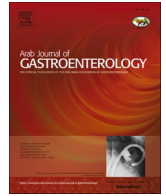


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Arab Journal of Gastroenterology

journal homepage: www.journals.elsevier.com/arab-journal-of-gastroenterology

Original article

Basic anthropometry, micronutrients status and growth velocity of patients with early-onset inflammatory bowel disease: A prospective cohort study

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ARTICLE INFO

Keywords:

IOIBD
VEO-IBD
Nutritional assessment
Nutritional support

ABSTRACT

Background and study aim: Failure of optimal growth and lack of appropriate weight gain are major nutritional problems in children with inflammatory bowel disease (IBD). Therefore, this study was designed to assess the nutritional and growth status of patients with very-early-onset IBD (VEO-IBD) before and after individual-based nutritional interventions.

Patients and methods: This prospective cohort study assessed the nutritional status of 30 pediatric patients with VEO-IBD by performing comprehensive clinical examinations and evaluating anthropometric and biochemical parameters. The latter included the initial evaluation of serum albumin, prealbumin, minerals, and 25-hydroxyvitamin D. A 24-month nutritional strategy was designed for each patient. Patients who completed the study were reassessed after 6 months and their growth rate was calculated 2 years later.

Results: The initial assessment of malnutrition severity using the World Health Organization's z-score revealed that 36.7%, 43.3%, and 26.7% of the study group were underweight, stunted, and wasted, respectively. Among the study population, Crohn's disease has the highest prevalence. Almost all patients had micronutrient deficiencies (i.e., iron, calcium, zinc, magnesium, and vitamin D) and subnormal serum levels of nutritional markers (i.e., prealbumin and albumin). Six months after the intervention, a significant improvement in anthropometric and biochemical parameters was detected ($p < 0.05$); nevertheless, the calculated growth rate revealed a considerable decrease after 2 years.

Conclusion: The early detection of nutritional impairment in patients with VEO-IBD remains a major challenge. Therefore, nutritional support and constant monitoring of these patients are necessary to ensure the improvement in their nutritional status and achieve an acceptable growth rate. Furthermore, we found that prealbumin could be a good discriminative tool for screening malnutrition in such patients.

Introduction

Recently, very-early-onset inflammatory bowel disease (VEO-IBD) was identified as IBD occurring in children younger than 6 years. A subset of these patients has infantile IBD, defined as IBD developing in children younger than 2 years [1–2]. The Paris pediatric modification of the Montreal classification defines VEO-IBD as a subtype of IBD different from that of older children, accounting for 4%–10% of pediatric IBD [3]. According to the revised Porto criteria, VEO-IBD includes the following subtypes: ulcerative colitis (UC), atypical UC, IBD unclassified (IBD-U),

and Crohn's disease (CD) [4–6].

Nutritional impairment is an important disease feature of IBD. According to the European Society for Pediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN), nutritional status assessment, including dietary intake and anthropometric measurements, is essential for treating and monitoring these children [7–9].

Micronutrient deficiency can occur even with mild disease or during remission. The risk of nutritional deficiency is more prevalent in individuals with CD than in those with UC and IBD-U. Even with sufficient caloric intake, malabsorption can cause deficiencies in micronutrients,

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Received 2 August 2021; Accepted 13 June 2022

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such as iron, zinc, and vitamin D, depending on the location and severity of illness [10]. Nutritional therapy helps replace nutrient loss, correct specific nutrient deficiencies, and promote energy and nitrogen balance for normal growth and maturation recovery [11].

Therefore, we assessed the nutritional status of patients with VEO-IBD at the time of diagnosis and the impact of nutritional support on their growth after 6 and 24 months of intervention by evaluating anthropometric and biochemical parameters.

Patients and methods

Study design

This prospective, cross-sectional study was approved by the Scientific Research Ethics Committee of the Pediatric Department, Faculty of Medicine, Cairo University, with approval number of **I-101018**. Informed consent was obtained from all parents or legal guardians of the patients before enrollment in the study. This research design complies with the requirements of the latest revision of the Helsinki Declaration of Bioethics (2012). The sample size was calculated using G*Power (version 3.1.9.2; Franz Faul, Universität Kiel, Germany) with input data, effect size of 0.09, α value of 0.05, and power of 0.75.

