Nutritional Adequacy of the Specific Carbohydrate Diet in Pediatric Inflammatory Bowel Disease

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ABSTRACT

Introduction: The specific carbohydrate diet (SCD) is an exclusion diet used as a therapy in inflammatory bowel disease. The aim of this study was to evaluate the nutritional adequacy of the SCD.

Methods: Prospective dietary data for 12 weeks were analyzed for pediatric patients on the SCD. Intake of 20 key nutrients was compared to dietary recommended intake levels and nutrient intake data from similarly aged children from The National Health and Nutrition Examination Survey National Youth Fitness Survey in 2012.

Results: Nine patients enrolled, with 8 patients completing the study. Six of 8 individuals completing the study had gained weight, 1 individual had weight loss, and 1 had no change in weight. Energy intake was significantly greater than 100% of the recommended daily allowance (RDA)/adequate intake for 64% of daily intakes completed for this study. The majority of participants' daily intakes met or exceeded the RDA for vitamins B2, B3, B5, B6, B7, B12, C, A, and E. One hundred percent of participants' intakes were below the RDA for vitamin D. Seventy-five percent of daily intakes were less than the RDA for calcium. The upper limit was met or exceeded for magnesium in 42% of daily intakes. Average vitamin A intake was significantly greater than the upper limit ($P = 0.01$).

Conclusions: Nutrient intake of pediatric inflammatory bowel disease patients on the SCD was adequate when compared with a healthy peer reference population, but adequacy was variable when compared with the dietary recommended intakes. Close monitoring with a multidisciplinary team for patients using the SCD as an alternative or adjunct therapy is recommend to ensure positive outcomes for overall patient health.

Key Words: Crohn disease, dietary recommend intake, inflammatory bowel disease, nutrition, specific carbohydrate diet, ulcerative colitis

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What Is Known

- The specific carbohydrate diet is an exclusion diet used as a therapy in inflammatory bowel disease.
- The specific carbohydrate diet excludes grains, sweeteners except for honey and milk/milk products except for hard cheeses and yogurt fermented for greater than 24 hours.

What Is New

- The specific carbohydrate diet can be a nutritionally complete diet with appropriate intake of macro and micronutrients.
- Vitamin D supplementation should be evaluated for all patients on the specific carbohydrate diet.

Complementary and alternative therapies are frequently utilized by patients with inflammatory bowel disease (IBD) with changes in dietary intake being commonplace. Although the number of individuals on dietary therapy is unknown, 36% to 50% of pediatric patients with IBD use some form of alternative therapy (1). In addition, >75% of IBD patients restrict food groups based on subjective worsening of symptoms (2). The specific carbohydrate diet (SCD), an exclusionary diet, has been used by many patients as an alternative or adjunct therapy. This diet first developed in the 1930s to treat celiac disease and then popularized in the 1990s has emerged as a potential diet therapy for patients with IBD (3,4). Case series and reports from our institution and others have demonstrated not only clinical improvements and remission but normalization of inflammatory markers for patients with IBD (5–7). Although the mechanism of action for dietary therapy is not known, attention has focused on the ability of diet to alter the fecal microbiome as well as the effect of diet on immune barrier function (8).

Although nutritional therapy in the form of exclusive enteral nutrition has a well-established role in treatment of active Crohn disease in pediatric patients, the SCD has primarily been used outside of the medical establishment. Patients have exhibited great interest in this dietary approach to IBD therapy, but often times this

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is without guidance from the medical team (9). The SCD excludes all grains, dairy products except for fully fermented yogurts and some hard cheeses and sweeteners except for honey. In addition, food additives such as emulsifiers, found in many processed foods, are excluded. Staples within the diet include meats, nut flours, fruits, legumes, and vegetables. Although exclusive enteral nutrition has been shown to meet nutritional requirements of patients with IBD, the dietary adequacy of the SCD has not been evaluated.

