity [9]. A recent study reports that up to 1/5 of children with CD and 1/3 of children with UC included in a multi-center registry in the USA are overweight or obese during the follow-up [10]. An abnormal nutritional status is a result of complex pathophysiological processes, such as, but not limited to, genetic predisposition, inappropriate food intake, malabsorption, increase in basal metabolism due to present inflammatory processes, disturbances of the growth hormone/insulin-like growth factor axis, and the use of drugs such as corticosteroids [11].

Current evidence across studies regarding the diet of adults with IBD has been rather inconsistent [3], and the number of studies on the diet of children with IBD is even smaller [12–16]. Moreover, the relationship between nutritional status and dietary intake in pediatric-onset IBD is complex and needs to be further explored. Therefore, the aim of this study was to assess the anthropometric measurements, body composition, and data regarding dietary intake in children and adolescents with newly diagnosed IBD, and to compare that data to the age- and sex-matched healthy controls.

Methods

Study design

This was a prospective cross-sectional study. Newly diagnosed patients with IBD who were diagnosed and treated in a tertiary medical center (Children's Hospital Zagreb) and healthy controls were included into the study, provided they were 18 years of age or younger. Healthy controls were matched by age, gender, and area of residence. They were recruited from randomly selected elementary and high schools in the urban and rural area in Croatia that responded positively to the invitation to participate in the study. Written consent was obtained from the patients who were 9 years of age or older and one of their parents. In patients who were younger than 9 years of age, the written consent was obtained only from their parents or caregivers. As for healthy controls, permission for the study was obtained from appropriate authorities; parents were informed about the survey from the school principals, and their written consent was obtained. This study was approved by the Ethics Committee Children's Hospital Zagreb (IRB no. 21102014).

The IBD diagnosis has been established according to the Porto criteria [17], and localization was determined based on the Paris classification [18]. The severity of the disease has been estimated by the pediatric Crohn's disease activity index (PCDAI) and pediatric ulcerative colitis activity index (PUCAI) [19, 20]. Patients in whom, based on the dietary intake interview, it was recognized that there was a recent significant change in the diet that was excluded from the study. Exclusion criteria in healthy controls included chronic illness or family history positive for chronic intestinal diseases (celiac disease, IBD, gastrointestinal carcinoma).

Anthropometric measurements, body composition, and food intake were measured in patients and healthy controls.

Anthropometric measurements and body composition

Anthropometric measurements and body composition were assessed for each participant. In children with IBD, the measurements were made during the within 24 h of the diagnosis. The anthropometric assessment included measurements of body weight (BW), body height (BH), middle-upper arm circumference (MUAC), triceps skinfold thickness (TSF), subscapular skinfold thickness (SSF), and handgrip strength (HS) were measured by the same two trained persons. BW was measured on an electronic scale with subjects being dressed in lightweight gym clothes. BH was measured with a portable stadiometer. TSH and SSF were estimated using a Holtain skinfold caliper. Jamar hydraulic handgrip dynamometer was used to estimate both right and left handgrip strength in children older than 6 years old.

Bioelectrical impedance was used to estimate the subjects' body composition (Maltron BF906, Maltron International Ltd., Rayleigh, Essex, UK). *Z*-scores for BW, BH, body mass index (BMI), and MUAC were estimated by the Growth Analyzer software. TSF and SSF were estimated using CDC (Center for disease control and prevention) reference curves [21]. *Z*-scores for a lean mass (LM) were estimated using UK reference data for a pediatric body composition [22].

The nutritional status of participants was determined using the World Health Organization (WHO) growth reference data for children and adolescents (5–19 years) [23].

Estimated energy requirements for each child were calculated using the Schofield equation. Since data about physical activity has not been collected, it was presumed that most of the participants had a "light" physical activity level (PAL) [24].

