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ORIGINAL ARTICLE



Nutritional intake and body composition in children with inflammatory bowel disease

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ABSTRACT

Purpose: In this study we assessed nutritional intake, body composition, and their relationship in patients with paediatric inflammatory bowel disease (IBD). **Methods:** We conducted a longitudinal, prospective study of 38 patients' nutritional intake using 3-day food records (FR) and bioimpedance analysis of body composition. FR were evaluated by Nutricomp DietCAD software. Results were analysed with Microsoft Excel 2013 and IBM SPSS Statistics 22 software. **Results:** Patients treated with biological and conventional therapy (CT) had a higher intake of vegetable protein and carbohydrate from starch than those treated earlier with exclusive enteral nutrition (EEN) in the remission phase ($F = 5.926$, $F = 5.130$, $P < 0.05$). The former EEN group had a higher intake of iron compared to the other two groups ($F = 3.967$, $P = 0.036$). Protein intake and fat-free mass (FFM) had a significant positive correlation, while added sugar correlated with body fat mass (BFM) in the same way ($R^2 = 0.122$, $R^2 = 0.169$, $P < 0.05$). Body-fat mass in patients of the biological therapy (BT) group overstepped the healthy median, and the FFM in the EEN group stayed under it. **Conclusions:** Our results confirm that it is essential to monitor body composition and not only measure body weight. Patients should be advised based on their body composition, therapy, and phase of the disease.

KEYWORDS

inflammatory bowel diseases, body composition, diet therapy

INTRODUCTION

Inflammatory bowel disease (IBD) has an autoinflammatory origin and is characterized by remission and active phases. Two major manifestations are Crohn's disease (CD) and ulcerative colitis (UC), differentiated by CD's ability to involve any component of the gastrointestinal tract, whereas UC only affects the colon. The prevalence of the disease is rising, and both adults and children can be affected. The incidence of paediatric IBD was 7.8 per 100,000 in Hungary between 2007 and 2011 [1].

As the disease involves the digestive system, it has a huge impact on the nutrition and development of paediatric patients. The risk of malnutrition is high in this population, mainly in CD and during active phases. Abnormally low body mass index (BMI) is measured at

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Table 1. Baseline characteristics of the patients

Therapy	EEN	BT	CT	Control Group
Total patients (N)	8	14	16	192
Gender (M, F)	4, 4	5, 9	6, 10	90, 102
Age (years, mean \pm SD)	13.08 \pm 2.19	16.32 \pm 2.12	13.67 \pm 2.343	14.76 \pm 1.92

BT: Biological Therapy Group, CT: Conventional Therapy Group, EEN: Former Exclusive Enteral Nutrition Group.

diagnosis in 17–32% of the cases and impaired growth in 8–10% [2–4]. According to a systematic review conducted by Thangarajah, lean body-mass deficit was reported in 93.6% of paediatric CD patients and 47.7% of UC patients, compared with healthy controls [5]. These results make it obvious that without body-composition analysis, the usefulness of measuring height and weight and calculating BMI is severely limited. Despite the results mentioned above, according to Kugathasan et al. overweight and obesity may still be present in 10–30% of the newly diagnosed patients [6, 7].

While most studies are focused on the role of diet in the aetiology of the disease rather than the current nutrition of the patients, recent research has shown that paediatric IBD patients have a higher fat intake than healthy subjects [8]. Prior to that, Silva et al. also reported a deficiency in the intake of energy and many micronutrients, while the consumption of fats and sweets were higher than recommended [9].

Patients often restrict their diet or stop eating altogether because they associate the symptoms with certain foods. This usually results in the avoidance of dairy products, legumes, nuts, and other high-fibre foods [9–13]. Unfortunately, there is no evidence-based oral IBD diet (except for exclusive enteral nutrition (EEN) in case of paediatric CD) that is suitable for induction of remission based on the guidelines [14]. However, because of the high risk of malnutrition, a highly restrictive diet may not prove to be beneficial.

