Specific carbohydrate diet: irritable bowel syndrome patient case study

Introduction

Irritable Bowel Syndrome (IBS) is defined as a functional gastrointestinal disorder that has no organic cause, despite the presence of chronic or reoccurring gastrointestinal symptoms (Fukudo et al., 2015). IBS affects 5-10% of people worldwide and results in a considerable reduction in quality of life. In a 2010 study, IBS patients indicated they would give up 25% of their remaining life span (average 15 years) and 14% of the respondents indicated they would risk a 1/1000 chance of death to receive a treatment that would make them symptom free (El-Salhy et al., 2010). Twelve to 14% of primary care patient visits and 28% of referrals to gastroenterologists are IBS patients, making this a more common reason for a visit to a physician than diabetes, hypertension or asthma (El-Salhy et al., 2010).

Diet strategies that have had a positive impact on IBS have focused recently on the restriction of fermentable carbohydrates, oligo-, di-, mono-saccharides and polyols (FODMAPS) (Shepherd et al., 2013) and gluten sensitivity (Verdu, 2011). The FODMAPS diet has shown excellent symptom reduction in patients with IBS. Ong and others have proposed that FODMAPs induce luminal distention through the fermentative activity of intestinal bacteria in combination with osmotic effects (Ong et al., 2010). Dietary restriction of FODMAPS has led to symptomatic improvement in a large majority of IBS patients (Shepherd and Gibson, 2006). Gluten has also been implicated in symptomology, and in fact, some authors speculate that gluten contributes to the pathogenesis of IBS (Verdu, 2011). Two placebo controlled trials using food challenges containing either gluten containing foods or a placebo found that non-celiac wheat sensitivity existed in patients with IBS (Biesiekierski et al., 2010; Carroccio et al., 2012).

Despite advances in diet therapy, there is a subset of IBS sufferers who may require further carbohydrate restriction, in addition to gluten restriction, and if necessary, FODMAPS, to alleviate symptoms of IBS.

"Carbohydrate fermentation is the single most important force driving the metabolic activities of the large intestinal microbiome, and it is quantitatively more important than amino acid catabolism"(Group and Kingdom, 2012). In one study, thirteen overweight and obese participants with moderate to severe IBS-diarrhea were provided 4 weeks of a very low carbohydrate diet (VLCD) (20 g carbohydrates/d) after a 2 week washout period with a standard diet. Symptom changes were monitored. Seventy-seven percent of patients had significant improvement in symptoms (reduced stool frequency, pain and quality of life). Overweight and obese individuals initiating a VLCD had a profound clinical response in their IBS-Diarrhea symptoms (Austin et al., 2009).

Probiotics in the treatment of IBS have been advocated widely. Probiotics are live bacteria that exert beneficial effects on the host through numerous mechanisms. It is believed that probiotics should be prescribed routinely as therapy in IBS (Hosseini et al., 2012). The mechanism of action for probiotics includes the maintenance of intestinal barrier function, (Ukena et al., 2007) inhibition of pathogen growth and adherence and production of chemicals such as cytokines and butyric acid (Rana et al., 2012).

The specific carbohydrate diet (SCD) restricts polysaccharides and disaccharides and allows monosaccharides (to an extent) and probiotics. Monosaccharides do not need the aid of digestive enzymes for absorption and therefore, can easily be absorbed in people who have inflamed and compromised digestive tracts. It is thought that the diet alters the gut microbiome (Nieves and Jackson, 2004). The SCD diet was developed in the 1950's by Dr. Sidney Haas. A

study by Haas (1955) in the American Journal of Gastroenterology, reported that 191 pediatric patients with purported celiac disease were treated with the SCD. These patients were followed for over 18 months. For a period of 12 months, carbohydrates other than monosaccharides were eliminated from the diet, while protein and fats were given in moderate quantities. In a large majority of the cases, the nutritional status normalized after 6-9 months. After 12 months, starches and sugars were added. If symptoms reoccurred, then the patient was put back on the diet for 3-6 months. Only one patient required the diet for greater than 18 months and this was due to noncompliance. Within 18 months of the therapeutic diet, all but one of the children (175 within 15 months) were able to tolerate a reintroduction of starches and sugars without any recurrence of symptoms (Haas, 1955).

A few studies have shown success with using the SCD to treat Inflammatory Bowel Disease (IBD). Crohn's disease and ulcerative colitis are two distinct conditions of IBD and are characterized by inflammation in the gastrointestinal tract. It is reasonable to believe that there will be positive outcomes employing the SCD in IBS given its favorable response in IBD.

New and immerging research makes it clear that diet plays a role in the pathology of IBS. Anecdotal evidence indicates that the SCD is successful in treating functional bowel disease; however, a clinical study has never been published for the use of this diet in the IBS population. It is the intent of this research project to provide scientifically valid data on the effects of the SCD on IBS symptoms.

Methodology

Subject

One female subject with IBS was referred from a local gastroenterology clinic and met the following inclusion criteria: diagnosis of IBS (made by the referring physician and fulfilling

the Rome III criteria), over 18 years of age, all ethnicity groups are included, male or female. The exclusion criteria were positive for celiac disease, IgA deficiency, pregnancy, breastfeeding, hereditary fructose intolerance, inflammatory bowel disease, any other condition associated with serious morbidity.

