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DIETARY ANALYSIS OF PATIENTS WITH CROHN'S DISEASE

NICOLE ZEKY
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Reviewed and approved* by the following:

Terryl J. Hartman
Professor of Nutritional Sciences
Thesis Supervisor

Jill Patterson
Assistant Professor of Nutritional Sciences
Honors Adviser

* Signatures are on file in the Schreyer Honors College.

ABSTRACT

Crohn's Disease (CD) is a disease that targets the digestive system leading to inflammation that can leave the patient with symptoms of diarrhea, abdominal pain, nausea, and malabsorption. Although there are many prescription treatment options for CD, there has yet to be any consistent dietary treatment options. This study, aims to look at the effect of various nutritional factors will have on a patient's Crohn's Disease Activity Index score (CDAI). It was thought that a diet recommended to prevent colon cancer would also help prevent symptoms of CD since the two are heavily linked. There were 18 patients recruited at both Penn State University and Penn State's Hershey Hospital with mild cases of CD. Each patient was followed over the course of 6 months. Their dietary data was collected via 24 hour dietary recalls and they were given various doses of vitamin D that ranged from 1,000 IU to 5,000 IU. Of all of the dietary data collected, the specific nutritional factors that were looked at for this study were alcohol, fiber, calcium, total servings of fruits and vegetables, BMI and supplement use. There was no association between the summation of these factors and CDAI score. Total dietary fat was also compared to CDAI score, but there was no association between the two variables. The baseline serum levels were compared to their baseline CDAI scores to see if there was a substantial association. Although not significant, this association warrants further research with a larger study population to rule out any significance to vitamin D as a potential source of treatment.

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I. BACKGROUND INFORMATION

More than half a million people in the United States have Crohn's Disease (Kane, 2010). Crohn's Disease (CD) is defined as one subset of a broader group of diseases called Inflammatory Bowel Disease (Kane, 2010). Inflammatory Bowel Disease, referred to as IBD, is described as a general term for a disease that causes intestinal inflammation (Black & Cummings, 2010). Inflammation is a normal process within the body that results in swelling, redness, warmth, and pain (Kane, 2010). Specifically, CD is a chronic illness that can affect any segment of the gastrointestinal tract (Chow, 2008). The intestine consists of four layers: serosa, muscularis, submucosa, and mucosa (Stein & Rood, 1999). CD typically in the intestine targets the entire thickness of the intestinal wall resulting in impaired absorption and digestion (Saibil, 2003). Since it can affect any part of the gastrointestinal tract, the symptoms of CD can drastically vary from patient to patient, making its diagnosis difficult (Saibil, 2003). A common list of symptoms include: abdominal pain, diarrhea, fatigue, nausea, vomiting, weight loss, constipation, and fever (Black & Cummings, 2010). In a clinical setting, the severity of CD is described by the Crohn's Disease Activity Index (CDAI) (Sostegni, Daperno, Saglione, Lavagna, Rocca, & Pera, 2003). CDAI was determined through a clinical trial to measured potential predictor variables and an equation was formed that produces one number that best represents each patient's disease severity (Sostegni, Daperno, Saglione, Lavagna, Rocca & Pera, 2003). It is a standardized score ranging from 0 to 600 that encompasses both clinical data, like hematocrit and body weight, as well as subjective data, like general well being (Sostegni, Daperno, Saglione, Lavagna, Rocca, & Pera, 2003). All the data is complied together in order to get one value that describes the patient's disease status (Sostegni, Daperno, Saglione, Lavagna, Rocca, & Pera, 2003). It is considered the gold standard for evaluating CD (Sostegni, Daperno, Saglione,

Lavagna, Rocca, & Pera, 2003). For this study, active disease was categorized by a score of at least 220 while a score of 150 or below corresponded to an inactive disease state.

The cause of CD is still unknown, but the accepted hypothesis is that there are several factors that need to come together in order for the disease to occur (Kane, 2010). Some researchers believe that the main factors are based in the individuals genetics and abnormal immune function that triggers an over reactive inflammation response targeting its own tissues (Saibil, 2003). CD is also hypothesized to be activated by a virus or a bacterial infection (Prantera & Korelitz, 1996). Other plausible triggers are the individual's environment, which includes diet and stress, and immune responses from illnesses (Prantera & Korelitz, 1996). CD has increased since the 1950s in the United States, along with America's increased consumption of fat and processed foods (Boros, 2003). Some health professionals think the two are linked (Chow, 2008). The prevalence of CD seems to be associated with climate, with higher incidence rates in areas farthest from the equator (Stein & Rood, 1999).

CD is typically treated with medications that either target the immune system, bacterial infections, or inflammation (Boros, 2003). Other therapies that have been tried include acupuncture, meditation, or supplements like vitamins, probiotics and fish oil tablets (Black & Cummings, 2010). Surgery is also a viable option which results in a resection of a severely inflamed section of the bowel (Boros, 2003). Although CD is a chronic illness of the digestive system, there has yet to be a specific and accepted dietary treatment plan that will alleviate its symptoms. The best advice for dietary treatment that all health professions seem to agree with is one that is both healthy and balanced (Black & Cummings, 2010). For individuals with chronic inflammation this often feels like frustrating advice. Some people find it is helpful to maintain a lactose free diet (Kane, 2010). Others find that diets low in fat and fiber seem to provide relief

from their symptoms (Saibil, 2003). Health professionals suggest the best way to find a diet plan is to keep a food diary, recording the food and beverages consumed along with the kinds of symptoms present (Black & Cummings, 2010).

