Original Article

Combined Patient-Generated Subjective Global Assessment and body composition facilitates nutritional support in inflammatory bowel disease: an ambulatory study in Shanghai

Dongsheng Bian MD[1], Yongmei Shi MD[1], Yongmei Jiang MD[1], Jie Zhong MD, PhD[2], Jing Sun MD[2], Yubei Gu MD, PhD[2]

[1]*Department of Clinical Nutrition, Ruijin Hospital Affiliated to Shanghai Jiao Tong University, School of Medicine, Shanghai, China*
[2]*Department of Gastroenterology, Ruijin Hospital Affiliated to Shanghai Jiao Tong University, School of Medicine, Shanghai, China*

Background and Objectives: Malnutrition is commonly diagnosed in patients with inflammatory bowel disease (IBD). However, only few clinical studies have adequately explored the importance of body composition in the nutritional assessment of Chinese patients with IBD. **Methods and Study Design:** A total of 78 IBD patients were enrolled, and Patient-Generated Subjective Global Assessment (PG-SGA) was used to assess malnutrition. Bioelectrical impedance analysis was used to analyze the body composition of IBD patients and their fat free mass indexes (FFMI) were also calculated. FFMI values <17 kg/m^2 in men and <15 kg/m^2 in women were considered low. Food consumption data were collected using the semi-quantitative food frequency questionnaire. **Results:** Of the 78 patients, 49 (62.8%) had low-FFMI. Among the patients with PG-SGA <4, 12 (41.4%) had altered body composition with low-FFMI. FFMI negatively correlated with the PG-SGA scores and disease activity. No statistically significant differences in fat free mass (FFM) and skeletal muscle mass were observed between patients in the active phase and patients in remission (p>0.05). However, the fat mass and visceral fat area of patients in remission were higher than those of patients in the active phase (p<0.05). The average energy derived from fat, proteins and carbohydrates was 29.6±8.45%, 10.4±1.97% and 60.3±9.33%, respectively. **Conclusions:** Our study shows that 41.4% of IBD patients had altered body composition despite being well-nourished according to the PG-SGA. Patients in the remission phase presented with fat accumulation and their FFM remained low. The dietary pattern was not adequate among the IBD patients, especially regarding protein intake.

Key Words: inflammatory bowel disease, body composition, FFMI, PG-SGA, dietary intake

INTRODUCTION

Inflammatory bowel disease (IBD), which collectively refers to Crohn's disease (CD) and ulcerative colitis (UC), is a chronic, relapsing intestinal inflammatory disorder of unidentified causes. IBD has long been thought to have a genetic basis and likely involves a response of the immune system to certain environmental agents.[1,2] The highest prevalence of IBD is reported in North America and Europe, affecting up to 3.5 million individuals.[3] In China, a recent meta-analysis showed that the summary incidence rate of IBD is 1.74 (95% CI: 1.08; 2.40) per 100,000 persons/year.[4]

Malnutrition is common in patients with IBD and negatively influences the outcome of the disease. Irregular eating, increased intestinal protein loss, frequent diarrhea and nutrient malabsorption contribute to malnutrition in IBD patients. A recent systematic review reported that the prevalence of malnutrition was 65–75% in patients with CD, and 18-62% in those with UC.[5] Data of the Canadian Nationwide Inpatient Sample database, collected between 1998 and 2004, indicate that the prevalence of malnutrition is higher in IBD patients than in non-IBD patients.[6] However, although a high proportion of examined patients with IBD were overweight, little is known about the body composition of these patients.

Altered body composition, such as loss of skeletal muscle mass, has been reported in IBD patients. Schneider et al found that approximately 60% of adult CD patients have decreased muscle mass, with the long-term decrease resulting in sarcopenia.[7] A recent Australian

Corresponding Author: Dr Yongmei Shi, Department of Clinical Nutrition, Ruijin Hospital Affiliated to Shanghai Jiao Tong University, School of Medicine, 197 Ruijin Er Road, Shanghai, 200025, China.
Tel: 0086-21-64370045-673376; Fax: 0086-21-64333548
Email: shi.yongmei@163.com
Manuscript received 24 December 2017. Initial review completed 15 April 2018. Revision accepted 06 August 2018.
doi: 10.6133/apjcn.201811_27(6).0009

study indicated that 21% of CD patients had low lean mass.[8] A Chinese study found that the prevalence of sarcopenia was 27.3% in UC patients and 59.0% in CD patients.[9] Recent reviews of existing data on malnutrition in patients with IBD suggest that lean mass loss is one of the most important components of malnutrition.[5] Besides, some studies have reported that lean mass loss is associated with poor clinical outcome in IBD patients.[8-10]

Certain tables and nutritional questionnaires were recommended to evaluate the nutritional state of IBD patients, such as the Malnutrition Universal Screening Tool (MUST), Nutritional Risk Screening (NRS) and Subjective Global Assessment (SGA). The ESPEN guidelines on clinical nutrition in IBD recommend that IBD patients should receive nutritional risk screening or nutritional assessment after diagnosis, and the screening should be, thereafter, routinized.[11] The Patient-Generated Subjective Global Assessment (PG-SGA) is recommended for the nutritional assessment of IBD patients by the IBD expert group of the Chinese Society of Gastroenterology.[12] However, few studies have reported on the nutritional assessment of Chinese IBD patients using PG-SGA.

