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Knowledge and understanding of gluten and the gluten-free diet by students at James Madison University

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Knowledge and Understanding of Gluten and the Gluten-Free Diet by
Students at James Madison University
Jessica Grace Bissinger

A Thesis submitted to the Graduate Faculty of
JAMES MADISON UNIVERSITY
In
Partial Fulfillment of the Requirements
for the degree of
Master of Science in Kinesiology
Exercise Science

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Abstract

Purpose: The purpose of this study was to explore public awareness and knowledge of gluten and the Gluten-Free Diet (GFD) with the intent to discover a difference between knowledge of gluten and related topics, and willingness to engage in the GFD fad.

Methods: A Qualtrics survey was distributed to students at James Madison University. Answers to an educational quiz were used to calculate an overall score, which were divided into tertiles identified as Low Knowledge (LK), Moderate Knowledge (MK), and High Knowledge (HK). Tertiles were compared against the question, “Have you considered using a gluten-free diet?”

Results: Data was analyzed using IBM SPSS version 19. There were 501 respondents and a response rate of 2.3%. Most respondents were female (n=408, 81.4%), mean age 20.3±1.7. The mean overall score on the quiz portion of the survey was 11.2±2.2 out of 19 points (M=11, range 4-17). The LK group was 36.1% of the sample (n=181, 8.9±1.3, M=9, range 4-10). The MK group was 36.7% of the sample (n=184, 11.5±0.5, M=11, range 11-12). The HK group was 27.1% of the sample (n=136, 13.8±2.2, M=14, range 13-17). Overall, most respondents indicated that they have not considered using a GFD (65.5%). Of the people who said “no”, 43.5% were in the LK group. Of the people who said “yes”, 40.9% of people were in the HK group. In the LK group, 20.8% responded that they would try a GFD while 79.2% responded that they would not try a GFD. For the MK group, 35% responded that they would try a GFD while 65% responded that they would not try a GFD. For the HK group, 52.2% responded that they would try a GFD while 47.8% responded that they would not try a GFD.

Conclusion: The more knowledgeable a respondent had, the more likely they considered trying a GFD. The opposite was also found for less-

knowledgeable respondents. The current diet fad has important implications for the willingness of the population to engage in such fads when there may be limited knowledge concerning the risk for nutrient deficiencies and impaired performance. Individuals should consult with their physician before adopting a diet without including the proper substitutions to achieve nutrient balance.

Introduction

Gluten is a water-insoluble protein composite found in wheat, barley, and rye. Components of gluten are found as gliadin in wheat, secalin in rye, and hordein in barley. It is used in bread products as a thickening and elastic agent, and allows dough to rise. As a result, it largely affects the texture of the foods that it is in. Gluten is also added to imitation meats and used in pet feed to help enhance flavor and texture.⁵³

Gluten components can be isolated by taking advantage of its water-insoluble properties, using ethanol, and a centrifuge. Studies have used gluten isolation as a method of testing the concentration of gluten in specific substances such as foods and pharmaceuticals.³⁵

Some individuals have an adverse reaction to gluten. Those with gluten-sensitivity experience a range of discomfort due to ingestion of the protein. In subclinical cases, individuals may experience an upset stomach, fatigue, loss of appetite, and possibly weight loss. Subclinical cases may be diagnosed as gluten-sensitive or gluten-intolerant. This suggests that it is advisable that they avoid gluten, but no villous atrophy or malabsorption will occur. In more severe cases, individuals may be diagnosed with Celiac Disease (CD), an autoimmune disorder that causes degradation of the small intestine and consequential malabsorption.^{1,2} To avoid the severe adverse effects, the prescription is a Gluten-Free-Diet (GFD), the only known, effective treatment for CD.¹⁴ Individuals are educated as to which foods include gluten and therefore avoid those products.

The GFD is not an easy diet to follow. Wheat, barley, and rye are found not only in grains, but also in over-the-counter medications, alcohol, and in some beverages and

trace amounts of other foods.^{13,14} If a product does not directly contain wheat, barley, or rye, but was produced on a production line where these substances are present, it is still not safe for a Celiac patient to ingest. Gluten-free foods are also not easy to find in the typical grocery store.¹³ The Federal Drug Administration loosely controls the amount of gluten present in “gluten-free” foods.^{5,6,8,9}

Recently, in the news and fitness periodicals, there has been the suggestion that a GFD is an effective method for weight loss and can improve aerobic training benefits and overall fitness. Some endurance athletes claim they utilize the diet to reduce gastrointestinal discomfort during training and events. The Australian Institute of Sport denies any advantages for healthy individuals using a GFD.⁴² Still, exercise enthusiasts curiously try the diet. The news has discussed how Drew Brees of the New Orleans Saints used a GFD to manage his weight and performance in-season with the help of a registered dietitian. Novak Djokovic was recently diagnosed with CD and began the GFD as treatment for his condition. The diet allowed Djokovic to excel in the game of tennis as it improved his comfort on the court, as well as strength and speed.

Currently no studies demonstrate the effectiveness of a GFD as a training or weight loss tool. Two studies recently conducted in Japan used wheat gluten hydrolysate in an intervention to determine its effects on post-exercise recovery. The results suggest that gluten may actually help recovery for aerobic endurance events, and should therefore not be excluded from the diet.^{31,32} To our knowledge no study has sought to investigate the knowledge of the general population regarding gluten, CD, and the GFD, given the heightened interest in this population. Also, no study has explored the relationship

between individuals engaged on an “unnecessary” GFD and their knowledge of this diet and its role in exercise.

Background

The Small Intestine

The small intestine is responsible for digestion of food stuffs and absorption of its nutrients. It is approximately 20 feet long and 1 inch wide. The small intestine is divided into 3 regions – the duodenum, the jejunum, and the ileum. Each region of the small intestine has certain functions and is able to absorb certain nutrients. For example, the duodenum is immediately distal the pyloric sphincter in the stomach. It receives food directly from the stomach and also receives secretions from the pancreas and gallbladder that help further breakdown food stuffs for easy absorption.^{44, 56}

The innermost lining of the small intestine is arranged in wavelike ripples, allowing for maximum surface area and therefore maximum absorption. The ripples create fingerlike projections called villi that reach into the intestinal lumen. Each villous has its own capillary network and lymphatic vessel that allows for rapid absorption of nutrients and further breakdown of fatty acids into the circulation for use by cells in the body. At the base of each villous is the deepest portion of the intestinal lumen. These areas are called crypts. Collectively, this layer of the gastrointestinal tract is referred to as the lamina propria.^{44, 56}

Each villous is covered by millions of single-cell enterocytes that have small projections called microvilli. These microvilli form such a dense coat in the small intestine that they are often referred to jointly as a brush border. The enterocytes and microvilli are the most fundamental cells in nutrient absorption.⁴⁴

Celiac Disease

CD was first described by Arataeus the Cappadocian in 2nd century AD. He noted the occurrence of CD in children.⁴ Later in 1887, Dr. Samuel Gee described the symptoms of CD in children. In his description he included “diarrhea, lassitude, and failure to thrive.”² During the early 1900s the only treatment for CD was rest and diet.⁴ In 1924, Sidney Haas suggested a banana diet. It wasn’t until 1953 that Dutch pediatrician Willem-Karel Dicke showed that wheat, rye, and barley triggered symptoms of CD and when omitted, those symptoms resolved.^{2,4}

CD is caused by gluten, a water-insoluble protein found naturally in wheat, barley, and rye.⁴ When gluten is ingested, a cascade of events within the small intestine takes place. “HLA-DQ peptide complexes trigger inflammatory T-cells which stimulate production of auto-antibodies.”² This inflammation infiltrates the epithelium and lamina propria of the small intestine, causing crypt hyperplasia and villous atrophy.² As a result, damage to the small intestine and decreased surface area of the intestine lead to malabsorption. The disease is known to affect approximately 1% of people in the United States and United Kingdom.¹ In the United States, CD affects 1 out of every 133 people.⁵⁴

Symptoms of CD include gastrointestinal discomfort, dyspepsia, fatigue, diarrhea, weight loss, and anemia.^{2,19,30} A skin rash called dermatitis herpetiformis manifests with 10-20% of CD patients. The skin condition is characterized by pus-filled blisters that are usually found on the knees, elbows, buttocks, and back.^{1,2}