Study Design

A registered dietitian, also the principle investigator, enrolled the patient and counseled the patient throughout the duration of the study. The patient was asked to complete an initial IBS Severity Score Questionnaire and IBS symptoms scale. A one month supply of Bio-Kult, a 14 strain commercial probiotic, was provided by the gastroenterologist. The diet was explained in full during the initial visit. Responsibilities regarding food diaries and symptom surveys were outlined and informed consent was obtained. The protocol was approved by the Stephen F. Austin State University Internal Review Board. At the end of each day, the patient was instructed to complete a food diary and symptom survey daily for 2 weeks. After 2 weeks, the symptom survey and food diaries were to be completed 2 times per week by random assignment for the remainder of the 6 month period. At the end of the study the patient completed another IBS Severity Score Questionnaire. Symptom surveys and food diaries were emailed monthly to the principle investigator.

Dietary Intervention for the SCD

The patient was introduced to the diet by the dietitian at the initial visit and was followed regularly by the dietitian for the duration of the study period. The quantity of food was not restricted. The diet was initiated in phases, starting with soft foods that were tolerated easily. The phase chart, foods allowed and foods not allowed were adapted from two published books written about the SCD (Campbell-McBride, 2010; Gottschall, 1994) as well as resources

published on the internet, including Pecanbread.com Kids & SCD (2015) and SCDLifestyles (Reasoner and Wright, 2015). Progression through the phases resulted in an increase in texture complexity, starting with well-cooked or pureed food to raw, whole foods in order to maximize absorption of nutrients in patients whose digestive capacity may be compromised. FODMAPS were discussed and the patient was told to restrict FODMAPS initially if any signs of intolerance developed. Gluten was strictly forbidden. The patient was instructed to introduce new foods one at a time and slowly increase serving size while monitoring symptoms, and to wait 3 days before trying new foods. This elimination diet approach allowed the patient to identity foods that were included on the diet but may not be tolerated on an individual basis. Each phase may last 1-5 days depending on individual tolerance levels (Table 1). The full SCD diet was implemented after the patient was able to tolerate phase four. Once on the full SCD, the patient was provided a chart indicating foods to avoid (Table 2) and foods allowed (Table 3), with instructions to continue to introduce new foods one at a time over a 3 day period.

Duration

The patient was enrolled on May 29, 2013 and the duration of the study was 6 months.

Assessment of Gastrointestinal Symptoms

Quality of life indicators were assessed using the IBS Severity Score Questionnaire, with permission (Francis et al., 1997). This questionnaire contained categorical questions and visual analog scales to assess quality of life and symptoms. It consisted of 4 pages and for this study's purpose, only the first and second pages were utilized. The first page collected demographic data and provided instructions for completing the survey. The second page consisted of 5 scored questions for a total maximum score of 500. Questions in this category were related to the

severity of abdominal pain, abdominal distention/tightness, bowel habit satisfaction, and the impact of IBS on general quality of life.

In addition, specific symptoms characteristic of IBS were recorded using a 7 point scale, with -3 = Substantially Worse to +3 = Substantially Better. Use of a 7 point scale has been shown to be a sensitive indicator of symptom changes (Gordon et al., 2003). Symptoms related to IBS include bloating, abdominal pain, altered motility patterns, gas production and luminal distention (Gibson, 2011). Specific symptom categories included bloating, abdominal pain/discomfort, flatulence/wind, bowel urgency, diarrhea, constipation, nausea, heartburn, energy levels, incomplete evacuation, abdominal rumbling, and burping. To properly identify diarrhea and constipation, the patient was taught the appropriate stool characteristics based on the Bristol stool scale.

Statistical Analysis

This was a pretest post-test study. Data were analyzed using the Statistical Software for Social Sciences, SPSS version 22 software. Multiple procedures were run to assess data from the IBS global symptoms scale. Univariate descriptive processes were used to examine central tendency and variability among all variables in the study. Pre-test and post-test statistics were run on the IBS global symptoms scale using paired sample t-test with intra-group design. Categorical data were analyzed using Chi-Square. All inferential tests used $p<.05$. The IBS Severity Score Questionnaire was administered as a one-time pre-test and post-test to assess quality of life. The severity score could range from 0-500, with 0 indicating no impact on quality of life and 500 indicating a severe impact on quality of life.

Results and Discussion

IBS Symptoms

Fourteen known IBS symptoms were tracked over a 6 month period. Constipation, nausea and heartburn were not an issue for this particular patient and were eliminated from the analysis, resulting in 11 symptoms included in the analysis.

Basic univariate statistics demonstrated essential IBS symptom outcomes (Table 4) with 62 possible observations per symptom. Symptoms were rated from -3 (substantially worse during the three months prior to starting the diet) to +3 (substantially improved during the three months prior to starting the diet). A 0 value indicated "no change" in a particular symptom. To examine whether the patient showed statistically significant improvement with these 11 IBS symptoms, a set of one-sample t-tests was executed with the initial symptom value used as the test value. Shown below are the results of the t-tests (see Table 4). All 11 symptoms showed a significant improvement ($p<.0005$). The patient exhibited the most improvement in bowel urgency (mean difference = 5.27), bloating (mean difference = 4.92), and energy (mean difference = 4.92).

