

Nutrient Intake and Bone Mineral Density by Nutritional Status in Patients with Inflammatory Bowel Disease

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Background: Malnutrition among inflammatory bowel disease (IBD) may arise from factors including inadequate dietary intake, malabsorption, and progression of disease. IBD has been reported an increased prevalence of low bone mass. The aims of the present study were to evaluate the nutritional status and to investigate the correlation between bone mineral density (BMD) and nutrient factors in patients with IBD. **Methods:** A total of 41 subjects were classified into normal group (n=21) and malnourished group (n=20) by the subjective global assessment result. We surveyed the dietary habit, nutrient intake, and BMD. **Results:** Subjects' average age was 36.7 years old, and included 26 ulcerative colitis and 15 Crohn's disease. The serum C-reactive protein (CRP) was significantly higher and serum calcium was significantly lower in the malnourished group. Lower bone density subjects were more in the malnourished group but no significant difference. Intake of energy, protein, carbohydrate, fiber, iron, sodium, potassium, zinc, vitamin B₆, vitamin C and folate were significantly lower in the malnourished group. The BMD of malnourished group showed correlation with triceps skin fold thickness (TSF), CRP, dietary calcium, phosphorous, iron, animal iron, zinc and vitamin. **Conclusions:** The results suggested that adequate intake of nutrients is important to prevent bone loss and systemic education programs are need for IBD patients.

Key Words: Bone density, Inflammatory bowel diseases, Nutritional status

INTRODUCTION

Inflammatory bowel disease (IBD) is a chronic condition that includes Crohn's disease and ulcerative colitis. The incidence of both intestinal disorders has recently increasing, and there are several problems associated with symptoms and side effects that follow a course of relapse and treatment.[1] Decrease in bone density is a relatively common complication of IBD, occurring in about 20-50% patients. Poor bone density may be caused by malabsorption of calcium and vitamin D, with steroid, malnutrition, and an unbalanced diet.[2] Another study reported that inflammatory mediators such as tumor necrosis factor, interleukin (IL)-1 β , and IL-6 cause abnormalities in the bone regenerating rate, which eventually lead to a decrease in bone density.[3]

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Bone density generally varies according to genetics or ethnicity. The effective way to prevent osteoporosis is to increase bone density when an individual is young, as the bone becomes dense during the growth period. Since various nutrients have already been proven to improve bone density, a long-term diet with good nutrients is important. [4] IBD can occur at a relatively young age and persist a lifetime. A previous study therefore suggested lifestyle changes to prevent bone loss and strategies to screen and treat high-risk patients.[1]

Individuals with IBD must limit their food intake due to the disease itself or other complications, which eventually leads to malnutrition. Weight loss, hypoalbuminemia, and anemia are the most frequent manifestations of malnutrition. Approximately 23% of outpatients and 85% of inpatients with IBD were reported to have malnutrition associated with the disease. Further, this prolonged malnutrition in turn decreases bone density.[5] Complete prohibition of certain foods or inappropriate food limits due to lack of adequate information also cause these problems. For effective treatment, the patient must be well nourished and be provided nutritional support when oral intake is not possible. Healthcare providers recommend that more attention be paid to the relationship between IBD, and poor nutrition.[6] However, only few studies have examined the nutritional needs of patients with IBD in Korea, although studies by decreased bone density caused by poor nutrition are currently underway.

The aim of the present study was to investigate the relationship between bone density and IBD in order to ensure that patients receive the proper nutrition needed to manage and prevent osteoporosis. Hence, we surveyed the dietary habit, nutrient intake, and bone density of patients with Crohn's disease and ulcerative colitis. The relationship of bone mineral density (BMD) and nutrient intake based on nutritional status were also investigated.

METHODS

1. Subject

This study was conducted on patients with IBD who were treated at the Department of Internal Medicine, Soonchunhyang University Bucheon Hospital, between September 2010 and September 2011. A doctor evaluated compliance of patients for study when the patient visited for check

ups, and they explained the purpose and procedures of the study. Patients who agreed to sign the experimental agreement were included in this study. Patients for whom the cause of poor bone density could have been completely unrelated to IBD were excluded. Other exclusion criteria included a history of colectomy, diabetes, thyroid disease, liver disease, kidney disease, sexual malfunction, fractures, and metabolic bone disease; menopause; medications such as vitamin D supplement, sex hormones, and phosphate binder; and a controlled diet that increases bone density. Although 70 patients were enrolled, data were collected only from 41 subjects who completed the study except for refused investigation, did not undergo a bone-related test, or had missing information. The 41 subjects were classified into two groups based on nutrition status: the normal group (n=21) and the malnourished group (n=20).