Despite having a normal weight or BMI, a patient can be malnourished if the body fat-muscle ratio is unbalanced. Unfortunately, the currently available nutritional assessment tools, such as the PG-SGA, NRS-2002, MUST et al., cannot provide accurate information on body composition. Several methods can be employed to measure the body composition, including the bioelectrical impedance analysis (BIA), total body water (TBW), dual-energy X-ray absorptiometry (DEXA), computed tomography (CT), and Total Body Electrical Conductivity (TOBEC). These methods can distinctly analyze the two major body components: fat mass and fat free mass (FFM).

We compared the different nutritional status and body composition of IBD patients with either clinical remission or active disease. In addition, the correlation between the fat free mass index (FFMI) and PG-SGA was explored. Using the proposed method, we also detected patients whose body composition had changed and should be monitored, which were ignored when only using PG-SGA. Lastly, we evaluated the dietary intake of these patients. Herein, we aimed to establish a suitable method for the routine nutritional assessment of Chinese patients with IBD.

METHODS

Study participants

Adult IBD patients treated at the Gastroenterology Clinic, Shanghai Ruijin Hospital, China, from Jan. 2014 to Apr. 2016, were selected for the study. All patients met the criteria established by the Inflammatory Bowel Disease Group of the Chinese Society of Gastroenterology. Relevant information was presented in detail and all patients consented to participate in this study. The medical history of the patients, with particular focus on related diseases, was then recorded. The following exclusion criteria were applied: patients with metabolic diseases (e.g. diabetes, hyperthyroidism), whose related indices were not well-controlled after hospitalization; patients with gastrointestinal tumors or tumors at other sites; patients with impaired water and mineral metabolism, caused by cortical hormone therapy; patients with metal implants (such as cardiac pacemakers) that could influence the BIA results. In total, 78 patients were enrolled (63 CD cases and 15 UC cases). The study was approved by the Research Ethics Committee of Shanghai Rui Jin Hospital. Informed consent forms were signed by all participants.

Disease phase

According to the Crohn's Disease Activity Index (CDAI),[13,14] CD patients were evaluated based on symptoms, physical condition and laboratory examinations. Patients with CDAI ≤150 were considered in clinical remission, whereas the active phase was defined as CDAI >150. UC patients were assessed using the Mayo score.[15,16] Patients that scored ≤2 were in the remission phase, whereas scores >2 indicated active disease. Overall, 40 patients were in the active phase.

PG-SGA

The PG-SGA assessment included body weight, dietary intake, symptoms, movement and body function, relationship between disease and nutritional requirement, metabolism requirement and physical examination. According to the criteria, a score of 0-1 indicated good nutritional status, 2-3 meant light malnutrition that needed nutritional education and/or nutritional intervention, 4-8 was moderate malnutrition that needed nutritional intervention and ≥9 indicated severe malnutrition that needed symptom improvement and nutritional therapy. Patients with scores ≥4 were classed as moderate or severe malnutrition, thus those with scores <4 were enrolled in the low PG-SGA group.[12]

Anthropometric measurements

After adopting a relaxed standing position, the triceps skinfold thickness was measured 3 times for each patient, using a crease thickness gauge. The values (in mm; degree of precision: 1 mm) were then averaged. The BMI of each patient was compared to the standard for a Chinese population: normal 18.5-23.9, overweight ≥24, obesity ≥28.[17]

Body composition analysis

Inbody S10 (Biospace, South Korea) was used to measure the body composition. Prior to the analysis, patients were fasted for over 2 h, followed by bowel and bladder emptying. While barefoot, after the height of the patient was input, small finger and the middle finger on both hands, the inner feet and the lower lateral malleolus were connected with electrodes, using 6 frequencies (1, 5, 50, 250, 500 and 1000 kHz). The distance between the arms and the body and between the legs was maintained at approximately 30-45 mm. The collected BIA data included body weight, BMI, body fat mass, FFM, skeletal muscle mass, skeletal lean mass, total body water, mineral content and body cell mass.

Calculation of fat free mass index

To detect the body composition of the patients, FFMI was calculated according to the following formula:

FFMI (kg/m^2) = FFM (kg) / height^2 (m^2)

The obtained FFMI values were correlated with malnutrition, by referring to the standard ESPEN guidelines. FFMI values <17 kg/m^2 (in men) and <15 kg/m^2 (in women) were considered low and indicative of a high risk of malnutrition.[18,19]

Dietary intake analysis

To assess the usual dietary intake, a semi-quantitative food frequency questionnaire (FFQ) was used to collect information on individual food consumption during the 3 months prior to enrollment. This questionnaire included 27 groups of foods and beverages which covered the majority of foods commonly consumed in China. Three aspects of each item were listed in the questionnaire, including whether the item was consumed, the usual frequency of consumption (number of times per day/week/month/year) and the estimated amount of food eaten each time, expressed using the local unit liang for weight (1 liang = 50 g) or cup for volume (1 cup = 250 mL).

Nutrients and total energy intake were calculated by multiplying the usual frequency and portion size of each food item by the nutrient content using the food composition values from China Food Composition (National Institute of Nutrition and Food Safety, China CDC).

Statistical analysis

SPSS22.0 was used to analyze the data. Measurement data were expressed as mean ± SD, and enumeration data were expressed as percentage. Independent two-sample t-test was used to compare the enumeration data, and the Pearson correlation was used to analyze the measurement data. $p<0.05$ was considered statistically significant.

