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The Gluten-Free Diet: An Effective Treatment for Autistic Spectrum Disorders?

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Effectiveness of the Gluten-Free, Casein-Free Diet as a Treatment Modality for Autistic Spectrum Disorders

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Abstract

In 2006, autism was recognized as a national problem due to a sharp increase in the prevalence of autism spectrum disorders (ASD). Characteristics of autism include impairments in the areas of social interaction, communication, and play, while demonstrating restricted or repetitive interests and activities. Children diagnosed with ASDs may also develop angry outbursts or feeding difficulties. An estimated one-third of autistic children have a gastrointestinal (GI) disorder. Theories as to why GI distress is common with autism have resulted in the research of different therapeutic treatments. Most notably, researchers have completed studies on the gluten-free, casein-free (GFCF) diet as a possible intervention for ameliorating core behaviors associated with autism. An identified connection between the brain and the gut justifies why a GFCF diet could potentially treat autism; this is especially true if the child has food allergies or is a problem feeder. A review of past studies and an interview with an individual, who has worked directly with autistic children on GFCF diets, revealed no distinct link between GFCF diets and an amelioration of common ASD symptoms. In conclusion, more research is needed on this topic before parents can be advised to initiate a GFCF diet regimen with their autistic child.

Introduction

The public's interest in autistic spectrum disorders has peaked in recent years correlating with a sudden spike in its prevalence. In 2012, the Autism and Developmental Disabilities Monitoring (ADDM) Network office of the Centers for Disease Control and Prevention (CDC) published a study uncovering an increase in autism prevalence of 23% since 2009.[1] Results showed that compared to the one in 10,000 cases in the 1980s, and the one in 110 cases in 2009, one in 88 children have an autistic spectrum disorder (ASD). The surveillance study was constructed by collecting data from eight-year old children; the specific age was chosen because it is the age of peak prevalence of autism.[2] Theories attempting to explain this upsurge have varied from genetics, diet, digestive tract changes, mercury poisoning, and even vaccine sensitivity as possible root causes. Lori McIlwain, the National Autism Association Executive Director demands the government take action and draw attention to the increasing rates of autism:

> Autism is a national health emergency. Our hope is that the government will finally declare it as such so that proper prevention, treatments and resources will be put in place. Immediate action is necessary for our community, and for members of the general public who just became one doorstep closer to autism.[1]

Until the true source behind autistic spectrum disorders can be unearthed, researchers will continue to search for effective treatments.

Autism: Effects on the Brain and Behavior

Autism spectrum disorders (ASD) are linked to developmental and functional abnormalities of the brain appearing before 36 months of age. They are characterized by impairments in reciprocal social interactions, impairments in verbal and non-verbal communication skills, and stereotyped behavior and interests.[3] The Fourth Edition of the *Diagnostic and Statistical Manual of Mental Disorders,* (DSM-IV-TR) identifies five disorders that fall under this title: autistic disorder, Asperger disorder, pervasive development disorder not otherwise specified (PDD-NOS), Rett disorder, and childhood disintegrative disorder (CDD). Emphasis will be placed on the more commonly known autistic disorder and Asperger syndrome (AS) for the purpose of this thesis.

Children diagnosed with autistic disorder, often referred to as 'autism,' usually display impairments in the areas of social interaction, communication and play, while demonstrating restricted or repetitive interests and activities. Lack of social awareness and knowledge is seen through failure to develop friendships, awkwardness and avoidance of eye contact, repetitive, one-sided interactions, tendency towards socially embarrassing comments unintentionally, and an impaired comprehension of other individual's feelings or perspectives. The unusual social characteristics become more noticeable as the child progresses in age to adolescence; however, communication and play discrepancies seen at an early age assist in initial diagnosis. An autistic child may present a delay in developing speech with the accompaniment of hand gestures, difficulty in initiating play and conversation with others, and a lack of imagination and creativity observed in play compared to children of the same age. A child with autism reveals excessively narrow interests, adheres to rigid routines, and may experience repetitive motor mannerisms, such as hand flapping.[3]

Adolescents with autistic disorder often have several other identifying features. An estimated 70% have intellectual disabilities.[3] Also, autistic individuals may become epileptic at any age and develop behavior disorders, such as angry outbursts or feeding difficulties. Anxiety caused by poor communication skills may result in sleep problems or self-induced injury.[3] Furthermore, autistic children may display unusual sensory responses; these include but are not limited to an aversion to a specific sound or tangible sensation, intolerance to certain foods, and an enthrallment to spinning objects or lights.