2. Clinical information and nutritional status

The subjects' age and gender were obtained. The weight and height were also measured and the body mass index (BMI) was calculated. The triceps skin fold thickness (TSF) and waist circumference were measured and weight loss rate within the past 6 months were surveyed. The clinical information on the diagnosis and diagnostic period were derived from the medical records. Disease activity and cumulative steroid dose were assessed by a doctor. Disease activity of ulcerative colitis was classified by the Truelove and Witts severity index[7] and disease activity of Crohn's disease was assessed by a Crohn's disease activity index (CDAI).[8] The nutritional status was evaluated using subjective global assessment (SGA)[9] by the clinical dietitian and the subjects were classified into normal group or malnourished group.

3. Blood and BMD test

The blood sample was collected from the subjects after 10-12 hours fast. The test items included hemoglobin, hematocrit, C-reactive protein (CRP), serum albumin, calcium and phosphorous (Technicon AutoAnalyzer methods). Serum intact parathyroid hormone (iPTH) was measured by an electrochemiluminescent immunoassay and serum 25-hydroxy-vitamin D3 (25-[OH]D₃) was measured using a chemiluminescent immunoassay. The BMD was measured using the dual energy X-ray absorptiometry (DXA) equipment (Lunar Prodigy; GE Lunar Corp., Madison, WI, USA) on

the subject's lumbar spine and femoral neck. Bone density was expressed as BMD, Z-score and T-score. The bone density was evaluated using a T-score -1.0 or over was normal; $-2.5 \sim -1.0$ was osteopenia; and -2.5 or less was osteoporosis. Dichotomizing the Z-score, a cutoff value of ≤ -1 standard deviation (SD) was defined as reduced bone mass.[10]

4. Dietary habit and nutrient intake

The questions on the regularity of usual meals, skipped meals, meal time and amount of meals, drinking, smoking and exercise habits were surveyed per individual. Skilled clinical dietitian interviewed subjects using photographs of food items and a booklet containing eye measurement data as aids for the nutrient intake survey. Data on dietary intake amount were collected using the 24-hr recall method for three days and intakes of nutrients were analyzed with the CAN-Pro 3.0 (Korean Nutrition Society, Seoul, Korea). In addition, to evaluate the intake excess or deficiency by nutrient, the intake was compared with the recommended nutritional intake for Koreans.[11]

5. Statistical analysis

The mean and standard deviation were calculated using SPSS statistical software ver. 18.0 (SPSS Inc., Chicago, IL, USA). The difference on the frequency of food intake between the two groups was tested chi-square test while the mean was compared using t-test. The correlation between bone density and its related variables was analyzed using Pearson's correlation coefficient. All results were considered statistically significant when $P < 0.05$.

RESULTS

1. Clinical characteristics of the patients

There were 25 male and 16 female subjects (total 41 subjects) and their mean age was 36.7 years old. Although more male subjects in the malnourished group, there was no significant difference. The average BMI was 22 kg/m^2 and 1.9% of subject showed weight loss within the recently 6 months. The weight loss rate was 0.4% in normal group and 3.4% in malnourished group which was significantly different ($P < 0.001$). The average waist circumference was 81.1 mm and average TSF was 12.2 mm. Twenty-six subjects (63.4%) had ulcerative colitis and 15 subjects (36.6%) had Crohn's disease. There were more ulcerative colitis

patients in general but the ratio between ulcerative colitis and Crohn's disease was the same in the malnourished group. The average disease period was 44.2 months (approximately 3.7 years) which showed 32 subjects (78%) had the disease for more than one year while only 9 subjects (22%) had it for less than a year. In comparison of disease activity, most of ulcerative colitis was remission and mild status. Disease activity of Crohn's disease also assessed remission status. A dose of steroids were more in the malnourished group, there was no significant difference (Table 1).