With evidence of clinical efficacy for the SCD and increasing patient interest in the diet, the nutritional adequacy and any potential nutritional risks of the diet need to be evaluated. Malnutrition in IBD is associated with increased morbidity, and restrictive diets have the potential to increase this risk by contributing to micronutrient deficiencies and/or inability to meet energy and protein needs. Concern has been raised with restrictive diets in IBD, such as the SCD, for the potential to induce deficiency in folate; thiamin; vitamin B6; calcium; potassium; and vitamins A, C, and D (2). To evaluate the nutritional adequacy of the SCD, we compared nutrient intake of pediatric patients following the SCD to dietary reference intake (DRI) levels and population-based intake for 20 key nutrients.

METHODS

Study Design

This is a single-center analysis of nutrient intake in an open-label study designed to determine nutrition adequacy of the specific carbohydrate diet in pediatric patients with inflammatory bowel disease. The protocol was approved by the institutional review board of Seattle Children's Hospital. All patients/participants provided written informed consent or assent. The study was registered with *ClinicalTrials.gov* (number: NCT02213835). Study participants were recruited from Seattle Children's Hospital from April 2014 to August 2015.

Participants

Patients with Crohn disease or ulcerative colitis with mild or moderate disease activity as defined by Pediatric Crohn's Disease Activity Index (PCDAI) score of 10 to 45 or Pediatric Ulcerative Colitis Index (PUCAI) of 10 to 60 were enrolled into this study. The maximum PCDAI in this study was 45, and the maximum PUCAI was 55. Before the study no change in medication(s) for IBD could occur for a minimum of 1 month for immunosuppressive medications and 2 months for biologics.

Study Intervention

Patients went on to the SCD as the sole intervention for the study. Patients received one-on-one education and counseling by a dietitian trained in the SCD during each visit. Before each visit patients completed a 3-day food intake record to help assure compliance and adequate intake (AI) while on the diet. Dietary guidance included overview of the SCD; which foods are included and excluded. The dietitian counseled on weight loss prevention/management and provided several resources to help with meal planning such as recipe books and meal and snack recommendations. A staged approach, which involved introduction of new SCD foods in a stepwise manner, working toward the complete SCD was used. Patients followed up and were in contact with the dietitian, research assistant and primary gastroenterologist for questions and troubleshooting for the 12-week study (10). Patients had clinical follow-up at 2 weeks, 4 weeks, 8 weeks, and 12 weeks. Dietary assessment included a 3-day detailed food intake record with date, time, food/drink, portion, description of how the food was prepared, amount eaten, and recipe when indicated. These food intake records were provided by each family at every follow-up visit. Counseling sessions involved weight loss prevention, increasing efficiency with meal planning, cooking, and diet variety. Based on diet recalls, some individuals were recommended to either start a multivitamin with mineral supplement and/or vitamin D supplement. These supplements were not included in nutrient analysis summary due to variable compliance.

TABLE 1. Percent of specific carbohydrate diet patients and National Youth Fitness Survey (1) participants achieving nutritional adequacy

	Percent achieving nutritional adequacy	
Nutrient	SCD patients (N = 8)	NYFS patients (N = 605)
Vitamins		
B1	37.5	79.2
B2	87.5	83.6
B3	87.5	81.0
B5	75.0	—
B6	87.5	77.2
B7	75.0	—
B9	37.5	6.1
B12	87.5	79.3
C	100	52.9
A	100	83.6
D	0	5.1
E	75.0	12.2
K	62.5	34.7
Minerals and trace elements		
Calcium	12.5	26.8
Iron	75.0	70.1
Magnesium	50.0	30.9
Phosphorus	37.5	46.6
Selenium	100	89.3
Zinc	50.0	52.4
Energy	62.5	—
Protein	100	84.3

NYFS = National Youth Fitness Survey; SCD = specific carbohydrate diet.

Diet Analysis

Diet analysis of all detailed food intake records was completed using The Food Processor version 10.12.0 (ESHA Research, Salem, OR) for each study participant. To ensure accuracy of nutrient content, recipes were built within the program for all homemade foods and baked goods. Intake of 20 key nutrients was then compared to DRI levels and nutrient intake data from The National Health and Nutrition Examination Survey (NHANES) National Youth Fitness Survey (NNYFS) (11). NNYFS collected nutrient information from healthy children in 2012 using in-person dietary interview to capture 24-hour recall data. The full list is shown in Table 1.