Quality of Life

The main reason for her visit to the gastroenterologist on 5/13/2013 was due to generalized abdominal pain and diarrhea. The patient's quality of life was poor due to the severity of her symptoms. She was unable to travel and feared leaving her home to go out to eat or attend church. The patient's IBS severity score from the IBS Severity Scoring System questionnaire upon enrollment was 315 points (Francis et al., 1997). According to the authors who developed the questionnaire, a score between 75-175 points is considered a mild case,

moderate is 75-300 points and 300-500 points indicates a severe case of IBS. At the end of the study period, the patient's severity score was 15 points, showing a marked improvement in quality of life.

Symptoms

When starting the SCD, it is expected that symptoms get worse before they get better. This is termed the herxheimer reaction. It is hypothesized that upon deprivation of carbohydrate substrate, the microbrial residents in the intestinal track start to die, resulting in the release of toxins and microbial by-products. This reaction initially increases the symptoms that the diet is attempting to reduce. Figure 1 includes the mean of the 11 symptoms, and indicates the erratic pattern experienced during the first 38 days. Anecdotal evidence indicates that this is normal and the patient was advised of this and to remain on the diet. After 22 days, the overall symptoms stabilized and there were no change in symptoms throughout the remainder of the 6 month study period. Therefore, we only reported specific symptom data for the first 38 days of the study period.

Food Diary

The patient's food diary indicated that she was on the introduction phase for 3 days and reached the full SCD within 16 days. Symptom resolution was seen on day 22 and beyond. Almost all foods on the SCD allowable list were tolerated well except for strawberries-both raw and cooked. There were certain times when she strayed from the diet which precipitated a return of symptoms. Popcorn was one of the worst offenders. She did not have any problems with FODMAPS, indicating that she tolerated broccoli, mushrooms, and apples well. In some cases, the SCD typically involves a decrease in carbohydrate from the standard American diet. However, the diet is not considered a low carbohydrate diet and in fact, because the patient had

type 2 diabetes, the carbohydrate was not severely restricted. The patient was advised to keep her carbohydrate at 45 grams per meal and to check her blood sugar 5 times per day-upon awakening, 2 hours after breakfast, lunch, dinner and before bed. She used glucose tablets, sometimes 4 at a time, to keep her blood sugar stable if she experienced low blood sugar. She did not need to use the glucose tablets after reaching the full SCD. The patient verbally indicated that she had reduced her insulin requirement while on the diet; however, this was not documented in her medical record from her primary care physician. The commercial probiotics were used during the first month of the study period. During that time, the patient was taught how to make her own yogurt and to ferment it for 24 hours to decrease lactose content. The homemade yogurt was consumed daily.

Other medical parameters

Other medical parameters were not obtained as a goal of this study; however, it is worthy to note that the patient's weight recorded at the gastroenterologist's office on 6/19/2013 was 199 pounds and on 9/17/2013, her weight was recorded at 188 pounds, indicating an 11 pound weight loss in approximately 3 months.

Limitations

There are a couple of limitations that need to be addressed. The first limitation was the fact that dysbiosis or SIBO were not measured. Abnormalities in the bacterial population of the gut, known as dysbiosis, have been associated with the pathophysiology of IBS (Balsari A, 1982; Carroll et al., 2012; Codling et al., 2010; Kassinen et al., 2007; Kerckhoffs, 2009; Matto et al., 2005; Maukonen et al., 2006; Si et al., 2004). These bacteria, rather than being confined to the large intestine, can also propagate the small intestine in large numbers, leading to small intestinal bacteria overgrowth (SIBO) (Majewski and McCallum, 2007). SIBO has been found in 30-75%

of irritable bowel sufferers (Anderson et al., 2010; Ewaschuk et al., 2008; Lin, 2004; Lupascu et al., 2005; Pimentel et al., 2003; Sapone et al., 2011; Ukena et al., 2007). Some researchers have implicated SIBO as the cause of IBS (Ghoshal et al., 2012; Parkes et al., 2008; Pimentel et al., 2000, 2006). It is difficult to measure the gut microbiota and subsequent changes. The proposed mechanism of the SCD is manipulation of the gut microbiome by bacterial substrate reduction and probiotic administration in patients with IBS through long term dietary intervention. The patient populations who will best benefit from this diet are those with dysbiosis and SIBO. Culturing microorganisms that reside in the gut are difficult, and molecular techniques also have limitations (Lee and Bak, 2011). Hydrogen breath testing can be simple and useful, although research has shown wide variations in sensitivity and specificity, making it an unreliable test to detect SIBO (Parrish, 2008). Further research will need to be developed to quantify the diet's exact mechanism of action. Quality of life and symptom reduction was an appropriate tool to measure success and a statistically significant reduction in symptoms ($p<.05$) from initial symptom assessment was considered successful over the 6 month study period.

Another limitation is diet adherence. Patient's may find it difficult to adjust to the diet restrictions and may find the labor intensive aspects of the diet difficult to incorporate into their lifestyle. One way to account for this is to only assign patients to the SCD who have exhausted all other treatment efforts (including FODMAPS and gluten exclusion). It is anticipated that participant's will have a significant reduction in symptoms, which will encourage adherence. In order to ensure successful adherence to the diet, a significant amount of education may be required regarding the specifics of the diet, cooking techniques, as well as regular intervals for follow-up.