2. Blood parameters and BMD according to the nutritional status of the patients

The blood test showed that the average hemoglobin was 12.6 g/dL , below the normal range ($13\text{-}17 \text{ g/dL}$). The malnourished group showed a lower range than that of the normal group but the difference was not that significant. The result showed the serum albumin, calcium and phosphorous levels were within normal range but the average CRP was at 0.8 mg/dL slightly higher than the normal range ($0\text{-}0.5 \text{ mg/dL}$). The result of CRP was significantly higher in the malnourished group than that of the normal group ($P < 0.05$). The serum calcium and $25\text{-}(\text{OH})\text{D}_3$ level were also significantly lower in the malnourished group ($P < 0.05$). The bone density test showed that T-score of lumbar spine and femoral neck were lower in the malnourished group than those of the normal group but the difference was not significant. Fifteen subjects (36.6%) were classified into osteopenia based on their T-score while 2 subjects (4.9%) have osteoporosis. There were more subjects in the malnourished group who had a lower bone density compared with the normal group but the difference was not significant (Table 2).

3. Comparison on dietary habits according to the nutritional status of the patients

The comparison of eating behaviors and their life habit is presented in Table 3. For the regularity of meals, 20 subjects (48.8%) answered 'regular' while 21 subjects (51.2%) answered 'irregular,' which meant more than half of the subjects were having irregular meals. The skipping of meals rate showed that breakfast accounted for the highest percentage with 13 (76.5%) out of the 17 subjects (41.5%) who answered 'I skip meals.' For the duration of meals, 20 sub-

Table 1. Comparison of clinical characteristics and anthropometric data according to nutritional status

	Total (n = 41)	Normal group (n = 21)	Malnourished group (n = 20)	P-value
Age (yr)	36.7 ± 11.9	39.2 ± 12.5	34.1 ± 11.0	0.171
Gender - Male (%)	25 (61.0)	10 (47.6)	15 (75.0)	0.069
Female (%)	16 (39.0)	11 (52.4)	5 (25.0)	
Height (cm)	166.2 ± 9.0	163.1 ± 8.7	169.5 ± 8.3	0.022 ^{a)}
Weight (kg)	61.0 ± 13.4	61.6 ± 14.9	60.3 ± 11.8	0.753
BMI (kg/m ²)	22.0 ± 4.0	23.0 ± 4.4	20.9 ± 3.2	0.085
Weight loss (recently 6 months, %)	1.9 ± 2.6	0.4 ± 1.0	3.4 ± 2.9	0.000 ^{b)}
WC (mm)	81.1 ± 8.3	81.7 ± 9.8	80.4 ± 6.6	0.619
TSF (mm)	12.2 ± 2.6	13.3 ± 2.5	11.1 ± 2.8	0.787
Type - Ulcerative colitis (%)	26 (63.4)	16 (76.2)	10 (50.0)	0.078
Crohn's disease (%)	15 (36.6)	5 (23.8)	10 (50.0)	
Disease duration (months)	44.2 ± 30.3	40.3 ± 28.4	48.3 ± 32.5	0.411
< 1 yr (%)	9 (22.0)	4 (19.0)	3 (15.0)	0.551
≥ 1 yr (%)	32 (78.0)	17 (81.0)	17 (85.0)	
Disease activity				
Ulcerative colitis - Mild (%)	15 (57.7)	11 (68.7)	4 (40.0)	0.349
Moderate (%)	9 (34.6)	4 (25.0)	5 (50.0)	
Severe (%)	2 (7.7)	1 (6.3)	1 (10.0)	
Crohn's disease	104.91 ± 88.23	82.4 ± 26.1	116.2 ± 106.7	0.505
Cumulative steroid dose (mg)	4,116.6 ± 3,913.3	3,405.8 ± 3,264.8	4,929.1 ± 4,215.3	0.473

Mean ± standard deviation (SD), ^{a)}P < 0.05, ^{b)}P < 0.001.

BMI, body mass index; WC, waist circumference; TSF, triceps skin fold thickness.