Villous atrophy in the small intestine inhibits absorption, leading to malnutrition, particularly in minerals and fat-soluble Vitamins A, D, E, and K. As an individual with

CD matures, there is an increased risk of osteoporosis, small bowel cancer, lymphoma, Grave's disease, and Hashimoto's thyroiditis.¹

Research shows that genetics largely contribute to the susceptibility for CD as well as surgery and other autoimmune disorders.¹ The disease has been identified on chromosome 6p21. The presence of antigen HLA-DQ2 and HLA-DQ8 are common in the development of CD. HLA is an acronym for Human Leukocyte Antigen.⁴ "HLA-DQ2 is expressed in >90% of patients with CD and HLA-DQ8 is found in most of the remainder."² The antigen is activates the T-cell, eliciting an autoimmune response.² Researchers are still exploring the role of other genes as the HLA complex only presents in 30% of cases in Caucasians, suggesting that HLA does not give the whole story. These genes are "CELIAC2 on 5q31 to 33, CELAIC 3 on 2q33, and CELAIC4 on 19p13."⁴

Autoimmune disorders occur 3-10x more frequently in patients with CD.² Some conditions with an increased prevalence of CD are rheumatoid arthritis, systemic lupus erythematosus, autoimmune liver disease, Turner syndrome, Williams syndrome, Addison's disease, psoriasis, cardiomyopathy, and many others.²

Diagnosing Celiac Disease

Diagnosing CD begins with an evaluation by a physician and referral to a gastroenterologist. Patients are first tested using oral serological testing. If positive, or if the symptomology is convincing, the gastroenterologist may order a biopsy of the small intestine. During the biopsy, the physician can ascertain the presence and severity of CD. One important note regarding diagnosis is that patients should not attempt to self-medicate by using a gluten-free diet before they have been properly diagnosed. Failing to

follow through with the appropriate treatment protocol can result in a false-negative on the serological test. Therefore the patients may not receive the correct care for their CD.^{1,2}

Once CD is diagnosed via serological examination, it is further defined by a Type. These “Types” are also called Marsh Types because they were first defined by Dr. Michael N. Marsh in 1992. Marsh Type 0 is normal. Marsh Type 1 is also called “infiltrative” in which the villous has been infiltrated by lymphocytes. This type is most common in first degree relatives of CD patients. Marsh Type 2 is also called “hyperplastic” is like Marsh Type 1, but also includes enlarged crypts. Marsh Type 3 is also called “destructive” presents as flat mucosa. It is further described based on the degree of villous atrophy, from Marsh Type 3a (lowest) to Marsh Type3c (highest). Lastly, Marsh Type 4 is also called “hypoplastic” which presents as total villous atrophy. In some cases, this type may not be reversible, which is called refractory CD.^{4,55}

Risk Factors Associated With Celiac Disease

The damage that occurs to the small intestine as a result of untreated CD creates thick mucus that makes it difficult for nutrient absorption to occur. As stated previously, malnutrition is evident in fat-soluble vitamin deficiency. These vitamins have important roles in the body. Vitamin A deficiency, for example, can cause visual disturbances.

Vitamin D is especially important in the development and maturation of bone. When children are affected by untreated CD, they run the risk of having rickets, stunted growth, delayed puberty, dental issues, or infertility.^{1,21,22} Decreased bone mineral density can lead to osteopenia or osteoporosis in all populations. Vitamin K is also important for bone health and wound healing. Vitamin E deficiency can result in

decreased nerve conduction and subsequent neurological deficits. There are also higher risks for cancer and other major illnesses.^{1,21,22}

Lactose intolerance may be seen secondary to CD because the small intestinal villi are unable to produce lactase. Anemia may be present because of reduced iron, folate, and Vitamin B₁₂ absorption. “Frequency of iron-deficiency anemia in CD varies from 12-69%.”² “Incidence of Vitamin B₁₂ deficiency in untreated patients ranges from 8-41%.”²

The Gluten-Free Diet

The only known effective treatment for CD is a GFD. Patients are taught to avoid foods that contain gluten beginning with wheat, barley, and rye. It is also vital that patients avoid foods that may have come into contact with gluten. For example, corn is typically gluten-free, but if it was prepared on a manufacturing line that also produces wheat products, it is not deemed safe.²

Avoidance of gluten does not end with food intake. A CD patient must also be careful to avoid certain alcohols and beverages such as barley-based beers and PowerAde which contains wheat. A study completed by Miletic et. al. in 1994 investigated the presence of wheat gliadins in over-the-counter medicines. The study reported that wheat was found in 71% of the tested medications with the highest rate occurring with Tylenol. This is an important implication because gluten can reach toxic levels when these medications are taken regularly. Further research needs to be completed to test the presence of gluten on oral contraceptives, beta-blockers, and other commonly used pharmacological interventions.³⁵

Another challenge of the GFD is finding safe and affordable foods. Gluten-Free foods are often expensive and difficult to find in groceries.¹³ Patients may need to visit health food stores or the internet to find safe products. One study by Lee et. al. in 2007 explored the availability of gluten-free products compared to their gluten-containing counterparts in different venues including a general grocery store, upscale grocery store, health food store, and internet-based grocery store. They also looked at geographic region. Compared to the gluten-containing counterparts, regular grocery stores carried 36% gluten-free products, while upscale grocery stores carried 41% and health food stores carried 94%. There is 100% availability on the internet. The price of these products was also explored. Overall, gluten-free products are more expensive than their wheat-based counterparts. Gluten-free bread and pasta were twice as expensive. Prices were more dependent upon the product than the geographic region.¹³

The rate of GFD-adherence is especially low in low-income families because of food expense.¹⁴ A study by O'Donnell and Edelstein in 2009 involved surveys that were completed by dietitians. Dietitians who treat CD patients completed the survey. The findings of this study showed that patients have difficulty adhering to a GFD because of increased price, lack of knowledge, and poor access to the correct foods.¹⁴

The Food and Drug Administration (FDA) has in effect the Food Allergen Labeling and Consumer Protection Act of 2004 that issues mandatory labeling of gluten-free foods. Despite these efforts, there are inconsistencies regarding acceptable limits in foods despite a CD patient's zero-tolerance.⁵ Currently this limit is set at starch with over 0.30% protein. When above this limit, the food cannot be labeled gluten-free.⁵³

A study by Skerritt and Hill from 1992 helped expose the inconsistencies in food labeling and gluten analysis. The study took 17 different wheat starch samples and distributed them to 3 different labs to assess their gluten content. There were variations in the amount of gluten in each sample between different laboratories. Some of these levels refuted an “acceptable” label.⁵³ The results of this study further demonstrate that an appropriate threshold needs to be set. A gold-standard quality technique and procedure for gluten detection needs to be decided and adhered to by food manufacturers.

In 2011, an improved detection system was described by Mena et. al.. The current detecting system is the R5 antibody-based sandwich ELISA (enzyme-linked immuosorbent assay), combined with the cocktail-extraction solution.⁴⁵ Because the current technique involves using fragments from the food source, it was necessary to develop a more sophisticated system that would use the entire sample. Referred to as the “competitive ELISA” that also utilized new extracting solution called UPEX (universal prolamin and glutelin extractant solution), the samples were assessed against the PAGE assay and R5 antibody test. The results of the study showed that the competitive ELISA was best at detecting gliadins in hydrolyzed foods. The accuracy of the UPEX solution did not differ from the cocktail-extraction solution.⁴⁵

Having a well-balanced diet is difficult for a CD patient. So many foods are fortified with the necessary nutrients including grains and cereals. Even when treated, CD patients usually have deficiencies in magnesium, iron, folate, and selenium.⁶ Because of these risks and limitations, a CD patient should consult with a registered dietitian for guidance concerning adherence to the GFD. When transitioning to a GFD, one may experience changes in body composition and complications concerning

gastrointestinal upset and lack of appetite. A registered dietitian can also provide quality information, education, and management strategies to make educated decisions when shopping and preparing food.⁸ It is important to realize that GFD patients may be on a select diet, but it is not without its own risks.