CD patients are more prone to developing colon cancer or colorectal cancer (Boros, 2003). Most people have a colon cancer risk of about 6% in the United States (Hofman, 2011). Having CD doubles that risk with risk increasing with increased number of years of being diagnosed with CD, the severity of disease, and the presence of a family history of colon cancer (Kane, 2010). Colon cancer is often diagnosed through the observation of colon polyps which are inward bulges of colon lining that can become cancerous (Kane, 2010). Colorectal cancer can be controlled for those at high risk through early detection (Hofman, 2011). In order to help prevent colon cancer in CD patients, colonoscopies are typically done every 2 years, which consists of viewing and biopsing the cells within the colon (Kane, 2010).

One dietary nutrient that has been proposed to be beneficial for CD patients is Vitamin D. Absorbed in the small intestine, vitamin D is a fat soluble vitamin that can be obtained through the diet, supplements, or conversion in the skin by UV light (Stein & Rood, 1999). Good dietary sources of vitamin D can be found in liver, eggs, and fortified milk and orange juice (Zempleni, Rucker, McCormick & Suttie, 2007). Vitamin D is made in the skin through activation from ultraviolet light exposure (Stoker, 2004). This could explain the decrease in CD incidence in areas of the world with higher sun exposure all year long (Stoker, 2004). Structurally it looks like a hormone and can act like one too (Sikorski & Kolakowska, 2011). It functions to maintain blood calcium and phosphorus levels along with mineralizing bone and teeth (Sikorski & Kolakowska, 2011). Vitamin D suppresses the production of antibodies by inhibiting their synthesis (Zempleni, Rucker, McCormick & Suttie, 2007). This may help to counteract the over

reactive immune response that is commonly thought to cause CD (Prantera & Korelitz, 1996). Targeting the immune system may be an effective way to help alleviate symptoms of CD.

II. OBJECTIVES

1. To evaluate the relationship between the baseline dietary data, biomarkers in blood, and disease status among patients with mild to moderate Crohn's Disease.
2. To compare dietary intakes of adult Crohn's Disease patients to recommendations made for colon cancer prevention.

III. HYPOTHESES

1. Dietary recommendations for preventing colon cancer also generate positive disease status scores for CD. This includes a diet that is higher in fruits, vegetables and fiber and lower in fat content while maintaining a healthy BMI between 18.5 and 24.9.
2. Higher total fat intakes by adult patients with CD are associated with unfavorable disease status scores.
3. Higher values of serum vitamin D among CD patients yield favorable disease status scores.

IV. METHODS

A. Participants

Patients were recruited for this study by gastroenterologists at Penn State's Hershey Medical Center from areas surrounding the hospital as well as Penn State's University Park campus in State College. To be eligible for the trial, patients had to be between the ages of 18 and 70, with mild to moderate Crohn's Disease activity. Patients were excluded from the study if they had other forms of inflammatory bowel disease like ulcerative colitis or if they were currently on steroids, smoked, were pregnant, or consumed more than a moderate amount of alcohol per day (>1 drink for women or >2 drinks for men). Patients were their own control in this study since their data were collected at both baseline and week 24.

B. Crohn's Disease Activity Index (CDAI)

There are several biomarkers and factors that were collected for this study in order to determine both the nutritional status and the disease status of the participants. Disease status was measured by the Crohn's Disease Activity Index (CDAI). The CDAI includes clinical laboratory data that is collected by a clinician or trained nurse and subjective data given by the patient through a questionnaire about their disease (Sostegni, Daperno, Saglione, Lavagna, Rocca & Pera, 2003). It is the gold standard for measuring CD status in patients for clinical trials (Sostegni, Daperno, Saglione, Lavagna, Rocca & Pera, 2003). Appendix A shows the variables that are taken into account when determining CDAI scores. This data was collected and tabulated into one CDAI score at the time of the screening and week 24. A score of 220 indicates active disease while a score of 150 indicates the patient's disease is in remission. A drop in 70 points or

greater indicates a favorable response while a 100 point or greater rise indicates the disease has flared up.

C. Vitamin D Treatment

Each patient was also given vitamin D supplements to take throughout the 6 month study. The capsules encompass 1000 IU units and were to be taken once a day. The patients received different vitamin D doses to reach vitamin D adequacy as measured in their blood. In order to assess each patient's diet, Penn State's Diet Assessment Center (DAC) obtained their dietary intake through three separate telephone 24 hour diet recalls which constitutes one set of recalls. Another set of recalls was done at week 24. This method allowed the patient to state what he/she consumed in the last 24 hours. The DAC then analyzed the data and determined how much was consumed. Three 24 hour recalls were averaged in order to obtain one reading for each set.

D. Data Collection

Data was collected over the course of 6 months out of the year. Every two weeks each participant had their height and weight measured along with their serum vitamin D levels. The CDAI scores were determined at both baseline and at week 24.

E. Dietary Analysis

Through all of the data collected, each participant's diet was analyzed in order to determine whether he/she had good nutritional status. Good nutritional status was defined according to colon cancer prevention recommendations. Since CD patients are at higher risk for colon cancer, it was assumed that a preventative diet for colon cancer would be adequate at preventing CD symptoms. To obtain a preventative diet plan for colon cancer, information was

pooled from The National Cancer Institute's (NCI) website along with American Institute for Cancer Research's (AICR) website. Both concluded that people increase their risk of colon cancer if they have a high BMI, a low intake of fiber, and a low dietary intake of fruits and vegetables ("Colorectal cancer prevention," 2011). These dietary factors will be compared to each participant's corresponding baseline CDAI scores in order to see if there is a significant association.