Table 2. Comparison of blood parameters and bone mineral density according to nutritional status

	Total (n=41)	Normal group (n=21)	Malnourished group (n=20)	P-value
Hemoglobin (g/dL)	12.6 ± 2.4	13.0 ± 2.5	12.1 ± 2.4	0.225
Hematocrit (%)	37.0 ± 6.6	38.1 ± 6.5	35.9 ± 6.6	0.282
CRP (mg/dL)	0.8 ± 1.7	0.3 ± 0.7	1.4 ± 2.0	0.016 ^{a)}
Albumin (g/dL)	4.1 ± 0.6	4.4 ± 0.4	3.9 ± 0.7	0.013 ^{a)}
Calcium (mg/dL)	8.7 ± 0.4	9.1 ± 0.3	8.4 ± 0.5	0.048 ^{a)}
Phosphorous (mg/dL)	3.5 ± 0.6	3.5 ± 0.6	3.5 ± 0.7	0.908
iPTH (pg/mL)	39.9 ± 13.0	39.0 ± 10.6	41.3 ± 15.4	0.482
25-(OH)D ₃ (ng/mL)	13.8 ± 5.8	15.4 ± 5.7	12.3 ± 6.0	0.043 ^{a)}
Spine L1-4 (BMD, g/cm ²)	1.09 ± 0.16	1.12 ± 0.19	1.05 ± 0.12	0.219
Spine L1-4 (T-score)	-0.60 ± 1.32	-0.32 ± 1.50	-0.79 ± 1.90	0.173
Spine L1-4 (Z-score)	-0.54 ± 1.25	-0.35 ± 1.41	-0.74 ± 1.04	0.326
Femoral neck (BMD, g/cm ²)	0.93 ± 0.13	0.92 ± 0.14	0.94 ± 0.12	0.697
Femoral neck (T-score)	-0.40 ± 1.45	-0.19 ± 1.10	-0.60 ± 1.50	0.285
Femoral neck (Z-score)	0.13 ± 1.02	-0.09 ± 0.95	0.26 ± 1.10	0.450
Total hip (BMD, g/cm ²)	0.96 ± 0.13	0.97 ± 0.14	0.95 ± 0.11	0.364
Total hip (T-score)	0.07 ± 1.02	0.10 ± 1.15	0.04 ± 0.89	0.312
Total hip (Z-score)	0.23 ± 1.03	0.19 ± 1.05	0.27 ± 1.04	0.489
T score - Normal (%)	24 (58.5)	13 (61.9)	11 (55.0)	0.901
Osteopenia (%)	15 (36.6)	7 (33.3)	8 (40.0)	
Osteoporosis (%)	2 (4.9)	1 (4.8)	1 (5.0)	
Z-score - Normal (%)	37 (90.2)	18 (85.7)	19 (95.0)	0.606
Osteoporosis (%)	4 (9.8)	3 (14.3)	1 (5.0)	

Mean ± standard deviation (SD), ^{a)}P < 0.05.

CRP, C-reactive protein; iPTH, intact parathyroid hormone; 25-(OH)D₃, 25-hydroxy-vitamin D₃; L, lumbar; BMD, bone mineral density.

Table 3. Comparison of dietary habits according to nutritional status

		Total (n=41)	Normal group (n=21)	Malnourished group (n=20)	P-value
Meal regularity	Regular	20 (48.8)	12 (57.1)	8 (40.0)	0.451
	Irregular	21 (51.2)	9 (42.9)	12 (60.0)	
Meal skipping	None	24 (58.5)	14 (66.7)	10 (50.0)	0.258
	Skipping	17 (41.5)	7 (33.3)	10 (50.0)	
	Breakfast	13 (76.5)	5 (71.4)	8 (80.0)	
	Lunch	3 (17.6)	2 (28.6)	1 (10.0)	
	Dinner	1 (5.9)	0 (0.0)	1 (10.0)	
Meal time	< 10 min	15 (36.6)	8 (38.1)	7 (35.0)	0.979
	10-20 min	20 (48.8)	10 (47.6)	10 (50.0)	
	≥ 20 min	6 (14.6)	3 (14.3)	3 (15.0)	
Meal amount	A lot	15 (36.6)	10 (47.6)	5 (25.0)	0.095
	Appropriate	16 (39.0)	8 (38.1)	8 (40.0)	
	Small	10 (24.4)	3 (14.3)	7 (25.0)	
Alcohol	Yes	14 (34.1)	6 (28.6)	8 (40.0)	0.329
	No	27 (65.9)	15 (71.4)	12 (60.0)	
Smoking	Yes	7 (17.1)	2 (9.5)	5 (25.0)	0.391
	No	34 (82.9)	19 (90.5)	15 (75.0)	
Exercise	Yes	13 (31.7)	8 (38.1)	5 (25.0)	0.664
	No	28 (68.3)	13 (61.9)	15 (75.0)	