Adhering to a GFD ensures regeneration of small intestinal villi and reversal of malabsorption and malnutrition in as little as 3-6 days.²⁹ In one study, 70% of patients reported symptom improvement within 2 weeks of using the GFD.² However, should an individual break from their GFD, the autoimmune reaction is inevitable and will cause remission. Long-term adherence is of highest importance in treating CD.²⁹

Athletes and Celiac Disease

A GFD also gives rise to other daily difficulties for CD patients who are also athletes. When an athlete has been undiagnosed and is training, many outsiders may suspect an eating disorder. Eberman (2005) followed a Division-I collegiate volleyball player who had dramatically lost weight and exhibited signs and symptoms of an eating disorder. Her initial signs and symptoms included a rapid decrease in body mass, loss of appetite, diarrhea, and vomiting after meals. She was fatigued during class time and deferred social engagements. The coaching staff and athletic training staff noted a decrease in her performance. After a referral it was discovered that she did not have psychological issues consistent with an eating disorder. Eventually she was referred to a gastroenterologist who did a biopsy and identified this athlete as having CD. She was treated with a GFD and eventually returned to play.²⁹

Athletes who have been diagnosed with CD and follow their GFD still experience complications and limitations. These athletes may experience steatorrhea, diarrhea,

abdominal cramps, dehydration, and fatigue. They are also at a higher risk for anemia and stress fractures because of the combined stressors of exercise as well as deficiencies in iron, folate, and fat-soluble vitamins.³⁰ Athletes with CD often perform on a low-energy diet, experience degrading muscle mass, and women experience menstrual irregularities.²⁹ In addition to these issues, a GFD places extreme limits on carbohydrate selection and sports drinks. Keihanian et. al. (2010) examined 1163 sports drinks, sports bars, and sports gels and beans. It revealed that 716 of the 1163 (62%) were gluten-free, giving many choices but reiterating the need to thoroughly check labels.³⁰

Diagnostic strategies for athletes who may have CD were described by Mancini et. al. in 2011. Major areas of consideration include how long the athlete has been experiencing symptoms (one year or more), symptoms, a differential diagnosis and a method for ruling out false diagnoses with lab tests. Overall, 4 out of 5 of the following criteria should be met in order to proceed with a CD diagnosis: (1) symptomology, (2) positive serum CD IgA class autoantibodies, (3) HLA-DQ2 or HLA-DQ8 genotypes, (4) celiac enteropathy with small intestinal biopsy, and (5) response to the GFD.⁴⁶ These procedures are described as a strategy for athletes because their physical activity often clouds judgment and prolongs diagnosis, but certainly these criteria can be applied to the general population.

The Gluten-Free Diet as a Training Strategy

CD and the GFD have both received headlines in recent news reports. It is being used as a weight-loss strategy, advocated by celebrities Elisabeth Hasselbeck and Gwyneth Paltrow. The reasoning behind this is that by eating foods with a higher glycemic index you are able to control blood sugar and food cravings. It is also a diet that utilizes

protein, thereby adding bulk and making you feel fuller than you would on simple carbohydrates and fats. That being said, overeating on these foods can still result in weight gain.

Athletes have also experienced the GFD. In the case of Novak Djokovic, he was diagnosed with CD last year and began using the GFD as treatment. Since then he has improved stamina and fitness on the tennis court and has excelled in the game. Elsewhere, Drew Brees has no diagnosed gastrointestinal condition, but uses a GFD during football season to improve his performance and control weight.

With professional athletes and celebrities touting the effectiveness of the GFD, recreational athletes have begun to consider how a GFD can help them. Recent articles in popular publications like *Runner's World* and *The New York Times* have brought this Gluten-Free Diet Fad into the limelight.³³ However, it remains unclear whether a GFD is altogether necessary in these individuals when CD or a gluten-allergy is not indicated as treatment.

Claims supporting a GFD as a dieting and training strategy have not been substantiated through scientific literature. A study conducted in Japan in 2004 used experienced runners who took a supplement during and after a half-marathon and a 45km running bout. The supplement was glutamine peptide or wheat gluten hydrolysate, an amino acid with a gluten component. This study was looking for the relationship between glutamine and exercise performance, not gluten; however there were interesting implications considering the gluten component. Subjects experienced a decreased Trp:BCAA ratio that has received attention as an indicator of fatigue. This is because “tryptophan, a precursor of serotonin, competes with BCAA when tryptophan enters the

central nervous system through the blood-brain barrier.”³¹ The results also showed a decreased Gln/Glu ratio which indicates fatigue as well. While this study does not demonstrate a direct relationship between gluten and exercise, it does show improved performance with a substance that contained gluten. Therefore it is puzzling why gluten should be excluded to enhance performance.³¹

Another Japanese study in 2009 investigated the effects of delayed-onset muscle soreness after ingesting wheat gluten hydrolysate. The subjects took the supplement one day before the race, one hour after the race, one day after the race, and two days after the race. There were 3 different supplement groups: placebo, 10g, and 20g. The results of the study showed that creatine kinase levels peaks one day after the race, but there was a dose-dependent creatine kinase suppression thereafter. Like the previous Japanese study, this was not meant to demonstrate a direct relationship between gluten and exercise but it shows improved recovery with gluten included in the diet.³²

Another study by Horiguchi et. al. in 2005 explored the effect of wheat gluten hydrolysate on immune system function in healthy adults. The study included 9 total subjects, 5 of which were in the test group and 4 in the control group. The test group consumed 3g of wheat gluten hydrolysate per day for 6 days. At day 6 their NK cell activity and hematological parameters were assessed. In the test group they observed a significant increase in NK cell activity. NK cells are believed to do surveillance and combat the generation of tumors and viral disease, to name a few.⁴⁷

Athletes and the Gluten-Free Diet

Because of limited scientific literature regarding exercise and a GFD, many questions have been raised in the media. As stated previously, athletes and celebrities advocate the

diet as a weight-loss and training strategy. CD affiliated organizations refute these claims, stating that there is no need to use a GFD if the gastrointestinal tract is healthy.⁴² An article in *Runner's World* published in 2010 describes a GFD as difficult, time-consuming, and expensive.³³ Before considering a GFD one should also consider the nutrient deficiencies that are often found because many gluten-free foods are not fortified like enriched grains common in the typical American diet.⁴²

Athletes who have diagnosed CD should find relief and improved performance after being on a GFD for a few weeks, depending on the severity of the disease. With gluten eliminated from the diet, the intestinal tract can heal. Hypoglycemia, which naturally occurs with exercise, is limited because nutrients are more effectively absorbed by intestinal lining. Also, blood sugar levels are stabilized which allows glucose to be absorbed by cells, including muscle cells.⁴¹

It is important that an athlete on a GFD emphasizes the foods they can eat including fruits and vegetables, legumes, meats, and certain whole grains. They still need to be careful to read food labels and consider cross-contamination that can happen in the kitchen. Any pots or pans that may have gluten on them from previous meals should be discarded.⁴¹

Transitioning to a GFD is not easy. A radical change in diet should not be taken lightly. Individuals should be careful to read the literature and become well-informed before attempting a diet. Consultation with a physician, dietitian, and other appropriate allied health professionals should be considered before proceeding.

Previous Research

To date, there are no studies exploring the knowledge of subjects on gluten, gluten-allergies, and the GFD and their willingness to try a GFD. Other studies have been completed to assess public knowledge of healthy eating compared to subjects' dietary consumption. A U.S. study by Hess et. al. in 2005 sought to assess the knowledge of *trans* fats in a group of adults to determine their nutrition education needs and need for further information. This study found that participants who had a bachelor's degree or higher knew more about *trans* fats than those without a degree, as well as individuals who followed the Nutrition Facts label. Even though these individuals knew about *trans* fats, they were ill-informed on its relevance and making good food choices. The results suggested that a revised Nutrition Facts label could help lead to healthier food choice.⁵¹

A Canadian study assessed the knowledge of the citizens of Prince Edward Island. The results from this study showed that the participants were knowledgeable about food sources and food choices, but were not aware of the diet-disease relationship.⁴⁸ Another study from England followed a similar pattern where higher knowledge about nutrition was positively correlated to healthy eating.⁵⁰ Furthermore, a U.S. study of nutrition knowledge and eating behavior in a highly Mexican-American population in Texas found that nutritional knowledge was significantly related to proper consumption of grains, meats, and water, but not for fruits and vegetables.⁴⁹

Another study from December 2011 examined the racial and ethnic food choices of U.S. adults based on nutrition- and health-related psychosocial factors and socioeconomic status. Based on the results of this study, much of the disparity in food choice was explained by socioeconomic status (education level and income).⁵²

Summary

CD is a chronic gastrointestinal disease that has detrimental effects on the digestion and absorption of foods. The only known treatment is a GFD that helps treat CD by avoiding wheat, barley, rye, and other products that may be harmful to the individual. Following a GFD is a difficult task for someone with CD. Athletes also have added difficulty because they have limited sources for glycogen repletion, proper hydration, and nutrient balance.