Body Mass Index, or BMI, is a standardized screening tool used to identify an adult's weight status (Ferrera, 2005). It takes into account the person's height (in cm) and weight (in kg), to calculate their ratio of weight to height (Ferrera, 2005). The BMI range classified as normal weight to height ratio is between 18.5 and 24.9 kg/m^2 (Ferrera, 2005). For this study, anything higher than 25, will correspond with a high or unhealthy BMI.

The amount of fiber in each participant's diet also had to be defined as being either a healthy amount or an unhealthy amount. According to the United States Department of Agriculture (USDA), a man should consume 38 g of fiber per day while a woman should consume 25 g per day (Kritchevsky & Bonfield, 2007). For the dietary analysis of this study, a diet below these recommendations will be defined as inadequate fiber intake.

Servings of fruits and vegetables were also determined through dietary assessment. According to AICR, it is recommended to consume five or more servings of fruits and vegetables per day in order to decrease the risk of developing colon cancer ("Aicr's food that,"). For each set of three days of 24 hour recall collected, the patient's average consumption of fruits and vegetables in servings per day was calculated. The averaged number of servings of fruits were added to the averaged number of servings of vegetables. If this number was below 5, then we can

conclude that the patient did not consume the recommended number of servings of fruits and vegetables.

The Institute of Medicine (IOM) provides guidelines for the general public and health professionals to follow in order to help to maintain a healthy diet (Otten, Hellwig & Meyers, 2006). These guidelines will be used in order to assess the dietary status of the participants in this study. Dietary Reference Intakes (DRI) are used for all vitamins and minerals needed in the diet. Calcium and iron status were based on of the DRIs. The DRI for calcium is 1,000 mg/d for both males and females within the age range of interest for this study (Otten, Hellwig & Meyers, 2006). Females between the ages of 19-70 years have an iron DRI value of 18 mg/d while for males of similar age range have a value of 8 mg/d (Otten, Hellwig & Meyers, 2006). Values that fall below the DRIs for both calcium and iron were judged as inadequate dietary status.

According to the AICR, alcohol consumption should be kept at a minimum in order to prevent the onset of colorectal cancer ("Reduce your cancer"). Minimum alcohol consumption is defined as less than 1 drink per day for women and less than 2 drinks per day for men ("Reduce your cancer"). Despite being a requirement for participation in this study, some patients did consume some amounts of alcohol. Although no patient consumed more than recommendations, alcohol was still considered when determining overall nutrition status.

The last part of the diet that was used to assess the nutritional status of each participant was whether or not they consumed a multivitamin. This was simply assessed by determining either yes they did consume one or no they did not. There are no specific guidelines on which vitamin is superior to any other kind of vitamin, so it was assumed that any vitamin is associated with good nutritional status.

F. Analysis of Dietary Fat Consumption

Acceptable Macronutrient Distribution Ranges (AMDR) are a list of acceptable ranges of percents that are judged as important for overall health (Otten, Hellwig & Meyers, 2006). Maintaining intakes within the ranges of the AMDR decreases the risk of chronic diseases (Otten, Hellwig & Meyers, 2006). Fat in general should be between 20% and 35% but more specifically saturated fat should be ≤ 10% and polyunsaturated should be between 5% and 10% (Otten, Hellwig & Meyers, 2006). These guidelines established by the USDA were used as guidelines for the assessment of the diets in this study. The only value that was considered for evaluating nutritional status was total percent of fat. If this value was greater than 35%, then the patient was defined as having poor nutritional status for the consumption of fat. The total fat percent of calories from fat will be compared to each participant's CDAI scores at baseline.

G. Analysis of Vitamin D

Another major nutrient of interest in this study was vitamin D. Serum vitamin D levels were obtained from each participant at every two week clinical session however only the serum levels at baseline were used. Vitamin D levels were compared to corresponding CDAI in order to see if there was an association. The vitamin D recommendations were set at being at least 50 nmol per liter (Zempleni, Rucker, McCormick & Suttie, 2007). Appendix B shows serum vitamin D data at baseline along with their CDAI values.

V. RESULTS

There were 18 participants enrolled in the study after meeting the study criteria. There were seven males ranging from ages 18 to 66 years of age. The study also included 11 women who varied in age from 22 to 63. Table 1 shows the basic information that describes each patient along with their baseline BMI and CDAI scores. Seven patients began the study with active disease, having a CDAI score above 220. A BMI value over 25 classifies that patient as being overweight and their BMI number is in bold. BMI did not have an impact on CDAI score alone because there were patients who were overweight that showed active and inactive disease status. Table 2 shows the mean and standard deviation for each variable for both the males and females in the study population. Both males and females showed an average age of around 38 (37.7 and 37.8 respectively) and an average BMI of about 24 (23.9 and 24.0 respectively). The CDAI scores showed a lot of variability between the two genders. Males had a mean CDAI score of 190 (inactive disease status) with a standard deviation of 36.2. The female participants had a mean CDAI score of 255.8 indicating active disease status on average. Three female participants, however, did have CDAI over 300 at the time of their baseline readings.