Dietary intake

Information about food consumption was obtained at the time of diagnosis for all included patients. In healthy controls, food consumption was estimated during late winter and early spring. Food consumption was obtained using a Food Frequency Questionnaire (FFQ) version which was previously validated for Croatian children and adolescents [25]. FFQ is a tool that estimates the frequency of consumption of different foods as well as their quantity. FFQ that was used contained 87 different food items divided into 8 different food groups: "milk and milk products," "cereals and grains," "juices and sodas," "fruits," "vegetables," "snacks," 'meat, poultry, eggs, and fat' and 'fast food'. FFQ included frequently consumed national foods and estimated the frequency and quantity of consumption of food items in the last month. Available frequencies of food consumption were "never," "1–3 times a month," "once a week," "2–4 times per week," "5–6 times per week," "once a day," "2–3 times per day," "4–5 times per day," or "6+ times per day." Available portion sizes were small, medium, large, and simple portion sizes photos were used to distinguish the former. The frequency of consumption was obtained in a form of a personal interview with trained interviewers, with the presence of the caregivers (in children younger than 12 years of age) or without their presence in older participants.

The individual food records data obtained by the FFQ were analyzed by Microsoft Office Excel 2007 worksheet that was generated by using a combination of USDA [26] and Kaić-Rak et al. [27] food composition databases. Approximately, 10 min were taken to administer the FFQ for each participant by a trained interviewer. The frequency of consumption of food items was multiplied by the portion size to calculate the amount of nutrients consumed in a 30-day period, from which an average daily energy and nutrient intake per each participant were calculated.

Statistics

The differences between categorical variables were assessed by chi-square test. The differences for non-categorical variables were assessed by one-way ANOVA followed by Bonferroni test for post hoc analysis. Pearson correlation was performed in order to assess the correlation between nutritional status and body composition and food intake. *P* values less than 0.05 were considered significant. Statistical analysis was performed using SPSS 19.0 (IBM Corporation, Chicago, Illinois, USA) statistical software.

Results

Patient characteristics

Table 1 summarizes baseline characteristics of enrolled participants. Overall, there were 89 patients with newly diagnosed IBD and 159 healthy controls included in the study. Of those, 49 (55 %) patients were affected by CD and 40 (45 %) by UC. No significant difference in age was found between the CD patients, UC patients, and healthy controls (mean age 14.6 ± 2.6 years for CD; 14.0 ± 3.7 years for UC; 14.7 ± 2.3 years for healthy controls; $p = 0.349$). Based on PCDAI/PUCAI scoring, 54 patients (63.5 %) had mild disease, and 31 patients (36.5 %) had moderate to severe disease at the time of diagnosis.

Anthropometric measurements and body composition

BMI *z*-score was used to estimate the nutritional status of all participants. The nutritional status of newly diagnosed IBD patients and healthy controls is shown in Fig. 1. Overall, 32.6 % of CD patients and 25 % of UC patients were malnourished according to the WHO criteria (22). Overweight was found in 16.3 % and 17.5 % of CD and UC patients, respectively. None of the patients were obese. Only 4 (4.5 %) IBD patients were stunted (BH-for-age *z*-score ≤ 2 SD), of whom 3 were CD patients.

Table 1 Baseline characteristics of enrolled patients

	CD ($n = 49$)	UC ($n = 40$)	Healthy controls ($n = 159$)
Age, mean (SD)	14.6 (2.6)	14.0 (3.7)	14.7 (2.3)
Male, *n* (%)	29 (59.2)	23 (57.5)	80 (50.3)
BW, mean (SD)	51.5 (14.6)	51.0 (16.8)	59.0 (14.2)
BH, mean (SD)	163.2 (14.7)	161.1 (18.7)	167.4 (11.9)
BMI, mean (SD)	19.6 (2.8)	18.2 (2.8)	20.7 (3.2)
Duration of symptoms in months, mean (SD)	7.6 (2.1)	4.2 (1.0)	–
Localization of the disease*	L1 (ileal): 12 (24.5 %) L2 (colonic): 6 (12.2 %) L3 (ileocolonic): 31 (63.3 %) L4 (additional upper gastrointestinal disease): 18 (36.7 %)	E1 (proctitis): 1 (2. 5%) E2 (left-sided): 8 (20 %) E3 (extensive): 5 (12.5 %) E4 (pancolitis): 26 (65 %)	–