Conclusion

The SCD significantly improved this female patient's quality of life and global IBS symptoms within 22 days of starting the diet. This is the first account of using the SCD to treat IBS. However, there have been several studies published using the SCD diet to treat inflammatory bowel disease (IBD). Researchers from the University of Massachusetts completed a study using a modified version of the SCD called the Anti-inflammatory Diet (AID) to treat IBD (Olendzki et al., 2014). Patients were put on the AID diet for approximately 6-10 months. Out of 11 patients, 9 were able to discontinue anti-tumor necrosis factor therapy and symptoms were reduced in 100% of the study population. Rush University Medical Center is currently conducting a study using the SCD in patients with IBD while monitoring changes in the intestinal microbiota (Mutlu, n.d.). Suskind et al. (2014) reviewed medical records of 7 children with Crohn's disease who were on the SCD and no immunosuppressive meds. The researchers found through chart review that stool calprotectin and C-reactive protein (inflammatory markers) were greatly improved or normalized. Although the exact time frame could not be ascertained, it was estimated that within three months of adopting the SCD, all symptoms were notably resolved (Suskind et al., 2014). Because there are possible overlaps between IBS and IBD (Spiller and Lam, 2011), this diet can produce the same positive outcomes in IBS as it has in IBD. Larger populations need to be studied using the SCD in people who have IBS.

References

Anderson, R.C., Cookson, A.L., McNabb, W.C., Park, Z., McCann, M.J., Kelly, W.J. and Roy, N.C. (2010), "Lactobacillus plantarum MB452 enhances the function of the intestinal barrier by increasing the expression levels of genes involved in tight junction formation", *BMC Microbiology*, Vol. 10 No. 1, p. 316.

Austin, G.L., Dalton, C.B., Hu, Y., Morris, C.B., Hankins, J., Weinland, S.R., Westman, E.C., et al. (2009), "A very low-carbohydrate diet improves symptoms and quality of life in diarrhea-predominant irritable bowel syndrome", *Clinical Gastroenterology and Hepatology*, Vol. 7 No. 6, pp. 706–708.e1.

Balsari A, C.A.D.F.F.P.G. (1982), "The fecal population in the irritable bowel syndrome", *Microbiologica* , No. 5, pp. 185–194.

Biesiekierski, J.R., Newnham, E.D., Irving, P.M., Barrett, J.S., Haines, M. and Doecke, J.D. et al. (2010), "Gluten causes gastrointestinal symptoms in subjects without celiac disease: a double-blind randomized placebo-controlled trial", *American Journal of Gastroenterology*, No. 106, pp. 508–514.

Campbell-McBride, N. (2010), *Gut and Psychology Syndrome: Natural Treatment for Autism, Dyspraxia, A.D.D., Dyslexia, A.D.H.D., Depression, Schizophrenia*, Medinform Publishing, Soham, 2nded., p. 392.

Carroccio, A., Mansueto, P., Iacono, G., Soresi, M., D'Alcamo, A., Cavataio, F., Brusca, I., et al. (2012), "Non-celiac wheat sensitivity diagnosed by double-blind placebo-controlled challenge: exploring a new clinical entity", *The American Journal of Gastroenterology*, Vol. 107 No. 12, pp. 1898–906; quiz 1907.

Carroll, I.M., Ringel-Kulka, T., Siddle, J.P. and Ringel, Y. (2012), "Alterations in composition and diversity of the intestinal microbiota in patients with diarrhea-predominant irritable bowel syndrome", *Neurogastroenterology and Motility*, Vol. 24 No. 6, pp. 521–30, e248.

Codling, C., O'Mahony, L., Shanahan, F., Quigley, E. and Marchesi, J. (2010), "A molecular analysis of fecal and mucosal bacterial communities in irritable bowel syndrome", *Digestive Diseases and Sciences*, Vol. 55 No. 2, pp. 392–397.

El-Salhy, M., Lillebø, E., Reinemo, A., Salmelid, L. and Hausken, T. (2010), "Effects of a health program comprising reassurance, diet management, probiotics administration and regular exercise on symptoms and quality of life in patients with irritable bowel syndrome", *Gastroenterology Insights*, Vol. 2 No. 1, p. e6.

Ewaschuk, J.B., Diaz, H., Meddings, L., Diederichs, B., Dmytrash, A., Backer, J., Looijer-van Langen, M., et al. (2008), "Secreted bioactive factors from Bifidobacterium infantis

enhance epithelial cell barrier function", *American Journal of Physiology. Gastrointestinal and Liver Physiology*, Vol. 295 No. 5, pp. G1025–34.

Francis, C.Y., Morris, J. and Whorwell, P.J. (1997), "The irritable bowel severity scoring system: a simple method of monitoring irritable bowel syndrome and its progress", *Alimentary Pharmacology & Therapeutics*, Vol. 11 No. 2, pp. 395–402.

Fukudo, S., Kaneko, H., Akiho, H., Inamori, M., Endo, Y., Okumura, T., Kanazawa, M., et al. (2015), "Evidence-based clinical practice guidelines for irritable bowel syndrome", *Journal of Gastroenterology*, Vol. 50 No. 1, pp. 11–30.

Ghoshal, U.C., Shukla, R., Ghoshal, U., Gwee, K.-A., Ng, S.C. and Quigley, E.M.M. (2012), "The gut microbiota and irritable bowel syndrome: friend or foe?", *International Journal of Inflammation*, Vol. 2012, http://www.pubmedcentral.nih.gov/articlerender.fcgi?artid=3346986&tool=pmcentrez&rendertype=abstract (accessed 29 October 2012).