Patient population

All patients younger than 6 years and newly diagnosed with VEO-IBD were recruited prospectively from the Pediatric Gastroenterology Unit at Cairo University Pediatric Hospital between January 2017 and December 2017. Patients who had recently experienced a noticeable diet change and those whose legal guardians declined participation were excluded from this study.

The study participants were classified into two groups according to their age: group I consisted of patients with infantile IBD (<2 years) and group II included patients aged 2–6 years. Furthermore, based on localization, the patients were subclassified into CD, UC, and IBD-U.

The IBD diagnosis was confirmed in all patients using the ESPGHAN “Porto” criteria [6].

Study measurements

The severity and extent of IBD were determined using the pediatric modification of the Montreal classification for IBD (the Paris classification) [3]. **E1** (ulcerative proctitis is used when the disease involvement is limited to the rectum; **E2** (left-sided UC) is assigned when the disease involvement is limited to the colorectum distal to the splenic flexure; **E3** (extensive UC) is used when the disease extends proximally to the splenic flexure and distally to the hepatic flexure; and **E4** (pancolitis) is assigned when the disease extends proximally to the hepatic flexure. For CD, **L1** (terminal ileum and limited cecal disease), **L2** (isolated colitis), **L3** (ileocecal disease), **L4a** (disease proximal to ligament of Treitz), and **L4b** (distal to ligament of Treitz and proximal to distal one-third of ileum) were used to classify the patients.

IBD activity was quantified using two indices: the Pediatric Ulcerative Colitis Activity Index (PUCAI) and the Pediatric Crohn’s Disease Activity Index (PCDAI).

PCDAI values of <10, 10–27.5, 30–37.5, and >40 indicated remission, mild disease, moderate disease, and severe disease, respectively. Regarding the PUCAI, scores of <10, 10–34, 35–64, and >65 were determined as remission, mild disease activity, moderate disease activity, and severe disease activity, respectively [4]. Gastroenterologists with extensive experience performed all calculations.

Steroids were the medication used to induce remission in the study participants with a dose of 2 mg/kg daily and were gradually withdrawn over 10 weeks. All patients were carefully monitored for the disease’s activity index. In the same context, the cornerstone of maintenance therapy was anti-inflammatory drugs (sulfasalazine/mesalamine) and

azathioprine.

The patients were followed up for 6 months after enrollment, and their growth rate was calculated 2 years later. They were subjected to the following:

1. Initial nutritional assessment:

i. *The Pediatric Subjective Global Assessment questionnaire* [12] was used to assess the general nutritional status of individuals. The questionnaire included weight change, dietary intake, oral motor skill development, feeding tolerance, functional capacity, muscle wasting, and ankle edema. All items were assessed relative to one another when calculating the overall score. Accordingly, the patients were categorized as being well-nourished if they received normal ratings on all or most items or malnourished if they received moderate to severe ratings on most or all items.

ii. *Anthropometric measurements* of weight, height, and body mass index (BMI) were assessed. The mid-upper arm circumference (MUAC), thickness of triceps skinfold (TSF) and midarm muscle circumference (MAMC) were also estimated. The MAMC was calculated using either the following formula: $MUAC = 3.1415 \times TSF$ or the Midarm Muscle Circumference Calculator through the Pediatric Oncall mobile application [13]. Dry weight was estimated for patients with edema. All measurements were further categorized using standard deviation scores (z-scores) for the World Health Organization (WHO) growth charts computed using the ANTHROCALC software application [14]. The WHO criteria were used to assess and grade the severity of malnutrition into underweight, stunted, and wasted [15–16].

All measurements were recorded during the initial assessment and after 6 months of nutritional support. At the 2-year follow-up, weight velocity z-score and length velocity z-score were evaluated.

iii. *Basic laboratory parameters*: complete blood count (CBC), serum albumin, total proteins, and minerals (i.e., iron, calcium, phosphorus, magnesium, and zinc) were evaluated. The zinc level was determined using an A-Analyst 800 atomic absorption spectrophotometer (Perkin Elmer, USA). Prealbumin and 25-hydroxyvitamin D were measured using an immunoturbidimetric assay (Roche/Hitachi MODULAR P analyzer: CAN 710) and immunoassay (Roche/Hitachi MODULAR P analyzer: E170), respectively.