The main goals of this study were to assess and monitor the nutritional intake and body composition of children with IBD in a longitudinal prospective study. We were particularly interested in the intake of energy, protein, and sugar, as well as their effects on body composition. We also wanted to know whether there is a difference in the nutritional intake of patients treated with biological therapy (BT), EEN, and more conventional therapy (CT). Since the effects of relapses on nutrition are not negligible, we analysed the food records (FR) written in remission for comparisons. Body composition gives a better picture of a paediatric IBD patient than height and weight alone. The lack of reference data for parameters such as body-fat mass (BFM) and fat-free mass (FFM), however, forced us to measure healthy controls too, so that the results could be comparable and easier to interpret.

MATERIAL AND METHODS

Our research involved 38 patients from the 1st Department of Pediatrics of Semmelweis University in Budapest, Hungary.

We followed them in a longitudinal, prospective manner for about a year. 8 received EEN, 14 BT, and 16 CT (corticosteroids, immunomodulators, folic acid antagonists) (Table 1).

Body composition of the patients and the control group was measured with an InBody720 Body-Composition Analyzer (InBody Co., Ltd. Cerritos, CA) on an empty stomach, with both groups wearing light clothes. Nutritional intake was assessed multiple times during the study using 3-day FR attached to each body composition analysis. We asked the patients to record their consumption of foods and drink, in as much detail as possible, on two weekdays that did not follow each other and on a weekend day.

Patients in the EEN group first reported about their consumption on an average day before starting EEN, then their next FR came after the 8-week-long period of EEN. This way the FR included not only the oral nutritional supplements (ONS) (which they still drank for weeks after EEN) but the normal food of their choice, as well.

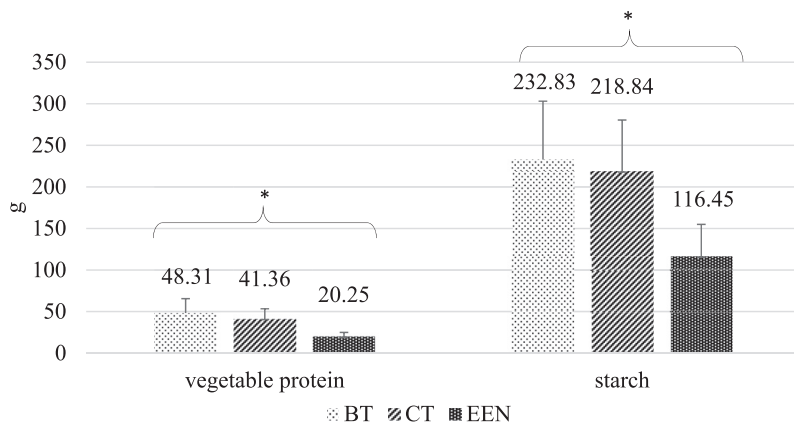
Patients were measured for body composition and asked to write the FR one to four times during the one-year follow-up. The 3-day FR were analysed with NutriComp DietCAD (NutriComp Lp. Budapest, Hungary) meal planning software – which automatically calculates the meals' macro- and micronutrient content – after validation via email or telephone.

Microsoft Excel 2013 and IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp. Released 2013, Armonk, NY: IBM Corp.) were used to analyse the results of the body-composition analysis and the nutritional intake, using parametric (ANOVA, Levene's Test, one-sample t-test, Pearson correlation, linear regression) and non-parametric tests (Kruskal-Wallis test, Spearman's rank correlation). The Shapiro-Wilk normality test was used for every macro- and micronutrient, grouped by therapy. It showed a normal distribution for most nutrients, except for saturated fat (SFA) in the BT group and monounsaturated fat (MUFA) in the CT group. For SFA and MUFA, the Kruskal-Wallis Test was applied. ANOVA was used for normal distribution and Levene's test for equality of variances. The Least Significant Difference (LSD) post-hoc test was conducted to see in which groups the results were significantly higher. The patients' parameters of body composition were converted into Z-scores based on the healthy subjects' data after they were adjusted by age, gender, and BMI. We sorted the results by the number of analysis and therapeutic groups. The patients' Z-scores were compared to the adjusted groups' median with one-sample t-test. To investigate the connection between nutritional intake and body composition, linear regression, Pearson correlation, and Spearman's rank correlation (for non-normal distributional variables) were used.

RESULTS

To compare nutritional intake in the different therapeutic groups, first we excluded the FR written in the relapse phase.