Asperger syndrome differs from autism because it excludes significant language delay as a feature in diagnosis Nonetheless, individuals with AS still present signs of impaired social abilities and repetitive interests. The unusual social and communication behaviors are the same as witnessed in the case of a child with autistic disorder. Other typical characteristics are clumsiness, pedantic speech, lack of common sense, better verbal than non-verbal skills on psychological assessments, intolerance of change, and anxiety.[3] Most of these traits are also seen in children with other disorders across the autism spectrum.

Anatomically, research has shown the brain of an autistic child differs from that of a child who exhibits no signs of autism. Multiple studies dating back to the 1980's have completed magnetic resonance imaging (MRI) tests on autistic individuals and their counterparts. Surprising results have shown that autistic people have a larger brain size, specifically in regards to the cerebrum and corpus callosum. A 2007 study involving MRIs showed that women with ASD had smaller grey matter density in the front-temporal cortices and limbic system, as well as, larger white-matter density in regions of the association and projection fibers of frontal, parietal, posterior temporal, and occipital lobes.[4] In addition, this research discovered a negative relationship between a lessened amount of grey-matter density in right limbic regions and social

communication ability.[4] This demonstrates how brain anatomy has a direct effect on observable features of autism. A similar study published in 2011 performed brain analyses on over 700 subjects who were given visual-processing tasks to perform in the hopes of detecting an observable difference between the experimental and control group. The conclusion was that autistic persons have above normal abilities in pattern detection, matching, and learn to read at unusually young ages, which could be due to anatomical differences.[5]

The pathophysiology of Asperger Syndrome diverges slightly from that of autism disorder. In a 2011 study, fifteen adult individuals with AS and 15 control participants performed a series of visual-audio priming tasks, requiring the identification of sounds that were primed as semantically congruent or incongruent preceding pictures. All individuals completed congruent trials faster and more accurately than the incongruent trials. In addition, AS persons did not perform considerably different than the control group. This outcome opposes the idea that AS individuals possess a general multisensory processing deficit, which is true of the entire autism spectrum.[6] Persons diagnosed with Asperger syndrome have the same increases in white matter as high-functioning autism individuals, but in the right hemisphere instead of the left hemisphere.[7] MRI studies discovered that the grey matter differences between people with AS and non-ASD persons were fewer than between people with autism and non-ASD individuals.[7]

Autism and Gastrointestinal Problems

An estimated one-third of autistic children have a gastrointestinal disorder.[8] These gastrointestinal abnormalities encompass a group of issues including duodenitis, ileitis, colitis, dysmotility, excessive gut permeability, dysbiosis, and food sensitivities. Therefore, current research in the area of autism has been focused on identifying a link between the brain and the digestive system. In recent years, irregularities distinguishing significant differences in the functioning capacity of the gastrointestinal tract of autistic children have been identified.

Several dissimilarities in the nutrient metabolism of individuals with autism have been uncovered. A 2004 randomized, double-blind, placebo-controlled, 3-month study using twenty autistic children between the ages of 3-8 reported that levels of vitamin B6, pyridoxine, were increased in the experimental group by 75% compared to the control.[9] The only plausible explanation for this find is that autistic persons cannot efficiently convert pyridoxal to the active coenzyme form of vitamin B6, pyridodoxal-5-phosphate. This valuable micronutrient is critical for amino acid absorption and metabolism, carbohydrate and fat metabolism, the functioning of at least sixty enzyme systems, and the generation of erythrocytes and antibodies. Furthermore, elevated levels of vitamin B6 could account for the higher incidence of antibodies in certain parts of the brain among autistic children.[8] Reports of lower plasma levels of omega-3 polyunsaturated fats in autistic children have been made as well; omega-3 polyunsaturated fats are important for decreasing blood triglyceride levels and reducing the risk of a myocardial infarction.

