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ARTICLE

Body composition, energy expenditure and physical activity

# Nutritional status and body composition in children with inflammatory bowel disease: a prospective, controlled, and longitudinal study

S. Selbuz[1] · A. Kansu[1] · M. Berberoğlu[2] · Z. Şıklar[2] · Z. Kuloğlu[1]

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## Abstract

**Background** Malnutrition and growth retardation (GR) are major extraintestinal presentations of inflammatory bowel disease (IBD) in childhood and are especially prevalent among those with Crohn's disease (CD). We aimed to evaluate nutritional and growth status and body composition (BC) of children with IBD during a 1-year follow-up.

**Methods** Thirty-eight children with IBD and 57 age- and sex-matched controls were recruited prospectively. Anthropometry (weight, height, body mass index (BMI), and triceps skinfold thickness (TSFT) indicated as $z$ scores for age and sex and mid-arm circumference) and bioelectrical impedance analysis were performed at baseline (T0) and after 1 year (T1). Disease activity was evaluated by clinical scoring systems. GR was defined as HAZ < −2, undernutrition as WAZ < −2, severe malnutrition (SM) as BMIZ < −2, and obesity was defined as BMIZ > +2. A $p$ value of <0.05 was considered statistically significant.

**Results** Thirty-six children with IBD (22 ulcerative colitis, 12 CD, and 2 indeterminate colitis) and 43 controls completed the study. Most patients were in remission during the study period (T0:71.4%; T1:72.2%). No significant differences were found regarding the frequency of GR (5.6%/8.3%), undernutrition (11.1%/2.8%), and SM (11.1%/5.6%) between T0 and T1 in the IBD group. The changes in anthropometrics and BC measurements during the study period did not differ between the groups except for the TSFT $z$ score.

**Conclusion** Most patients with IBD were well nourished and grown, although some children were underweight and had GR. Our results suggest that, in IBD patients, the fat mass (FM) showed a gradual increase over time compared with controls.

## Introduction

Malnutrition and growth retardation (GR) are major extra-intestinal presentations in childhood inflammatory bowel disease (IBD) and are especially prevalent among those with Crohn's disease (CD) [1]. Various factors such as inadequate food intake, poor absorption of nutrients, and increased energy need contribute to the development of GR and malnutrition [2]. While the assessment of linear growth is very easy, evaluation of malnutrition is quite complex and is often limited to weight and body mass index (BMI) measurement. Unfortunately, these measurements provide little information about what actually happened in the body compartments and the increase in these parameters may not always reflect the improvement in nutritional status [3]. The measurement of body composition (BC) provides a more basic and detailed examination of nutritional status compared with anthropometry.

Recently, changes in the lean body mass have been described in investigations of children with IBD, however, body fat alteration is less well defined [4]. The lack of knowledge on the nutritional status of children with IBD in developing countries encouraged us to do this study. We

These authors contributed equally: S. Selbuz, Z. Kuloğlu

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✉ S. Selbuz
kaymaksuna@gmail.com

✉ Z. Kuloğlu
zarifekuloglu@yahoo.com

[1] Ankara University School of Medicine, Pediatric Gastroenterology, Hepatology and Nutrition, Ankara, Turkey

[2] Ankara University School of Medicine, Pediatric Endocrinology, Ankara, Turkey

aimed to analyze nutritional and growth status and BC of children with IBD during a 1-year follow-up and to compare with healthy subjects.

## Materials and methods

### Study design

This single-center, prospective, controlled, and longitudinal study (ClinicalTrials.gov Identifier NCT02704026) were carried out in our Department of Pediatric Gastroenterology outpatient clinic between July 2015 and February 2017.

### Subjects

Patients with IBD at any stage of disease activity and duration while on treatment and age- and sex-matched healthy controls were included. The control group was selected among the population of general outpatients service who were thought to be healthy based on history, examination, and routine laboratory tests. Children were eligible if they were between 6 and 18 years old in both two groups. Patients with a diagnosis of IBD according to ESPGHAN Revised Porto Criteria were included [5]. Control subjects were included if they had no evidence of inflammatory or chronic disease. Exclusion criteria include the age <6 years and >18 years of age at the time of enrollment. IBD patients who were known to have other diseases that might have an impact on height, weight, and nutritional status were excluded from this study. Control subjects were excluded if they had a diagnosis of any disease that affects growth, nutritional status, dietary intake, or development.