Table 1. Baseline patient characteristics

	All	CD	UC
Patients	78	63	15
Age (mean)	35.5±12.2	35.7±11.2	36.4±13.8
Gender			
Men	44	36	8
Women	34	27	7
CDAI (mean)	-	106.2±82.3	
Mayo (mean)	-		5.91±2.84
PG-SGA	6.64±5.22	6.09±5.25	8.81±4.65
BMI (kg/m^2)	19.4±3.01	19.5±3.11	18.9±2.53
Smoking	10	8	2
Drinking	9	5	4
Years since diagnosis	6.48±5.01	7.03±5.54	4.20±2.76
Educational level			
No studies	4	3	1
Elementary	13	8	5
High school	14	12	2
College	47	40	7
Body composition			
Triceps skinfold thickness (mm)	11.5±4.37	11.7±4.31	10.6±4.65
Visceral fat area (%)	45.8±26.2	45.9±25.9	45.5±28.5
Fat mass (kg)	10.3±4.89	10.4±5.03	9.66±4.35
FFMI (kg/m^2)	15.6±1.88	15.6±1.90	15.3±1.82

CD: Crohn's disease; UC: ulcerative colitis; CDAI: Crohn's Disease Activity Index; Mayo: disease activity index for UC; PG-SGA: Patient-Generated Subjective Global Assessment; FFMI: fat free mass index.

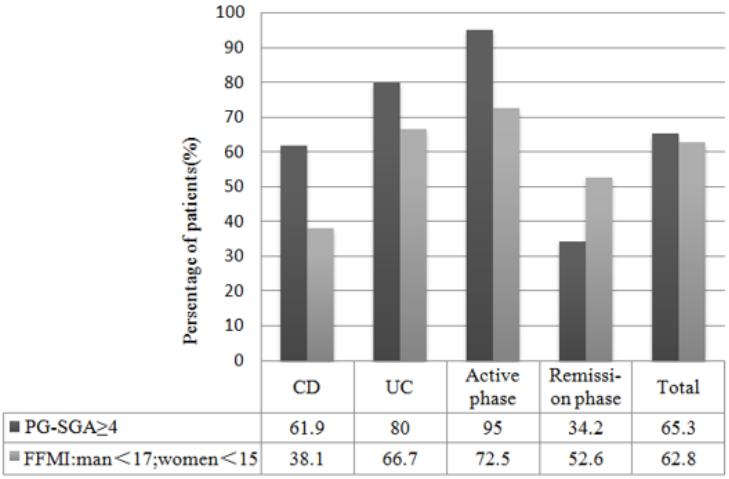

Figure 1. Patients at risk of malnutrition based on PG-SGA and FFMI. CD: Crohn's disease; UC: ulcerative colitis; FFMI: fat free mass index, kg/m^2.

Table 2. Comparison of IBD patients in the active and remission phase

	Active (n=40)	Remission (n=38)	*p*-value
Age, years	35.6±12.3	36.2±11.1	0.824
Male, n (%)	26 (65)	19 (50)	0.290
UC	11	4	-
CD	29	34	-
Smoking, n (%)	7 (17)	3 (8)	0.225
Drinking, n (%)	7 (17)	2 (5)	0.110
BMI (kg/m^2)	18.3±2.42	20.4±3.21	0.001**
PG-SGA	10.0±4.57	2.89±1.13	<0.001***
Body composition			
FFMI (kg/m^2)	15.2±1.67	15.9±2.06	0.092
Fat mass (kg)	8.74±4.01	11.8±5.29	0.005**
TBW/FFM (%)	73.5±0.31	73.3±0.30	0.008**
ECW/TBW (%)	0.378±0.006	0.380±0.003	0.055
Triceps skinfold thickness (mm)	10.3±4.27	12.9±4.13	0.017*
Visceral fat area (%)	40.4±25.4	51.6±26.1	0.049*
FFM (kg)	42.8±6.48	42.9±8.27	0.857
Skeletal muscle mass (kg)	23.2±4.09	23.5±5.15	0.834

CD: Crohn's disease; UC: ulcerative colitis; PG-SGA: Patient-Generated Subjective Global Assessment; FFMI: fat free mass index; TBW/FFM: total body water/fat free mass; ECW/TBW: extracellular water/total body water.
Significance is shown by *p<0.05, **p<0.01, ***p<0.001.

RESULTS

Subject characteristics (Figure 1)

As shown in Table 1, a total of 78 patients were enrolled in the study, comprising 44 men and 34 women. Among them, 63 had CD and 15 had UC. The average age was 35.5±12.3, and the average PG-SGA score was 6.64±5.22. Of the 78 patients, 51 (65.3%) patients with PG-SGA ≥4 had moderate or severe malnutrition, and 49 (62.8%) patients had low-FFMI. Of the patients with CD, 38 (61.9%) had moderate or severe malnutrition based on PG-SGA and 38.1% patients had low-FFMI.

The average FFMI of CD patients was 15.64±1.90, whereas that of UC patients was 15.29±1.82.

The average disease duration, defined as the number of years since diagnosis, of IBD, CD and UC was 6.48±5.01, 7.03±5.54, and 4.20±2.76, respectively.

Comparison of nutritional status between patients with active disease versus those in remission (Table 2)

Of the total number of patients, 72.5% had low-FFMI, and 95% of patients in the active phase had moderate or severe malnutrition, as assessed by PG-SGA. The average FFMI was 15.18±1.67 kg/m^2 in the active phase, not significantly lower than that in the remission phase (15.97±2.06 kg/m^2; p>0.05).