Other Measures

Vitamin D 25-OH levels were assessed at baseline and upon completion of the 12-week intervention. Patients with low vitamin D 25-OH levels <30 ng/mL at baseline were supplemented with an SCD-approved D supplement.

Statistical Analysis

Descriptive summaries were prepared for all variables including mean, standard deviation, quartiles, and range for

TABLE 2. Baseline demographic and clinical characteristics of specific carbohydrate diet patients

Characteristic	Mean ± standard deviation or frequency (%)
Age	13.6 ± 2.0
Sex	
Female	4 (44%)
Male	5 (56%)
Disease duration	1.6 ± 1.7
Supplementation	
Multivitamins	Pt 1: 2000 IU/day D3 + MVI Pt 2: SCD adult MVI + 2000 IU/day D3 Pt 3: Folic acid + vitamin D + Iron + MVI Pt 4: 2000 IU/day D3 Pt 5: SCD vitamin D × 2000 IU/day Pt 6: non SCD MVI with minerals Pt 7: 2000 IU/day D3 Pt 9: 6000 IU/day D3 + fish oil × 1000 mg/day + curcumin/theracumin 30 mg/day
Probiotics	Pt 9: VSL #3

MVI = multivitamin; SCD = specific carbohydrate diet.

quantitative variables (eg, age, nutrient intakes) and frequencies and percentages for categorical variables (eg, sex, receipt of supplementation). After preliminary visualization of daily intake values, nutrients that were markedly skewed right were log-transformed for analyses. All dietary data for patients were included as separate intakes in analyses, representing up to 12 daily intakes per patient. Comparisons to recommendations were based on the difference between the daily value and the RDA, AI, or the upper limit (UL). Linear mixed-effects models (12), a generalization of 1-sample *t* tests in this setting, were used to account for the multiple daily available per patient. For comparison to NNYFS nutrient intake data, NNYFS data were first subset to include only participants in the age range of the SCD patients. Next, NNYFS data were summarized to estimate population means. SCD patient data were compared with these population means using 1-sample *t* tests. *P* values <0.05 were considered statistically significant. All statistical analyses were conducted using SAS Version 9.4 (SAS Institute Inc, Cary, NC) and R Version 3.0.3 (The R Foundation for Statistical Computing, Vienna, Austria) (13).

RESULTS

Subjects

Nine individuals from Seattle Children's Hospital enrolled in the study. Baseline demographics and clinical characteristics are shown in Table 2. Mean age of participants was 13.6 ± 2.0 years (range 11–17 years). Average disease duration before study was 1.6 ± 1.7 years (range 0–5 years). One patient stopped the study at 2 weeks because of difficulty maintaining the diet. By week 12, 7 of 8 patients achieved clinical remission based on PCDAI/PUCAI scoring, normalization of laboratories, and clinical assessment. Diet therapy was ineffective for 1 patient (10).

Growth: Weight/Height Velocities

Anthropometric measurements of weight and height for the 3-month trial varied significantly for patients within the study. Although the 6 of 8 individuals completing the study had positive weight gain, 1 individual had weight loss, and 1 had no change. The mean weight *z* score for participants who completed the study was -0.29 (SD = 0.73) with a mean increase for the course of the study of 0.14 (SD = 0.28). The mean height *z* score for participants who completed the study was -0.19 (SD = 0.88) with a mean increase over the course of the study of 0.12 (SD = 0.14) (Fig. 1). Body mass index (BMI) *z* score for all individuals that completed the study remained greater than -1.

Diet Analysis

Energy intake was significantly greater than 100% of the RDA/AI for 64% of daily intakes completed for this study. The mean energy intake ranged from 88% to 145% of the RDA. Two of 8 study participants had mean energy intake <97% of the RDA. Similarly, protein intake was significantly higher than the NHANES reference population at approximately 3 times the RDA for protein for all individuals' average daily intakes (Fig. 2).