Studies have revealed that intestinal permeability was increased in 43% of the 21 autistic children used in the study compared to the control group.[8] Enhancement of intestinal permeability could permit the absorption of incompletely digested peptides, particularly gluten and casein.[10] This could have an effect on the brain, eliciting unusual behaviors. Modifications in

the intestinal mucosal barrier that have occurred in conjunction with rising intestinal permeability need to be evaluated individually to determine a subsequent course of action. Other studies on gastrointestinal flora have suggested that an increased intestinal permeability results in a greater absorption rate and minimal amounts of short chain fatty acids.[11]

Autistic children have an increased oxidative stress level caused by an accumulation of reactive oxygen free radicals, also referred to as reactive oxygen species (ROS). Reactive oxygen species are naturally occurring chemical products of the metabolism; they can react and damage fats, proteins, DNA, and over time, organs. Scientists have associated the buildup of free radicals in autistic children with elevated levels of nitric oxide, a free radical, and xanthine oxidase, a ROS generator, as well as, reduced levels of antioxidant nutrients and enzymes.[8] A hypothesis for increased nitric oxide and xanthine oxidase is the pre-natal or post-natal presence of certain environmental factors, such as metals of organic compounds found in the environment.[12]

As of late, researchers have also begun to illuminate the exact differences in the gastrointestinal tract of autistic individuals through medical procedures. Maffini et al. depicted the gastrointestinal similarities in 24 children between the ages of 4 and 17 years old based on ileocolonscopy and upper endoscopy with multiple biopsy procedures. Mucosal lesions on the ileum and ileal lymphoid nodular hyperplasia were reported in all patients. Additionally, fifty percent of patients exhibited signs of nonspecific inflammatory colitis.[13] The final conclusion was that a correlation between autism and gastrointestinal symptoms does exist; however, the explanation behind the connection remains inconclusive and is dependent on further research.

Research completed on the gastrointestinal flora status of autistic children revealed encouraging results of a link between the brain and the digestive system. After collecting stool samples from 58 children with ASD and 39 ‘healthy typical’ children, researchers performed

several tests, including a bacterial and yeast culture test. Participants' gastrointestinal symptoms and autistic symptoms were evaluated with a modified six-item GI Severity Index (6-GSI) questionnaire and the Autism Treatment Evaluation Checklist (ATEC), respectively.[11] Findings proved a strong correlation between the severity of autism and the severity of gastrointestinal symptoms. This suggests the likelihood of certain autistic behaviors and symptoms being worsened by undiagnosed gastrointestinal issues.[11]

Since it is a question of ethics whether experiments involving autistic children are deemed immoral, numerous studies have opted to base research conclusions on the opinions of caregivers and parents. For this reason, available information on a link between the gastrointestinal functionality and autistic behaviors are contradictory. One such study noted that children with autism experience recurrent digestive problems aggravated by wheat or dairy products.[12] Nevertheless, despite the general agreement that many autistic children have gastrointestinal disease, a research study based on data from the Autistic Genetic Resource Exchange (AGRE), a DNA repository and family registry sponsored by Autism Speaks, denies that such a correlation exists. The 2010 study compiled parental reports distinguishing whether their autistic children and non-autistic children had a gastrointestinal disease. Data confirmed that a significant difference in the presence of a disease, chronic diarrhea, and constipation were noted between affected children and their siblings.[14] However, the authors refute their findings based on the way the information was collected by parents or caregivers retrospectively.[14]

Theories Behind Gastrointestinal Problems in Autism

There are several hypotheses circulating the general public about the one true cause of gastrointestinal distress in autistic children. Although much debate has been over if there even is a correlation between gastrointestinal issues and autism, those that believe it exists cannot agree on a single reason. Of the many theories, some have already been disproven while research is currently being completed on others. Four suppositions will be investigated in this thesis: the hyposecretion of secretin, a possible link with Celiac Disease (CD), the leaky gut hypothesis, and the discovery of autistic enterocolitis.