BT: Biological Therapy Group, CT: Conventional Therapy Group, EEN: Former Exclusive Enteral Nutrition Group

Fig. 1. Significant differences in nutritional intake in the remission phase

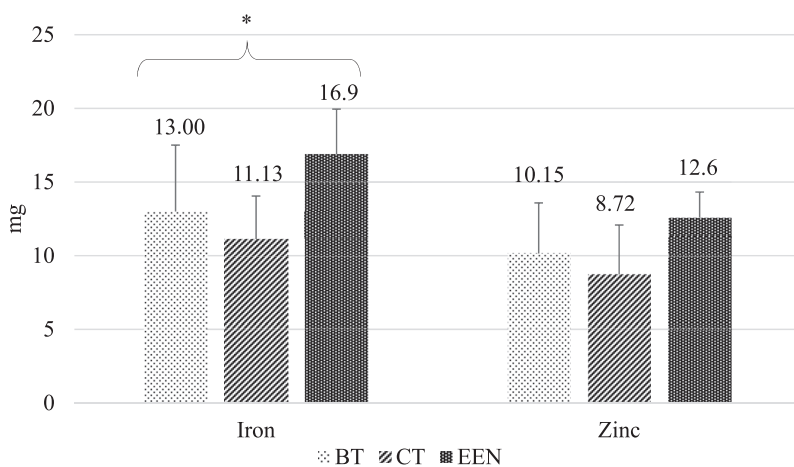
If a patient had written more records during remission, we selected only one of them. Following this selection process, 22 records were compared. Remission was defined as a period when the Pediatric Crohn’s Disease Activity Index (PCDAI) or the Pediatric Ulcerative Colitis Activity Index (PUCAI) was under 10.

We examined many nutrients (e.g. total energy – kcal per day, total protein – g per day, protein – g/kg body weight per day, total carbohydrate – g per day, etc.) to find significant differences in various ways. The ANOVA showed a significant difference ($P < 0.050$) in the therapeutic groups only in the cases of vegetable protein (g) ($F = 5.926$), carbohydrate from starch (g) ($F = 5.130$), and iron (mg) ($F = 3.967$).

The intake of vegetable protein (g) was significantly lower in the EEN group compared to the BT ($P < 0.001$) or the CT ($P = 0.010$) group (Mean Difference = -28.05 and -21.11). We observed the same results for starch (g), which

was significantly lower in the EEN group compared to the BT ($P = 0.010$) and the CT ($P = 0.010$) group (Mean Difference = -116.38 and 102.39) (Fig. 1).

The Kruskal–Wallis Test was also conducted, and it confirmed the results for vegetable protein and carbohydrate from starch. For energy (kcal), total protein (g), fat (g), animal (g) and vegetable fat (g), carbohydrate (g), and added sugar (g), the intake of the BT group was the highest according to their means (energy_{BT}: $2,567.11 \pm 598.62$, total protein_{BT}: 102.15 ± 27.54 , total fat_{BT}: 105.53 ± 38.39 , animal fat_{BT}: 50.31 ± 17.49 , vegetable fat_{BT}: 52.22 ± 24.47 , total carbohydrate_{BT}: 352.84 ± 103.60 , added sugar_{BT}: 71.80 ± 50.43). Typically, the intake of the CT group was the second-highest, and the EEN group’s intake was the lowest in almost every case (except for vegetable fat, in which case the EEN groups’ intake was the second-highest). However, the difference was not significant. The protein intake, when adjusted to body weight



BT: Biological Therapy Group, CT: Conventional Therapy Group, EEN: Former Exclusive Enteral Nutrition Group

Fig. 2. Iron and zinc intake of the patients in the remission phase

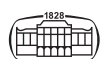


Table 2. Results of the first body composition analysis

	weight (kg)	FFM (kg)	FFMI (kg/m ²)	BFM (kg)	BFMI (kg/m ²)
BT (mean ± SD)	47.52 ± 12.02	39.21 ± 10.99	14.37 ± 1.56	8.53 ± 3.08	3.26 ± 1.28
CT (mean ± SD)	49.44 ± 14.48	39.56 ± 10.41	14.43 ± 1.63	9.88 ± 5.38	3.59 ± 1.70
EEN (mean ± SD)	38.36 ± 6.99	30.48 ± 3.51	13.34 ± 0.83	8.38 ± 5.92	3.79 ± 2.91

BT: Biological Therapy Group, CT: Conventional Therapy Group, EEN: Former Exclusive Enteral Nutrition Group, FFM: Fat-free mass, FFMI: Fat-free mass index, BFM: Body fat mass, BFMI: Body fat mass index

(g/kg body weight/day), was the highest in the EEN group (2.17 ± 0.56) according to their mean.