The majority of participants' daily intakes met or exceeded the RDA for vitamins B2 (82%), B3 (67%), B5 (70%), B6 (90%), B7 (74%), B12 (82%), C (76%), A (92%), E (55%). Seventy-one percent of participants' daily intakes were below the RDA for vitamins B1 and 67% for B9. One-hundred percent of participants' daily intakes were below the RDA for vitamin D. Fifty-six percent of participants' daily intakes met the RDA for vitamin K (Fig. 3). Seventy-four percent of participants' daily intakes exceeded the RDA for iron, and 91% for selenium (Fig. 4). Forty-eight percent of intakes met RDA for zinc and 42% for magnesium. Forty-six percent on average met the RDA for phosphorus. Seventy-five percent of daily intakes were less than the RDA for calcium.

The UL was met or exceeded for magnesium in 42% of participants on average and in 66% of participants on average for vitamin A (Fig. 5). The average vitamin A intake was significantly greater than the UL ($P = 0.01$).

Other Measures

Patients 2, 4, and 7 presented with hypovitaminosis D with level <30 ng/mL at our institution. Out of these patients, all started on varying dosages of SCD-approved vitamin D. Patient 2 began vitamin D3 supplementation at 200 IU/day with improvement in levels from 18 to 25 ng/mL. Patient 4 presented with a level of 26 ng/mL, started on 2000 IU/day D3 with follow-up level of 28 ng/mL. This patient reported taking the supplement irregularly. Patient 7 started the study with a level of 17 ng/mL, initiated 2000 IU/day vitamin D3, and completed the study with a level of 36 ng/mL. Other participants either presented on vitamin D supplementation already, or did not require supplementation during the study.

DISCUSSION

With recent reports suggesting efficacy of the SCD in patients with IBD, analysis of nutrient intake is essential to assure the nutritional adequacy of the SCD for these patients. The results of this study show that in a small cohort of pediatric patients with active IBD, intake on the SCD was comparable to that of healthy peers in the NNYFS for 20 key nutrients.

The DRIs provide reference values for energy and nutrient intake in healthy individuals. They are used for assessing diets for individuals and groups, setting goals to be achieved over time. These were established as guidelines for adequate nutrition in hopes of reducing the incidence of undernutrition and micronutrient deficiencies. The AI is used when data are insufficient to establish an RDA and is set at a level assumed to ensure nutritional adequacy. The disadvantage with using DRIs in relation to this study include the lack of reference values for individual with chronic disease or malabsorptive states. This may underestimate the true needs of our