A lesser-known philosophy behind the gastrointestinal difficulties is the reduced secretion of secretin. Secretin is a hormone released by the duodenum to stimulate secretions by the liver and the pancreas, thus decreasing acidity of the intestinal luminal contents. Without normal amounts of secretin being discharged into the bloodstream, less pancreatic sodium bicarbonate and water will be secreted while more gastric acid will collect in the gut. The result is a disturbance in the pH of the intestinal luminal fluid, which has an optimal level of 7 to 8.[15] In rats, intestinal mucosa exposure to acidic saline for 30 minutes caused drastic injury to the villi and increased the passage of serum albumin from the lumen to the blood.[15]

If research manages to locate a connection between hyposecretion of secretin and autism then the next step would be to test whether elevating the level of serum secretin would help cure this problem. Numerous studies have been completed with mixed results. For example, a study completed in 1999 produced promising results that five weeks of intravenous secretin infusions were adequate in boosting the pancreatic secretory rate to the point of decreased gastrointestinal distress and behavioral issues.[15] However, a meta-analysis of 16 studies published in 2012

concluded that a single or multiple dose of intravenous secretin is not an effective intervention for ASD and therefore should not be propagated as a treatment modality.[16]

Another proposition is that autistic children are more likely to have Celiac disease (CD), which is causing the gastrointestinal problems. CD is an inherited autoimmune disorder resulting in a failure to digest food set off by hypersensitivity of the small intestine to gliadin. In newborns, an estimated 1 in 100 births have an incidence of CD.[17] Persons diagnosed with CD have the presence of IgA and IgG anti-transglutaminase autoantibodies in their system. A 2010 study tested whether a larger number of non-autistic or autistic children had these antibodies in their blood. There was a significant correlation between the IgG anti-transglutaminase and anti-neutrophil cytoplasmic antibody in ASD children, hinting that steroids and anti-inflammatory medications may be useful for gastrointestinal disease in autism.[17] A more recent study completed by the University of Brazil determined the occurrence of CD in ASD individuals and the occurrence of ASD in biopsy-proven CD persons. These researchers investigated the levels of antigliadan antibodies in ASD and non-celiac children, finding no statistical evidence of a correlation between CD and ASD.[18] Nevertheless, this does not mean that an ASD child suffering from gastrointestinal disease is incapable of having CD. A juxtaposition of this theory is the idea that ASD is complemented with an innate immune response to dietary proteins, resulting in gastrointestinal aggravation and behavioral problems.[19] Clearly, more research is needed on this alleged hypothesis.

The autistic child's enhanced intestinal permeability is the foundation for the leaky gut hypothesis, or opioid excess theory. The leaky mucosa allows natural food digestion products to infuse into the blood inducing antibody formation and interfering with the central nervous system. Digestion of dietary gluten by intestinal peptidases in the lumen of the small intestine

releases short chain peptides called exorphins. A type of exorphin, gliadorphin, also called gluteomorphin, is derived from the partial digestion of the wheat protein gliadin. Similarly, casomorphins are peptides obtained from the digestion of the milk protein casein. A current hypothesis is that autistic children with leaky gut syndrome release this compound into the blood, which then passes into the brain and disturbs proper brain function. This belief is supported by an earlier study in rats fed gluten fragments that showed the possibility of exorphins gaining access to the brain and activating certain brain cells.[15]

An infamous study by Andrew Wakefield claiming to discover a new disease called 'autistic enterocolitis' emerged in 1998. The strain was said to be nonspecific because it did not fit in with the criteria for Crohn's disease or ulcerative colitis. In the study, 12 children, 9 of whom had autism, exhibited abnormal colonoscopies; 75% of the subjects had lymphoid nodular hyperplasia and 67% had mucosal abnormalities.[19] Shortly after he published his article, an expert panel had reviewed his experiment, disputing the results as false due to study-design limitations including 'flawed control group, lack of validated and standardized definitions, and speculative interpretation of results.'[20] In conclusion, the autistic enterocolitis strain conjecture has been disproved, but was believed to be a possible cause for gastrointestinal disease in ASD children within the past decade.

The Gluten-Free, Casein-Free (GFCF) Diet

The gluten-free (GF) diet is centralized around the elimination of gluten, a protein composite found in foods processed from wheat. The gluten-free diet is the prescribed medical nutrition therapy for individuals diagnosed with gluten intolerance or Celiac disease. In CD, the intolerance is to gliadin, a component of the gluten complex. This inability to digest gluten results in malabsorption, gastrointestinal distress, and after a period of time malnutrition. Interestingly, Celiac disease is more common in North Americans and Europeans, where wheat is largely consumed, than in Asian or African-Caribbean descendants.[21] Nonetheless, just because the gluten-free diet was created to alleviate the symptoms of CD does not mean individuals without CD will not abide by it. A rise in the popularity of the gluten-free diet has peaked in recent years as celebrities have gravitated toward this diet for the fictitious belief that it is lower in calories and 'healthier.' Furthermore, researchers have been testing the effectiveness of this diet with other diseases, the most notable being autism.