BM, body weight; BH, body height; BMI, body mass index; SD, standard deviation

*Paris classification of the inflammatory bowel disease [17]

There was a significant difference in BW-for-age, BMI-for-age, and basal metabolic rate (BMR) but not for triceps and subscapular skinfold thickness between both CD patients and UC patients vs. healthy controls (Table 2). A significant difference in BH-for-age *z*-score and MUAC-for-age *z*-score was found only between CD patients vs. healthy controls. There was no significant difference in any of anthropometric measures between CD and UC patients.

As for the body composition estimated by bioelectrical impedance, there was no statistically significant difference in body fat percentage between CD and UC patients vs. healthy controls. However, both CD and UC patients had significantly lower lean mass-for-age *z*-scores compared to healthy controls (Table 2.)

There was no association between duration of symptoms and anthropometric measures or body composition. Similarly, the nutritional status did not significantly differ depending on the disease severity estimated by the PUCAI/PCDAI score.

Dietary intake

The mean energy intake differed significantly between UC patients and healthy controls (7780.9 ± 2774.5 kj; 10,198.3 ± 4409.5 kj; $p = 0.003$), but not CD patients (8915.4 ± 3377.6 kj; 10,198.3 ± 4409.5 kj; $p = 0.202$). On average, CD patients satisfied 90 ± 52.8 %, UC patients 86.6 ± 39.6 %, and healthy controls 109.3 ± 45.9% of their estimated energy requirements.

Lower intake of all macronutrients and dietary fiber has been found between UC patients vs. healthy controls (Table 3). In CD patients, a significant difference was found only for animal proteins when compared to healthy controls

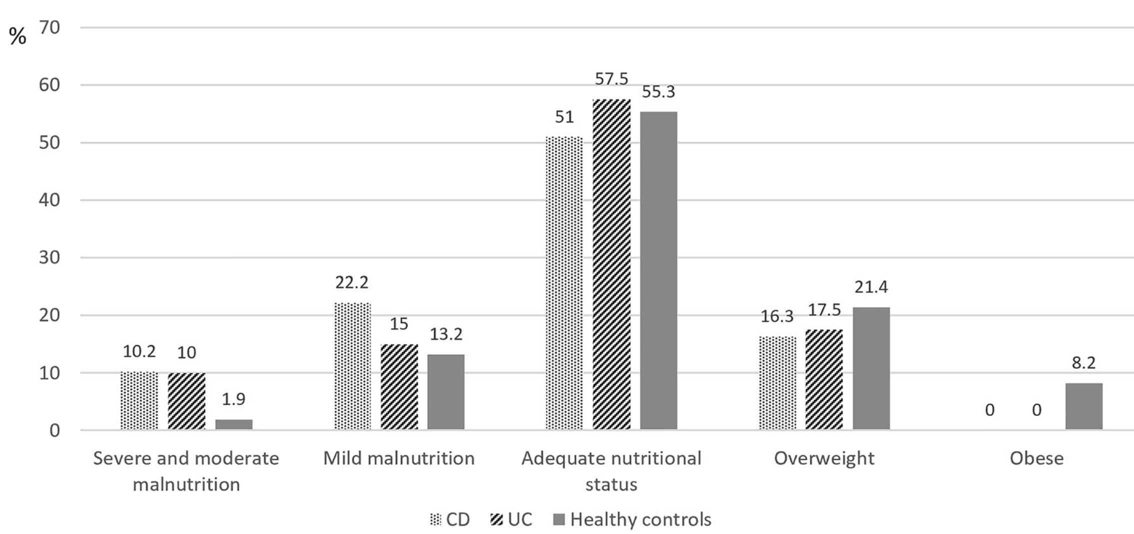

Fig. 1 Comparison of nutritional status according to WHO criteria between IBD patients and healthy controls