Table 1. Selected Patient Information at Baseline (n=18)

Patient ID	Gender	Age	Height (cm)	Weight (kg)	BMI	BMI Classification	CDAI Score	Disease Status
800	Male	31	188	86.5	24.5	Normal	259.4	Active
803	Female	23	163.5	73.6	**27.5**	Overweight	161.2	Inactive
804	Female	57	157.1	49.7	20.1	Normal	171	Inactive
808	Male	19	192.0	85.2	23.1	Normal	181.1	Inactive
700	Female	48	163.9	57.1	21.3	Normal	202	Inactive
701	Female	63	163.6	60.0	22.4	Normal	273	Active

703	Male	57	186.9	97.8	**28.0**	Overweight	209	Inactive
704	Female	29	161.5	75.2	**28.9**	Overweight	222	Active
707	Female	24	158.3	55.9	22.3	Normal	271	Active
708	Male	55	178.8	84.0	**26.3**	Overweight	155	Inactive
709	Female	30	165.2	67.4	24.7	Normal	410	Active
711	Male	66	177.8	85.3	**27.0**	Overweight	156	Inactive
712	Male	18	174.1	63.7	21.0	Normal	193	Inactive
714	Female	45	157.5	59.5	24.0	Normal	348	Active
716	Male	18	171.8	51.0	17.3	Underweight	175	Inactive
717	Female	33	161.8	76.4	**29.2**	Overweight	200	Inactive
719	Female	42	164.1	67	24.9	Normal	345	Active
721	Female	22	166.9	52.8	19.0	Normal	211	Inactive

Values in bold correspond to poor nutritional status

Table 2. Mean Patient Information at Baseline by Gender (N=18)

	Age	Height (cm)	Weight (kg)	BMI	CDAI Score	% with CDAI ≥220
Male (n=7)						
Mean	37.7	181.3	79.1	23.9	190.0	14%
Std. Dev.	21.0	7.7	16.0	3.8	36.2	
Female (n=11)						
Mean	37.8	162.1	63.2	24.0	255.8	55%
Std. Dev.	14.1	3.2	9.3	3.4	81.3	

There were eight nutritional factors that were used to assess nutritional status. Table 3 shows the eight factors that were in the analysis. The data was averaged from their 24 recalls in order to obtain one value for each category except the value of BMI which was taken at baseline. All of the 18 patients did meet the recommendations for the alcohol consumption which was one of the entrance requirements into the study. Every patient did consume some sort of daily vitamin throughout the study, too. When looking at the average dietary fiber consumed by each patient, all 18 of them fell short of the recommendations. Most of the patients did not meet the recommendations for calcium and total servings of fruits and vegetables (15 out of 18 and 16 out of 18 respectively). Half of the patients did not meet the recommendations for daily iron consumption. At the end of each row, the patient's total number of categories that did not meet recommendations was added up. This number was compared to the CDAI score at baseline. This association is presented in Figure 1. There was a slight negative association between the two variables.

Table 4 presents the percent of individuals within the trial that did not meet each specific nutritional recommendation. It also shows the mean and standard deviation of each factor according to the two different gender types. All of the patients did not meet the fiber recommendations while all of them did meet the alcohol recommendations. More than half of the participants did not meet the recommendations for calcium, iron, and total serving of fruits and vegetables as well. Table 5 shows the correlations and p-values for the associations between each nutrition factor and baseline CDAI. All of them showed a negative correlation indicating that as each of these values increased, the CDAI score decreased. The only significant relationship at a confidence level of 0.05 was the total number of servings of fruits and vegetables (P-value=0.046).

The data collected from the two 24 hour recall sessions was averaged together in order to obtain one value. The average percent of total fat consumed was also compared to the CDAI scores at baseline in order to determine if there was any kind of association between the two factors. This data is reported in Table 3 along with the other nutritional factors. There were three participants that consumed more than the recommendations for percent of calories from fat. Only one of these participants had a CDAI score that would classify them as in a state of active disease. For those that were in an active disease state at baseline (n=7), they had a mean percent of calories coming from fat to be about equal to those that were inactive at baseline (30.98% and 29.29% respectively). For those participants who consumed more than the recommended calories from fat, there were more participants who had inactive disease.