Following a gluten-free diet does not require restriction of all common foods from the diet. According to the Academy of Nutrition and Dietetics' Nutrition Care Manual, there are a number of foods one can consume: amaranth, arrowroot, buckwheat, corn, flax, legumes, millet, nuts, potato, sweet potato, quinoa, rice, seeds, sorghum, tapioca, teff, and wild rice. Oats are still a controversial issue due to the possible contamination during milling; however, pure-uncontaminated oats are considered safe.[22] Milk, aged cheese, unprocessed meats, fish, eggs, dried beans, and all fruits and vegetables are allowed as long as they do not have gluten-containing additives. With the prevalence of CD and rising interest in gluten-free diets, numerous companies have emerged with gluten-free products: Udi's Gluten Free, Bob's Red Mill, Glutino, Glutenfreeda Foods, Enjoy Life Foods, and General Mills. To help instill ease into

individuals' worried of consuming gluten in unwarranted foods, the Gluten-Free Certification Organization (GFCO) of the Gluten Intolerance Group and the Celiac Sprue Association (CSA) have developed gluten-free certification programs. The programs only grant gluten-free certification if the product passes an ingredient review and verification that it is free of wheat, barley, oats and rye and after a provision of written facility procedures and on-site facility audits to assure that procedures are in place to control any cross or outside contamination in processing and packaging.[21]

The three major ingredients to avoid when abiding by a gluten-free diet are wheat, barley, and rye.[22] Foods to steer clear of include beer, bleu cheese, hot dogs, root beer, couscous, pickles, pudding, soy sauce, Twizzlers® licorice, most salad dressings, fried foods, candy, marinades, processed lunch meats, thickeners, gravies, imitation bacon and seafood, natural flavorings and more. People must be aware of how to read a nutrition label and recognize food additives that contain gluten as well. For example, unidentified starch, modified food starch, hydrolyzed vegetable or plant protein, and texturized vegetable protein, contain gluten. Unfortunately an individual's attempt to follow this diet can be thwarted easily by consuming a product that was dusted with a gluten product, such as wheat flour, to prevent it from sticking. In this case, the ingredient list would not even contain wheat flour and could be potentially harmful to the customer. Other non-food items need to be avoided on a gluten-free diet; for instance, unidentified starch, binders and fillers in medications, supplements, or vitamins and adhesives in stamps and stickers and play dough need to be evaded.[22]

Adjusting to a therapeutic diet of any kind can be a struggle. Gluten-free diets in particular require a full lifestyle change since they are usually prescribed for long-term treatment. Dietitians and nutritionists are a valuable resource for individuals starting this diet. People who

are serious about following this diet must continually read ingredient labels to check for harmful fillers or if the manufacturer has changed the ingredients. When eating at a restaurant, the wait staff must be informed, so that adherence to the diet can be achieved.[23] Although the loyalty to this diet may be a nuisance at times, the beneficial effects for the body in those with CD or gluten-intolerance make the hassle worth it.

Rising in popularity is the gluten-free, casein-free (GFCF) diet. The GFCF diet takes the GF diet one step further by also eliminating casein from the diet. About 80% of the protein in cow's milk is casein. Casein is also the part of milk that forms cheese or curds. Individuals with milk allergies may be allergic to whey, casein, or both; milk allergy symptoms present in infants usually subside with age in majority of adults. When following a casein diet, milk, butter, cheese, sour cream, yogurt, ice cream, and other dairy products must be eliminated from meals. Moreover, casein is added to some margarines, soy cheese, and hot dogs for texture in the form of caseinate. A common misconception is that cow's milk is the only milk with casein in it. This is false; casein is present in milk of all mammals including sheep, goats, and even human's breast milk. Infants with a casein allergy can still be breast-fed as long as the mother eliminates dairy and casein products from her diet. Casein is also in adhesives and paints, so infants and toddlers following a GFCF diet must be monitored around these items.