Table 2 Difference in anthropometric characteristics between Crohn's disease patients, ulcerative patients and healthy controls

	CD ($n = 49$)	UC ($n = 40$)	Healthy controls ($n = 159$)	p value
BW-for-age, mean (SD)	− 0.5 (1.2)	− 0.2 (1.1)	0.3 (1.1)	< 0.001*
BH-for-age, mean (SD)	− 0.5 (1.0)	− 0.2 (0.9)	0.0 (1.0)	0.013**
BMI-for-age, mean (SD)	− 0.4 (1.3)	− 0.2 (1.2)	0.4 (1.1)	< 0.001*
EER (kj), mean (SD)	8743.0 (1524.8)	8694.7 (1744.3)	9451.3 (1602.6)	0.003*
MUAC-for-age, mean (SD)	− 0.7 (1.0)	− 0.5 (0.8)	− 0.3 (0.8)	0.009**
Triceps skinfold thickness-for-age, mean (SD)	0.8 (0.8)	0.7 (0.9)	0.8 (0.7)	0.871
Subscapular skinfold thickness-for-age, mean (SD)	0.7 (0.8)	0.7 (0.6)	0.7 (0.8)	0.998
Handgrip strength				
Right hand (kg), mean (SD)	20.2 (9.9)	20.7 (14.1)	25.3 (9.3)	0.006**
Left hand (kg), mean (SD)	17.9 (9.9)	16.3 (9.7)	23.2 (8.6)	< 0.001*
Body fat %, mean (SD)	19.3 (7.6)	18.5 (7.6)	20.7 (7.7)	0.239
BMR (kcal), mean (SD)	1438.1 (315.3)	1469.4 (301.9)	1598.4 (237.3)	0.001
Lean mass-for-age, mean (SD)	0.2 (1.4)	0.4 (1.2)	1.2 (1.4)	< 0.001*

BM, body weight; BH, body height; BMI, body mass index; EER, estimated energy requirements; MUAC, middle upper arm circumference; BMR, basal metabolic rate; SD, standard deviation

Post hoc analysis: $*p < 0.05$ for CD and UC vs. healthy controls; $**p < 0.05$ for CD vs. healthy controls

(46.0 ± 21.5 g in CD; 57.2 ± 27.4 g in healthy controls; $p = 0.037$). There was no difference in energy and macronutrient intake between UC and CD patients.

Table 3 shows the mean intake of micronutrients. When compared to healthy controls, there was no significant difference in intake of most micronutrients, except for intake of phosphorus and calcium between CD and UC patients vs. healthy controls and for iron and zinc in UC patients vs. healthy controls.

When contributions of different food groups to total energy intake were estimated, a difference was found for intake of fruits in CD patients compared to healthy controls. The contribution of other food groups to total energy intake did not differ significantly (Table 3).

There was no association between duration of symptoms and dietary intake in both CD and UC patients.

Pearson correlation revealed no significant correlation in BMI z-score, lean mass-for-age z-scores, and TST and dietary intake (total energy and micronutrient intake). A positive correlation was found for SST and total energy (correlation coefficient 0.282, $p = 0.015$), total carbohydrates (correlation coefficient 0.252, $p = 0.026$), total protein (correlation coefficient 0.282, $p = 0.012$), and total fat (correlation coefficient 0.275, $p = 0.015$) intake.

Discussion

This study is, best to our knowledge, the first study which investigated food intake at diagnosis of pediatric patients with IBD compared to healthy controls and showed lower intake in energy and all macronutrients in IBD patients. This difference was mainly contributed to UC patients.