Table 3. Nutritional Factors with Corresponding CDAI Scores at Baseline

Patient ID	Alcohol (g) [males < 28 g] [females <14 g]	Dietary Fiber (g) [males ≥ 38] [females ≥ 25]	Calcium (mg) [males 19-70y ≥ 1000] [female 19-50 y ≥ 1000; 51-70y ≥ 1200]	Iron (mg) [males ≥ 8] [females 19-50 y ≥ 18; 51-70 y ≥ 8]	Total F+V (svgs) [≥5]	Baseline BMI [< 25]	Suppl. (y or n)	Avg. % Calories from Fat [20-35%]	Total Nutr. Factors Not meeting Recomm.	CDAI
800	0.06	**16.37**	1298.07	28.67	**4.49**	24.5	y	30.70	2	259.4
803	0.04	**6.17**	**542.80**	**6.64**	**1.79**	**27.5**	y	28.33	5	161.2
804	6.82	**22.90**	**471.39**	13.09	**4.66**	20.1	y	31.84	3	171.0
808	0.00	**9.63**	**578.71**	11.40	6.55	23.1	y	34.25	2	181.1
700	0.03	**9.31**	**324.55**	**12.78**	**1.90**	21.3	y	24.42	4	202.0
701	0.03	**10.94**	**245.95**	9.79	**1.26**	22.4	y	31.34	3	273.0
703	2.33	**17.74**	**969.15**	20.10	9.38	**28.0**	y	31.16	3	209.0
704	0.03	**6.83**	**615.22**	**13.17**	**4.54**	**28.9**	y	**37.42**	6	222.0
707	0.00	**11.23**	**675.40**	**10.33**	**2.03**	22.3	y	32.52	4	271.0
708	7.78	**17.89**	**597.24**	18.90	**3.86**	**26.3**	y	34.94	4	155.0
709	0.00	**6.37**	**319.90**	**7.49**	**2.06**	24.7	y	31.09	4	410.0
711	0.00	**13.97**	1221.22	12.88	**4.33**	**27.0**	y	**35.32**	4	156.0
712	4.70	**9.86**	**987.69**	19.74	**3.30**	21.0	y	33.98	3	193.0
714	0.01	**4.89**	**550.46**	**4.46**	**0.27**	24.0	y	21.82	4	348.0
716	0.16	**10.44**	**546.85**	13.59	**4.74**	17.3	y	**35.68**	4	175.0
717	0.10	**5.71**	**409.35**	**9.06**	**2.38**	**29.2**	y	31.48	5	200.0
719†	0.00	**12.71**	1039.34	**10.19**	**1.39**	24.9	y	31.98	3	345.0
721†	13.01	**12.97**	**673.04**	**10.73**	**2.89**	19.0	y	20.77	4	211.0

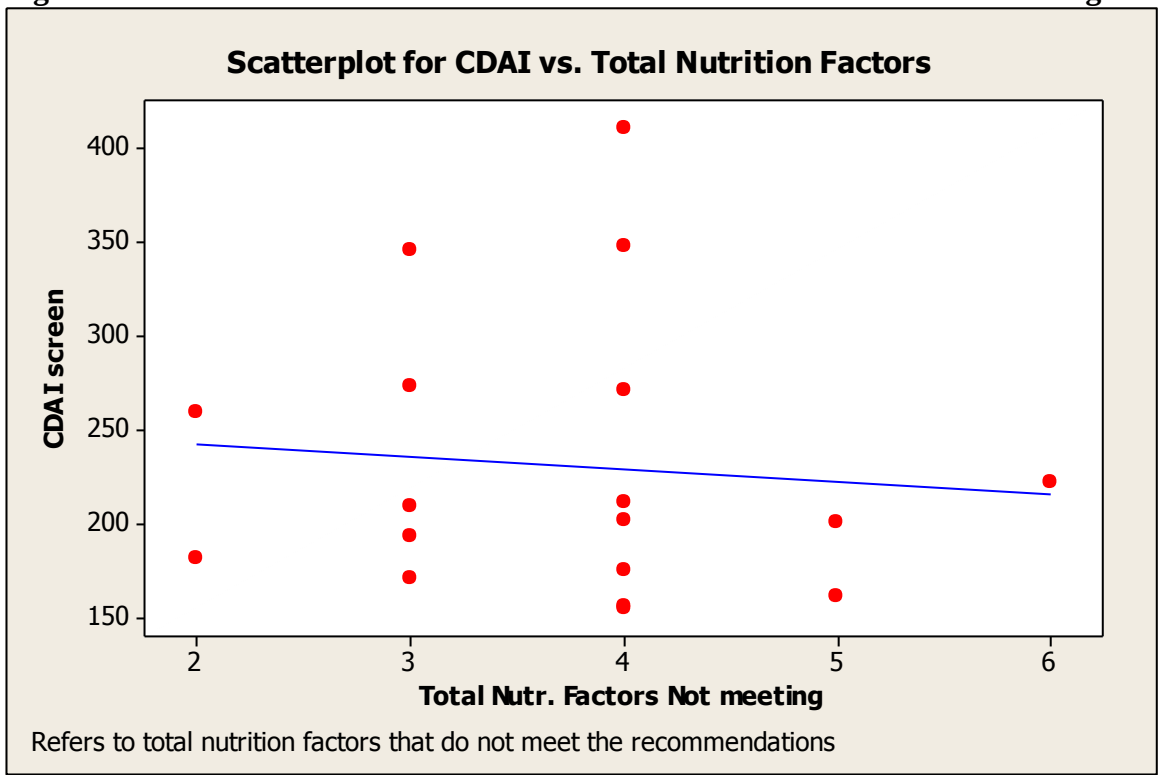
Values in bold correspond to poor nutritional status

† indicates that diet data for these patients was only available for the first 24 recall group

Table 4. Breakdown of Nutritional Factors

	Alcohol	Dietary Fiber	Calcium	Iron	Total F+V	Baseline BMI	Fat
Percent Not Meeting Recommendations:							
Male	0%	100%	71%	0%	71%	43%	29%
Female	0%	100%	91%	82%	100%	27%	9%
Male							
Mean	2.15	13.70	886.00	17.90	5.23	24.01	33.72
Std. Dev.	3.05	3.72	314.00	5.93	2.09	3.74	2.00
Female							
Mean	1.83	10.00	533.40	9.79	2.29	23.95	29.36
Std. Dev.	4.23	5.18	222.20	4.46	1.32	3.53	5.05

Figure 1. Baseline CDAI Scores and Number of Nutritional Factors Not Meeting the Recommendations