The Reasoning Behind the Usefulness of a GFCF Diet for an Autistic Child

In December 2006, autism was first recognized as a national problem and government funded research began. Due to the lack of knowledge about the etiology of autism, treatments have been tested based on the circulating hypotheses. For example, the GFCF diet gained interest as a possible intervention resulting from the leaky gut hypothesis and high prevalence of autistic children with a comorbidity of gastrointestinal distress. Scientifically and logically, the initiation of this treatment to alleviate certain behavioral symptoms of autism makes sense.

A report claims that 36% of children with ASD have a history of cow's milk or soy protein intolerance during infancy.[19] If the child has not outgrown this allergy or was mistakenly thought to and continued to eat dairy products then suddenly following a GFCF diet would be beneficial. Food allergies are not the only cause of GI inflammation when it comes to food substances. A 2008 study researched why a group of ASD children endured frequent infections compared to other ASD children. There were 138 child participants: 26 ASD children with atopy, asthma, food allergy, primary immunodeficiency, or innate immune responses; 107 ASD controls; 24 non-ASD controls with a food allergy; 38 non-ASD controls with chronic rhinosinusitis/recurrent otitis media; and 43 normal controls. Researchers discovered that children with autism had more pro-inflammatory cytokines following challenge with food proteins from gluten, casein, and soy compared with normal controls and non-autistic children with food allergies.[24]

Elizabeth Strickland, a Registered Dietitian who authored the book *Eating for Autism*, makes the statement that most autistic children are 'problem feeders.' Problem feeders are notably different than the usual classification majority of children receive as 'picky eaters.' There are several characteristics of what constitutes a problem feeder: a very poor diet, a vitamin

and mineral deficiency, eating fewer than 20 foods, eat less over time until only accepting 5-10 foods, refusing an entire texture, and eating the same 'favorite' food every day before burning out and stopping consumption of it for 2 weeks. An average child takes 8-10 exposures to a new food to accept it. Problem feeders are unwilling to eat new food after 10 exposures and refuse to taste new food through a tantrum.[25]

As mentioned previously, approximately one-third of ASD children have a gastrointestinal disorder. A possible explanation for problem feeders is the presence of GI distress caused by a combination of factors including impaired communication, holding in stool, medication side effects, malnutrition, food allergy, inadequate dietary fiber, etc. There are feasible diet-related problems that could be causing GI problems, resulting in associated autistic behaviors. For instance, a nutrient deficiency could cause an ASD child to be irritable and lethargic. Likewise, a nutritional problem that happens when an autistic child fills up on juice and does not want to eat food could produce a tantrum. Unknown food allergies that inflame and irritate the intestine could upset the ASD child when he or she begins to link stomach pain to eating. In these cases, altering the diet could lessen problematic mealtime behavior like refusing to come to the dinner table, refusing to eat, throwing food, and gagging. If the GI distress is a result of adverse reactions to gluten or casein, then the GFCF diet could be used as a logical treatment.[25]

The Gluten-Free, Casein-Free Diet as an Intervention for Autism

To test the logic behind gluten-free diets and the alleviation of certain autistic behavioral symptoms, research has been conducted to evaluate the usefulness of this intervention. Results and conclusions from various studies have been mixed. While some experiments claim beneficial effects, others report no conclusive evidence. Three studies and one systematic review will be addressed to illustrate the wide array of reported findings.

A survey study was published in 2012 completed by the Department of Biobehavioral Health at Pennsylvania State University. Three hundred and eighty seven participants who were parents or primary caregivers of children with diagnosed ASDs completed an online 90-item questionnaire survey over a 5-month period in 2008. All participants were recruited through e-mail listservs, autism organization websites, or word-of mouth with implied consent and no exclusion criteria. Of the participants key components to keep in mind are that 88.9% were Caucasian, 82% were male, and 49.4% had children with diagnosed autistic disorder. Parents who claimed their child followed a GFCF diet stated slight improvements in physiological and ASD-associated behaviors and a significant enhancement with social behaviors compared to parents of ASD children not following a GFCF diet. Parents who reported 'breaking' the diet less often also stated there was a smaller occurrence of ASD behaviors. Parents who utilized the GFCF diet for a less amount of time than other parents reported a higher frequency of ASD-associated symptoms.[26]

Although the findings were promising, there are several issues to keep in mind when considering the strength of the reported results. For example, parental reports are highly subjective. In many American families, men are still considered the breadwinner and may not be around the children as much as the mother, yet 82% of the participants were male. Also, it must

be questioned how many of the participants were completely telling the truth with their answers. Another key point is to consider how many parents or caregivers fully understand what a gluten-free diet consists of and eliminates; they may be feeding children gluten or casein products without realizing it. Despite the questionable methods of the study, the results are promising.