The fat mass, visceral adipose tissue and triceps skinfold thickness during the remission phase were higher than in the active phase (p<0.05). However, no statistically significant differences in skeletal muscle mass, FFM and FFMI were identified between active phase and remission phase patients (p>0.05).

Consequences of dietary and energy intake

Table 3 summarizes the information obtained from the food recall. The average intakes of energy (933±282 kcal/d), protein (24.5±9.75 g/d), fat (30.8±14.6 g/d), carbohydrates (123±39.7 g/d), calcium (301±142 mg/d) and iron (9.47±2.81mg/d) were below the recommended amounts, according to the Dietary Reference Intakes (DRIs). The average energy derived from fat, proteins and carbohydrates was 29.6±8.45%, 10.4±1.97% and 60.3±9.33%, respectively. Protein contribution on total energy (%) was relatively lower than that of fat and carbohydrates (just 10%). The intakes of cereal & potato, meat, total energy and total fat of patients in remission phase were higher than those of patients in the active phase (p<0.05).

Correlation between nutritional parameters in patients with FFMI (Table 4)

The FFMI score had good positive correlations with BMI, hemoglobin, age, albumin, triceps skinfold thickness, body cell mass and bone mineral content (p<0.05). In contrast, the FFMI score had negative correlations with PG-SGA and ECW/TBW. We also observed a negative correlation between the disease activity defined by CDAI scores and FFMI (p=0.005). Moreover, we found a positive correlation between energy, protein, fat, carbohydrate, and iron intakes and FFMI (p<0.05).

Consistency test between PG-SGA and FFMI (Table 5)

Patients with low-FFMI belong to a high-risk population, with moderate (or above) malnutrition. The FFMI of the group with PG-SGA ≥4 was lower than of the group with PG-SGA <4 (15.1±1.68 vs 16.4±1.99, p=0.004). This was confirmed by the Kappa test, which showed consistency between FFMI and PG-SGA, with K=0.267, X^2=5.97, p=0.026. Table 5 also shows that, of the patients with PG-SGA <4, 12 (41.4%) had altered body composition with low-FFMI. Furthermore, all 12 patients were in the remission phase, and 11 of them were CD patients (Figure 2).

DISCUSSION

The detailed evaluation of the nutritional status and body composition of patients with IBD is very important in determining the correct nutritional management and improving the patients' quality of life. Previously, nutritional assessment tools were mainly based on body weight. However, these tools could not provide detailed

Table 3. Food consumption and dietary nutrient intake in the different study groups

Parameters	CD (n=63)	UC (n=15)	*p*	Active (n=40)	Remission (n=38)	*p*
Cereal & potato (g/d)	258±66.2	230±59.0	0.144	245±82.0	278±54.2	0.036*
Beans (g/d)	46.6±62.5	27.0±34.8	0.248	34.4±44.8	48.7±68.9	0.296
Meat (g/d)	81.1±43.3	57.4±49.5	0.067	58.2±41.0	75.3±28.5	0.047*
Vegetables & fruits (g/d)	347±140	321±168	0.538	211±99.4	244±82.3	0.133
Egg & egg products (g/d)	54.3±33.2	56.1±39.9	0.860	55.6±40.5	58.5±25.6	0.713
Milk & dairy products (g/d)	38.4±66.8	24.0±51.4	0.493	27.1±60.3	51.5±87.4	0.178
Fish & shrimp (g/d)	43.4±24.3	37.7±28.1	0.426	39.7±28.4	47.3±18.9	0.179
Energy (kcal/day) †	979±226	919±187	0.376	920±262	1021±144	0.046*
Total protein (g/day) ‡	25.9±8.35	20.9±9.44	0.110	24.2±9.41	27.0±7.31	0.167
Total fat (g/d)	33.4±13.1	27.1±13.7	0.146	28.5±14.0	36.4±11.5	0.010*
Total carbohydrates(g/d)	127±32.9	128±33.8	0.927	126±39.0	129±24.8	0.735
Fat intake energy (%)††	30.0±7.96	26.3±10.2	0.147	27.2±8.78	31.8±7.48	0.021*
Protein intake energy (%)††	10.5±1.74	10.0±2.88	0.464	10.3±2.04	10.5±1.91	0.737
Carbohydrate intake energy (%)††	59.5±8.81	63.7±11.1	0.142	62.5±9.53	57.7±8.57	0.030*
Calcium(mg/d) §	308±142	269±141	0.348	280±143	330±131	0.110
Iron(mg/d)	9.78±2.69	8.17±3.02	0.045*	9.46±3.14	9.73±1.95	0.649
Vitamin A(μgRE/d) ¶	834±496	706±482	0.368	769±551	853±428	0.565

CD: Crohn's disease; UC: ulcerative colitis .

Normally distributed values are presented as means±SD. Significance is shown by $^{*}p<0.05$, $^{**}p<0.01$.

Guide for estimating nutritional requirement in stable patients, †Energy: 20-35 kcal/kg/day; ‡Protein: 0.8-2.0 g/kg/day (in clinical practice 0.8-1.0 g/kg/day for the majority of patients; in those who are metabolically stressed, requirements may be higher); §Calcium: 800 mg/d; Iron: 15 mg/d in male and 20 mg/d in female; ¶Vitamin A: 800 μgRE/d in male and 700 μgRE/d in female;††The distribution of energy intake is: 10-15% protein, 20-30% fat, 55-60% carbohydrate for the majority of patients.