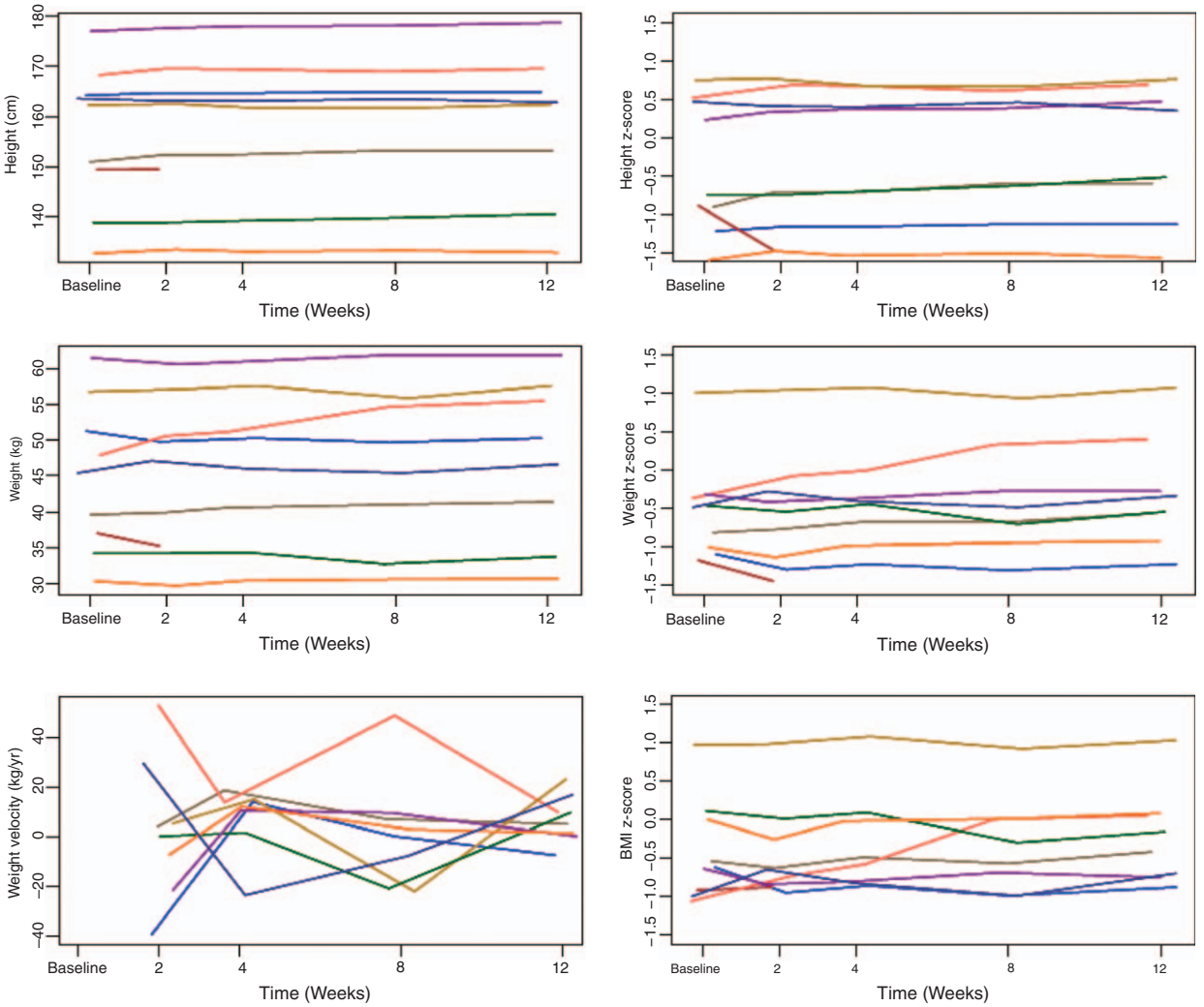

FIGURE 1. Height, weight, weight velocity, and body mass index (BMI) *z* score for specific carbohydrate diet (SCD) patients. Each color shows the profile of an individual patient.

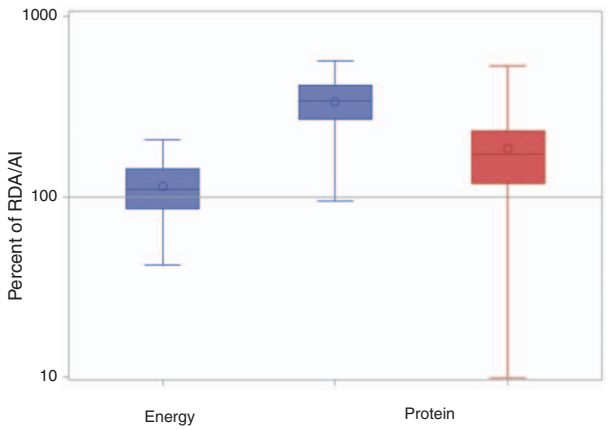

FIGURE 2. Percent of recommended daily allowance (RDA)/Adequate Intake (AI) for energy and protein. Specific carbohydrate diet (SCD) patient data are displayed in blue. National Youth Fitness Survey (NYFS) data are displayed in red. Circles shown on boxplots are means.

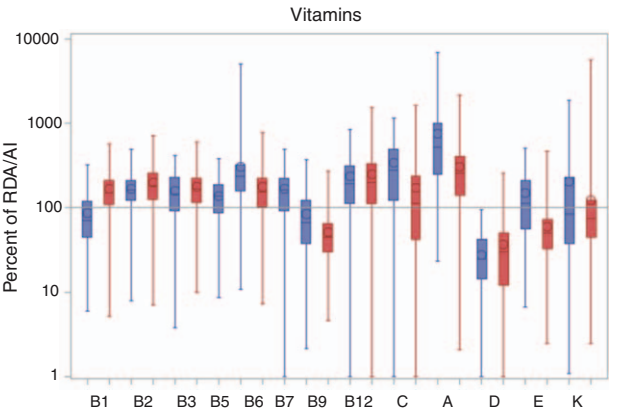

FIGURE 3. Percent of recommended daily allowance (RDA)/Adequate Intake (AI) for vitamins. Specific carbohydrate diet (SCD) patient data are displayed in blue. National Youth Fitness Survey (NYFS) data are displayed in red. Circles shown on boxplots are means.