Regarding anemia, hemoglobin concentrations of < 11, <7, and < 5 g/dL were classified as mild, moderate, and severe anemia, respectively [17]. Hypoalbuminemia was defined as serum albumin concentrations of <3.5 g/dL.

C-reactive protein (CRP) was assessed in all study participants at the time of enrollment to assess disease activity. As it is expensive and nonspecific for IBD, stool calprotectin was not assessed in any patient.

2. Nutritional intervention:

According to the recommended daily allowance (RDA), the specific diet plan was designed for each patient considering their age, nutritional status, and protein requirements, as follows:

- i. Properly calculated caloric requirements multiplied by 1.2 as a stress factor
- ii. Protein determined by age and increased by up to 20%–50% for catch-up growth.

There were no dietary restrictions. Monthly modifications were made based on the patients’ symptoms, activity index, disease location, small intestinal stricture, and specific nutritional deficits. Patients with poor compliance were provided oral high-caloric formulas (1 mL = 1 kcal), and if unavailable, a regular formula enriched with fortified cereals to give the same caloric value was provided. A tube feeding using a

20-mL syringe was applied if adequate oral caloric intake was not tolerated. Patients who were not tolerant of the push method (e.g., vomiting and abdominal distention) were admitted to the hospital and received enteral feeding using a syringe infusion pump. The energy requirements of patients with CD were increased by >120%–150% above the acceptable levels. The caloric intake was administered gradually in increments depending on the patients' nutritional status, tolerance, and disease activity [18]. In the same context, protein requirements were determined based on age and increased by 20%–50% for catch-up growth. A balanced diet was designed based on the second edition of the National Nutrition Institute Food Composition Tables for Egypt (2006) [19]. Table 1 demonstrates the recommended doses of micronutrient supplementation.

3. Nutritional assessment, follow-up, and reassessment:

These assessments were conducted after 6 months with re-evaluation of anthropometric measurements, CBC, iron, total proteins, albumin, calcium, PO₄, and 25-hydroxyvitamin D. Two years later, the growth rate was calculated using the WHO growth velocity standards [20].

Statistical analysis

Data were entered into a computer using "Microsoft Office Excel" for Windows 2010. Data were then transferred to Statistical Package of the Social Sciences (version 23; IBM Corporation, Armonk, NY, USA) to be statistically analyzed. Data were described as ranges, means, standard deviations, medians, and interquartile ranges for quantitative variables, whereas, for qualitative variables, data were presented as frequencies and percentages. The Mann–Whitney *U* test was used to compare groups for quantitative factors, and the chi-square test or Fisher's exact test was used to compare groups for qualitative variables. Comparison of paired measures was performed using McNemar's test for binary variables or the Wilcoxon test for ordinal ones. *P*-values of <0.05 were used to indicate statistical significance.

Results

In total, 30 children diagnosed with VEO-IBD were enrolled in this study; 25 completed the study at 6 months and 20 at 2 years. All dropouts were excluded from the final analysis at 6 and 24 months (Fig. 1).

Table 2 shows the basic demographic and clinical features of the study participants. In this study, VEO-IBD was more common among boys than girls with a male-to-female ratio of 1.5:1. Patients with UC comprised the largest group in this study (*n* = 15), followed by those diagnosed with IBD-U (*n* = 8).

Approximately two-thirds of the study participants (*n* = 20, 66.6%) were categorized as having severe disease, with 13 patients were in

Table 1

The recommended daily allowances (RDA) of micronutrients in the pediatric age group [19].