Table 4. Relationships of FFMI with body composition, dietary intake and disease activity

	FFMI	
	r	*p* value
Age (years)	0.168	0.136
BMI (kg/m^2)	0.777	<0.001***
PG-SGA	-0.362	0.001**
Body composition		
ECW/TBW (%)	-0.690	<0.001***
Triceps skinfold thickness (mm)	0.338	0.007**
Body cell mass (kg)	0.854	<0.001***
Bone mineral content (kg)	0.793	<0.001***
Skeletal muscle mass (kg)	0.843	<0.001***
FFM (kg)	0.816	<0.001***
Visceral adipose tissue (%)	0.123	0.282
Arm muscle circumference (mm)	0.901	<0.001***
Fat mass (kg)	0.233	0.040*
Disease activity		
CDAI (CD)	-0.420	0.005**
Mayo (UC)	-0.055	0.880
Dietary intake		
Energy (kcal/d)	0.353	0.002**
Total protein (g/d)	0.322	0.004**
Total fat (g/d)	0.340	0.002**
Total carbohydrates (g/d)	0.245	0.031*
Iron (mg/d)	0.317	0.005**

CD: Crohn's disease; UC: ulcerative colitis; PG-SGA: Patient-Generated Subjective Global Assessment; FFMI: fat free mass index; TBW/FFM: total body water/fat free mass; ECW/TBW: extracellular water/total body water.
Significance is shown by $^*p<0.05$, $^{**}p<0.01$, $^{***}p<0.001$.

Table 5. Consistency test between PG-SGA and FFMI

		FFMI		X^2 (P)	Kappa
		Men ≥17, Women ≥15	Men <17, Women <15		
PG-SGA	<4	15	12	5.97 (0.026*)	0.276
	≥4	14	37		

Significance is shown by $^* p < 0.05$.

information on body composition. Recent literature indicates that the loss of FFM and skeletal strength could increase morbidity, infections and fatigue.[20] Unfortunately, despite the increasing prevalence of IBD in China, few studies have focused on body composition when assessing the nutritional status of these patients.

The current study found that 51 IBD patients (65.4%) suffered from moderate or severe malnutrition, which is in agreement with previously described results.[5] Thus, malnutrition is more common among Chinese patients with IBD. No significant differences were noticed in body composition and nutritional status between UC and CD patients in the active phase or remission phase by using BIA analysis and PG-SGA (data not shown). Several studies using DEXA or BIA analysis, showed that the lean mass differed between CD and UC patients.[21,22] Moreover, a Chinese IBD study found that skeletal muscle mass was less frequent in UC patients than in CD patients.[5] However, two studies found no significant differences in body composition between UC and CD by using BIA analysis.[23,24] The different results may be due to the small number of UC patients in our study. Therefore, additional epidemiological data of Chinese IBD patients are needed to confirm our findings.

Our study also showed that the nutritional status of patients with active disease was worse than that of patients with disease remission, particularly regarding the visceral fat area and fat mass. However, we found no statistically significant differences in skeletal muscle mass and FFM between active phase and remission phase patients. This suggests that fat mass depletion occurred in the active phase and partially recovered during the remission phase, however, the muscle mass remained depleted in the remission phase. One longitudinal study examining pediatric CD patients revealed that the BMI z scores normalized in patients with CD, but the FFM z scores did not increase significantly during the 2-year study period.[25] Besides, one cross-sectional study that assessed the whole-body lean and fat mass by using DEXA, in 104 subjects with IBD, observed the loss of lean mass but not fat mass.[26] Rocha et al also found that muscle mass depletion was a common feature of both diseases during the active and remission phases.[24] Another study reported that body composition alterations amongst IBD patients with loss of lean mass and preservation of fat mass were consistent with cachexia.[26] In agreement with our findings, Rocha et al. reported that FFM depletion was associated with disease activity in IBD.[26]

The mechanisms underlying the development of altered body composition in patients with IBD remain unclear. Reduced caloric intake, the secretion of pro-inflammatory cytokines, malabsorption, low physical activity and me-