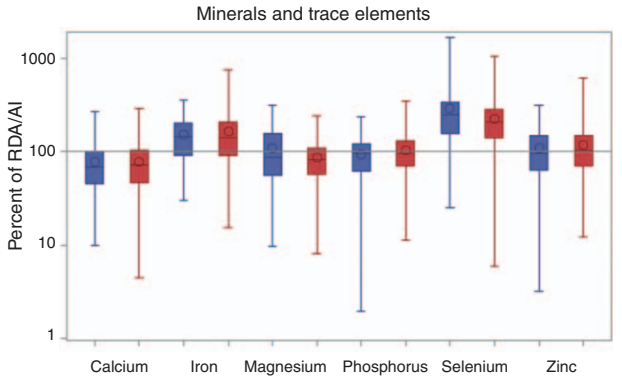

FIGURE 4. Percent of recommended daily allowance (RDA)/Adequate Intake (AI) for minerals and trace elements. Specific carbohydrate diet (SCD) patient data are displayed in blue. National Youth Fitness Survey (NYFS) data are displayed in red. Circles shown on boxplots are means.

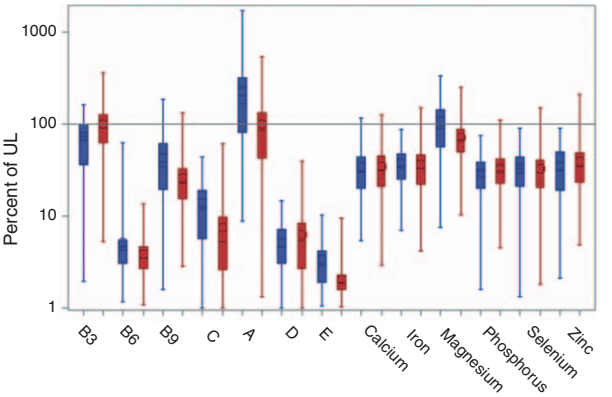

FIGURE 5. Percent of upper limit (UL) for vitamins, minerals, and trace elements. Specific carbohydrate diet (SCD) patient data are displayed in blue. National Youth Fitness Survey (NYFS) data are displayed in red. Circles shown on boxplots are means.

patient population. In addition, there is not an RDA established for many key nutrients, and some of these reference values are based on supplementation and not dietary intake. We do not currently have a criterion standard for nutrient adequacy in pediatric IBD. Therefore, the DRIs and NNYFS were used as comparison.

The mean energy intake of our study participants varied from 88% to 144% of the RDA. Two of 9 study participants had energy intake <97% of the RDA. A mean energy intake <80% of the RDA has been associated with reduced growth velocity (14). In a previous study on dietary intake of children with Crohn disease, 47% consumed <80% of the RDA, a much higher percentage than what we observed in our cohort despite additional dietary limitations (15). Other studies comparing energy intake to calculated estimated energy requirements or intake of healthy controls have also found intake of children with active disease to be inadequate (16,17). Six of 8 patients who completed the study in our cohort had weight gain demonstrating that despite the exclusionary nature of the SCD, the majority of patients remained able to consume adequate energy intake to support growth despite the increased energy needs that we know are associated with active disease. Protein intake was three times the RDA indicating sufficient protein and amino acid intake.