Energy and macronutrient intake

Previously, studies have looked into the dietary intake of IBD patients [12–16, 28]. However, these studies have assessed dietary intake in children and adolescents with already established disease, which was both active and in relapse [12–16]. One study estimated the consumption of food items of newly diagnosed IBD patients over a past year (using a yearly FFQ) and did not include a control group [28]. Results of all previously published studies are not unified; study by Hartman et al. [13] found that patients with active and inactive IBD had a lower intake of energy, carbohydrates, and dietary fiber in comparison with healthy Israeli children. However, this study did not stratify patients with a disease type. Diederen et al. [15] included CD, UC, and IBD-U patients, of which 46 % had active disease. Energy intake and total carbohydrate intake in all IBD patients were lower, while intake of vegetable proteins and total fat intake were higher compared to the reference population. When distributed by the type of IBD, the energy intake of CD patients was lower compared to that of the general population, while UC patients did not significantly differ from the reference population. These results are opposite to ours, where patients with UC had the lowest energy and macronutrients consumption. This difference could be at least partially explained by the acute symptoms (bloody diarrhea and abdominal cramps) at the time of the UC diagnosis. The acute symptoms could cause the restriction in the food intake and increase the likelihood of the restrictive diet introduction. However, it should be noted

Table 3 Difference in nutritional intake between Crohn's disease patients, ulcerative colitis patients, and healthy controls

	CD ($n = 49$)	UC ($n = 40$)	Healthy controls ($n = 159$)	p value
Energy intake (kj), mean (SD)	8915.4 (3377.6)	7780.9 (2774.5)	10,198.3 (4409.5)	0.002***
% EER (%), mean (SD)	90.0 (52.8)	86.6 (39.6)	109.3 (45.9)	0.004*
Total proteins (g), mean (SD)	92.4 (33.3)	83.5 (31.6)	107.1 (43.8)	0.002***
Vegetable proteins (g), mean (SD)	25.7 (11.1)	23.6 (8.7)	29.0 (14.3)	0.043
Animal proteins (g), mean (SD)	46.0 (21.5)	43.7 (20.7)	57.2 (27.4)	0.002*
Total fat (g), mean (SD)	102.1 (45.9)	81.1 (31.1)	108.1 (52.9)	0.010***
Saturated fat (g), mean (SD)	35.9 (17.3)	30.3 (13.8)	43.6 (22.0)	0.001***
Unsaturated fat (g), mean (SD)	31.9 (14.5)	25.6 (10.7)	54.0 (27.2)	0.006***
Total carbohydrates (g), mean (SD)	252.7 (100.8)	228.7 (85.1)	292.9 (133.9)	0.007***
Mono- and disaccharides (g), mean (SD)	107.8 (62.3)	98.5 (51.8)	131.3 (59.3)	0.002***
Fibers (g), mean (SD)	21.8 (9.2)	20.8 (8.0)	25.8 (12.3)	0.014***
Calcium (mg), mean (SD)	765.1 (399.7)	766.6 (385.1)	987.4 (446.2)	0.001*
Magnesium (mg), mean (SD)	247.3 (193.3)	219.1 (123.5)	279.5 (160.4)	0.091
Phosphorus (mg), mean (SD)	1455.7 (521.1)	1364.9 (508.3)	1742.2 (674.1)	0.001*
Iron (mg), mean (SD)	13.2 (5.5)	11.3 (4.5)	14.7 (6.4)	0.005***
Zinc (mg), mean (SD)	8.6 (3.9)	7.3 (3.5)	8.9 (3.6)	0.047***
Proteins (% EI), mean (SD)	17.3 (2.8)	17.9 (2.8)	17.7 (2.5)	0.622
Carbohydrates (% EI), mean (SD)	46.5 (7.1)	48.8 (5.6)	47.6 (7.5)	0.355
Fat (% EI), mean (SD)	41.8 (7.0)	38.7 (5.7)	39.0 (6.8)	0.044
Fruits (%EI), mean (SD)	3.3 (3.9)	5.2 (5.3)	6.2 (4.7)	0.002**
Vegetables (%EI), mean (SD)	3.7 (1.7)	4.2 (2.0)	3.8 (2.3)	0.535
Juices and sodas (%EI), mean (SD)	5.2 (4.0)	5.2 (3.9)	4.9 (4.0)	0.814
Snacks (%EI), mean (SD)	10.8 (9.9)	8.7 (6.2)	9.9 (6.6)	0.444
Fast food (%EI), mean (SD)	13.5 (6.9)	11.3 (4.2)	13.0 (6.3)	0.246