The general population has been exposed to the GFD as a possible strategy for improving athletic performance and weight loss. However, there are no scientific studies supporting the presence of this relationship. The only related studies have explored the relationship between nutrition knowledge and eating behaviors, as well as the effects of socioeconomic status and other demographics on nutrition knowledge and diet quality.

Purpose & Hypothesis

The purpose of this study was to explore public awareness and knowledge of gluten and GFD. From these data we will be able to determine if there is a difference between knowledge of gluten consumption and whether people would try a GFD. The hypothesis of the researchers is that the population will have limited knowledge of a GFD but would be willing to utilize it as a training strategy.

Methodology

Participants

The survey was distributed to 2000 randomly selected students in its first distribution and 19783 students in its second distribution, for a total of 21783 students. Five-hundred-one (n=501) James Madison University undergraduate students volunteered to participate in the study. Inclusion criteria included being a full-time undergraduate between the ages of 18-25 years. These limitations were selected to identify a population from the sample. All risks and procedures were fully explained via email and participation in this study was strictly voluntary. By proceeding to the survey, the subject implied consent. Approval for the study was received from the Institutional Review Board for the use of Human Subjects in Research at James Madison University.

Research Design

Survey

A survey was designed to obtain demographic data on the participants including questions on their gender, age, academic level, college of study at James Madison University, and current activity level. Preliminary questions concerning previous knowledge of gluten included whether or not they have heard of the term, previous diagnosis, and knowledge of GFD. After these preliminary questions, there was a quiz portion to explore the participants' knowledge of gluten. The quiz portion included questions asked in 4 different clusters: gluten, CD, GFD, and athletes and gluten. The latter questions included their knowledge of the effects of CD and GFD on athletes, whether they would try the diet, and if so, why. Questions were either True/False or multiple choice. A copy of the survey can be found in Appendix A with labeled answers.

The survey was designed electronically by Qualtrics. The researchers went through Qualtrics training with a member of the Center for Instructional Technology at James Madison University to become familiar with the software. Qualtrics does not make any identifiable markers on the subjects, therefore protecting their anonymity. The survey was distributed to all undergraduate email addresses with the help of James Madison University's registrar office.

The survey was distributed on November 18, 2011 and again on December 14, 2011. The time needed to complete the survey did not exceed 5-10 minutes.

Statistical Analysis

A descriptive analysis was completed on the data including a review of the demographic statistics, overall knowledge, and knowledge of each of the aforementioned clusters. Tertiles based on subjects' overall knowledge were identified. The Mann-Whitney U test for 2 independent samples was used to verify the tertiles being significantly different. Chi-Square (χ^2) analysis was completed to test if the proportion of people that considered trying a GFD (Preliminary Question #5) differed across tertiles that were based on knowledge of dietary gluten consumption and the associated issues. Data will be analyzed using IBM SPSS version 19.

Results

Distribution

The survey was first distributed to 2000 randomly selected undergraduate students at James Madison University. This was not intended as a pilot run. It yielded 55 responses, not enough for the power equation which required a minimum of 300. As a result, the survey was distributed to all undergraduate students at James Madison University. The second distribution went to 19783 students.

Five-hundred-one (n=501) undergraduate students from James Madison University participated in the study. All responses were included in the study despite a small sample of graduate students who took the survey and categorized themselves as Seniors. These responses could not be distinguished from the others and were therefore included with this caveat. Also, the survey was distributed in two separate attempts. During the first attempt there were fifty-five (n=55) responses. Despite a request in the second distribution for there to be no repeat attempts, there were subjects who had duplicate entries. Again, these repeat responses could not be distinguished from the overall sample and were thus included. The overall response rate was 2.3%.

Demographics

Of the 501 responses, 18.6% (n=93) were male and 81.4% (n=408) were female. The mean age was 20.3±1.7 years. Only 8.4% of subjects were 23-25 years old. Most of the students were Seniors (n=187, 37.3%). Subjects were enrolled in the College of Integrated Science and Technology (ISAT) (n=134, 25.3%). The self-described current activity for most students was considered Moderate (30-60 minutes per day) by 60.3% of students (n=302). Tables 1-3 further describe the demographic findings of this sample.

Answering the Problem

Overall, the mean score was 11.2 ± 2.2 out of 19 possible points. The median score was 11 points. The scores were further sorted into tertiles based on the score value. Therefore the Low Knowledge tertile (LK) was the lower one-third of scores by respondents. The Moderate Knowledge tertile (MK) was the middle one-third of scores by respondents. The High Knowledge tertile (HK) was the upper one-third of scores by respondents. Table 4 describes the qualities of the knowledge groups. Means and standard deviations for the knowledge groups as well as the medians are displayed in Figure 1. The knowledge groups are not an even 33.3% of the sample because the tertiles were defined by the scores, not the sample.

The Mann-Whitney U Test for non-parametric independent samples was used to verify a significant difference in the quiz scores between the knowledge groups. These values should be significant because we intended distinction between the groups. The test was significant at a $p > 0.05$ significance level across knowledge groups.

Responses to the question, “Have you considered using a gluten-free diet?” (PQ5) were compared between knowledge groups using a CrossTab Chi-Square (χ^2) analysis. For this question there were four-hundred-ninety-five ($n=495$) valid responses because it was follow-up to the previous question (i.e. 6 subjects did not answer the question). CrossTab Analysis showed a trend between the amounts of information the respondent knew compared to their response to PQ5.

Examining PQ5 by knowledge group, the researchers were able to explore the proportion of responses. For respondents listed in the LK group, 20.8% responded that they would try a GFD while 79.2% responded that they would not try a GFD. For the

MK group, 35% responded that they would try a GFD while 65% responded that they would not try a GFD. For the HK group, 52.2% responded that they would try a GFD while 47.8% responded that they would not try a GFD.

When exploring the PQ5 by either a “yes” answer or “no” answer, there are different proportions. For respondents who responded “yes”, that they would try a GFD, 21.6% were in the LK group, 37.4% were in the MK group, and 40.9% were in the HK group. The respondents who responded “no”, that they would not try a GFD, fell into the LK group, MK group, and HK group at 43.5%, 36.7%, and 19.8%, respectively. A summary of this data can be found in Table 5.

A Chi-Square (χ^2) analysis was completed to determine if there was an overall significant difference between the proportions of subjects responding that they would try a GFD across knowledge groups. Overall the test was significant as $p=0.000$ at the $p<0.05$ level.

Knowledge by Cluster

Clusters were identified as being based on Gluten (Questions 1-4), CD (Questions 5-9), the GFD (Questions 10-13), and Athlete-related (Questions 14-19). Table 6 shows the percentage of responses that were correct for each question.

Table 1: Current Academic Level

	Frequency (n)	Percent
Freshman	101	20.2%
Sophomore	86	17.2%
Junior	127	25.3%
Senior	187	37.3%
Total	501	100

Table 2: Affiliated College of Study

	Frequency (n)	Percent
Liberal Arts	106	21.2%
Business	48	9.6%
Education	61	12.2%
Integrated Science and Technology (ISAT)	134	26.7%
STEM (Science and Math)	127	25.3%
Performing Arts	25	5.0%
Total	501	100

Table 3: Current Activity Level

	Frequency (n)	Percent
Sedentary (< 30 min/d)	120	24.0%
Moderate (30-60 min/d)	302	60.3%
Vigorous (60-120 min/d)	68	13.6%
Elite (>120 min/d)	11	2.2%
Total	501	100

Table 4: Tertile Groups

	Frequency (n)	% of Sample	Mean Score \pm SD	Median	Minimum	Maximum
LK group	181	36.1%	8.87 \pm 1.271	9	4	10
MK group	184	36.7%	11.49 \pm 0.501	11	11	12
HK group	136	27.1%	13.8 \pm 2.18	14	13	17
Total	501	99.9%	11.17 \pm 2.18	11	4	17