Gibson, P.R. (2011), "Food intolerance in functional bowel disorders", *Journal of Gastroenterology and Hepatology*, Vol. 26 Suppl 3, pp. 128–31.

Gordon, S., Ameen, V., Bagby, B., Shahan, B., Jhingran, P. and Carter, E. (2003), "Validation of irritable bowel syndrome Global Improvement Scale: an integrated symptom end point for assessing treatment efficacy", *Digestive Diseases and Sciences*, Vol. 48 No. 7, pp. 1317–23.

Gottschall, E.G. (1994), *Breaking the Vicious Cycle: Intestinal Health Through Diet*, Kirkton Press, Limited, Baltimore, 2nded., p. 207.

Group, G.B. and Kingdom, U. (2012), "Bacteria, Colonic Fermentation, and Gastrointestinal Health", *Journal of AOAC International*, Vol. 95 No. 1, pp. 50–60.

Haas, S. (1955), "The treatment of celiac disease with the specific carbohydrate diet; report on 191 additional cases", *American Journal of Gastroenterology*, Vol. 23 No. 4, pp. 344–360.

Hosseini, A., Nikfar, S. and Abdollahi, M. (2012), "Are probiotics effective in management of irritable bowel syndrome?", *Archives of Medical Science*, Vol. 8 No. 3, pp. 403–5.

Kassinen, A., Krogius-Kurikka, L., Mäkivuokko, H., Rinttilä, T., Paulin, L., Corander, J., Malinen, E., et al. (2007), "The fecal microbiota of irritable bowel syndrome patients differs significantly from that of controls", *Gastroenterology*, Vol. 133, pp. 24–33.

Kerckhoffs, A.P. (2009), "Lower Bifidobacteria counts in both duodenal mucosa-associated and fecal microbiota in irritable bowel syndrome patients", *World Journal of Gastroenterology: WJG*, Vol. 15 No. 23, p. 2887.

Lee, B.J. and Bak, Y.-T. (2011), "Irritable bowel syndrome, gut microbiota and probiotics", *Journal of Neurogastroenterology and Motility*, Vol. 17 No. 3, pp. 252–66.

Lin, H.C. (2004), "Small intestinal bacterial overgrowth: a framework for understanding irritable bowel syndrome", *The Journal of the American Medical Association*, Vol. 292 No. 7, pp. 852–8.

Lupascu, A., Gabrielli, M., Lauritano, E.C., Scarpellini, E., Santoliquido, A., Cammarota, G., Flore, R., et al. (2005), "Hydrogen glucose breath test to detect small intestinal bacterial overgrowth: a prevalence case-control study in irritable bowel syndrome", *Alimentary Pharmacology & Therapeutics*, Vol. 22 No. 11-12, pp. 1157–60.

Majewski, M. and McCallum, R.W. (2007), "Results of small intestinal bacterial overgrowth testing in irritable bowel syndrome patients: clinical profiles and effects of antibiotic trial", *Advances in Medical Sciences*, Vol. 52, pp. 139–42.

Matto, J., Maunuksela, L., Kajander, K., Palva, A., Korpela, R., Kassinen, A. and Saarela, M. (2005), "Composition and temporal stability of gastrointestinal microbiota in irritable bowel syndrome â a longitudinal study in IBS and control subjects", *FEMS Immunology & Medical Microbiology*, Vol. 43 No. 2, pp. 213–222.

Maukonen, J., Satokari, R., Mättö, J., Söderlund, H., Mattila-Sandholm, T. and Saarela, M. (2006), "Prevalence and temporal stability of selected clostridial groups in irritable bowel syndrome in relation to predominant faecal bacteria", *Journal of Medical Microbiology*, Vol. 55 No. 5, pp. 625–33.

Mutlu, E. (n.d.). "The Specific Carbohydrate Diet: Does it change the intestinal microbiota and metabolome?", http://www.rush.edu/rumc/page-1298328953440.html (accessed 14 March 2013).

Nieves, R. and Jackson, R.T. (2004), "Specific carbohydrate diet in treatment of inflammatory bowel disease", *Tennessee Medicine*, Vol. 97 No. 9, p. 407.

Olendzki, B.C., Silverstein, T.D., Persuitte, G.M., Ma, Y., Baldwin, K.R. and Cave, D. (2014), "An anti-inflammatory diet as treatment for inflammatory bowel disease: a case series report", *Nutrition Journal*, Vol. 13, p. 5.

Ong, D.K., Mitchell, S.B., Barrett, J.S., Shepherd, S.J., Irving, P.M., Biesiekierski, J.R., Smith, S., et al. (2010), "Manipulation of dietary short chain carbohydrates alters the pattern of gas production and genesis of symptoms in irritable bowel syndrome", *Journal of Gastroenterology and Hepatology*, Vol. 25 No. 8, pp. 1366–73.

Parkes, G., Brostoff, J., Whelan, K. and Al, E. (2008), "Gastrointestinal microbiota in irritable bowel syndrome: their role in its pathogenesis and treatment", *American Journal of Gastroenterology*, Vol. 103 No. 6, pp. 1557–1567.

Parrish, C.R. (2008), "Nutritional Consequences of Small Intestinal Bacterial Overgrowth", *Practical Gastroenterology*, Vol. 32 No. 12, pp. 15–28.

"Pecanbread.com Kids & SCD". (2015), , http://www.pecanbread.com/p/index.html (accessed 1 June 2013).