Surprisingly, the intake of iron (mg) was significantly higher in the EEN group, when compared to the BT ($P = 0.090$) or the CT ($P = 0.010$) group (Mean Difference: 3.90 and 5.77). There was no significant difference in zinc intake; however, it was also the highest in the EEN group, followed by the BT group (Fig. 2).

For the body-composition analysis, we first had to measure height, then enter height, gender and age in the body-composition analyser. The appliance gave us data in a few minutes about the different body compartments, for example BFM, FFM, and intracellular and extracellular water (ICW, ECW).

Table 2 demonstrates the results of the first analysis (mean, standard deviation). We also created indexes (FFMI, BFMI) from the FFM and BFM data, using the patient's recent height. Basically, we wanted to concentrate on the body-fat mass and FFM of the subjects, as they give a clearer picture of the nutritional status. Body composition analysis was carried out in healthy subjects as well, in order to compare our data to the general population.

At the time of the first measurements, the FFM Z-scores showed a lower value than the healthy population in each therapeutic group. The difference was significant for the EEN group (using one-sample t-test). This parameter improved for the next measurements in the EEN and BT groups.

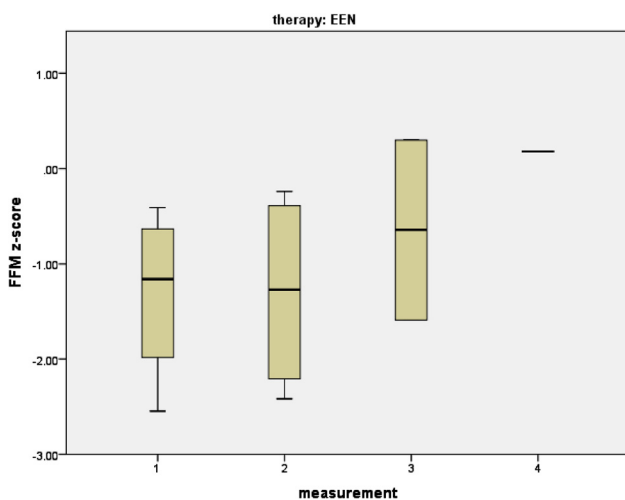


Fig. 3. Fat-free mass (FFM) Z-scores of the (former) exclusive enteral nutrition (EEN) group during the measurements

Fig. 3 illustrates the results of the EEN group compared to the median of the healthy controls (value 0). The high ratio of dropouts is also observable in this figure, as it only shows only two results at the time of the 3rd and one result at the time of the 4th measurement.

The BFM Z-scores were typically as high as in the control group, or even higher. Based on the first, second, and third measurements, the results were significant in the BT group (Fig. 4). We used one-sample t-test, as the data showed a normal distribution.

The relations between body composition and nutritional intake were also investigated. After conducting a Shapiro-Wilk normality test, we used Pearson correlation for normal, and Spearman's rank correlation for non-normal distributional data. Pearson correlation showed a significant positive correlation between FFM and total protein intake (g) ($r = 0.350$, $P < 0.050$), between FFM and total carbohydrate intake (g) ($r = 0.448$, $P < 0.050$) and between FFM and total fat intake (g) ($r = 0.374$, $P < 0.050$).

Using Spearman's rank correlation, we concluded that there is a significant positive correlation between BFM and added sugar consumption (energy %) ($r = 0.349$, $P < 0.050$), while protein intake (g/kg/d) showed a significant negative correlation with BFM ($r = -0.673$, $P < 0.050$).