Figure 1: Means and Medians of Tertiles and Total

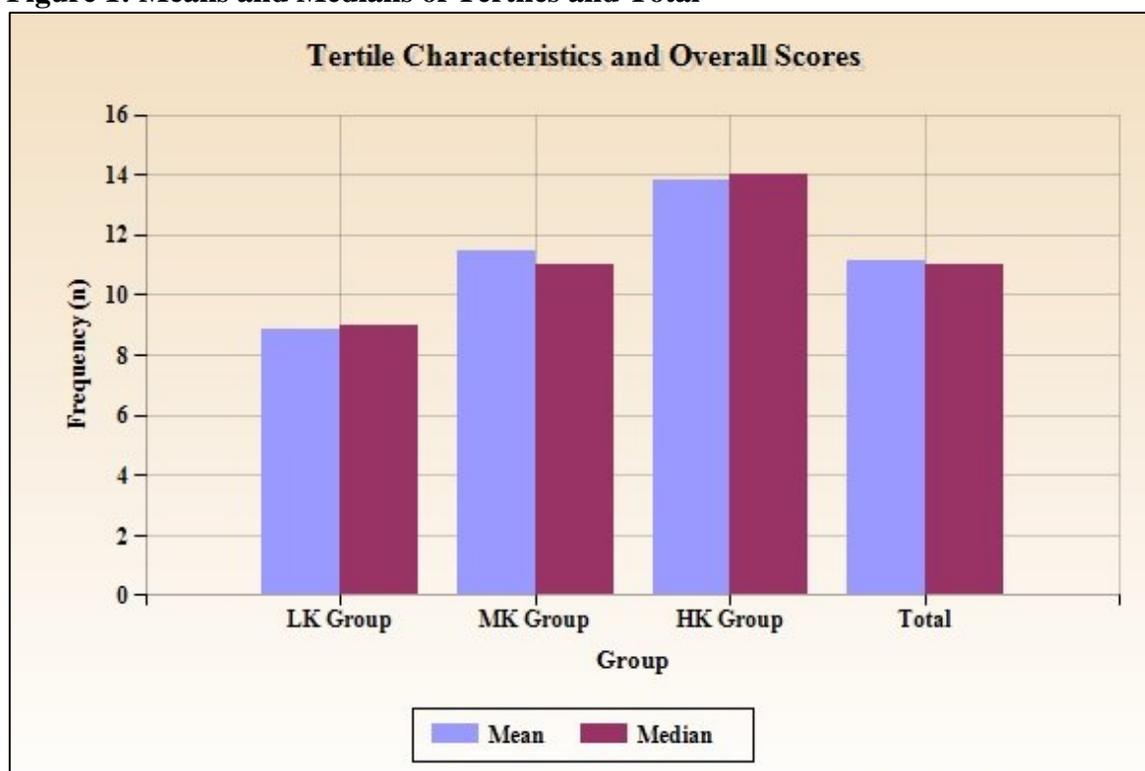


Table 5: Tertiles vs. the Question “Have you considered using a GFD?”

		Group			Total
		LK	MK	HK	
Answered “Yes”	Frequency (n)	37	64	70	171
	Expected	61.5	63.2	46.3	171
	% within question	21.6%	37.4%	40.9%	100%
	% within percentile	20.8%	35.0%	52.2%	34.5%
	% of total	7.5%	12.9%	14.1%	34.5%
Answered “No”	Frequency (n)	141	119	64	324
	Expected	116.5	119.8	87.7	324
	% within question	43.5%	36.7%	19.8%	100%
	% within percentile	79.2%	65.0%	47.8%	65.5%
	% of total	28.5%	24.0%	12.9%	65.5%
Total	Frequency (n)	178	183	134	495
	Expected	178	183	134	495
	% within question	36.0%	37.0%	27.1%	100%
	% within percentile	100%	100%	100%	100%
	% of total	36.0%	37.0%	27.1%	100%

Table 6: Responses to Questions

Cluster		Type of Question	Answer	% Correct	% Incorrect
Gluten	Q1	Mult	Protein	68.9	31.1
	Q2	Mult	Rice	68.9	31.1
	Q3	T/F	True	44.9	55.1
	Q4*	T/F	True	83.2	16.8
CD	Q5*	T/F	False	28.1	71.9
	Q6	Mult	1	17	83.1
	Q7	Mult	SOB	50.7	49.4
	Q8	Mult	WW	84.4	15.6
	Q9	Mult	Sm Intest	60.5	39.5
GFD	Q10	T/F	False	67.5	32.5
	Q11	T/F	False	91.8	8.2
	Q12	T/F	True	80.4	19.6
	Q13	Mult	All	90.4	9.6
Athletes	Q14	Mult	All	84.6	15.4
	Q15	T/F	True	88.6	11.4
	Q16*	T/F	False	15.4	84.6
	Q17**	Mult	Iron	55.5	44.5
	Q18*	T/F	False	8	92
	Q19*	T/F	False	28.1	71.9

* gross amount of incorrect replies; ** poorly-worded question

Discussion

The purpose of this study was to explore public awareness and knowledge of gluten and the GFD. From these conclusions the researchers sought to determine if there is a difference between knowledge of gluten consumption and whether people would try a GFD. The researchers hypothesized that individuals with the least knowledge (LK) about GFD would be more willing to try it.

Demographics

Demographic data for the sample were skewed versus the James Madison University population. Of the 501 responses, 81.4% of subjects were female. This distribution is not congruent with the student population of James Madison University that states it has a 60% female population.⁵⁷

There were modestly higher number of Seniors who participated in the study (37.3%), compared to other undergraduate levels. The researchers hypothesized that erroneous Graduate student submissions were falsely categorized as Seniors. As with gender, academic level was not proportionate with the population of James Madison University. Our study had a distribution of Freshman, Sophomore, Junior, and Senior as 20.2%, 17.2%, 25.3%, and 37.3%, respectively. University research implies a more even distribution of 25.8%, 25.3%, 23.8%, and 25.1%, respectively.⁵⁷

The researchers explored enrollment status as a factor in the demographics. It was found that colleges with more exposure to science, technology, and exercise were more apt to take the survey. The College of Health and Human Services (ISAT) yielded 26.7% of the responses and another 25.3% were enrolled in the College of Science, Technology, Engineering, and Mathematics (STEM). There were fewer responses from

students enrolled in the College of Business (9.6%), College of Education (12.2%), or Performing Arts (5%). It may be deduced that people enrolled in ISAT and STEM were more likely to respond to the survey because it was more closely related to their field of interest.

Also of interest was the physical activity level of the subjects. Most subjects qualified themselves as either Moderate activity level (60.3%) or Sedentary (24%). Only 13.6% believed themselves to be at a Vigorous activity level. With this question there was a subjective component suggesting that a tendency to overrate activity level can cloud the statistic.

The researchers of this study did not analyze respondent ethnicity or socioeconomic status as a variable. The population of James Madison University generally has a high socioeconomic status. This should be taken into consideration when interpreting the data. Other studies have demonstrated that adherence to a GFD is limited by education level and socioeconomic status.¹⁴

Educational Quiz

On the quiz portion of the survey there was a maximum possible score of 19 points. Overall, subjects had a mean score of 11.2 ± 2.18 points. The range of scores was 4-17 points with a median score of 11 points. Subjects were further divided into tertiles based on their overall score. These tertiles (knowledge groups) had an uneven distribution because the tertiles were defined by score, not the number of respondents. Overall, 36% of respondents were in the LK group, 37% in the MK group, and 27.1% in the HK group. Characteristics concerning the tertiles are reviewed in Table 4 and Figure 1.

The knowledge groups were compared against Preliminary Questions #5: “Have you considered using a gluten-free diet?” to assess whether knowledge of GFD influenced respondent willingness to use the diet. Generally, this analysis revealed that the more a subject knew about gluten (HK) and the GFD, the more willing they were to try the diet. The opposite was found between the LK group, meaning that they did not know much about the diet and had not considered using a GFD. For subjects who stated that they have considered trying a GFD (“Yes”), 40.9% scored in The HK group while only 20.8% scored in The LK group. 43.5% of subjects who said “No” were in The LK group while 19.8% were in The HK group. Only 19.8% of subjects who scored in The HK group stated that they had not considered using a GFD.

In summary, the hypothesis of the researchers is rejected. The researchers expected the study to demonstrate that those with only limited knowledge (LK) about gluten would try the diet. This was only true for only 7.5% of the total population. On the contrary, 12.9% of people were well-informed (HK) and said they would not try a GFD.