Pimentel, M., Chow, E. and Lin, H. (2003), "Normalization of lactulose breath testing correlates with symptom improvement in irritable bowel syndrome", *Journal of Gastroenterology*, Vol. 98 No. 2, pp. 412–19.

Pimentel, M., Chow, E.J. and Lin, H.C. (2000), "Eradication of small intestinal bacterial overgrowth reduces symptoms of irritable bowel syndrome", *The American Journal of Gastroenterology*, Vol. 95 No. 12, pp. 3503–6.

Pimentel, M., Park, S., Mirocha, J., Kane, S. V and Kong, Y. (2006), "The effect of a nonabsorbed oral antibiotic (Rifaximin) on the symptoms of the irritable bowel syndrome", *Annals of Internal Medicine*, Vol. 145 No. 8, pp. 557–563.

Rana, A., Pandhi, N. and Khunt, M. (2012), "Comparative study of effect of various parameters affecting growth and physiology of normal flora of human & animal GIT with commercial probiotics", *International Journal of Pharma and Bio Sciences*, Vol. 3 No. 2, pp. B230–241.

Reasoner, J. and Wright, S. (2015), "SCDLifestyles", http://scdlifestyle.com/ (accessed 20 March 2006).

Sapone, A., Lammers, K.M., Casolaro, V., Cammarota, M., Giuliano, M.T., De Rosa, M., Stefanile, R., et al. (2011), "Divergence of gut permeability and mucosal immune gene expression in two gluten-associated conditions: celiac disease and gluten sensitivity", *BMC Medicine*, Vol. 9 No. 1, p. 23.

Shepherd, S.J. and Gibson, P.R. (2006), "Fructose malabsorption and symptoms of irritable bowel syndrome: guidelines for effective dietary management", *Journal of the American Dietetic Association*, Vol. 106 No. 10, pp. 1631–9.

Shepherd, S.J., Lomer, M.C.E. and Gibson, P.R. (2013), "Short-chain carbohydrates and functional gastrointestinal disorders", *The American Journal of Gastroenterology*, Vol. 108 No. 5, pp. 707–17.

Si, J., Yu, Y., Fan, Y. and Chen, S. (2004), "Intestinal microecology and quality of life in irritable bowel syndrome patients", *World Journal of Gastroenterology*, Vol. 10 No. 12, pp. 1802–1805.

Spiller, R. and Lam, C. (2011), "The shifting interface between IBS and IBD", *Current Opinion in Pharmacology*, Vol. 11 No. 6, pp. 586–92.

Suskind, D.L., Wahbeh, G., Gregory, N., Vendettuoli, H. and Christie, D. (2014), "Nutritional therapy in pediatric Crohn disease: the specific carbohydrate diet.", *Journal of Pediatric Gastroenterology and Nutrition*, Vol. 58 No. 1, pp. 87–91.

Ukena, S.N., Singh, A., Dringenberg, U., Engelhardt, R., Seidler, U., Hansen, W., Bleich, A., et al. (2007), "Probiotic Escherichia coli Nissle 1917 inhibits leaky gut by enhancing mucosal integrity.", *PloS One*, Vol. 2 No. 12, p. e1308.

Verdu, E.F. (2011), "Can Gluten Contribute to Irritable Bowel Syndrome?", *American Journal of Gastroenterology*, Vol. 106 No. 3, pp. 516–518.

Acknowledgments:
The authors are very grateful to the patient volunteer who took part in the study as well as Dr. Carl Jones, a gastroenterologist, who referred the patient and helped with the design of the study.

Funding: This study was conducted under a grant from the Stephen F. Austin State University Research Enhancement Program.

Ethical approval: The study was approved by Stephen F. Austin State University Institutional Review Board (Case # AY2013-1183).

Biographical Details:

Darla O'Dwyer, (Ph.D. in Food and Nutrition from Texas Tech University, 2003) is an Associate Professor and Registered Dietitian in the School of Human Sciences. She is coordinator of the Food, Nutrition and Dietetics program and the Dietetic Internship Director. Her primary research interest is gastrointestinal nutrition. She teaches a wide range of courses, including food science, medical nutrition therapy, nutrition through the lifecycle, advanced nutrition and pediatric nutrition.

Ray Darville (Ph.D. in Sociology from University of North Texas, 1984) is Professor of Sociology at Stephen F. Austin State University. His primary teaching areas in sociology are introduction to sociology, social science research methods and data analysis. His research areas include nutrition, interior design, natural resource interpretation, and human dimensions. He also teaches and conducts research in the Arthur Temple College of Forestry and Agriculture and in the School of Human Sciences. He has about 30 publications. He was selected as Regents Professor at SFA for 2015-2016 .