In our analysis of the SCD, mean intake of vitamins B1 (thiamin), B9 (folate), D, calcium, and phosphorus were found to be <100% of the RDA/AI reference values. A percentage of patients met the RDA for the remaining B vitamins, as well as zinc and magnesium intake, whereas others did not meet the RDA for these nutrients (see Table 1). Although not statistically significant, the average trajectory of nutrient intake relative to RDA/AI for the SCD patients showed a trend toward increasing intake for all nutrients with the exception of B3, zinc, and selenium (see Supplemental Digital Content 1, *http://links.lww.com/MPG/A986*). Given the exclusion of fortified grains and the limited dairy products of the diet the lower intake of these nutrients is understandable. The majority of our patients were not on an SCD multivitamin at the time of this study; however, given these results SCD multivitamins are now recommended when nutritional assessments suggest lower intake of micronutrients. Despite intake being lower than reference values, we were reassured when comparison to NHANES data demonstrated no significant differences in nutrient intake between pediatric patients on the SCD and population data from healthy peers of the same age and sex. Vitamin D was the only nutrient in our analysis, which was significantly less than the RDA. As discussed above, the low intake of individuals within our cohort was, however, similar to that of data from healthy peers. In our population, this may be been partially due to the avoidance of foods that are conventionally fortified. Due to malabsorption and increased intestinal losses of nutrients associated with the inflammation of IBD, it is possible that even if intake of vitamin D was similar to the RDA it may not support normal serum levels. Vitamin D deficiency is common in children and adolescents with IBD, affecting up to 34.6% of patients (18). Vitamin D plays a role in the immune system of the gut and is emerging as a nutrient that may play a role in regulating disease severity in IBD (19). As such, individuals with IBD, including those following the SCD, should have monitoring of serum levels and supplementation as needed to prevent and treat deficiency.

The mean calcium intake of our study participants varied from 58% to 144% of the RDA of 1300 mg/day. Given that dairy products on the SCD are limited to homemade yogurt and some hard cheeses, it is understandable that intake could be lower than recommendations. Other studies of pediatric IBD patients without dietary restrictions also, however, report inadequate calcium intake. In a recent study of 68 pediatric IBD patients, half of study participants consumed <50% of the RDA for calcium. Dairy products are a frequently self-imposed diet restriction with IBD patients (16). Multiple other studies have found calcium intake of children with IBD to be significantly less than the RDA and/or intake of healthy controls (17,20,21). Poor dietary intake of calcium has the potential to impact bone health and increase risk of bone disease and therefore should be evaluated in IBD patients by a healthcare practitioner or dietitian.

The only nutrient found to exceed the UL within our study for the majority of individuals was vitamin A. In spite of this, intake of vitamin A was not significantly different than data from NHANES. It is hypothesized to be related to the high intake of eggs and vitamin A rich produce within the diet. None of the study participants demonstrated signs or symptoms of toxicity and after the study was completed, serum vitamin A levels checked for a few individuals were found to be normal. Additionally, the UL for magnesium was met or exceeded in 50% of participants. Of note, the UL for magnesium was established based on a pharmaceutical supplement, which could pose varying bioavailability to that of whole-food–rich magnesium. Magnesium toxicity can result in diarrhea, and the majority of individuals experienced improvement in stool consistency aside from 1 participant that suffered from constipation.

This study also highlights the importance of a multidisciplinary approach to the treatment of IBD especially when incorporating dietary therapy. With patients and parents having variable nutrition knowledge, it is essential to have both physician and dietitian working in concert addressing not only disease activity but also nutritional intake and status. Within both our research and clinical dietary program at

Seattle Children's Hospital, we spend time addressing all patient questions regarding the diet and highlight nutritional concerns proactively with appropriate nutrient supplementation when indicated.

In conclusion, this study demonstrates that on the SCD, nutrient intake is comparable to that of similarly aged healthy children in the United States. An SCD multivitamin with mineral and/or vitamin D supplement may be indicated depending on diet variety, as individuals with inadequate intake of allowed foods on the SCD may be lacking as seen with the nutrient intake of some of our patients as compared to the DRIs. Patient access to a dietitian and multidisciplinary team with knowledge on the SCD likely had a positive influence on the overall nutritional quality of the diets for the children and adolescents in this study and is highly recommended to ensure the best outcomes for patients. While controlled trials are needed to determine the efficacy of the SCD in treating and controlling disease activity in patients with IBD, our data show nutritional adequacy and safety of the diet in general. The sample size of this study is small, and we are currently designing controlled follow-up studies to increase our knowledge of the dietary intervention. Future studies should evaluate whether similar results are found in adult populations on the SCD. Additionally, future studies need to assess whether gradual liberalization of the SCD can make it easier for patients to consume a nutritionally adequate diet while maintaining similar outcomes in the treatment of their IBD.

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