### Data collection

#### Anthropometry and body composition

At the time of enrollment (T0) and after 1 year (T1), anthropometric measurements including weight, height, middle arm circumference (MAC), triceps skinfold thickness (TSFT), and assessment of BC by bioelectrical impedance were performed for each child. Data about weight and height at the time of diagnosis in patients with IBD were also recorded.

#### Puberty

The pubertal stage was evaluated according to the criteria of Tanner by the same investigator at T0 and T1 [6, 7]. It was categorized into three groups as pre (Tanner stage 1), peri (Tanner stage 2–4), or postpubertal stage (Tanner stage 5).

#### IBD-related parameters

IBD-related parameters were evaluated in patients with IBD only. Data about the duration of symptoms, extra-intestinal manifestations, and endoscopy findings at the time of diagnosis were collected. Disease location, behavior, and severity of the disease at the time of diagnosis were classified according to Paris classification [8]. During the study, the medications being used were noted. Disease activity for IBD patients was evaluated using a clinical scoring system for CD and UC. The inactive disease was defined as these scores <10 (Supplementary Table S1). Biochemical parameters including complete blood count, albumin (g/dL), C-reactive protein (CRP), and erythrocyte sedimentation rate were recorded at two study visits in all IBD patients.

#### Assessment of anthropometry and body composition

All anthropometric and BC measurements were obtained in the morning hours following 8–12 h of fasting period at the same time for each subject. All measurements were carried out by the same investigator (SS).

Total body weight, total body water (TBW), fat-free mass (FFM), FM, and fat percentage (%) were measured by bioimpedance device (Tanita Body Fat Analyzer, model TBF 300) with light clothing. Height measurement was done with a standing stadiometer with bare feet.

The mid-arm circumference was measured by a measuring tape at the mid-point between the olecranon process and acromion from the right side of the body. The same point was used for skinfold thickness measurements by Holtain skinfold calipers. Three measurements were recorded and the average was noted. Age- and sex-specific $z$ scores for weight, height, BMI, and TSFT were calculated by using CDC data (https://www.cdc.gov/growthcharts/computer_programs.htm). Age and sex specific linear growth velocity $Z$ scores (GvZ) were calculated from normative reference data [9].

GR was defined as the height for age $z$ score (HAZ) $<-2$, undernutrition as the weight for age $z$ score (WAZ) $<-2$, severe malnutrition as the BMI z score (BMIZ) $<-2$, and obesity was defined as BMIZ more than $+2$.

### Statistics

The $t$ test was used when comparing clinical characteristics between the IBD and control groups and between the CD and UC groups. For non normally distributed parameters, the Mann–Whitney nonparametric U test was used. Differences in categorical variables were tested using Pearson's chi-squared test. The Wilcoxon signed-rank test was used to compare repeated measurements to assess whether their

mean ranks differ. Δ change was calculated as T1 value – T0 value. $P < 0.05$ was considered statistically significant. All statistical analyses were conducted with SPSS 20 (IBM Software Group, San Francisco, CA, USA).

## Results

### Subjects Characteristics

Thirty-eight IBD patients and 57 controls initially recruited. Finally, 36 IBD patients and 43 controls completed the study. Of these 36 IBD patients, 22 patients were UC, 12 CD, and 2 were indeterminate colitis (Fig. 1). All participants were followed up for 1 year. The demographic characteristics of the IBD and control groups at baseline are shown in Table 1. The median age, gender distribution, puberty stage, HAZ, and WAZ score were similar in the IBD and control groups.

In the IBD group, the median age was 13.9 years (range; 6–17.8 years), 19 children were male. The median follow-up of IBD patients was 23 months (range; 0–159 months). Among 36 IBD patients included in the study, there was only one patient who was newly diagnosed. The follow-up from the diagnosis to the beginning of the this study was 3 months in two patients. As a result, the follow-up was longer than 6 months in all IBD patients except for three patients. The median age at the time of diagnosis was 10.5 years (range; 1–17.5 years), in the IBD group. At the time of diagnosis, five patients (17.9%) had growth failure while five (17.9%) and eight (28.6%) had undernutrition and severe malnutrition, respectively.