When exploring what questions were more frequently incorrect, the questions that were categorized as “Athlete-Related” were most commonly answered incorrectly. In this cluster, 84.6% were incorrect in responding that gluten-free products were enriched and fortified as normal food products. Ninety-two percent (92%) were incorrect in stating that a GFD is safe for those without gluten-sensitivity or related issue. CD patients still experience deficiencies in magnesium, iron, folate, and selenium, showing that it is still difficult to have a balanced diet, which can be very risky.⁸ Also, 71.9% were incorrect in stating that the GFD has improved the performance of athletes without

gastrointestinal illness or disease. This relationship has not yet been investigated in scientific literature. It is also important to mention that Question 17 concerning nutrient deficiencies and the GFD was scored as incorrect for 44.5% of subjects. The correct answer was considered Iron deficiency, but Vitamin D deficiency is also common.^{1,21,22}

It was previously stated that 35% of all respondents considered using a GFD (PQ5). A follow-up to this question gave an opportunity for respondents to describe why they would attempt such a diet. Twenty-four percent (24%) of respondents replied they have considered because a doctor suggested it, 23% have considered for weight concerns, and 5% have considered the diet as a method to improve their athletic performance. The most common response was “Other” (48%) which gave respondents an opportunity to explain. Common explanations included “allergies”, “family medical history”, “healthier diet”, “chronic illness”, and “curiosity”. Many subjects considered the diet as self-diagnosis for gastrointestinal upset and distress, or as a method of controlling inflammation manifested as acne, central nervous system illness, irritable bowel syndrome, and migraine prevention.

It is important to note that research has not substantiated claims for relief from acne, central nervous system illness, or migraine prevention. As with any new dietary adaptation, it is important that a dieter consider substitutions to replace vital micronutrients and achieve the proper macronutrient distribution. One should consult their doctor before making any drastic changes.

Another interesting statistic found in our research was that according to PQ2, 8% of our sample said that they have been told by a doctor that they have CD or an allergy to gluten. This is interesting because CD is found in approximately 1% of the population of

U.K. and the United States, or 1/133 of the United States population.^{1,54} Furthermore, based on PQ3, 14% of our sample responded that they believe they have a gluten allergy. Also, as stated above, 24% of respondents said that they would try a GFD because a doctor suggested it. These proportions are staggering compared to the national average.

There are no scientific studies suggesting the efficacy of gluten as a dietary method of improving anaerobic performance or weight loss. Two studies conducted in Japan show that wheat gluten hydrolysate, a pill used to attenuate the effects of DOMS and fatigue post-race, improved recovery and immunosuppression. While this study was not directly testing the gluten component, gluten was still included in the intervention which showed favorable results.^{31,32,47}

Limitations

This study was limited to the student population of James Madison University. The intent of the researchers was to identify a sample of students, rather than expanding to faculty and staff members who may demonstrate varying levels of knowledge. By identifying a sample based on an age group and education level, the results of this study could be extrapolated to similar populations.

Conclusions

The results of this study can be applied to the current GFD fad. Generally the data shows that the less knowledgeable (LK) a respondent, the less likely they considered trying a GFD. In comparison, the more knowledgeable (HK) a respondent, the more likely they considered trying a diet. It is important to understand that the question specifically asked if the respondent “considered” trying the diet. It was not a well-worded question to truly assess if those that considered the diet actually tried the diet. For example, within the HK

group, 52.2% said they had considered the diet. It is possible that people who considered trying the GFD took the time to research it and decided they were not interested in trying the diet.

For the respondents who were open to trying the diet, the most common reason why involved a family history of CD or gluten-allergy. Because statistics indicate that only 1% of the population has CD, it is interesting that so many responses within such a large sample claimed to have CD. As researchers, we are left to assume that cases of CD were properly diagnosed by a physician.

Despite of the reasons for trying the GFD, individuals must carefully consider all of the risks involved. Although they seem minimal, long-term nutrient deficiencies can impair weight loss and performance. Before trying a new diet, it is important that individuals seek evidence of the benefits and remain suspicious, while accounting for all the risks. It is useful to address dietary changes with a physician or registered dietitian who can provide advice. More research needs to be done in the area of substantiating the claims of GFD as an intervention for healthy individuals before drawing any preemptive conclusions.

Considering the limited availability of studies regarding gluten and its exercise enhancing effects, studies conducted in a manner that would test a GFD intervention on exercisers to determine if there is in fact a relationship are still warranted. To date, no studies have been completed to test the knowledge of a population and correlate that data to a likelihood of participating in the GFD fad. Gluten-testing methods for foods and stricter regulation by the FDA also encourage another area of research as more sophisticated measurement techniques are being developed. Also, CD and gluten still

deserve some research as medicine and medical technologies develop. Diagnosing CD earlier before serious ramifications happen is of primary concern.

Appendix A: Distribution Email #1

“Knowledge and Attitudes on Gluten – Campus Survey”

Dear Fellow JMU Student,

You are receiving this email as an invitation to participate in an anonymous online survey regarding gluten and gluten-free diet awareness. Potential benefits from participation in this study include gaining perspective on public understanding of gluten and gluten-allergies.

The survey will take 5-10 minutes of your time. Your responses are anonymous.

Your participation is entirely voluntary. You are free to choose not to participate. Should you choose to participate, you can withdraw at any time without consequences of any kind. If you have questions or concerns during the time of your participation in this study, or after its completion or you would like to receive a copy of the final aggregate results of this study, please contact:

Jessica Bissinger
Master’s Student, Kinesiology Department
James Madison University
bissinjg@dukes.jmu.edu

Giving of Consent

I have read this consent and I understand what is being requested of me as a participant in this study. I freely consent to participate. The investigator provided me with a copy of this form through email. I certify that I am at least 18 years of age. By clicking on the link below, and completing and submitting this anonymous online survey, I am consenting to participate in this research.

http://jmu.qualtrics.com/SE/?SID=SV_3xuwWgA10DNisdK

Thank you for your participation!

Appendix B: Distribution Email #2

“Short Survey on Gluten”

Dear Fellow JMU Student,

You are receiving this email as an invitation to participate in an anonymous online survey regarding gluten and gluten-free diet awareness. **If you have already taken this survey, please disregard this email.** Potential benefits from participation in this study include gaining perspective on public understanding of gluten and gluten-allergies.

The survey will take 5-10 minutes of your time. Your responses are anonymous.

Your participation is entirely voluntary. You are free to choose not to participate. Should you choose to participate, you can withdraw at any time without consequences of any kind. If you have questions or concerns during the time of your participation in this study, or after its completion or you would like to receive a copy of the final aggregate results of this study, please contact:

Jessica Bissinger
Master's Student, Kinesiology Department
James Madison University
bissinjg@dukes.jmu.edu

Giving of Consent

I have read this consent and I understand what is being requested of me as a participant in this study. I freely consent to participate. The investigator provided me with a copy of this form through email. I certify that I am at least 18 years of age. By clicking on the link below, and completing and submitting this anonymous online survey, I am consenting to participate in this research.

http://jmu.qualtrics.com/SE/?SID=SV_3xuwWgA10DNisdK

Thank you for your participation!

Appendix C: Survey as it Appeared in Qualtrics

D1 Gender

- Male (1)
- Female (2)

D2 Age

- 18 (18)
- 19 (19)
- 20 (20)
- 21 (21)
- 22 (22)
- 23 (23)
- 24 (24)
- 25 (25)

D3 Current Academic Level

- Freshman (1)
- Sophomore (2)
- Junior (3)
- Senior (4)

D4 What is your affiliated college of study?

- Arts and Letters (1)
- Business (2)
- Education (3)
- Integrated Science and Technology (4)
- Science and Mathematics (5)
- Visual and Performing Arts (6)

D5 What would you consider your current activity level?

- Sedentary (less than 30 minutes per day) (1)
- Moderate (30-60 minutes per day) (2)
- Vigorous (60-120 minutes per day) (3)
- Elite (greater than 120 minutes per day) (4)

P1 Have you heard the term "gluten" before?

- Yes (1)
- No (2)

P2 Have you ever been told by a doctor that you have Celiac Disease or an allergy to gluten?

- Yes (1)
- No (2)

P3 Do you believe that you have a gluten allergy?

- Yes (1)
- No (2)

P4 Have you heard of a gluten-free diet?