Linear Regression P-value: 0.720

Table 5. Correlations of Nutrition Factors and Baseline CDAI

	Avg. Alcohol	Avg. Dietary Fiber	Avg. Calcium	Avg. Iron	Total F+V	Baseline BMI	% Calories from Fat
Correlation	-0.315	-0.341	-0.098	-0.371	-0.476	-0.010	-0.274
P-value	0.202	0.166	0.698	0.200	0.046	0.969	0.271

The vitamin D levels were collected throughout the entirety of the study. Table 6 shows the baseline serum vitamin D values for each patient along with their baseline CDAI scores. The values in bold indicate that that patient did not meet the normal recommendation of serum vitamin D levels. All of the patients did not meet the recommendations for vitamin D. This is a common side effect to CD patients due to their malabsorptive issues. Each patient was given a vitamin D supplement to take throughout the 6 month trial. For complete data on dosage and serum vitamin D status see appendix B. Most patients were already consuming some amount of vitamin D at the time of screening in the study.

Table 7 shows the breakdown of the serum vitamin D levels at baseline for both males and females. As mentioned earlier, 100% of the clinical trial patients entered this study with vitamin D deficiency. It was found that the mean for both males and females in this study were well below the recommendations. Males had a mean serum vitamin D level of 18.20 nmol/L with a standard deviation of 9.35 nmol/L. Women had a slightly lower mean vitamin D of 15.29 nmol/L and a standard deviation of 10.07 nmol/L. The mean baseline CDAI for males was 189.8 with a standard deviation of 36.2. The women presented a higher mean CDAI value with greater variation. Their mean value was 255.8 with a standard deviation of 81.3. Table 7 also shows the correlation and the p-value between baseline serum vitamin D levels and baseline CDAI scores which were 0.031 and 0.902 respectively. This is the only correlation within this study that was not negative. This indicates that for this study there was no negative association between baseline serum vitamin D levels and baseline CDAI scores.

Table 6. Serum Vitamin D and CDAI Scores from Baseline

Patient ID	Serum Vitamin D [≥50 nmol/L]	CDAI scores
800	**32.2**	259.4
803	**8.1**	161.2
804	**10.9**	171.0
808	**7.61**	181.1
700	**35.5**	202.0
701	**27.71**	273.0
703	**29.7**	209.0
704	**11.46**	222.0
707	**20.66**	271.0
708	**17.19**	155.0
709	**3.95**	410.0
711	**15.63**	156.0
712	**9.98**	193.0
714	**23.53**	348.0
716	**15.12**	175.0
717	**9.32**	200.0
719	**11.05**	345.0
721	**6.01**	211.0

Table 7. Baseline Vitamin D Percents, Averages and Correlation with CDAI

	Vitamin D	CDAI
Percent Not Meeting the recommendations	100%	n.a.
Male		
Mean	18.20	189.80
Std. Dev.	9.35	36.20
Female		
Mean	15.29	255.80
Std. Dev.	10.07	81.30
Correlation	0.031	n.a.
p-value	0.902	

VI. DISCUSSION

It was expected that a diet recommended to prevent colon cancer would also be shown to lower disease activity in Crohn's Disease patients. Colon cancer prevention diets include high intakes of dietary fiber, fruits and vegetables and a BMI lower than 25. There were seven nutrition factors that were analyzed in this study that were used to determine whether there was an effect on CDAI scores. The nutritional factors included alcohol, dietary fiber, calcium, iron, total number of fruits and vegetables, BMI, supplemental use of any kind, and percent of calories from fat. At baseline, all of the patients did meet all of the recommendations for these 8 factors. The patients showed a variation of 2 to 6 in the number of nutritional factors they did not meet. There was no correlation between the total number of nutritional factors not meeting the recommendations and the CDAI at baseline. This suggests that as a whole, these factors do not have a significant effect on CDAI score. It was then thought that maybe one factor might play more of a role in determining CDAI than another. When examining each individual factor, however, the total number of servings of fruits and vegetables did have a significant relationship with CDAI score with a p-value of 0.046. This corresponds to the initial hypothesis that a diet for preventing colon cancer will have positive results in lowering CD activity because increasing fruit and vegetable consumption is thought to decrease colon cancer prevalence. Although there was no significant relationship with the other factors included in the colon cancer preventative diet like fiber and BMI, this study shows that there was an association between total servings of fruits and vegetables in decreasing CD activity. There might be a relationship between any of the other factors and CDAI scores, but more studies would have to be done that target these variables and their effect on CD.

There are many different dietary recommendations out there for patients with CD. Most are not based on scientific evidence but rather personal testimonies. Of all of the sources available, health professionals would all agree that a healthy and well rounded diet is especially important for CD (Saibil, 2003). Most patients have disease activity in their small intestine, the primary site of digestion and absorption, so they need a balanced diet that consists of adequate amounts of carbohydrates, fat, protein, fiber, and vitamins in order to prevent deficiencies ("Diet and nutrition," 2011). This coincides with what was expected for this study, although the results did not support this claim. Other sources support a balanced diet but they recommend that patients with CD avoid some foods like raw fruits and vegetables as well as other high fiber foods ("Crohn's disease health," 2011). They refer to these as “trigger foods” and feel that most patients actually develop symptoms after their consumption ("Crohn's disease health," 2011). Lots of CD physicians recommend diets lower in fiber because it is thought to increase symptoms of bloating, stomach cramps, and could lead to blockages during a flare up (Kane, 2010). Finding one set of dietary guidelines for CD is difficult because each patient has their own set of symptoms and their own dietary “triggers”. This is an area that should be further explored in order to find a set of recommendations that will help most CD patients stay in remission.