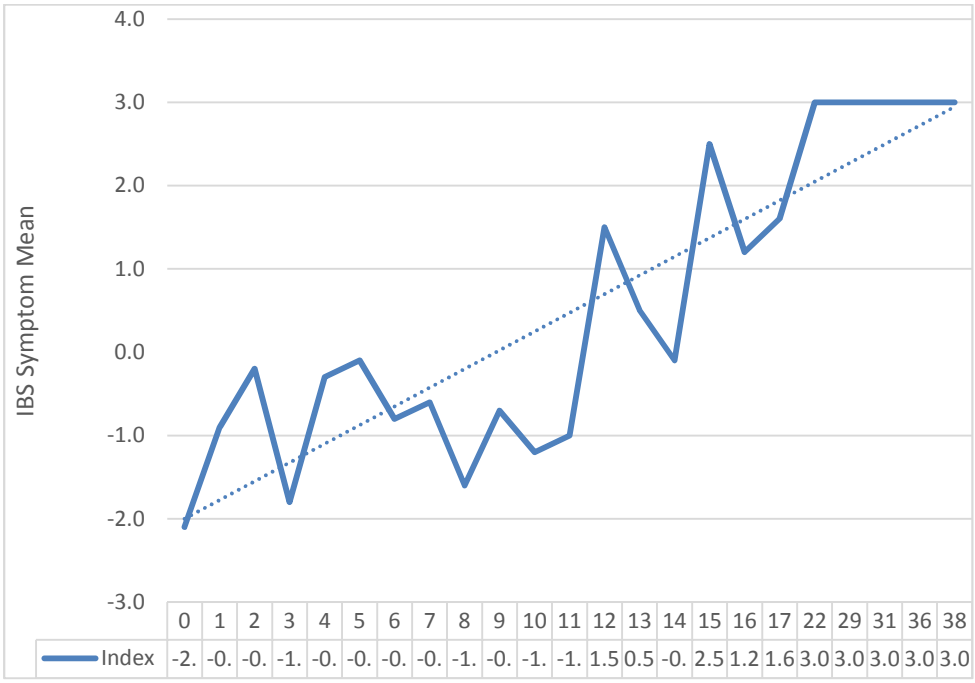

Figure 1. Means of the 11 irritable bowel syndrome symptoms rated from -3 (substantially worse during the three months prior to starting the diet) to +3 (substantially improved during the three months prior to starting the diet) for a period of 23 data points represented in days.

Table 1. Phase Chart for the Introduction of the Specific Carbohydrate Diet

Cooking method/preparation style for the introduction phase, phase 1 and phase 2. All meats should be boiled, broiled, pan-fried, grilled, or roasted. Incorporating the meats and vegetables into a soup works best initially. All vegetables and fruits should be peeled, deseeded, well-cooked and for maximum digestion, pureed.					
	Meats	Vegetables	Fruit	Fat, Nuts and Sweeteners, Dairy and Non-dairy	Probiotics
Introduction-this is your safe zone. Wait until your symptoms subside before adding foods in the next phase.	Beef, pork, chicken, turkey, lamb, fish, sardines, meat broth	Carrots, green beans, summer squash, zucchini, (onions and garlic to flavor only)	100% grape juice diluted by half (made into gelatin)	Fat: Coconut oil, olive oil Sweeteners: Honey (keep to small amounts), Stevia	Start with ¼ to ½ of recommended amount. Take probiotics with each meal
Phase 1 (in addition to the introduction phase)	Eggs			Butter, Coconut milk	Increase to ½ of recommended amount. Homemade yogurt or kefir, fermented vegetables
Phase 2 (in addition to phase 1)	Sausage, no MSG, sugar-free	Avocado*, winter squash except for spaghetti		Bacon (sugar free if available), Nut butter	Increase to ¾ to full amount
Phase 3 (in addition to phase 2)			Applesauce* Raw banana (must be ripe, indicated by multiple black spots)	Nut flours such as coconut and almond flour (you can make muffins, cookies, etc with these flours)	Full amount
Phase 4 (in addition to phase 3)		Raw vegetables starting with lettuce and peeled, deseeded cucumber			Full amount
Full SCD Diet	See Foods to Avoid and Foods Allowed, introduce foods one at a time over a 3 day period as instructed. Monitor for tolerance				

*Fermentable Oligosaccharides, Disaccharides, Monosaccharides and Polyols (reduce/eliminate if gastrointestinal symptoms increase after addition)

Table 2. Foods to Avoid on the Specific Carbohydrate Diet

Additives	Beverages	Condiments	Dairy	Grains, Flours, Starches	Sweets/ Sweeteners	Vegetables
Agar-agar	Bark Tea	Balsamic	American	Amaranth	Agave Syrup	Algae
Arrowroot	Beer	vinegar	cheese	flour	Corn Syrup	Artichokes
Carrageenan	Brandy	Bouillon	Buttermilk	Arrowroot	Cyclamate	(Jerusalem)
Cellulose	Coffee	cubes	Chevre	Barley	Date Sugar	Barley
Gum	(Instant)	Ketchup	cheese	Buckwheat	Dextrose	Bean sprouts
Cornstarch	Cordials	Margarine	Cocoa	Bulgur	Isoglucose	Okra
FOS	Evaporated	Soy sauce	powder	Chestnut	Maltitol	Bitter gourd
Guar gum	cane juice	(unless	Cottage	flour	Maple syrup	Black-eyed peas
Gums	Juice from	gluten free)	cheese	Corn	Marshmallow	Butter beans
HFCS	concentrate	Tamari	Cow and	Durum	Molasses	Cannellini beans
Inulin	Port wine		goat milk	flour	Sorbitol	Chick peas
Lignin	Sake		Cream	Ezekiel	Xylitol	Chickoryroot
Maltodextrin	Sherry		cheese	bread	Splenda	Fava beans
Mannitol	Vegetable		Dried milk	Garfava	Sucralose	Garbanzo beans
MSG	juice		solids	flour	Sucrose	Jicama
			Feta cheese	Millet	Tagatose	Kohlrabi
			Gjetost	Oats	Turbinado	Mungbeans
			cheese	Pasta		Nettles
			Heavy	Pea flour		Okra
			cream	Psyllium		Parsnips
			Ice cream	husks		Pinto beans
			Lactaid	Quinoa		Potatoes
			milk	Rice		Sweet potatoes
			Lactose	Rice bran		Taro
			Mozzarella	Rice flour		Turnips
			cheese	Rye		Yams
			Neufchatel	Seed flour		Yucca root
			cheese	Soy		
			Primost	Spelt		
			cheese	Sprouted		
			Processed	grain bread		
			cheeses	Tapioca		
			Ricotta	flour		
			cheese	Triticale		
			Sour Cream	wheat		
			Tofutti	Wheat germ		
			cheeses®			
			Yogurt			