EI, energy intake

Post hoc analysis: *$p < 0.05$ for CD and UC vs. healthy controls; **$p < 0.05$ for CD vs. healthy controls; ***$p < 0.05$ for UC vs. healthy controls

that in the study by Diederen et al. [15], the dietary intake of IBD patients was estimated using FFQ, while dietary intake of reference population was estimated by 24-h recalls. Interestingly, studies mentioned above did not find a difference in macronutrient intake when stratified by the disease activity, meaning that restriction was noted also in patients who were in the clinical remission [13, 15]. Opposite to that, in an older study by Pons et al. [12], total energy and all macronutrient intakes were lower in children with active CD, compared with children with CD in remission and controls. In our cohort, neither disease activity nor duration of symptoms was associated with dietary intake. This could be related to our relatively coherent population of patients, in whom PCDAI/PUCAI scoring was fairly similar as well as the duration of the disease.

Micronutrient intake

As for micronutrients, lower intakes of calcium, iron, and zinc in UC patients and of calcium in CD patients were detected in our study. Results of other studies have shown mixed results. In a study by Thomas et al. [14] where food diary records were used to estimate dietary intake, intake of iron and zinc in CD patients in relapse was significantly lower compared to controls. Using the same methods as Thomas et al. [14], Hartman et al. [13] detected lower intakes of calcium in Israeli IBD patients. Pons et al. [12] have used FFQ to estimate the nutritional intake and have not detected lower intakes of calcium in CD patients compared to controls. In addition to the IBD itself, the low calcium intake has been described as a risk factor for fractures among adult IBD patients [29]. Additional to the low calcium intake, risk of developing osteoporosis in IBD patients is related to malnutrition, altered absorption of nutrients, lower physical activity, and due to the administration of corticosteroids [30]. IBD patients are prone to reduce the intake of milk and milk products for fear of lactose consumption [31]. Although this could be a plausible explanation, we do not know whether this was a case in our cohort.

Intake of different food groups

Although this study was not designed to assess causality of different diets and IBD, we confirmed a lower contribution of fruits to total energy intake in CD patients compared to healthy controls. Opposite to ours, Diederen et al. [15] have found higher intakes of vegetable and fruit in children with IBD, but as previously mentioned, those were the patients with established diagnosis and, thus, could be advised during their treatment to increase the intake of "healthy foods" like fruits and vegetables. Regarding our study, we could speculate that patients with CD avoided fruit intake due to active symptoms of their disease; however, this is highly unlikely since the intake of other nutrients and food groups (vegetables, soda and juices, snacks, and fast food) did not differ from that of a healthy population.