Nutrient	RDA
Calcium	According to age 1–3 years: 700 mg/day 4–8 years: 1000 mg/day 9–13 years: 1.300 mg/day
Vitamin D	2000 IU, oral cholecalciferol (vit. D3) daily
Vitamin B12	1000 µg intramuscular every other day for one week, then weekly until clinically improved if clinically deficient
Folic acid	0.5 mg/day
Iron	3 mg/kg/day oral elemental iron with mild (>10 g/dL) anemia and negative inflammatory markers
Zinc	3–5 mg/day oral elemental zinc for 2–3 weeks with significant diarrhea
Omega 3	1 g/day

remission (43.3%). Most patients with UC were classified as E2 (*n* = 5) and E4 (*n* = 5); four patients were classified as E1, whereas only one patient was classified as E3. For children with CD, three had L1, one had L2, and three had ileocolonic lesions (L3). In terms of CD behavior, four patients had non-stricturing non-penetrating behavior (B1), while three exhibited stricturing behavior (B2). All patients but one (G0) with CD had growth delay (G1).

Severe wasting and severe stunting were the most prevalent forms of malnutrition among the study groups, accounting for 23.4% of the study participants (Table 2).

None of the patients under study had lymphopenia or had a family history of analogous illnesses, except for one patient who was screened for primary immunodeficiency disease and was found to be negative. Only three patients had high CRP levels on the initial evaluation.

Baseline anthropometric characteristics

Table 3 shows the difference in anthropometric parameters among the entire study population at baseline and 6 months after the nutritional interventions. Based on the z-scores for the initial anthropometric parameters, 40% of the patients under study had H (L) AZ < -2 SD, 32% had WAZ < -2 SD, 32% had BMI Z-score < -2 SD, 12% were < 3rd percentile for TSF, 56% were < 3rd percentile for MUAC, and 43.3% were < 3rd percentile for MAMC.

In the same table, after 6 months of follow-up, there was an increase in the mean z-score values of weight, height, and BMI compared with the baseline parameters. However, these differences had no statistical significance. Approximately 80% (*n* = 24), 64%, and 60% of the study participants were >3rd percentile in terms of their mean TSF, MUAC, and MAMC values, respectively.

The calculated height velocity was statistically lower at 24 months than at 6 months from the initiation of the nutritional interventions (12.98 ± 15.83 cm and 18.94 ± 15.88 cm, respectively). In the same context, the corresponding z-score of the computed height velocity at 2 years was -1.04 ± 2.96, whereas that at 6 months was 4.93 ± 2.96 (*p* < 0.001) (Table 3).

Laboratory and hematological parameters

Table 4 shows the laboratory values of the study participants at baseline and after 6 months of follow-up. Statistically significant differences were observed between baseline and 6-month follow-up laboratory values, except for serum phosphate (*p* = 0.127).

Anemia was found in 56% (*n* = 14) of the children under study, being more prevalent among those with UC. Similarly, patients with UC have the lowest median serum iron levels. Hypocalcemia and zinc deficiency were found in 24% (*n* = 6) and 30% (*n* = 9) of the children, respectively. The serum levels of magnesium of 25 children were determined, among whom 16 (64%) had inadequate serum magnesium levels. Prealbumin deficiency was noticed in 20 (66.6%) children. The median prealbumin levels were significantly lower in patients with CD (*n* = 6) than in those with UC (*n* = 11) and IBD-U (*n* = 5.8), respectively (*p* = 0.027).

The patients were classified into three groups based on the medications received for inducing remission (Table 5). Approximately half of the study participants (48%) received aminosalicylates (*n* = 12). Regarding steroid therapy, patients who had recurrent courses of steroids exhibited statistically significantly lower values of most growth and laboratory parameters, including micronutrients, 25-hydroxyvitamin D, serum albumin, and prealbumin, than those who received steroids once or aminosalicylates (*p* < 0.05) (Table 5).

Table 6 shows the serum prealbumin levels relative to the mean z-scores of the anthropometric parameters of the children under study. Approximately two-thirds of the study participants had low serum prealbumin levels on the initial evaluation of their nutritional status (*n* = 20). The weight-for-age and BMI z-scores were the only anthropometric parameters significantly associated with low prealbumin levels (*p* =