### Disease characteristics

Disease location at the time of diagnosis, disease activity, and therapies administered during the study period are summarized in Supplementary Tables S2–S4, respectively. The majority of the patients with UC had extensive colitis or pancolitis at the diagnosis. Ileocolonic involvement with and without upper GI involvement was most common in CD patients. Majority of the patients had mild (23.5% at T0/23.5% at T1) or inactive (67.6% at T0/73.5% at T1) disease during the study period. Most patients were treated with aminosalicylates and only two patients were taking steroid therapy at T0. Thirteen patients had used steroids and two patients had colectomy in the past.

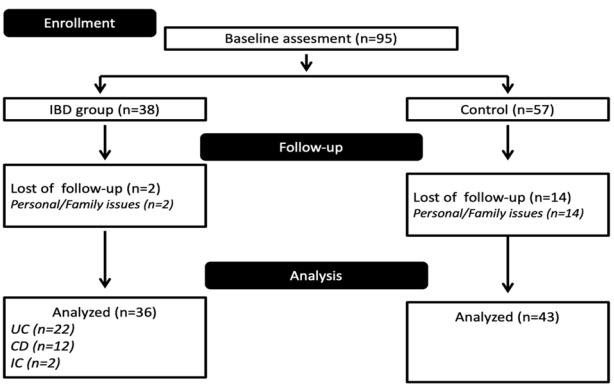



**Fig. 1 Flow chart showing the allocation of children with IBD and control group.** IBD inflammatory bowel disease, UC ulcerative colitis, CD Crohn's disease, IC indeterminate colitis.

**Table 1** Demographic characteristics at baseline.

| | IBD ($n = 36$) | Control ($n = 43$) | $p$ |
|---|---|---|---|
| Age (year) | 12.9 (5–17.8) | 13.6 (7–17.8) | n.s |
| Sex (male), $n$ (%) | 19 (52.8) | 23 (53.5) | n.s |
| Pubertal stage, $n$ (%) | | | n.s |
| Prepubertal | 11 (30.5) | 14 (32.5) | |
| Peripubertal | 6 (16.7) | 12 (27.9) | |
| Postpubertal | 19 (52.8) | 17 (39.5) | |
| HAZ[a] | −0.4 (−2.4 to 2.3) | −0.2 (−2.0 to 2.3) | n.s |
| WAZ[a] | −0.6 (−2.7 to 1.9) | −0.2 (−2 to 1.5) | n.s |
| Disease activity $n$, (%) | | | |
| Inactive | 23 (67.6) | NA | |
| Mild | 8 (23.5) | NA | |
| Moderate | 1 (2.9) | NA | |
| Severe | 2 (5.9) | NA | |
| Treatment $n$ (%) | | | |
| Aminosalicylates | 28 (77.8) | NA | |
| Steroids | 2 (5.5) | NA | |
| Immunomodulators | 4 (11.1) | NA | |
| Enteral nutrition | 4 (11.1) | NA | |