Linear regression analysis was also conducted, and positive significant correlation were shown, among others, between FFM and total protein (g) ($R^2 = 0.122$, $B = 0.141$), and between FFM and vegetable protein (g), ($R^2 = 0.251$,

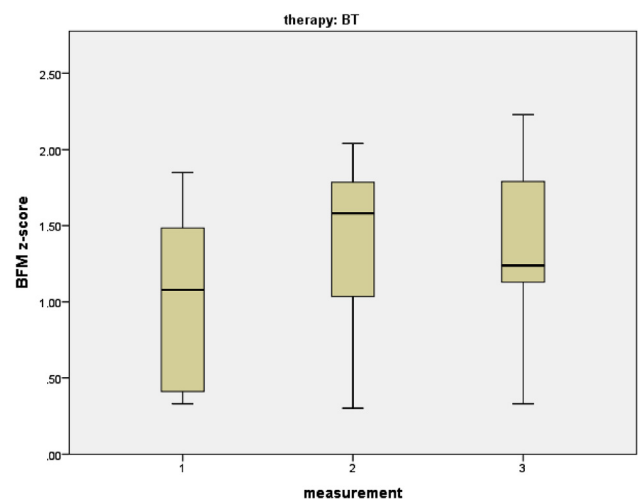


Fig. 4. Body fat mass (BFM) Z-scores of the biological therapy (BT) group during the measurements



$B = 0.408$). Body-fat mass and body-fat mass index (BFMI) both had a positive significant correlation with added sugar (energy %) ($R^2_{BFM} = 0.169$, $B_{BFM} = 0.513$, $R^2_{BFMI} = 0.209$, $B_{BFMI} = 0.214$).

DISCUSSION

We conducted a niche study, aiming to investigate the nutritional intake and body composition of paediatric inflammatory-bowel-disease patients. There is limited data on these patients' body-fat mass and FFM in the literature, especially compared to the general population or examined in the course of therapy. We were able to interpret the patients' results, as we involved healthy subjects' body composition analysis, as well.

The 3-day FR, used for assessing nutritional intake multiple times, matched to the body composition analysis of each child, provided us with the opportunity to get a clearer picture of the eating habits of the patients, as well as their alteration with time and therapy. This method of data collection is quite difficult, as it demands motivation and full commitment from both the child and the parents. The validation process made it even more complicated, because it required us to contact every participant and thoroughly clarify every meals' ingredient if it was not obvious (e.g. what kind of meat was used in a specific dish, or what was the milk's fat content when mixed with the cocoa, etc.). Even though this method caused an unfortunately high percentage of dropouts, we still believe that this is one of the most accurate methods for assessing nutritional intake.

To investigate the differences in nutritional intake between the therapeutic groups, we excluded the first FR, written in the active phase, because the symptoms can profoundly modify eating habits. After that, only one FR of each patient was selected for the comparison, even if one had more, so that further records of the same person would not affect the results. ANOVA was conducted on the variables with a normal distribution. It showed significant differences in terms of vegetable protein, starch, and iron. The BT and CT groups had a significantly higher intake of vegetable protein and starch than the EEN group, while the EEN group consumed significantly more iron than the other two groups. The highest mean of protein consumption of the EEN group, when adjusted to body weight probably derived from the lower age and bodyweight of this particular group.

These previous two results could also have originated from the composition of the ONS, which was typically consumed by the EEN group for weeks after the EEN (this is due to their nutritional status and slower adaptation to solid foods after the 8-week long EEN). Oral nutrition supplements consumed by the patients examined contained about 6 g/100 ml milk protein (casein, whey protein), 18 g/100 ml carbohydrate in form of maltodextrin and saccharose (but no starch because of technological reasons), and

6 g/100 ml vegetable oils (e.g.: rapeseed oil, sunflower oil). The higher amount of milk protein could have contributed to the higher ratio of animal protein intake, and the lack of starch in the ONS to the lower starch consumption in the EEN group. The higher amount of iron and zinc intake in the EEN group could also have originated from the ONS consumed, as it is quite high in minerals. 100 ml contains about 2 mg of iron, 1.5 mg of zinc, 100 mg of calcium, and many other micronutrients. (This means 8 mg iron, 6 mg zinc and 400 mg calcium consumption if a patient had two bottles of ONS.)