Values are presented as number (%).

jects (48.8%) answered '10-20 minutes' while 15 subjects (36.6%) answered 'less than 10 minutes'. For the subjective assessment on the food intake 15 subjects (36.6%) answered 'I eat a lot'; 16 subjects (39%), 'I eat appropriate amount'; and 10 subjects (24.4%) 'I eat small amount'. 34 subjects (82.9%) answered they do not smoke while 28 subjects (68.3%) answered they do not exercise. There was no significant differences in smoking and drinking but the malnourished group had a lower exercise rate and a higher smoking and drinking alcohol rate. Generally, item on the diet or life habit not showed significant differences between the groups (Table 3).

4. Daily nutrient intake evaluation according to the nutritional status of the patients

The average energy intake was 1,753.7 kcal; 1,906 kcal in the normal group and 1,527.9 kcal in the malnourished group. The energy intake was significantly lower in the malnourished group ($P < 0.05$). Intake of protein ($P < 0.05$), carbohydrate ($P < 0.05$), fiber ($P < 0.05$), iron ($P < 0.05$), sodium ($P < 0.05$), potassium ($P < 0.05$), zinc ($P < 0.01$), vitamin B₆ ($P < 0.05$), vitamin C ($P < 0.05$), and folate ($P < 0.01$) were significantly lower in the malnourished group. The intakes of fiber, calcium, vitamin B₂, vitamin C and folate were lower than the recommended nutritional intakes for Koreans in the normal group. The intakes of fiber, calcium, zinc, vi-

tamin B₁, vitamin B₂, niacin, vitamin C and folate were lower than the recommended nutritional intakes for Koreans in the malnourished group (Table 4).

5. The correlation with BMD and variables according to nutritional status of the patients

The correlation with as T-score of lumbar spine and all related variables by nutritional status were analyzed and only significant results were presented in Table 5. The BMD of malnourished group showed correlation with TSF ($P < 0.01$), CRP ($P < 0.05$), calcium ($P < 0.01$), phosphorous ($P < 0.05$), iron ($P < 0.05$), animal iron ($P < 0.05$), zinc ($P < 0.05$) and vitamin B₁ ($P < 0.05$) in their diet while the normal group showed correlation with TSF ($P < 0.05$), phosphorous ($P < 0.05$) and iron ($P < 0.05$) in their diet (Table 5).

DISCUSSION

Over the last few decades, the incidence of IBD has increased in Asian countries.[12] The present study investigated the correlation of bone density and the rate of malnutrition with the nutrient intake of patients with IBD. A nutritional approach to determining the treatment plan for IBD is considered very important. Therefore, it is first necessary to determine the nutritional status of patients in