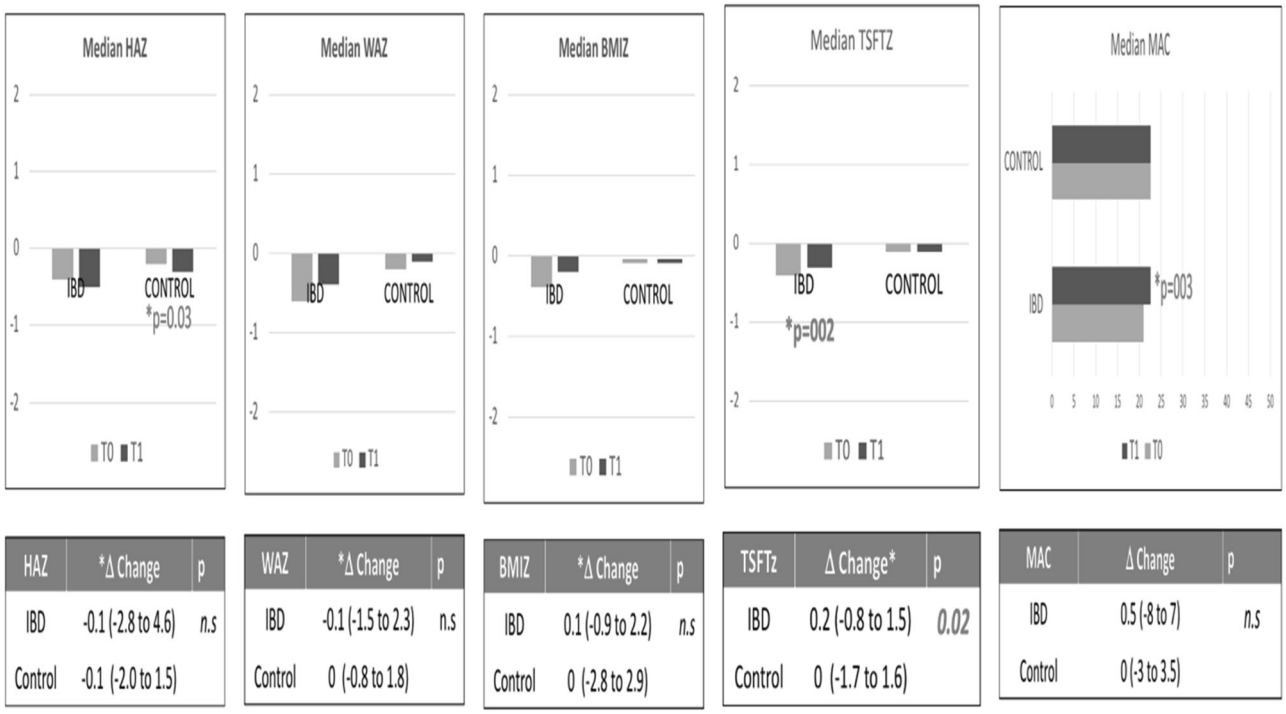
*IBD* inflammatory bowel disease, *HAZ* height for age $z$ score, *WAZ* weight for age $z$ score, *NA* non available

[a]Median (minimun–maximum)

### Changes in anthropometry and body composition parameters during the study period

Anthropometric parameters including HAZ, WAZ, BMIZ, TSFTz, and MAC during the study period are presented in Fig. 2. Median HAZ, WAZ, BMIZ, and TSFTz were within the normal limits in both IBD and controls. TSFTz and MAC of IBD patients improved significantly during the study. However, there was no significant difference between the two groups in terms of delta change, except for TSFTz.

The median annual linear growth velocity was similar in both IBD group (5 cm/year (range 0–11 cm/year) and control group (5.5 cm/year (range 0–10 cm/year) ($p$ = n.s). The median GvZ was −1.0 (range −2.0 to 1.7) for IBD group and −1.0 (range −2.4 to 1.9) in the control group, and there




| HAZ | *Δ Change | p |
|---|---|---|
| IBD | -0.1 (-2.8 to 4.6) | *n.s* |
| Control | -0.1 (-2.0 to 1.5) | |

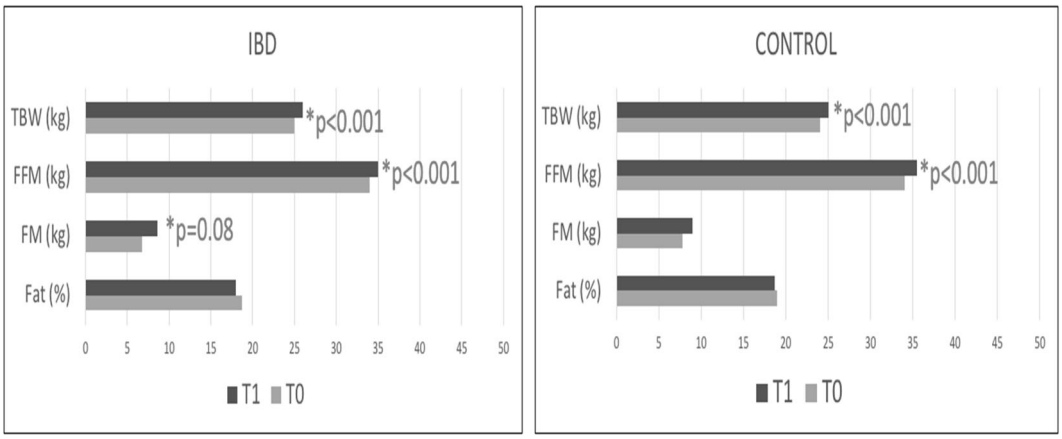
| WAZ | *Δ Change | p |
|---|---|---|
| IBD | -0.1 (-1.5 to 2.3) | n.s |
| Control | 0 (-0.8 to 1.8) | |