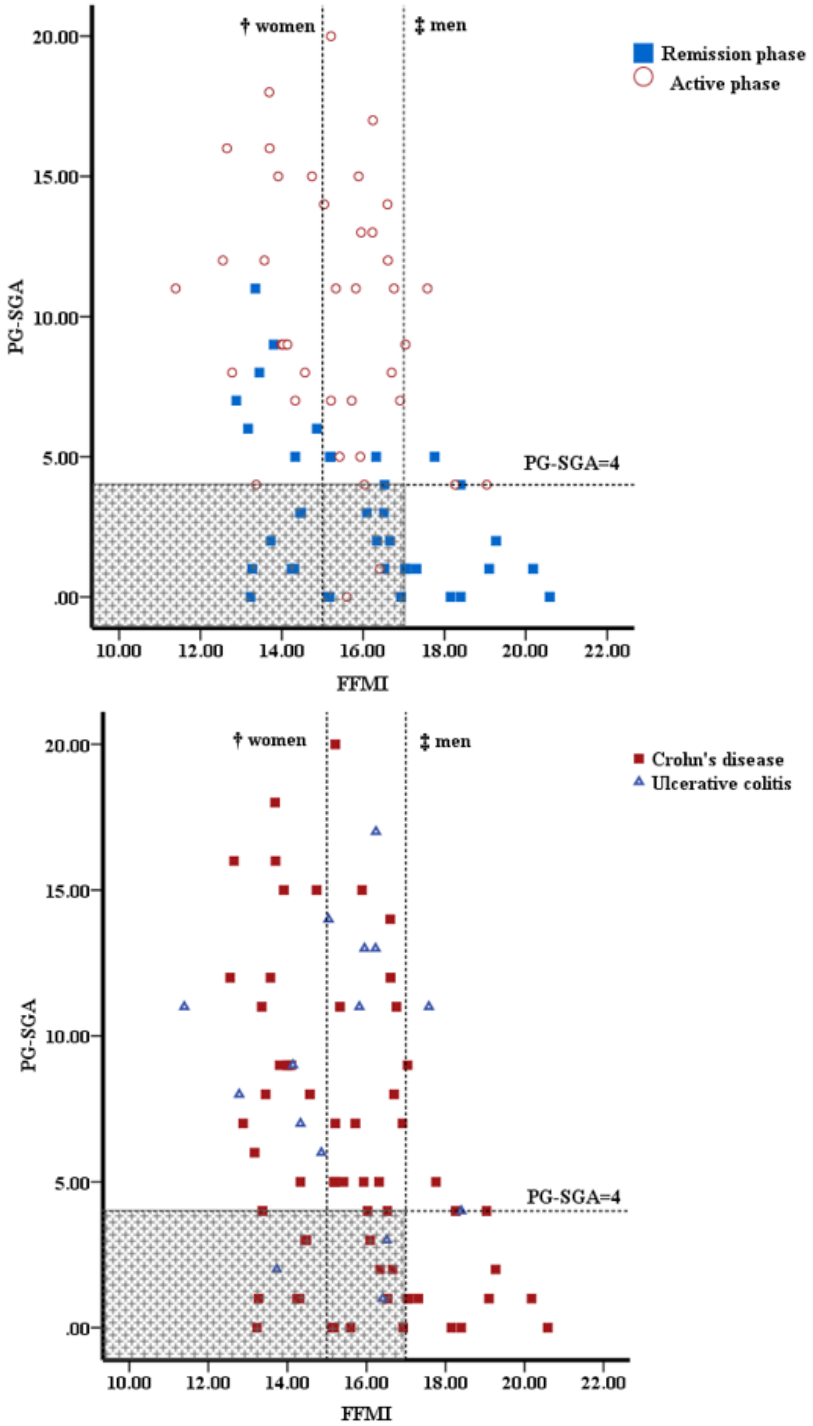

Figure 2. Scatter plots of different classifications of IBD patients**.** FFMI, fat free mass index, kg/m^2; †women, FFMI=15kg/m^2; ‡men, FFMI=17 kg/m^2.

tabolic perturbations may contribute to FFM depletion. Muscle protein degradation involves several cellular pathways, especially the IGF-1-Akt pathway which is important for the release of cytokines, such as NF-kb, tumor necrosis factor alpha (TNF-α) and interleukin 6 (IL-6). We analyzed the dietary intake of the patients in order to explore the possible underlying causes of our findings and discovered that the dietary intake was not adequate among the Chinese IBD patients. Although the energy, fat and protein intake were lower than the recommended amounts, fat and carbohydrates were important energy-yielding nutrients in the diet. One study reported that a high carbohydrate diet, including refined sugar, without physical exercise, caused nutrient malabsorption in the remission phase,[27] which resulted in FFM depletion in the remission phase, as well as in visceral adipose tissue accumulation. In our study, protein contribution to total energy was only 10%. Increased protein intake may result in a reduction of proteolysis and acquisition of lean tissue in adults with IBD.[28] Campos et al suggested that micronutrient supplements should be routinely administered in clinical remission.[29]

These findings highlight the importance and necessity of individualized dietary counseling. Nutritional assessment is important for IBD patients, and the various available methods present advantages and disadvantages that have been previously discussed.[30] Csontos found that one third of the patients with FFM depletion were not consid-

ered to be at risk by their MUST score.[31] Bin appealed that the BMI should not be used as reference in IBD patients.[32] When combining the PG-SGA and BIA methods, we found that 19.2% of patients with moderate or severe malnutrition already had altered body composition. In addition, 12 (41.4%) patients who were classed as being relatively well-nourished by PG-SGA (<4) had altered body composition. This means that the FFM of these patients decreased but the fat mass relatively increased. Besides, all 12 patients were in the remission phase, and 11 of these patients had CD. A recent systematic review reported CD patients typically present with chronic inflammation in the intestinal tract and amyotrophy, but the co-occurrence of obesity is increasing.[33] Valentini et al used SGA to assess the nutritional status of 144 IBD patients, and found that the body cell mass was decreased in 74% of the patients with good nutritional status.[34] Although, there were no obese patients in our research, their fat mass was relatively increased. A study reported that visceral adipose tissue was associated with leptin and IL-6 but not with adiponectin, IL-8, or TNF-α. Moreover, visceral adipose tissue accumulation could be a prospective risk factor for increased disease activity in CD.[35] In addition, Bin found that handgrip strength detected in patients with CD in remission, and BMI or weight should not be used as reference in IBD patients.[32] Therefore, a detailed assessment of the nutritional status (especially body composition) of IBD patients is important, particularly, for those in remission.

Appropriate nutritional management of patients with IBD in remission can ameliorate nutritional depletion and improve the quality of life if and when the disease again becomes active. It has also been found that effective therapy can reduce patient inflammation. During remission, IBD patients should improve dietary quality, particularly their protein intake and be more physically active.