Table 4. Daily nutrient intake according to nutritional status

	Total (n=41)	Normal group (n=21)	Malnourished group (n=20)	P-value
Energy (kcal)	1,753.7 ± 47.1	1,906.0 ± 502.4	1,527.9 ± 391.1	0.041 ^{a)}
Protein (g)	64.5 ± 22.4	71.4 ± 23.7	56.3 ± 20.2	0.048 ^{a)}
Plant protein (g)	34.3 ± 11.0	35.4 ± 8.1	31.1 ± 13.5	0.509
Animal protein (g)	34.6 ± 17.8	36.5 ± 19.6	32.7 ± 16.1	0.503
Fat (g)	48.4 ± 20.9	52.9 ± 23.2	43.6 ± 17.5	0.156
Plant fat (g)	22.9 ± 11.8	23.3 ± 12.3	22.5 ± 11.6	0.848
Animal fat (g)	28.6 ± 17.8	31.5 ± 17.0	25.5 ± 18.5	0.283
Carbohydrate (g)	242.4 ± 85.6	291.3 ± 69.0	212.6 ± 98.0	0.045 ^{a)}
Fiber (g)	18.1 ± 7.5	20.8 ± 5.6	14.2 ± 8.2	0.013 ^{a)}
Calcium (mg)	506.3 ± 252.9	546.8 ± 217.1	465.2 ± 291.1	0.588
Plant calcium (mg)	305.7 ± 157.6	296.7 ± 118.3	305.3 ± 193.4	0.711
Animal calcium (mg)	229.6 ± 168.7	236.2 ± 181.7	222.6 ± 158.4	0.801
Phosphorous (mg)	990.4 ± 368.7	1091.2 ± 395.9	866.9 ± 323.6	0.055
Iron (mg)	12.4 ± 5.4	14.1 ± 5.1	10.5 ± 5.2	0.030 ^{a)}
Plant iron (mg)	9.3 ± 3.7	10.2 ± 3.0	8.3 ± 4.3	0.104
Animal iron (mg)	3.8 ± 2.2	4.4 ± 2.6	3.2 ± 1.5	0.074
Sodium (mg)	4,454.4 ± 1,481.1	4,983.7 ± 1,468.4	3,898.7 ± 1,309.1	0.017 ^{a)}
Potassium (mg)	2,412.2 ± 873.8	2,816.8 ± 756.5	1,986.9 ± 796.0	0.011 ^{a)}
Zinc (mg)	8.1 ± 3.0	9.3 ± 3.1	6.8 ± 2.3	0.005 ^{a)}
Vitamin A (mgRE)	799.2 ± 650.4	852.6 ± 385.8	752.0 ± 849.5	0.466
Retinol (µg)	131.6 ± 130.9	137.2 ± 167.0	125.3 ± 78.7	0.442
Carotene (µg)	3,734.2 ± 3,761.6	3,639.3 ± 2,144.7	4,015.1 ± 4,976.8	0.630
Vitamin B ₁ (mg)	1.1 ± 0.4	1.1 ± 0.4	0.9 ± 0.4	0.346
Vitamin B ₂ (mg)	1.1 ± 0.4	1.1 ± 0.5	1.2 ± 0.4	0.285
Vitamin B ₆ (mg)	1.9 ± 0.9	2.2 ± 0.8	1.6 ± 0.8	0.022 ^{a)}
Niacin (mgNE)	16.9 ± 10.4	18.3 ± 12.7	15.5 ± 6.6	0.139
Vitamin C (mg)	73.7 ± 38.4	96.6 ± 32.1	58.1 ± 40.5	0.025 ^{a)}
Folate (µg)	193.9 ± 84.9	243.9 ± 67.2	131.9 ± 82.5	0.001 ^{b)}
Vitamin E (mg)	13.9 ± 8.2	16.2 ± 9.5	11.6 ± 6.0	0.069
Cholesterol (mg)	274.9 ± 168.4	273.9 ± 322.8	275.9 ± 204.8	0.981

Mean ± standard deviation (SD), ^{a)}P < 0.05, ^{b)}P < 0.01.

Table 5. Correlation coefficients between bone mineral density and variables according to nutritional status

	TSF	CRP	Calcium	P	Iron	Animal iron	Zinc	Vitamin B ₁
Normal group	0.575 ^{a)}	0.053	0.346	0.550 ^{a)}	0.484 ^{a)}	0.318	-0.107	-0.077
Malnourished group	0.680 ^{b)}	0.554 ^{a)}	0.607 ^{b)}	0.471 ^{a)}	0.628 ^{a)}	0.506 ^{a)}	-0.496 ^{a)}	-0.506 ^{a)}

^{a)}P < 0.05, ^{b)}P < 0.01.