Anthropometry measurements and body composition

As reported by others, our study found a significant difference in anthropometric measurements and lean mass between CD and UC patients vs. healthy controls. One of the most prominent presenting features of IBD includes malnutrition [32]. In our cohort, 10.2 % of CD and 10 % of UC patients were undernourished (z-score ≤ 2 SD) at the time of diagnosis. Compared to ours, in the French cohort, even 32 % of pediatric patients with CD had BMI z-score ≤ 2 SD at the time of diagnosis [33], similar to the results of El Mouzan et al. [34] where 35 % of CD and 24 % of UC patients had BMI z-score ≤ 2 SD. Contrary to undernutrition, 16.3 % of CD and 17.5 % of UC patients in our cohort had BMI z-score > 1 SD, similar to that of the general population [35]. Our results are comparable to the results of other countries [9, 34]. Whether the lower proportion of undernourished patients in our cohort is a result of an overall increase in the BMI of the general population that can influence the BMI at the diagnosis is yet to be determined. Some studies suggested a possible shared environmental link between the increase in IBD and obesity incidence. Moreover, it was also observed that obesity might impact disease development and response to therapy in patients with IBD [36]. It has been emphasized recently that assessing body composition, rather than simple anthropometric changes, gives a much better indication of nutritional status in all chronic diseases as well as in IBD [37]. In our cohort, despite having lower BMI-for-age z-scores compared to healthy controls, both CD and UC patients had significantly lower z-scores for lean body mass while having the same body fat percentage. That clearly confirms that BMI is not an ideal marker of body composition in children with IBD. Similarly, Burnham et al. [37] reported fat mass adjusted for age and fat mass adjusted for the height that was not significantly different from controls. Furthermore, in our cohort, no difference in skinfold thickness has been found in IBD patients compared to healthy controls, which could be explained by higher body fat percentage in relation to total body mass in these children. Comparable to ours, in their study, Wiskin et al. [38] found lower values of proxies for lean tissue but not for fat only in children with CD, and not in those with UC. Our results together with previously published studies indicate that nutritional assessment should not be solely based on anthropometric measures and should include estimation of body composition. Interestingly, in our cohort, symptoms duration and disease activity were not associated with anthropometric measures and body composition, which could be related to our relatively coherent population of patients. Furthermore, this study has found that only SST, but not TST, BMI, and lean mass-for-age z-score, positively correlates with total energy and all macronutrients intake in IBD patients. This could indicate that higher energy intake was associated with a more truncal deposition of body fat even in children with IBD.

Our study has several limitations mainly related to the relatively small sample size and usage of FFQ for estimation of dietary intake. For more accurate nutritional intake, a 3-day food diary would be more appropriate. However, FFQ used in this study was compared and correlates strongly with the results of a 3-day nutritional intake diary [25]. Nevertheless, this study compared newly diagnosed patients with IBD and healthy-matched controls, and as previously mentioned, for the first time provides an insight into the nutritional intake in patients with newly diagnosed IBD.

In conclusion, this study showed significantly lower intake of energy, macronutrients, and various micronutrients in patients with UC compared to healthy controls, while patients with CD had a lower intake of fruits, calcium, and animal protein. Furthermore, altered anthropometry, and more importantly, body composition in both CD and UC patients, at the diagnosis has been shown. This study indicates that specific nutritional interventions should be implemented early after diagnosis, since malnutrition and its consequences are often seen in pediatric IBD patients. Furthermore, IBD patients are prone to unnecessary restrictions in their diets, which can further deteriorate their nutritional status. This study contributes to the still scarce literature on diet and anthropometry in pediatric patients with IBD.

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Authors' contributions SS was responsible for writing the research protocol, conducting the research, extracting the data, interpreting the results, and writing the manuscript. IT was responsible for writing the protocol, conducting the research, extracting the data, interpreting the results, and writing the manuscript. AMP was responsible for writing the protocol, conducting the research, extracting the data, and reviewing the manuscript. TN was responsible for conducting the research, interpreting the results, and reviewing the manuscript. SK was responsible for designing the research protocol, interpreting the results, and reviewing the manuscript. IH was responsible for designing the research protocol, analyzing the data, interpreting the results and reviewing the manuscript.

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Compliance with ethical statements

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Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional ethics committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. This study was approved by the Ethics Committee Children's Hospital Zagreb (IRB no. 21102014).

Informed consent Informed consent was obtained from all individual participants and at least one of their parents included in the study.

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