It was thought that for those patients that consumed a higher percent of calories from fat they would see higher CDAI scores. Only 3 of the 18 patients consumed more than the recommendation for percent of calorie from fat which is set at 20-35%. One of these patients had active disease status with a CDAI score over 220 and the other two were inactive in their disease. When comparing the disease status of those that met the recommendation and those that did not, a majority of the patients in both categories had a CDAI that classified them as being in an

inactive state. It was concluded that there was no association between percent of fat consumed and CDAI score. Since more patients entered the study with a CDAI low enough to classify them as an inactive disease state, more studies would have to be done to see if there is a more significant relationship between the two.

There is not a lot of current data that supports or disclaims the effects of dietary fat on CD activity. If data is available, they do not look at total dietary fat intake, but rather they focus on specific types of fat categories. Typically patients are recommended to consume lower amounts of saturated fats, below 10% of calories, and focus on consuming medium chain fatty acids (MCFA) because these are easier to digest (Saibil, 2003). Polyunsaturated fats are recommended, specifically omega-3 fatty acids, because they provide anti-inflammatory responses (Kane, 2010). The effects of omega-3 fatty acids on alleviate CD symptoms has yet to be proven by studies (Kane, 2010).

Higher levels of serum vitamin D were expected to be associated with lower CDAI scores indicating a lower CD activity. All of the patients that entered this clinical trial started out with a serum vitamin D level so low that they would all be considered deficient according to normal standards. Most CD patients are deficient in several key nutrients including vitamin D (Kane, 2010). This is often due to the lack of absorption of the gut due to such high amounts of inflammation in the tissue (Kane, 2010). The results of this study agree with that. Even when looking at each gender individually, it was found that they both showed very low means for serum vitamin D levels. Each patient also had to have moderate CD symptoms in order to be recruited within the trial. Despite both of these trends, the correlation between baseline serum vitamin D levels and baseline CDAI scores was not significant. Since the cause of what triggers

CD activity is still unknown there are many reasons why each patient's CDAI might have increased or decreased.

Vitamin D has been a major area of focus in recent research studies for several different types of chronic diseases including CD. Vitamin D is a steroid that acts within the nucleus of cells to alter transcription, specifically it is known to regulate T-cell development and function (Ulitsky, Ananthakrishran, Naik, Skaros, Zadvornova, Binion & Issa, 2011). T-cells play a role in the body's immune system (Ulitsky, Ananthakrishran, Naik, Skaros, Zadvornova, Binion & Issa, 2011). This may be the link to which vitamin D affects CD since CD is an autoimmune disease. Several studies have been done to see the effects of vitamin D status on CD activity. One study looked that the overall blood levels of vitamin D from both supplemental and dietary sources and the risk of CD development in women (Ananthakrishnan, Khalil, Higuchi, Bao, Korzenik, Giovannucci, Richter & Fuchs, 2012). They found that there was a significant inverse relationship between the two variables (Ananthakrishnan, Khalil, Higuchi, Bao, Korzenik, Giovannucci, Richter & Fuchs, 2012). Another study noticed that CD patients typically have a higher incidence of vitamin D deficiency (Ulitsky, Ananthakrishran, Naik, Skaros, Zadvornova, Binion & Issa, 2011). Specifically those patients with vitamin D deficiency experienced increased CD activity and a decrease in their quality of life (Ulitsky, Ananthakrishran, Naik, Skaros, Zadvornova, Binion & Issa, 2011). These findings support the results of this study and the hypothesis that increased vitamin D levels seem to be associated with lower CD activity.

There are three limitations to this study. The first is the number of participants that were included. With only 18 participants it was hard to find statistically significant associations between the variables. The second limitation is the length of the study. This study only lasted 6 months with each patient entering the study at various points in the year. This could play a role

in disease status by adding more stress at certain times of the year, like allergies or infections, increased physical activity at different seasons, or increased sun exposure which leads to an increase vitamin D production in the skin. A study design that encompasses the entire calendar year will eliminate any of these confounding variables and give a better look at the long term effect diet might play on CD activity. The third limitation was that most of the patients entered the study in a classification of inactive disease status according to their CDAI score. This limits the kinds of effects that can be seen in the patients because they were already feeling healthy and showing limited symptoms. Each patient's body may react differently to dietary factors during inactive disease versus active disease.

There are several directions that future studies can focus on that will provide information or an association between CD activity and dietary status. Despite the small sample size, this study showed a significant association between total servings of fruits and vegetables and CDAI score. A plausible future study could focus on one particular dietary factor, like total servings of fruits and vegetables, along with its subsequent effect on CDAI scores in order to see if there is a significant relationship between the two. Since both fruits and vegetables contain high amounts of various kinds of vitamins, a future study could be further analyzed to see what vitamin distribution each of the patients would be consuming. Maybe there is one particular vitamin or group of vitamins that significantly lowers CDAI. Another possible direction would be a study that enrolls CD patients at a time of active disease status and uses diet as a primary means of treatment. This might be more difficult because the level of active disease status is varied and can include a wide variation of symptoms that might make dietary absorption more difficult and therefore nutritional treatment ineffective. It could be worth it to design a study that has patients in an active disease state according to their CDAI, but limited severity in their symptoms such

that dietary treatment plan could be implemented over prescription medicine to see the possible effect it might have on CD activity.