In summary, general malnutrition and low-FFMI were commonly detected among patients with IBD. PG-SGA contributed to IBD patient assessment. However, body composition should also be assessed directly, especially during disease remission to provide for effective interval nutrition support. Body composition may be assessed by DEXA, CT, or MRI. BIA can be an alternative to DEXA, with lower cost and competitive with the economic advantage of anthropometric measures. Many IBD IBD patients require nutritional therapy, but are overlooked when nutritional screening is too basic. PG-SGA combined with body composition measurements, as part of the nutritional assessment, could more reliably detect malnutrition and facilitate its management. A limitation of our study was that patient sample size was relatively small, lacking especially in UC patients. Larger and prospective studies are required to understand and manage better the body compositional disorders in IBD.

ACKNOWLEDGEMENTS

We thank all the patients for their cooperation in this study. Each author made an equal contribution to the study.

AUTHOR DISCLOSURES

None of the authors have conflicts of interest to declare.

REFERENCES

1. Tremaine WJ, Timmons LJ, Loftus EV, Jr Pardi DS, Sandborn WJ, Harmsen WS, Thapa P, Zinsmeister AR. Age at onset of inflammatory bowel disease and the risk of surgery for non-neoplastic bowel disease. Aliment Pharmacol Ther. 2007;25:1435-41. doi: 10.1111/j.1365-2036.2007.03341.x.
2. Li X, Song P, Timofeeva M, Meng X, Rudan I, Little J, Satsangi J, Campbell H, Theodoratou E. Systematic meta-analyses and field synopsis of genetic and epigenetic studies in paediatric inflammatory bowel disease. Sci Rep. 2016; 6:34076. doi: 10.1038/srep34076.
3. Molodecky NA, Soon IS, Rabi DM, Ghali WA, Ferris M, Chernoff G et al. Increasing incidence and prevalence of the inflammatory bowel diseases with time, based on systematic review. Gastroenterology. 2012;142:46-54 e42. doi: 10.1053/j.gastro.2011.10.001.
4. Li X, Song P, Li J, Tao Y, Li G, Li X, Yu Z. The disease burden and clinical characteristics of inflammatory bowel disease in the Chinese population: a systematic review and meta-analysis. Int J Environ Res Public Health. 2017;14:238. doi: 10.3390/ijerph14030238.
5. Scaldaferri F, Pizzoferrato M, Lopetuso LR, Musca T, Ingravalle F, Sicignano LL et al. Nutrition and IBD: malnutrition and/or sarcopenia? A practical guide. Gastroenterol Res Pract. 2017;2017:8646495. doi: 10.1155/2017/8646495.
6. Nguyen GC, Munsell M, Harris ML. Nationwide prevalence and prognostic significance of clinically diagnosable protein-calorie malnutrition in hospitalized inflammatory bowel disease patients. Inflamm Bowel Dis. 2008;14:1105-11. doi: 10.1002/ibd.20429.
7. Schneider SM, Al-Jaouni R, Filippi J, Wiroth JB, Zeanandin G, Arab K, Hébuterne X. Sarcopenia is prevalent in patients with Crohn's disease in clinical remission. Inflamm Bowel Dis. 2008;14:1562-8. doi: 10.1002/ibd.20504.
8. Bryant RV, Ooi S, Schultz CG, Goess C, Grafton R, Hughes J, Lim A, Bartholomeusz FD, Andrews JM. Low muscle mass and sarcopenia: common and predictive of osteopenia in inflammatory bowel disease. Aliment Pharmacol Ther. 2015;41:895-906. doi: 10.1111/apt. 13156.
9. Zhang T, Ding C, Xie T, Yang J, Dai X, Lv T et al. Skeletal muscle depletion correlates with disease activity in ulcerative colitis and is reversed after colectomy. Clin Nutr. 2017;36:1586-92. doi: 10.1016/j.clnu.2016.10.004.
10. Zhang T, Cao L, Cao T, Yang J, Gong J, Zhu W, Li N, Li J. Prevalence of sarcopenia and its impact on postoperative outcome in patients with Crohn's disease undergoing bowel resection. JPEN J Parenter Enteral Nutr. 2017;41:592-600. doi: 10.1177/0148607115612054.
11. Forbes A, Escher J, Hebuterne X, Klek S, Krznaric Z, Schneider S et al. ESPEN guideline: Clinical nutrition in inflammatory bowel disease. Clin Nutr. 2017;36:321-47. doi: 10.1016/j.clnu.2016.12.027.
12. IBD expert group of the Chinese Society of Gastroenterology. Expert Consensus of clinical nutrition therapy in inflammatory bowel disease. Chin J Intern Med. 2013;52:1082-7. doi: 10.3760/cma.j.issn.0578-1426.2013.12.025.
13. Best WR, Becktel JM, Singleton JW, Kern F, Jr. Development of a Crohn's disease activity index. National Cooperative Crohn's Disease Study. Gastroenterology 1976; 70:439-44.
14. Sands BE, Ooi CJ. A survey of methodological variation in the Crohn's disease activity index. Inflamm Bowel Dis. 2005;11:133-8.