| BMIZ | *Δ Change | p |
|---|---|---|
| IBD | 0.1 (-0.9 to 2.2) | *n.s* |
| Control | 0 (-2.8 to 2.9) | |

| TSFTz | Δ Change* | p |
|---|---|---|
| IBD | 0.2 (-0.8 to 1.5) | *0.02* |
| Control | 0 (-1.7 to 1.6) | |

| MAC | Δ Change | p |
|---|---|---|
| IBD | 0.5 (-8 to 7) | *n.s* |
| Control | 0 (-3 to 3.5) | |

**Fig. 2 Anthropometric parameters over the course of 1 year.** *Δ Change was expressed as median (range). T0 at the time of enrollment, T1 after 1 year, IBD inflammatory bowel disease, HAZ height for age *z* score, WAZ weight for age *z* score, BMIZ body mass index *z* score, TSFTz Triceps skinfold thickness *z* score, MAC Mid- upper arm circumference.




| Fat (%) | Δ Change | p |
|---|---|---|
| IBD | 0.8 (-8.5 to 8.5) | *n.s* |
| Control | -0.1 (-9.1 to 10) | |

| FM (kg) | Δ Change | p |
|---|---|---|
| IBD | 0.8 (-10 to 8) | *n.s* |
| Control | 0.35 (-12.7 to 4.5) | |

| FFM (kg) | Δ Change | p |
|---|---|---|
| IBD | 2.4 (-2.6 to 19.8) | *n.s* |
| Control | 2.4 (-12 to 12) | |

| TBW (kg) | Δ Change | p |
|---|---|---|
| IBD | 1.8 (-1.9 to 14.5) | *n.s* |
| Control | 1.8 (-8.7 to 8.7) | |

**Fig. 3 Body composition over the course of 1 year.** *Δ Change was expressed as median (range). T0 at the time of enrollment, T1 after 1 year, IBD inflammatory bowel disease, TBW total body water, FFM fat-free mass, FM fat mass.

was no significant difference in linear growth rate between children with IBD and controls.

The changes in BC over time are shown in Fig. 3. In IBD patients, parameters of BC significantly increased throughout of the study, except for fat percentage. This trend was also seen in the control subjects for FFM and TBW components. However, delta change of these parameters was not different between groups.

## Nutritional status of IBD patients during the study period

The nutritional status of the patients with IBD is presented in Fig. 4. In IBD patients, the rate of GR increased whereas the rate of undernutrition and severe malnutrition decreased during the study period but these were not statistically significant.

## Subgroup analysis by disease category

Subdivided groups by disease category are presented in Tables 2 and 3. A small but significant decrease was noted in HAZ of controls and patients with UC ($p = 0.03$ and $p = 0.04$, respectively). However, there was no significant difference in linear growth rate between three groups ($p =$ n.s).

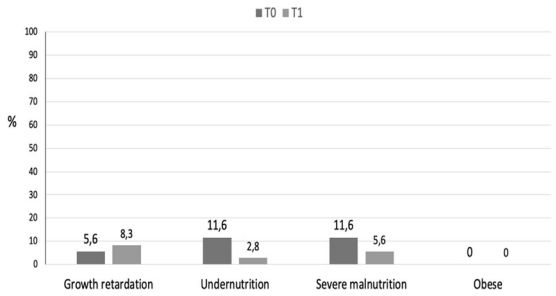



**Fig. 4 Nutritional status of children with IBD over the course of 1 year.** T0 at the time of enrollment, T1 after 1 year.