TSF, triceps skin fold thickness; CRP, C-reactive protein; P, phosphorous.

order to provide diet intervention or nutritional support. [13] Of the subjects in this study, 48.8% were malnourished and weight loss since the 6 months in the malnourished group was significantly higher compared to normal group. More patients with Crohn's disease were malnourished than those with ulcerative colitis, but the difference was not significant. This result is related to that of another study which reported Crohn's disease affects small bowels and causes more severe malnutrition.[14] Most blood test re-

sults were within the normal range in our patients; however, although the hemoglobin level was below normal (13-17 g/dL) overall, it was substantially lower in the malnourished group. In an acute response test, CRP levels were significantly higher in the malnourished group. In a previous study, anemia, a generally observed symptom of nutritional deficiency, was found in 16% outpatient subjects and 68% inpatient subjects.[15] Another study reported that anemia needs to be treated before other symptoms as it can

decrease the performance of routine activities and lower quality of life.[16] The results of the present study did not show any significant difference in anemia between the two groups with different nutritional status, although the hemoglobin level was low in the malnourished group. In general, more proactive management is required to maintain the hemoglobin level in the normal range.

Many epidemiologic studies have reported decreased bone density in IBD, and this association was considered closely related to vitamin D deficiency, systemic inflammation, or use of oral steroids.[17,18] The risk of fractures increases with disease activity. Despite this, most patients do not receive bone-protective treatment. A previous study recommended effective screening and treatment for high-risk patients in order to prevent IBD.[19] Bone density results showed that the average bone density was $-0.60 \pm 1.32 \text{ g/cm}^2$ for the lumbar spine and $-0.40 \pm 1.45 \text{ g/cm}^2$ for the femoral neck. In the present study, the decrease in bone density was greater in the malnourished group than in the normal group as determined by the World Health Organization osteoporosis criteria, but the difference was not significant. Further, the decrease in bone density of 41.5% reported in the Korean IBD patients in our study was lower than the 63.3% cited by Park et al.[20] It was difficult to accurately compare between our study and the study by Park et al.[20] because of the different set of subjects and disease period. Nonetheless, both studies showed that bone density testing and active management from the early stages of diagnosis are necessary to prevent long-term complications of IBD.

As part of their usual dietary habit, about half the subjects in our study had irregular meals and skipped breakfast, but the difference between groups was not significant. The malnourished group also had a higher proportion of patients with drinking and smoking habits and a lower proportion of patients who exercised. Smoking affects the incidence and activity of IBD. Compared to non-smokers, smokers require a higher dose of steroids and immunosuppressive agents for Crohn's disease treatment since smoking actually accelerates disease progression.[21,22] Thus, from the treatment viewpoint, drinking and smoking should be strictly prohibited. Most IBD patients show nutrient deficiency, the malnourished group in our study as well showed lower intake of nutrients, especially energy, protein, carbohydrates, fiber, iron, sodium, potassi-

um, zinc, vitamin B₆, vitamin C, and folate. The intake of calcium, zinc, vitamin B₂, vitamin C, and folate was lower than the recommended amount for Koreans.[11] However, the average intake of energy, calcium, iron, and vitamin A intake was higher in this study than in a previous study by Kang[23] Considering the malabsorption in patients with IBD,[24-26] selection of the right food, well-balanced nutrient intake, and use of supplements depending on an individual's nutrient intake are essential. In the statistical analysis performed in the present study to confirm the factors correlated with bone density, the results showed that inclusion of phosphorus and iron in the diet was correlated with the bone density in the normal group. On the other hand, nutrients such as calcium, phosphorous, iron, animal iron, zinc, and vitamin B1 showed a correlation with the bone density in the malnourished group.

Despite the evidence, the importance of nutritional factors as a cause of decreased bone density in IBD varies among studies.[20,27,28] However, more recommendations indicate that daily management is required to ensure adequate levels of calcium and vitamin D in the diet and to improve malnutrition to prevent osteoporosis.[1,29] Because of the limited number of subjects, this study was not able to represent all IBDs. Nonetheless, our results were useful in confirming the role of malnutrition, nutrient intake, and bone density in patients with chronic IBD. Our study also showed that patients with inflammatory bowel rarely receive treatment to improve bone density. Malnutrition among these patients was high, and about 40% had decreased bone density and unbalanced nutrient intake.

On the basis of our findings, we recommend that malnutrition be considered during the early stage of disease diagnosis and a nutrition intervention be conducted to ensure better treatment efficacy, improve quality of life, and prevent any complications related to IBD. Additionally, proper education about nutrition is required to prevent poor bone density, and multidisciplinary studies on this matter are required in the future.

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