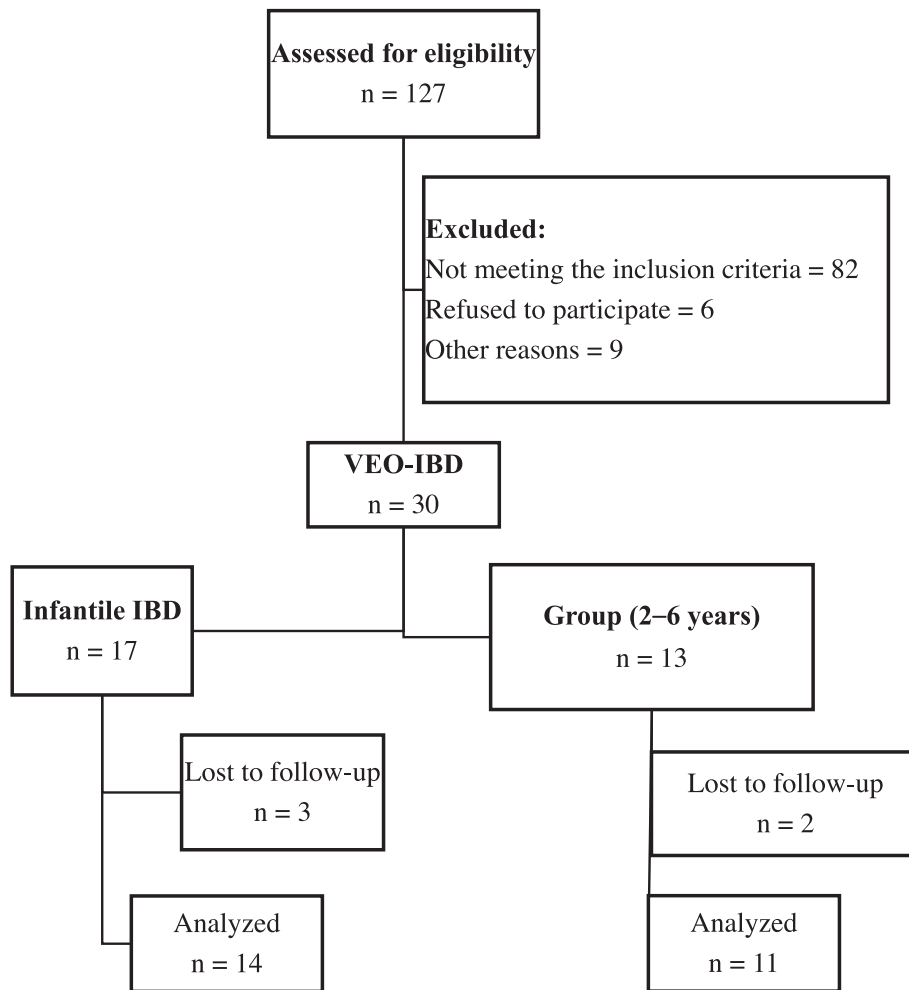


Fig. 1. The study flowchart.

0.049 and 0.030, respectively).

Discussion

Malnutrition and growth failure are major health problems among the pediatric population with IBD. Decreased food intake, which is partly because of the pathophysiology of the disease, including inflammation of the intestinal mucosa and anorexia, is the most significant factor contributing to the poor nutritional status of such children [21]. Hence, screening such patients for caloric and specific nutrient deficiencies and assessing their anthropometric parameters are crucial. This study represents a detailed nutritional assessment of Egyptian children diagnosed with VEO-IBD. Similar to previous studies, most children in this study were diagnosed with UC, followed by IBD-U, which appears to be a trend in VEO-IBD [22]. It has been reported that children younger than 8 years are 3.5 times more likely to have IBD-U than those older than 8 years [23–24].

Data from previous studies showed that children with IBD have significant lower weight and height for age and BMI z-scores than the controls [25–26]. Moreover, MAMC and TSF showed that those patients were more likely to have less lean but normal fat than the reference children; this feature was found to be more prevalent in patients with CD [27,28]. Similarly, in this study, a comparison of the anthropometric parameters based on disease localization showed that patients with CD had a more significant growth impairment than those with UC and IBD-U. In the former group, the prevalence of underweight, stunting, and low BMI was 36.7%, 43.3%, and 26.7%, respectively. Moreover, the mean

TSF values showed no statistical differences among the study groups.