The median GvZ was −0.8 (range −2.0 to 1.2) for children with CD, −1.1 (range −2.0 to 1.73) in children with UC and −0.97 (range −2.4 to 1.9) in controls. The TSFTz of UC patients improved significantly ($p = 0.03$). The rate of change over time in anthropometric data was not different between the groups. Fat mass significantly increased in only UC patients ($p = 0.02$), however, FFM and TBW significantly increased in all three groups over the course of study ($p < 0.01$).

At the beginning of the study, GR was observed in 16.7% ($n = 2$) and none of the patients with CD and UC, respectively. Moreover, 16.7% ($n = 2$) and 4.5 % ($n = 1$) of cases of CD and UC, respectively had undernutrition and, 8.3% ($n = 1$) of cases of CD and 13.6% ($n = 3$) of cases of UC were severe malnutrition. At the end of the study, GR was detected in 8.3% ($n = 1$) and 9.1% ($n = 2$) of patients with CD and UC, respectively. Moreover, 0 and 4.5% ($n = 1$) of cases of CD and of UC, respectively had undernutrition and, none of cases of CD and 9.1% ($n = 2$) of cases of UC were severe malnutrition.

## Discussion

This study which consisted mainly of IBD patients with the mild or inactive disease showed that the changes in anthropometrics and BC parameters during 1-year follow-up did not differ between IBD patients and age- and

**Table 2** Anthropometric parameters in children with CD and UC during the study.

| Parameters | Group | T0 | T1 | p1 | Δ change | p2 |
|---|---|---|---|---|---|---|
| WAZ | CD | −0.6 (−2.2 to 3.1) | −0.3 (−1.9 to 0.9) | 0.09 | −0.1 (−0.2 to 2.3) | 0.25 |
| | UC | −0.5 (−2.7 to 1.9) | −0.5 (−2.6 to 1.7) | 0.83 | −0.1 (−1.5 to 1) | |
| | Control | −0.2 (−2 to 1.5) | −0.1 (−2.3 to 1.7) | 0.68 | 0 (−0.8 to1.8) | |
| HAZ | CD | −0.5 (−2.4 to 1.2) | −0.3 (−2.2 to 2.4) | 0.96 | 0 (−0.6 to 4.6) | 0.35 |
| | UC | −0.3 (−1.9 to 2.3) | −0.6 (−2.3 to 1.9) | 0.04 | −0.1 (−2.8 to 0.8) | |
| | Control | −0.2 (−2.0 to 2.3) | −0.3 (−2.3 to 2.3) | 0.03 | −0.1 (−2.0 to 1.5) | |
| BMIZ | CD | −0.4 (−2.1 to 0.7) | −0.1 (−0.7 to 0.7) | 0.02 | −0.1 (−0.6 to 2.2) | 0.50 |
| | UC | −0.4 (−4.0 to 1.7) | −0.3 (−3.4 to 1.9) | 0.2 | −0.9 (−1.1 to 0) | |
| | Control | 0 (−3.5 to 2.3) | 0 (−3.2 to 1.7) | 0.71 | 0 (−2.8 to 2.9) | |
| TSFT z | CD | −0.1 (−1 to 0.6) | −0.1 (−0.9 to 0.9) | 0.47 | −0.01 (−0.8 to 1.5) | *0.09* |
| | UC | −0.4 (−1.8 to 1.7) | −0.4 (−1.7 to 2.1) | 0.03 | −0.3 (−0.6 to 1) | |
| | Control | −0.1 (−2.5 to 1.8) | 0.1 (−2.5 to 1.8) | 0.48 | 0 (−1.7 to 1.6) | |
| MAC (cm) | CD | 23.3 (17 to 36.5) | 24.7 (18 to 36.5) | 0.07 | 0.3 (−1 to 7) | 0.36 |
| | UC | 21 (15 to 34) | 22.3 (16 to 30) | 0.24 | 0.5 (−8 to 2.5) | |
| | Control | 22.5 (15 to 29) | 22.5 (15.5 to 30.5) | 0.57 | 0 (−3 to 3.5) | |