VII. CONCLUSION

Treatment for CD consists of many different prescription medications but there has yet to be some information on how to treat CD with diet. There is evidence to suggest that patients with CD have an increased chance of developing colon cancer later in life. It was suggested that a diet that would be ideal for preventing colon cancer would also prevent CD symptoms since the two diseases are linked. A preventative colon cancer diet includes one higher in fiber and fruits and vegetables while also maintaining a healthy BMI below 25. This study looked that the relationship between CDAI seven different nutritional factors: alcohol, dietary fiber, calcium, iron, total fruits and vegetables servings, BMI, and supplemental use. There was no association between the total number of factors that each patient did not meet the recommendations for and CDAI scores. Only the total number of servings of fruits and vegetables showed a significant association with CDAI. This indicates that a diet higher in fruits and vegetables should decrease CD activity.

The total dietary fat consumption was also analyzed with each patient's CDAI score. It was hypothesized that higher levels of dietary fat would correlate with higher CDAI scores. There was no significant association between total dietary fat and CDAI score for the patients. Only two patients consumed more than the recommendation of dietary fat, and some of them expressed higher CDAI scores while others yield more favorable CDAI scores. There are no reputable conclusions drawn from results of dietary fat and CD activity from this study.

Several previous studies have examined the effect of vitamin D on CD activity. This study found the CD patients started out at baseline with vitamin D deficiency and high CDAI scores. Although this study does not give solid evidence to support vitamin D in lower CDAI, it

may be worth pursuing as an outlet for treatment if it means alleviating the symptoms of CD. More studies would need to be done in order to make a more definitive decision on vitamin D as a potential treatment option for CD patients, but it seems to be a worthwhile approach.

In conclusion, it was found that a diet deemed helpful for preventing colon cancer was not found to be protective against CD activity. A diet high in fruits and vegetables was associated with lower CDAI scores but there was no association between other aspects of nutrition which included fiber, calcium, iron, alcohol, supplemental use, or BMI. There was no association between total dietary fat content and CDAI score. There was no significant association between vitamin D levels and CDAI. At baseline, it was found, however, that most patients in this clinical trial were found to be deficient in many of the nutritional aspects of this study including vitamin D. More studies with large number of subjects will be needed in order to determine the strength of these associations as well as if these associations are of significance.

APPENDIX A: Crohn's Disease Activity Index (CDAI)

Variable	Description		Multiplier
Number liquid stools	Sum of 7 days		×2
Abdominal pain	Sum of 7 days ratings	0 = none 1 = mild 2 = moderate 3 = severe	×5
General well being	Sum of 7 days ratings	0 = generally well 1 = slightly under par 2 = poor 3 = very poor 4 = terrible	×7
Extraintestinal complications	Number of listed complications	Arthritis/arthralgia, iritis/uveitis, erythema nodosum, pyoderma gangrenosum, aphtous stomatitis, anal fissure/fistula/abscess, fever > 37.8 °C	×20
Antidiarrhoeal drugs	Use in the previous 7 days	0 = no 1 = yes	×30
Abdominal mass		0 = no 2 = questionable 5 = definite	×10
Hematocrit	Expected–observed Hct	Males: 47-observed Females: 42-observed	×6
Body weight	Ideal/observed ratio	[1 − (ideal/observed)] × 100	×1 (NOT < −10)

Source: Sostegni, R., Daperno, M., Saglione, N., Lavagna, A., Rocca, R., & Pera, A. (2003). Review article: Crohn's disease. *Aliment Pharmacology & Therapeutics*, *17*, 11-17.

APPENDIX B: Vitamin D Levels with Corresponding CDAI Scores at Baseline

Patient ID	Serum Vitamin D	Vit D Dose (IU)	CDAI scores
800	**32.2**	1000	259.4
803	**8.1**	1000	161.2
804	**10.9**	1000	171.0
808	**7.6**	1000	181.1
700	**35.5**	400	202.0
701	**27.7**	400	273.0
703	**29.7**	650	209.0
704	**11.5**	1000	222.0
707	**20.7**	1000	271.0
708	**17.2**	1000	155.0
709	**4.0**	0	410.0
711	**15.6**	1000	156.0
712	**10.0**	1000	193.0
714	**23.5**	1000	348.0
716	**15.1**	1000	175.0
717	**9.3**	1000	200.0
719	**11.1**	1000	345.0
721	**6.0**	1000	211.0

Values in bold indicate correspond to poor nutritional status

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ACADEMIC VITA of Nicole M. Zeky

Nicole M. Zeky
1208 Northampton Ave
Northampton, PA, 18067
nmz5011@psu.edu

Education:

Bachelor of Science Degree in Nutritional Sciences
The Pennsylvania State University, Spring 2012
Minor in Biology
Honors in Nutritional Sciences
Thesis Title: Dietary Analysis of Patients with Crohn's Disease
Thesis Supervisor: Terry J. Hartman

Awards:

Dean's List Fall 2008-Spring 2012
Kappa Omicron Nu Human Sciences Honor Society
Phi Kappa Phi National Honor Society
The Robert T. Olver Memorial Scholarship in Nutrition
The General Federal of Women's Clubs Pennsylvania Scholarship

Activities:

Crohn's and Colitis Foundation club President
Crohn's and Colitis Foundation of America – Pittsburgh Chapter: Take Steps Internship
Crohn's and Colitis Foundation of America – Philadelphia Chapter: Take Steps Committee Member
Women's Club Ultimate Frisbee