Linear growth expressed as height/length-for-age and sex z-score is easily disrupted by inflammation and malnutrition, a finding frequently encountered in children with IBD, particularly those with CD. In 2018, Teitelbaum and Heyman reported that the height rate, determined by serial measurements of height, is a particular sensitive indicator of growth failure [8]. This is consistent with the findings of this study, which revealed that the growth rate of the study participants was severely affected, particularly on the prolonged follow-up period. This might be attributed to poor compliance and adherence to nutritional rehabilitation and dietary change, which is a common finding in pediatric populations with IBD receiving different nutritional interventions [8].

Subclinical micronutrient deficiencies are common in pediatric patients with IBD, being more prevalent in children with CD than in those with UC [29], a finding that corroborates the results of this study. We found that micronutrient deficiency (e.g., Ca, PO₄, and mg) was more common in children with CD, except for serum iron. Iron was more significantly deficient in patients with UC. This could be explained by frequent bleeding per rectum observed in children with UC.

The initial prevalence of anemia was 56%; however, this rate decreased to 20% at the end of the study. This percentage differs from that found in a previous study, reporting a decreasing incidence of anemia from 74% to 42% after 1 year [30]. This could be partially explained by the long follow-up period adopted in this study.

Magnesium and zinc deficiencies have been largely found in patients with IBD [6]. In a study involving 102 patients aged <18 years, zinc

Table 2

Demographic and clinical characteristics of children with very-early-onset inflammatory bowel disease at the study entry, Egypt, 2017.

Variable of patients with IBD (n = 30)	
Age (years) Mean ± SD	6.8 ± 2.9
Age of onset (years) Mean ± SD	2.8 ± 2.1
Gender [n (%)]	
• Male	18 (60)
• Female	12 (40)
Classification [n (%)]	
• Infantile (0–2 years.)	17 (56.7)
• 2–6 years.	13 (43.3)
Diagnosis [n (%)]	
• CD	7 (23.3)
• UC	15 (50)
• Unclassified	8 (26.7)
Activity during enrolment [n (%)]	
• Remission	13 (43.3)
• Mild	12 (40)
• Moderate	5 (16.7)
Breastfeeding history [n (%)]	
• Breastfed	20 (66.7)
• Formula fed	7 (23.3)
• Mixed	3 (10)
Consanguinity [n (%)]	17 (56.7)
Sibling or 1st degree relative affection [n (%)]	9 (30)
Residence [n (%)]	
• Urban	15 (50)
• Rural	15 (50)
PSGA [n (%)]	
• Normal	0 (0)
• Moderate	10 (33.3)
• Severe	20 (66.7)
Degree of malnutrition	
• Underweight (WAZ < -2 SD)	4 (13.3)
• Severely underweight (WAZ < -3 SD)	7 (23.4)
• Stunted (HAZ < -2 SD)	6 (20)
• Severely stunted (HAZ < -3 SD)	7 (23.4)
• Wasted (BMI Z-score < -2 SD)	7 (23.4)
• Severely wasted (BMI Z-score < -3 SD)	1 (3.3)

Data are presented as means ± standard deviations (SDs) or numbers (%) as appropriate. BMI, body mass index; CD, Crohn's disease; HAZ, height for age z-score; PSGA, Pediatric Subjective Global Assessment; UC, ulcerative colitis; WAZ, weight for age z-score. All anthropometric indicators are calculated for age.

deficiency was more prevalent in those with IBD than in the controls (40% vs. 19%) [31]. In this study, magnesium and zinc deficiencies were confirmed in 64% and 30% of the children under study, respectively, among whom most had CD.

It is strongly suggested that low serum levels of vitamin D are associated with CD activity, which was proven by the increased blood levels of vitamin D following successful CD treatment [32]. Therefore, vitamin D status should be routinely assessed at IBD diagnosis and during subsequent follow-up if it was deficient [30]. Vitamin D deficiency was a common finding detected in 40% of the patients included in this study at the initial evaluation; moreover, vitamin D insufficiency was observed in 16.7% of the study participants, most of whom had CD. This is higher than the levels detected in previous studies in which 19%–35% of the participants had vitamin D deficiency [31,33]. Different sample sizes and long follow-up periods may have resulted in such differences. Note that a weekly oral vitamin D supplementation at a dose of 14,000 IU significantly improved the vitamin D status of the patients included in this study. Another study demonstrated that a weekly intramuscular injection of 50,000 IU was adequate in maintaining serum 25-hydroxy-vitamin D concentration of >30 ng/mL [6].