Data were expressed as median (minimum–maximum)

p1: comparison of median values in T0 and T1 in each group

p2: comparison of delta change between three groups

*T0* at the time of enrollment, *T1* after 1 year, *Δ change* T1-T0, *CD* Crohn's disease, *UC* Ulcerative colitis, *WAZ* weight for age *z* score, *HAZ* height for age *z* score, *BMIZ* body mass index *z* score, *TSFTz* triceps skinfold thickness *z* score, *MAC* mid upper arm circumference

**Table 3** Body composition in children with CD and UC during the study.

| Parameters | Group | T0 | T1 | *p* | Δ Change | *p* |
|---|---|---|---|---|---|---|
| Fat (%) | CD | 19.7 (10– 28) | 19.5 (9–26) | 0.08 | 0.1 (−8.5 to 5.2) | *0.55* |
| | UC | 17 (9–36) | 15.7 (10–39) | 0.01 | 0.8 (−4.4 to 8.7) | |
| | Control | 19 (7– 39) | 18.7 (11.7–31) | 0.09 | −0.1 (−9.1 to 10) | |
| Fat mass (kg) | CD | 6.4 (4–18) | 8.6 (4–16.6) | 0.02 | 0.5 (−1.6 to 3.4) | *0.35* |
| | UC | 7 (2–24) | 8 (2–28.5) | 0.02 | 0.8 (−10 to 8) | |
| | Control | 7.8 (2–24) | 9 (3–18.6) | 0.50 | 0.35 (−12.7 to 4.5) | |
| Fat-free mass (Kg) | CD | 38 (18–59) | 45 (19.5–60.5) | 0.01 | 2.9 (−2.6 to 19.8) | 0.63 |
| | UC | 33 (13–49) | 34 (5–53) | 0.001 | 2.4 (−1,3 to 9) | |
| | Control | 34 (13–58) | 34.5 (15.5–60.5) | 0.001 | 2.4 (−12 to 12) | |
| Total body water (kg) | CD | 27.9 (13–43) | 33 (14–42) | 0.01 | 2.1 (−1.9 to 14.5) | *0.77* |
| | UC | 24 (10–36) | 25 (10–39) | 0.001 | 1.8 (−0.9 to 4.9) | |
| | Control | 24 (9–42) | 25 (11.5–44) | 0.001 | 1.8 (−8.7 to 8.7) | |

Data were expressed as median (minimum–maximum)

p1: Comparison of median values in T0 and T1 in each group

p2: Comparison of delta change between three groups

*T0* at the time of enrollment, *T1* after 1 year, *Δ Change* T1-T0, *CD* Crohn's disease, *UC* Ulcerative colitis

sex-matched controls except for TSFTz. The significant increase in TSFTz of the IBD group reflects an improvement of the fat mass, but not FFM.

Nutritional impairment is one of the most common features of IBD. Anorexia, inadequate caloric intake, malabsorption, and chronic inflammation play a markable role in the development of nutritional impairment [10]. Most studies have evaluated the nutritional status at the onset of the disease [11, 12]. As a result, subsequent nutritional impairment is less well known.

Similar to previous studies [13–15] our study emphasized the notable rates of nutritional impairment in children with IBD, although the majority of patients were in remission when included in the study. Our results indicated that undernutrition was more frequent than short stature in children with IBD which was consistent with the literature [14, 16]. No meaningful positive or negative change in the prevalence of nutritional impairment over time was observed although the rate of GR increased whereas the rate of undernutrition and severe malnutrition decreased compared with baseline in our study. This may be due to the small sample size that could limit the detection of significance. Recent studies draw attention to children with IBD who have obesity at the time diagnosis [17–19]. However, there was no obese patient with IBD in our cohort.

Previous studies of BC in children with IBD are predominantly cross-sectional [15, 20–23], longitudinal studies are scarce [24–27]. In these longitudinal studies, age- and sex-matched [23], or unmatched healthy subjects [25, 26] or historical reference data [27] were included as a control group and, longitudinal follow-up for controls is lacking. Our results have importance as they have supplied data on how these variables changed in both IBD patients and controls over time.