Table 3. Foods Allowed on the Specific Carbohydrate Diet

Additives	Beverages	Condiments	Dairy	Fruits	Meats	Nuts/Seeds	Fats/Oils	Spices/ Herbs	Sweets/ Sweeteners	Vegetables
Baking soda/ powder	Almond milk	All vinegars (except balsamic)	Hard natural cheese	Apples*	Anchovies	Almonds	Almond oil	Allspice	Aspartame	Artichoke (French)*
Gelatin (unflavored)	Club soda	Apple cider	Yogurt*	Apricots*	Bacon	Almond butter	Avocado oil	Basil	Glycerin	Asparagus*
Potassium sorbate	Coconut milk	Capers		Avocadoes*	Beef	Brazil nuts	Canola oil	Bay leaf	Glycerol	Beets*
Sulphates	Coffee	Citric acid		Bananas (ripe)	Eggs	Cashews	Coconut oil	Cilantro	Honey*	Bell peppers (green)*
	Ethanol	Horseradish sauce		Berries (blackberry)*	Fish (canned & fresh)	Chestnuts	Corn oil	Cinnamon	Saccharine	Bok choy
	Gin mead	Soy sauce (gluten free)		Canned fruits (fruits canned in their own juice are allowed)	Fowl	Coconut	Flax seed oil	Echinacea	Stevia	Broccoli*
	Green tea	Tabasco brand-pepper		Cantaloupe	Ham	Hazelnuts	Ghee (clarified butter)	Garlic*		Brussels sprouts*
	Peppermint tea	Sauce		Cherries*	Lamb	Macadamia nuts	Grapeseed oil	Ginger		Cabbage*
	Scotch whisky			Dates	Pork	Peanut butter	Macadamia oil	Nutmeg		Carrots
	Spearmint tea			Figs	Pork rinds	Peanuts	Mustard (plain)	Oregano		Cauliflower*
	Vodka			Grapefruit	Poultry	Pecans	Olive oil	Paprika		Celery
	Wine (dry red and white)			Grapes	Sashimi	Pine nuts	Peanut oil	Peppers		Chard
				Kiwi fruit	Shellfish	Pistachio nuts	Safflower oil	Rosemary		Collard greens
				Kumquats		Seeds	Sesame oil	Sage		Cucumbers (peeled, de-seeded)
				Lemons		Sesame seeds	Sunflower oil	Salt		Eggplant
				Limes		Walnuts	Walnut oil	Tarragon		Green beans
				Mangoes*		Water chestnuts		Thyme		Haricot beans
				Melon						Jalapenos
				Nectarines*						Kale
				Olives						Leek*
				Oranges						Lentils*
				Papayas						Lettuce
				Passion fruit						Lima beans
				Peaches*						Mushrooms*
				Pears*						Onions*
				Persimmons*						Parsley
				Pineapple						Peas
				Plums*						Pumpkin
				Prunes*						Rhubarb
				Raisins						Rutabaga
				Tangerines						Spinach
				Watermelon*						Split peas
										Squash (summer, butternut and spaghetti)
										String beans
										Tomato juice (canned)
										Tomatoes
										Turnip
										Wasabi
										Watercress
										Zucchini

*Fermentable Oligosaccharides, Disaccharides, Monosaccharides and Polyols (reduce/eliminate if gastrointestinal symptoms increase after addition)

Table 4. Statistical values related to IBS symptoms

IBS Symptom	First Value[1]	Mean Value[2]	Number of data points	Mean Difference[3]	t value	p value
Bowel Urgency	-3	2.27	62	5.27	24.15	<.0005
Bloating	-3	1.92	62	4.92	20.85	<.0005
Energy	-3	1.92	62	4.92	19.04	<.0005
Abdominal Rumbling	-3	1.89	62	4.89	19.64	<.0005
Stool Frequency	-2	2.64	53	4.64	28.68	<.0005
Stool Consistency	-2	2.62	53	4.62	27.06	<.0005
Flatulence or Wind	-2	2.03	62	4.03	19.25	<.0005
Abdominal Pain or Discomfort	-2	1.97	62	3.97	17.613	<.0005
Incomplete Evacuation	-2	1.82	62	3.82	13.46	<.0005
Diarrhea	-1	2.34	62	3.34	15.57	<.0005
Burping	0	1.92	62	1.92	8.42	<.0005

[1] Symptoms at initiation of the study, rated from -3 (substantially worse during the three months prior to starting the diet) to +3 (substantially improved during the three months prior to starting the diet)
[2]Mean of the symptoms out of 62 data points
[3]Difference between the first value and the mean value