- Yes (1)
- No (2)

Answer If Have you heard of a gluten-free diet? Yes Is Selected

P5 Have you considered using a gluten-free diet?

- Yes (1)
- No (2)

Answer If Have you considered using a gluten-free diet? Yes Is Selected

P6 Why have you considered using a gluten-free diet?

- Doctor prescribed treatment (1)
- Weight Loss (2)
- Exercise Performance (3)
- Other, please describe (4) _____

TXT

The following questions will test your knowledge of gluten and related issues. Please be honest in your answers.

Q1 Gluten is defined as:

- A type of carbohydrate found in certain proteins (1)
- A type of protein found in certain flours and breads (2)
- A type of fat found in grains (3)

Q2 Which of the following foods DOES NOT contain gluten?

- Rye (1)
- Wheat (2)
- Rice (3)
- Barley (4)

Q3 Gluten content in foods is regulated by the Food and Drug Administration (FDA).

- True (1)
- False (2)

Q4 There is a difference between a wheat allergy, gluten-sensitivity, gluten intolerance, and Celiac Disease.

- True (1)
- False (2)

Q5 The cause of Celiac Disease is still unknown.

- True (1)
- False (2)

Q6 Celiac Disease effects approximately ___% of the United States' population.

- 1% (1)
- 10% (2)
- 25% (3)
- 30% (4)

Q7 Symptoms of Celiac Disease include all of the following EXCEPT:

- Diarrhea (1)
- Fatigue (2)
- Difficulty breathing (3)
- Skin rash (4)

Q8 Of the choices below, which should be avoided by someone who has a gluten allergy?

- Potatoes (1)
- Whole wheat (2)
- Rice (3)
- Corn (4)

Q9 Celiac Disease directly affects which part of the body?

- Stomach (1)
- Small intestine (2)
- Liver (3)
- Heart (4)

Q10 Over the counter drugs are safe for those with a gluten allergy.

- True (1)
- False (2)

Q11 A gluten allergy is something that most people "grow out of".

- True (1)
- False (2)

Q12 A gluten-free diet is the only known treatment for Celiac Disease.

- True (1)
- False (2)

Q13 A gluten-free diet considers gluten found in which of the following products?

- Grains (1)
- Alcohol (2)
- Medication (3)
- All of the above (4)

Q14 Which of the following are concerns for an athlete with gluten sensitivity?

- Consuming enough calories (1)
- Hydration (2)
- Fatigue (3)
- All of the above (4)

Q15 Trace amounts of gluten are still found in food and drink even though the FDA regulates gluten-free products.

- True (1)
- False (2)

Q16 Gluten-free products are fortified and enriched with nutrients just like normal food products are.

- True (1)
- False (2)

Q17 Nutrient deficiencies associated with gluten-free diet include:

- Vitamin C (1)
- Vitamin D (2)
- Iron (3)
- Sodium (4)

Q18 If you do not have a gluten-sensitivity or related issue, it is still safe to use a gluten-free diet.

- True (1)
- False (2)

Q19 The gluten-free diet has improved the performance of athletes who have no gastrointestinal illness or disease.

- True (1)
- False (2)

Appendix D: Survey with Correct Answers

Educational Quiz:***Gluten***

1. Gluten is defined as:
 - a. A type of carbohydrate found in certain proteins
 - b. A type of protein found in certain flours and breads
 - c. A type of fat found in grains
2. Which of the following foods DOES NOT contain gluten?
 - a. Rye
 - b. Wheat
 - c. Rice
 - d. Barley
3. Gluten content in foods is regulated by the Food and Drug Administration (FDA). True/False
4. There is a difference between a wheat allergy, gluten-sensitivity, gluten intolerance, and Celiac Disease. True/False

Celiac Disease

5. The cause of Celiac Disease is still unknown. True/False
6. Celiac Disease effects approximately ___% of the United States' population.
 - a. 1%
 - b. 10%
 - c. 25%
 - d. 30%
7. Symptoms of Celiac Disease include all of the following EXCEPT:
 - a. Diarrhea
 - b. Fatigue
 - c. Difficulty breathing
 - d. Skin rash
8. Of the choices below, which should be avoided by someone who has a gluten allergy?
 - a. Potatoes
 - b. Whole wheat
 - c. Rice
 - d. Corn
9. Celiac Disease directly affects which part of the body?
 - a. Stomach
 - b. Small intestine
 - c. Liver
 - d. Heart

Gluten-Free Diet

10. Over the counter drugs are safe for those with a gluten allergy. True/False
11. A gluten allergy is something that most people “grow out of.” True/False
12. A gluten-free diet is the only known treatment for Celiac Disease. True/False
13. A gluten-free diet considers gluten found in which of the following products?
 - a. Grains
 - b. Alcohol
 - c. Medication
 - d. All of the above

Athletes and Gluten

14. Which of the following are concerns for an athlete with gluten sensitivity?
 - a. Consuming enough calories
 - b. Hydration
 - c. Fatigue
 - d. All of the above
15. Trace amounts of gluten are still found in food and drink even though the FDA regulates gluten-free products. True/False
16. Gluten-free products are fortified and enriched with nutrients just like normal food products are. True/False
17. Nutrient deficiencies associated with a gluten-free diet include:
 - a. Vitamin C
 - b. Vitamin D
 - c. Iron
 - d. Sodium
18. If you do not have a gluten-sensitivity or related issue, it is still safe to use a gluten-free diet. True/False
19. The gluten-free diet has improved the performance of athletes who have no gastrointestinal illness or disease. True/False

References

1. Phillips F. Coeliac disease. *Practice Nurse*. 2010;40(7):26-29.
2. Niewinski MM. Advances in Celiac disease and gluten-free diet. *J Am Diet Assoc*. 2008;108(4):661-672.
3. Lugg J. Celiac disease, gluten sensitivity, and the gluten-free diet. *Macrobiotics Today*. 2010;50(3):22-28.
4. Mearin ML. Celiac disease among children and adolescents. *Curr Probl Pediatr Adolesc Health Care*. 2007;37:86-105.
5. Thompson T, Lee AR, Grace T. Gluten contamination of grains, seeds, and flours in the United States: a pilot study. *J Am Diet Assoc*. 2010;110:937-940.
6. Wild D, Robins GG, Burley VJ, Howdle PD. Evidence of high sugar intake, and low fibre and mineral intake, in the gluten-free diet. *Aliment Pharmacol Ther*. 2010;32:573-581.
7. Jackson FW. Effects of a gluten-free diet on gut microbiota and immune function in healthy adult human subjects – comment by Jackson. *Brit J Nutr*. 2010;104:773.
8. Zarkadas M, Cranney A, Case S, Molloy M, Switzer C, Graham D et. al. The impact of a gluten-free diet on adults with coeliac disease: results of a national survey. *J Hum Nutr Dietet*. 2006;19:41-49.
9. Case S. The gluten-free diet: how to provide effective education and resources. *Gastroenterology*. 2005;128:S128-S134.
10. Lee AR, Ng DL, Ciaccio EJ, Green PHR. The effect of substituting alternative grains in the diet on the nutritional profile of the gluten-free diet. *J Hum Nutr Diet*. 2009;22:359-363.
11. Troncone R, Auricchio R, Granata V. Issues related to gluten-free diet in coeliac disease. *Curr Opin Clin Nutr Metab Care*. 2008;11:329-333.
12. Shellenbarger T, DeGeorge P. Helping patients adhere to a gluten-free diet. *American Nurse Today*. 2010;5(9):28-31.
13. Lee AR, Ng DL, Zivin J, Green PHR. Economic burden of a gluten-free diet. *J Hum Nutr Diet*. 2007;20:423-430.
14. O'Donnell B, Edelstein S. Dietitians' perceptions of adherence to a gluten-free diet among low-income individuals with celiac disease. *Top Clin Nutr*. 2009;24(1):82-89.
15. Öhlund K, Olsson C, Hernell O, Öhlund I. Dietary shortcomings in children on a gluten-free diet. *J Hum Nutr Diet*. 2010;23:294-300.
16. Cosnes J, Cellier C, Viola S, Colombel J, Michaud L, Sarles J, et. al. Incidence of autoimmune diseases in celiac disease: protective effect of the gluten-free diet.
17. Rubio-Tapia A, Van Dyke CT, Lahr BD, Zinsmeister AR, El-Youssef M, Moore SB, et. al. Predictors of family risk for celiac disease: a population-based study. *Clin Gastroenterol H*. 2008;6:983-987.