In terms of the medications used to induce remission, we found that children who received recurrent courses of steroids had initially lower 25-hydroxyvitamin D levels and lower anthropometric parameters than other groups. The levels improved with follow-up.

The ESPEN guidelines stated that the increased rates of protein

Table 3

Anthropometric parameters of the groups under study at baseline and after 6 months of nutrition interventions.

Anthropometric indicators	Baseline N (%)	After 6 months N (%)	P-value
WAZ			
• <-2 SD	8 (32)	5 (20)	0.071
• -2 to -1 SD	9 (36)	4 (16)	
• >-1 SD	8 (32)	16 (64)	
HAZ or (LAZ)			0.112
• <-2 SD	10 (40)	4 (16)	
• -2 to -1 SD	7 (28)	7 (28)	
• >-1 SD	8 (32)	14 (56)	
BMI z-score			0.111
• <-2 SD	8 (32)	2 (8)	
• -2 to -1 SD	4 (16)	4 (16)	
• >-1 SD	13 (52)	19 (76)	
MUAC (percentile)			0.156
• <3rd	14 (56)	9 (36)	
• >3 rd	11 (44)	16 (64)	
TSF (percentile)			0.609
• <3rd	3 (12)	1 (4)	
• >3rd	22 (88)	24 (96)	
MAMC (percentile)			0.395
• <3rd	13 (52)	10 (40)	
• >3rd	12 (48)	15 (60)	

BMI, body mass index; HAZ, height for age z-score; LAZ, length for age; MAMC, mid-arm muscle circumference; MUAC, mid-upper arm circumference; TSF, triceps skinfold, WAZ, weight for age z-score. All anthropometric indicators are calculated for age.

Table 4

Distribution of biochemical and hematological parameters in the groups under study at the study entry and after 6 months of nutrition interventions.

Serum values (normal)	Baseline N (%)	After 6 months N (%)	P-value
Hemoglobin (11–13 g/dL)			
• Normal	11 (44)	20 (80)	0.012 *
• Low	14 (56)	5 (20)	
Serum iron (50–120 µg/dL)			0.005 *
• Normal	7 (28)	12 (48)	
• Low	18 (72)	13 (52)	
Total protein (6–8.3 g/dL)			0.005 *
• Normal	23 (92)	25 (100)	
• Low	2 (8)	0	
Serum albumin (3.5–5 g/dL)			<0.001**
• Normal	21 (84)	23 (92)	
• Low	4 (16)	2 (8)	
Serum calcium (8.8–10.8 mg/dL)			0.004 *
• Normal	19 (76)	22 (88)	
• Low	6 (24)	3 (12)	
Serum PO4 (2.5–4.5 mg/dL)			0.127
• Normal	25 (100)	25 (100)	
• Low	0	0	
25-hydroxy-vitamin D (42.43–134.7 nmol/L)			<0.001 **
• Deficiency	10 (40)	0	
• Insufficiency	4 (16)	3 (12)	
• Sufficiency	11 (44)	22 (88)	

*P-value of < 0.05 is significant; ** highly significant at <0.001..

turnover either because of gut loss of nutrients during active disease or as a side effect of illness therapy reduce lean mass. Accordingly, protein requirements are increased in active IBD, and intake should be increased as well [28]. This study reported a high prevalence of prealbumin deficiency (66.7%) in pediatric patients with IBD. Thus, prealbumin could be used as a good discriminant tool for screening malnutrition in this patient population.

The main objectives of nutrition in IBD are to prevent and treat malnutrition, correct micronutrient deficiencies, promote growth and development, and improve the quality of life [34]. These objectives were

Table 5

Differences in anthropometric parameters during the follow-up period between the three groups according to the medications used to induce remission.