15. Higgins PD, Schwartz M, Mapili J, Krokos I, Leung J, Zimmermann EM. Patient defined dichotomous end points for remission and clinical improvement in ulcerative colitis. Gut. 2005;54:782-8. doi: 10.1136/gut.2004.056358.
16. Lewis JD, Chuai S, Nessel L, Lichtenstein GR, Aberra FN, Ellenberg JH. Use of the noninvasive components of the Mayo score to assess clinical response in ulcerative colitis. Inflamm Bowel Dis. 2008;14:1660-6. doi: 10.1002/ibd.20520.
17. Zhou BF. Predictive values of body mass index and waist circumference for risk factors of certain related diseases in Chinese adults--study on optimal cut-off points of body mass index and waist circumference in Chinese adults. Biomed Environ Sci. 2002;15:S685-93.
18. Luo Y, Zhou L, Li Y, Guo S, Li X, Zheng J et al. Fat-free mass index for evaluating the nutritional status and disease severity in COPD. Respir Care. 2016;61:680-8. doi: 10.4187/respcare.04358.
19. Cederholm T, Bosaeus I, Barazzoni R, Bauer J, Van Gossum A, Klek S et al. Diagnostic criteria for malnutrition - An ESPEN Consensus Statement. Clin Nutr 2015;34:335-40. doi: 10.1016/j.clnu.2015.03.001.
20. Bryant RV, Trott MJ, Bartholomeusz FD, Andrews JM. Systematic review: body composition in adults with inflammatory bowel disease. Aliment Pharmacol Ther. 2013; 38:213-25. doi: 10.1111/apt.12372.
21. Capristo E, De Gaetano A, Mingrone G, Addolorato G, Greco AV, Castagneto M, Gasbarrini G. Multivariate identification of metabolic features in inflammatory bowel disease. Metabolism. 1999;48:952-6.
22. Capristo E, Mingrone G, Addolorato G, Greco AV, Gasbarrini G. Metabolic features of inflammatory bowel disease in a remission phase of the disease activity. J Intern Med. 1998;243:339-47.
23. Valentini L, Schaper L, Buning C, Hengstermann S, Koernicke T, Tillinger W et al. Malnutrition and impaired muscle strength in patients with Crohn's disease and ulcerative colitis in remission. Nutrition. 2008;24:694-702. doi: 10.4187/respcare.04358.
24. Rocha R, Santana GO, Almeida N, Lyra AC. Analysis of fat and muscle mass in patients with inflammatory bowel disease during remission and active phase. Br J Nutr. 2009; 101:676-9. doi: 10.1017/S0007114508032224.
25. Sylvester FA, Leopold S, Lincoln M, Hyams JS, Griffiths AM, Lerer T. A two-year longitudinal study of persistent lean tissue deficits in children with Crohn's disease. Clin Gastroenterol Hepatol. 2009;7:452-5. doi: 10.1016/j.cgh.2008.12.017.
26. Burnham JM, Shults J, Semeao E, Foster BJ, Zemel BS, Stallings VA, Leonard MB. Body-composition alterations consistent with cachexia in children and young adults with Crohn disease. Am J Clin Nutr. 2005;82:413-20. doi: 10.1093/ajcn. 82.2.413.
27. Vaisman N, Dotan I, Halack A, Niv E. Malabsorption is a major contributor to underweight in Crohn's disease patients in remission. Nutrition. 2006;22:855-9. doi: 10.1016/j.nut.2006.05.013.
28. Hannon TS, Dimeglio LA, Pfefferkorn MD, Denne SC. Acute effects of enteral nutrition on protein turnover in adolescents with Crohn disease. Pediatr Res. 2007;61:356-60. doi: 10.1203/pdr.0b013e318030d11c.
29. Campos FG, Waitzberg DL, Teixeira MG, Mucerino DR, Habr-Gama A, Kiss DR. Inflammatory bowel diseases: principles of nutritional therapy. Rev Hosp Clin Fac Med Sao Paulo. 2002;57:187-98.
30. Waitzberg DL, Correia MI. Nutritional assessment in the hospitalized patient. Curr Opin Clin Nutr Metab Care. 2003; 6:531-8. doi: 10.1097/01.mco.0000087968.83880.de.
31. Csontos ÁA, Molnár A, Piri Z, Pálfi E, Miheller P. Malnutrition risk questionnaire combined with body composition measurement in malnutrition screening in inflammatory bowel disease. Rev Esp Enferm Dig. 2016; 109:26-32. doi: 10.17235/reed.2016.4557/2016.
32. Bin CM, Flores C, Alvares-da-Silva MR, Francesconi CF. Comparison between handgrip strength, subjective global assessment, anthropometry, and biochemical markers in assessing nutritional status of patients with Crohn's disease in clinical remission. Dig Dis Sci. 2010;55:137-44. doi: 10.1007/s10620-008-0692-1.
33. Nic Suibhne T, Raftery TC, McMahon O, Walsh C, O'Morain C, O'Sullivan M. High prevalence of overweight and obesity in adults with Crohn's disease: associations with disease and lifestyle factors. J Crohns Colitis. 2013;7:e241-8. doi: 10.1016/j.crohns.2012.09.009.
34. Valentini L, Schulzke JD. Mundane, yet challenging: the assessment of malnutrition in inflammatory bowel disease. Eur J Intern Med. 2011;22:13-5. doi: 10.1016/j.ejim.2010.07.021.
35. Buning C, von Kraft C, Hermsdorf M, Gentz E, Wirth EK, Valentini L, Haas V. Visceral adipose tissue in patients with Crohn's disease correlates with disease activity, inflammatory markers, and outcome. Inflamm Bowel Dis. 2015;21:2590-7. doi: 10.1097/MIB.0000000000000527.