18. Varjonen E, Vainio E, Kalimo K. Life-threatening, recurrent anaphylaxis caused by allergy to gliadin and exercise. *Clin Exp Allergy*. 1997;27:162-166.
19. Özaslan E, Akkorlu S, Eskiöğü E, Kayhan B. Prevalence of silent celiac disease in patients with dyspepsia. *Dig Dis Sci*. 2007;52:692-697.
20. Ojetti V, Nucera G, Migneco A, Gabrielli M, Lauritano C, Danese S, et. al. High prevalence of celiac disease in patients with lactose intolerance. *Digestion*. 2005;71:106-110.
21. Corazza GR, di Stefano M, Maurino E, Bai JC. Bones in coeliac disease: diagnosis and treatment. *Best Pract Res Cl Ga*. 2005;19(3):453-465.
22. Capriles VD, Martini LA, Areas JAG. Metabolic osteopathy in celiac disease: importance of a gluten-free diet. *Nutr Rev*. 2009;67(10):599-606.
23. Meyer KG, Fasshauer M, Nebel IT, Paschke R. Comparative analysis of conventional training and a computer-based interactive training program for celiac disease patients. *Patient Educ Couns*. 2004;54:353-360.
24. Leffler DA, Dennis M, George JE, Jamma S, Cook EF, Schuppan D, et. al. A validated disease-specific symptom index for adults with celiac disease. *Clin Gastroenterol H*. 2009;7:1328-1334.
25. Zanini B, Lanzarotto F, Mora A, Bertolazzi S, Turini D, Cesana B, et. al. Five year time course of celiac disease serology during gluten free diet: results of a community based “CD-Watch” program. *Digest Liver Dis*. 2010;42:865-870.
26. Kaukinen K, Lindfors K, Collin P, Koskinen O, Mäki M. Coeliac disease – a diagnostic and therapeutic challenge. *Clin Chem Lab Med*. 2010;48(9):1205-1216.
27. Sugai E, Nachman F, Vásquez H, González A, Andrenacci P, Czech A et. al. Dynamics of celiac disease-specific serology after initiation of a gluten-free diet and use in the assessment of compliance with treatment. *Digest Liver Dis*. 2010;42:352-358.
28. Solakivi T, Kaukinen K, Kunnas T, Lehtimäki T, Mäki M, Nikkari ST. Serum fatty acid profile in celiac disease patients before and after a gluten-free diet. *Scand J Gastroentero*. 2009;44:826-830.
29. Eberman LE, Cleary MA. Celiac disease in an elite female collegiate volleyball athlete: a case report. *J Athl Training*. 2005;40(4):360-364.
30. Keihanian S, Burke K, Levey J. Sports dietary supplements: overview and effect on the gluten-sensitive athlete. *AMAA J*. 2010;23(3):10-12.
31. Sawaki K, Takaoka I, Sakuraba K, Suzuki Y. Effects of distance running and subsequent intake of glutamine rich peptide on biomedical parameters of male Japanese athletes. *Nutr Res*. 2004;24:59-71.
32. N, Nakamura A, Ngaoka I, Aoki K, Sawaki K, Suzuki Y. Delayed-onset muscle injury and its modification by wheat gluten hydrolysate. *Nutrition*. 2009;25:493-498.
33. Kadey MG. Wheat Index. *Runner’s World*. 2010. November 2010.

34. Malandrino N, Capristo E, Farnetti S, Leggio L, Abenavoli L, Addolorato G, Gasbarrini G. Metabolic and nutritional features in adult celiac patients. *Dig Dis*. 2008;26:128-133.
35. Miletic ID, Miletic VD, Sattely-Miller EA, Schiffman SS. Identification of gliadin presence in pharmaceutical products. *J Pediatr Gastr Nutr*. 1994;19:27-33.
36. Capristo E, Addolorato G, Mingrone G, De Gaetano A, Gerco AV, Tataranni PA, Gasbarrini G. Changes in body composition, substrate oxidation, and resting metabolic rate in adult celiac disease patients after a 1-y gluten-free diet treatment. *Am J Clin Nutr*. 2000;72:76-81.
37. Capristo E, Mingrone G, Addolorato G, Greco AV, Corazza GR, Gasbarrini G. Differences in metabolic variables between adult celiac patients at diagnosis and patients on a gluten-free diet. *Scand J Gastroenterol*. 1997;32:1222-1229.
38. Capristo E, Farnetti S, Mingrone G, Certo M, Greco AV, Addolorato G, Gasbarrini G. Reduced plasma ghrelin concentration in celiac disease after gluten-free diet treatment. *Scand J Gastroenterol*. 2005;40:430-436.
39. Petersen, V. The Truth About Carb Loading, Gluten & Athletes. HealthNOW Web site. <http://www.everydayhealth.com/blogs/the-/the-truth-about-carb-loading-gluten-athletes>. Published 2011. Accessed August 10, 2011.
40. Huntington, AS. A Debilitating Disease That Is Often Unknown. *The New York Times*. October 10, 2008. <http://www.nytimes.com>. Accessed August 10, 2011.
41. Wellington, C. The Gluten-Free Athlete. Active.com Web site. <http://www.active.com/nutrition/Articles/The-Gluten-Free-Athlete.htm>. Accessed August 10, 2011.
42. AIS Sports Nutrition. Gluten-free diets. http://www.ausport.gov.au/ais/nutrition/factsheets/special_diets2/gluten-free_diets. Published 2009. Accessed August 10, 2011.
43. Skerritt JH, Hill AS. How “free” is “gluten free”? Relationship between Kjeldahl nitrogen values and gluten protein content for wheat starches. *Cereal Chem*. 1992;69(1):110-112.
44. McGuire M, Beerman KA. *Nutritional Sciences: From Fundamentals to Food*. 2nd ed. Belmont, CA: Wadsworth Cengage Learning; 2011:100-104.
45. Mena MC, Lombardia M, Hernando A, Mendez E, Albar JP. Comprehensive analysis of gluten in processed foods using a new extraction method and a competitive ELISA based on the R5 antibody. *Talanta*. 2012;91:33-40.
46. Mancini LA, Torjian T, Mancini AC. Celiac disease and the athlete. *Current Sports Medicine Reports*. 2001;10(2):105-108.
47. Horiguchi N, Horiguchi H, Suzuki Y. Effect of wheat gluten hydrolysate on the immune system in healthy human subjects. *Biosci Biotech Bioch*. 2005;69(12):2445-2449.

48. Gottschall-Pass K, Reyno L, MacLellan D. What do adults in Prince Edward Island know about nutrition? *Can J Diet Pract Res.* 2007;68(3):123-130.
49. Sharma SV, Gernand AD, Day RS. Nutrition knowledge predicts eating behavior of all food groups except fruits and vegetables among adults in the Paso del Norte region: que sabrosa vida. *J Nutru Educ Behav.* 2008;40:361-368.
50. Wardle J, Parmenter K, Waller J. Nutrition knowledge and food intake. *Appetite.* 2000;34:269-275.
51. Hess S, Yanes M, Jourdan P, Edelstein S. Trans fat knowledge is related to education level and nutrition facts label use in health-conscious adults. *Top Clin Nutr.* 2005;20(2):109-117.
52. Wang Y, Chen X. How much of racial/ethnic disparities in dietary intakes, exercise, and weight status can be explained by nutrition- and health-related psychosocial factors and socioeconomic status among US adults? *J Am Diet Assoc.* 2011;111:1904-1911.
53. Wikipedia.org. Gluten. <http://en.wikipedia.org/wiki/Gluten>. Accessed August 10, 2011.
54. Cause of Celiac Disease. Celiac Disease Foundation. http://www.celiac.org/index.php?option=com_content&view=article&id=5&Itemid=11. Accessed March 14, 2012.
55. Marsh MN. Gluten, major histocompatibility complex, and the small intestine. *Gastroenterology.* 1992;102:330-354.
56. Encyclopedia Britannica Online. Small intestine. <http://www.britannica.com/EBchecked/topic/549336/small-intestine>. Accessed March 14, 2012.
57. James Madison University. Office of Institutional Research. www.jmu.edu/instresrch/notes/Vol25no1.pdf. Accessed March 14, 2012.