Anthropometric indicators	Medications			P-value
	Steroids once N = 7 (%)	Recurrent steroids N = 6 (%)	Aminosalicylates N = 12 (%)	
WAZ				
• < -2 SD	0	3 (50)	1 (8.3)	*0.032
• -2 to -1 SD	1 (14.3)	2 (33.3)	1 (8.3)	
• > -1 SD	6 (85.7)	1 (16.7)	10 (83.3)	
HAZ or (LAZ)				
• < -2 SD	0	4 (66.7)	0	0.004 *
• -2 to -1 SD	3 (42.9)	1 (16.7)	4 (33.3)	
• > -1 SD	4 (57.1)	1 (16.7)	8 (66.7)	
BMI z-score				
• < -2 SD	0	1 (16.7)	1 (8.3)	0.744
• -2 to -1 SD	1 (14.3)	0 (0)	1 (8.3)	
• > -1 SD	6 (85.7)	5 (83.3)	10 (83.3)	
MUAC (percentile)				
• < 3 rd	0	5 (83.3)	1 (8.3)	0.005 *
• > 3 rd	7 (100)	1 (16.7)	11 (91.7)	
TSF (percentile)				
• < 3 rd	0	0	0	0.005 *
• > 3 rd	7 (100)	6 (100)	12 (100)	
MAMC (percentile)				
• < 3 rd	0	3 (50)	1 (8.3)	0.090
• > 3 rd	7 (100)	3 (50)	11 (91.7)	

BMI, body mass index; HAZ, height for age z-score; LAZ, length for age; MAMC, mid-arm muscle circumference; MUAC, mid-upper arm circumference; TSF, triceps skinfold; WAZ, weight for age z-score. * P-value of <0.05 is significant. † All anthropometric indicators are calculated for age.

Table 6

The association between the prealbumin serum values and the baseline anthropometric parameters in the groups under study.

Baseli > e anthropometric parameters	Prealbumin ^a		P-value
	Low values (n = 20) (%)	Normal values (n = 10) (%)	
WAZ			
• < -2 SD	10 (50)	1 (10)	0.049 *
• > -2 SD	10 (50)	9 (90)	
HAZ or (LAZ)			
• < -2 SD	9 (45)	4 (40)	0.829
• > -2 SD	11 (55)	6 (60)	
BMI z-score			
• < -2 SD	7 (35)	1 (10)	0.030 *
• > -2 SD	13 (65)	9 (90)	
MUAC (percentile)			
• < 3 rd	11 (55)	2 (20)	0.119
TSF (Percentile)			
• < 3 rd	1 (5)	0	1.000
MAMC (percentile)			
• < 3 rd	11 (55)	3 (30)	0.260
25-hydroxy-vitamin D (42.43–134.7 nmol/L)			
• Deficient	10 (50)	2 (20)	0.278

^aNormal values: 4–6 months, 2.8–5 µmol/L; 7–12 months, 3.2–5.7 µmol/L; 13–24 months, 1.9–5 µmol/L; 25–36 months, 3.3–5.8 µmol/L; 3–5 years, 2.9–5.8 µmol/L. BMI, body mass index; HAZ, height for age z-score; LAZ, length for age; MAMC, mid-arm muscle circumference; MUAC, mid-upper arm circumference; TSF, triceps skinfold. *P value of <0.05 is significant. † All anthropometric indicators are calculated for age.

achieved in the patients in this study during a brief follow-up period; however, a 2-year follow-up revealed a trend toward stunting, which might be related to noncompliance and chronic steroid use.

In conclusion, nutritional impairment significantly affects children with VEO-IBD, particularly those with CD; 40% of those may be stunted and underweight. In a descending order, the most common deficient micronutrients are magnesium, serum iron, vitamin D, zinc, and calcium. Prealbumin is a good discriminative tool for screening malnutrition in such patients. Nutritional support for those patients with close follow-up is mandatory to achieve acceptable growth and improve their nutritional status on short and long follow-up periods.

Regarding the study limitations, the relatively small sample size restricted the ability to adequately evaluate the nutrition interventions. Furthermore, a small proportion of the study participants dropped out of the study during the 24-month follow-up period.

Source of funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Contributor statement

All authors contributed to the data analysis and final revision of the manuscript.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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