In the case of the most nutrients, the highest intake was observed in the BT group. Even though this could indicate a better appetite, a more liberal diet, and successful therapy, the high ratio of animal fat, the added sugar, and the low amount of mineral intake refers to a Western-style diet, which is not recommended for any of these patients. It should also be considered that the mean of the age was the highest in this group, which also could have contributed to the results.

The nutrient intakes observed in the EEN group were a bit controversial, as the high iron and protein intake adjusted to bodyweight seem to indicate that the oral nutrition supplements were adequate, while the absolute intake of other nutrients usually stayed at a lower level than that of the other two groups.

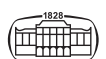
We cannot draw a long-term conclusion about the body-composition results because of the low sample size. Further investigation of the patients' body composition is needed in order to understand its relationship with the disease outcome.

The relation between nutritional intake and specific body compartments was also examined, and we confirmed the positive correlation between body-fat mass and added sugar and FFM and protein intake. This fact draws attention to the importance of the right nutrient ratios in the IBD population. We are often pleased when patients have a good appetite, especially with this disease, and we do not consider it a problem if they cover a part of their energy needs with sweets (if it means they eat something at last). Still, this relation confirms that we need to continue investigating the correlation of body composition and disease outcome, as there is scant evidence in this area, especially in paediatric IBD.

We believe the follow-up manner of the study, the validated 3-day FR, and the body-composition analysis contributed to its quality. The food-record method, however, contributed to the high ratio of dropouts, as it is quite hard to keep the patients motivated. This and the low sample size limit our results and confirms that we have to extend our study with a larger paediatric IBD population.

CONCLUSIONS

Our goals in this study were to assess body composition and nutritional intake, and investigate their relation, in



paediatric IBD patients in a longitudinal prospective study. We compared nutritional intake in the different therapeutic groups (BT, CT, (former) EEN), as recorded in a remission phase, and found that the BT group had the highest average intake of most nutrients examined. This could have resulted from a better appetite, a more liberal diet, better response to therapy, or from the higher average age. The intake of vegetable protein and starch were significantly higher in the BT and CT groups than in the former exclusive-enteral-nutrition group, while the iron intake was significantly higher in the EEN group compared to the other two. These results could have originated from the ONS's composition, (containing animal protein, and a fairly high amount of minerals among others) which was consumed in the EEN group for weeks after the EEN had been completed.

The results of the body composition analysis showed a decreased amount of FFM at the time of the first measurement, which is understandable considering the nature of the disease. Body-fat mass was about the same in the CT and EEN groups compared to the general population, while the BT group's BFM z-scores were significantly higher than the control group's. Further investigation is needed to determine the role of body composition in terms of disease outcome.

Our study confirmed the positive correlation between protein intake and FFM and between added sugar consumption and body-fat mass. This highlights the role of a well-balanced diet. Based on the results, we think team work among the medical staff should be better emphasized and the relevance of body composition analysis, the nutrition-care process, and dietetic intervention should not be forgotten.

LIST OF ABBREVIATIONS

BFM	Body fat mass
BFMI	Body fat mass index
BMI	Body mass index
BT	Biological Therapy
CD	Crohn's disease
CT	Conventional therapy
ECW	Extracellular water
EEN	Exclusive enteral nutrition
FFM	Fat-free mass
FR	Food record
IBD	Inflammatory Bowel Disease
ICW	Intracellular water
LSD	Least Significant Difference
MUFA	Monounsaturated fat
ONS	Oral nutritional supplement
PCDAI	Pediatric Crohn's Disease Activity Index
PUCAI	Pediatric Ulcerative Colitis Activity Index
SFA	Saturated fat
UC	Ulcerative colitis

Ethical approval: This study has been conducted in accordance with the Declaration of Helsinki and according to the requirements of all applicable local and international standards. The National Scientific and Ethical Committee, Medical Research Council of Hungary provided ethical approval for this study (TUKÉB 215/2016)

Authors' contribution: HP validated the 3-day food records, entered and analysed them, and performed the statistical analysis. KKB performed body composition analysis, collected and entered data, EP guided the dietetic section and summarized the scientific background. GV and EP revised the article and share senior authorship. GV supervised and coordinated the research and finalized the text.

Conflicts of Interest: The authors declare no conflict of interest and no financial support was received for this study.

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