The results of longitudinal studies in pediatric IBD agree on FFM or lean mass deficit compared with healthy controls, although the methodology, follow-up duration, and participant characteristics are different [24–27]. All these studies have been done in CD patients from developed countries. The causes of FFM deficit in children with IBD are not clearly understood. Muscle gains may be affected directly or indirectly by low-grade inflammation. Varille et al. [24] measured FFM 1 week before and 1 month after surgery by skinfold thickness in ten children with CD who had refractory disease and age- and sex-matched controls. They showed a deficit in FFM. A further study, which included 58 children with newly diagnosed CD and was compared with 902 unmatched healthy controls, assessed muscle mass using peripheral quantitative computed tomography and showed that muscle cross-sectional area was significantly lower in CD compared with controls. Moreover, this deficit was persistent after treatment at 12 months [25]. Sylvester et al. [26] investigated BC using DXA in 42 children with CD, compared with 81 unmatched healthy controls. They found lower BMI and FFM *z* scores in newly diagnosed cases of CD compared with controls. In 2 years follow-up, BMIZ of patients with CD normalized whereas no significant increase in the FFM *z* scores was observed. They emphasized that the improvement of BMI is associated with a gain in fat mass. Thayu et al. [27] evaluated BC using DXA in 78 newly diagnosed CD and 669 unmatched healthy controls. Children with CD were followed up for 24 months after diagnosis. They described a deficit in lean mass in children with CD at the time of diagnosis. They also showed improvement in BC parameters during the study period, however lean mass deficit persisted in girls when

compared with controls. Gerasimidis et al. [28] demonstrated amelioration in lean mass but not fat mass by BIA in 17 children with active CD after 6–8 weeks of EEN compared with baseline. Though it is difficult to compare our results with those of others, our results overall, are consistent with previous observations which showed improvement in BC of patients with IBD over time [27, 28]. Indeed, our results revealed significant improvements over time in the TSFT, MAC and all BC variables except for the fat percentage of IBD patients. On the other hand, the present findings provide that no remarkable difference was found between IBD and controls with regards to BC and anthropometric parameters except for TSFTz. This may be explained by the features of our study population including disease type, treatment modality and the time of enrollment to the study. In this present study, of IBD patients consisted of children with UC (61%). Furthermore, a high proportion of our IBD patients had the mild or inactive disease. Nutritional and growth problems are known to be present in both UC and CD, but more frequently in CD [29, 30]. As known, the active stage of the disease deteriorates the nutritional status and growth. There is a negative correlation between disease activity and lean mass measures [17, 22, 31]. The other possible explanation of our results is that related to the mild disease activity of our patients; thus, these patients needed less aggressive therapy which would otherwise negatively affect their nutritional status.

A small number of studies evaluated differences in the BC alterations between UC and CD patients [20, 23, 32, 33]. It seems that there is no remarkable difference between CD and UC in terms of FFM, however, FM is lower in CD than UC [20, 23, 33]. Similar results were also observed in our study.

The strength of this study is the longitudinal follow-up for IBD patients and controls. Furthermore, all anthropometric measurements have been performed under the same conditions by the same physician. Our study has some limitations such as small sample size, the heterogeneous patient population in terms of disease characteristics and pubertal stages and unavailable data for physical activity, dietary intake, and micronutrients. Most of the studied patients (67.6%) were in remission. Therefore, it should be noted that our study results did not reflect the nutritional status of children with active IBD. If the number of patients with high activity index or CD or newly diagnosed patients was more, the study results might be different. The other limitation is that the difference in BC between gender was not analyzed.

In conclusion, most patients with IBD were well grown although some children were underweight and had GR. The changes in anthropometrics and BC measurements during the study period did not differ between the groups except for TSFTz. Our results suggest that, in IBD patients, the fat mass showed a gradual increase over time compared with controls.

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**Author contributions** SS was responsible for data acquisition and analysis, and drafting of the manuscript. KA was responsible for critical review of manuscript. BM and ŞZ were responsible for critical review of BC measurements. KZ was responsible for study concept and design, analysis, intrepretation of data and drafting of the manuscript. All authors approved the final version of the manuscript.

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethics** The Ethics Committee of our University, School of Medicine approved the study protocol (*03-106-15*). Written informed consent was obtained from all participants and their parents.

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