A 2009 study crafted at Vanderbilt University focused on a five-and-a-half year old boy diagnosed with autistic disorder at the age of three as its sole participant. The objective was to test an intervention implemented through the parameters of a GFCF diet with an autistic child with food selectivity. The boy's mother completed a 7-day food diary to evaluate the amount of food, time it was offered, which food, if it was eaten when offered, and behavioral problems during mealtimes her son exhibited. The behaviors that were gauged included food consumption, rejection, gagging, and escapes (e.g. leaving the table). Thirty-nine fifteen-minute sessions were tape recorded by two observers and incidences were recorded if the individuals were in agreement of their classification. The three phases of sessions used were food consumption assessments, baseline and probes, and intervention. Results showed that the boy tried to escape the table less when new foods similar to old foods were introduced. Escapes increased with the presence of reinforcement techniques and physical prompting; there were no noted escapes during baseline sessions. Overall the number and variety of foods eaten by the participant increased from baseline.[27]

The most prominent limitation of this study is the fact it has only one participant. Results may not be replicated in children who are not classified on the same part of the spectrum. Also, there was no data collected in the journal completed by the mother on the boy's reaction to typical meals. This made efforts of comparing his behavior towards a GFCF regiment to a regular diet difficult to assess. In addition, foods were presented in bite-size pieces rather than

the size of a regular portion, which could have a lesser effect on his behavior. Finally, intervention sessions took place an hour before mealtimes when the boy may have been hungry and more willing to eat new foods.[27] Nevertheless, this study could influence parents to try a GFCF diet if their ASD child exhibits food selectivity.

The Scandinavian-British collaborative research group conducted a randomized, controlled sing-blind study to test the effects of a GFCF diet intervention for children with a diagnosed ASD. The study was conducted from April 2006 to October 2008 at the Center for Autisme in Denmark, and was broken into two stages. Seventy-two children with diagnosed ASD between the ages of four to 10 years 11 months were involved in the study. Stage 1 randomly divided participants into either a group following a GFCF diet or the control group that followed a non-therapeutic diet. During this stage, core autism behaviors, the developmental level, and the level of inattention and hyperactivity of each child were ascertained for 26 diet children and 29 controls at the beginning of the trial, at 8 months, and 12 months. Stage 2 reassigned control participants to active treatment for the last 12 months and then collected the same data from a random 18 diet children and 17 previous controls at 24 months. At 8 months, significant changes on the core autism behaviors were recorded for children following a GFCF diet. Only some participants who ate the GFCF diet for the whole study showed improvements in social interactions and repetitive behaviors. The positive effects of a GFCF diet reached a plateau after 8 months in most subjects with respect to improvement in core autism behaviors. Variations in scores, emphasized differences of among participants within the two groups in the level of response to the diet.[28]

Even though this study had the largest number of participants to-date for this specific intervention, a larger sample size may have strengthened the results. Also, this study was only

completed for 24 months; it would have been interesting to see results after two more years to observe if the plateau after 12 months continued. No placebo was utilized to classify it as a double-blind study, which could have offered more insight into the seemingly beneficial results of a gluten-free, casein-free diet.

A systematic review published in 2009 compared the participants, specifics of intervention, dependent variables, results, and certainty of evidence in fourteen different articles that tested the effects of GF, casein-free (CF) and GFCF diets in the treatment of ASD that fit the inclusion criteria. In the combined fourteen studies, there were 188 participants, 67% of the subjects were male, 93% were diagnosed with autism or Asperger syndrome, and all individuals were between the ages of 2 and 7 years old. The interventions used included studies that took place 4 days to 4 years with an average of 10 months and may have included vitamin supplementation or other intervention components during implementation of the GFCF diet. Dependent variables were either behavioral, such as communication, play, and challenging behavior, or biomedical variables. Seven studies reported positive results, four claimed negative results, two reported mixed results and one study could not determine results based on the intervention. Of the studies, all positive result studies were classified at the lowest level of certainty; the four negative result studies ranked at the second highest level of validity; and no studies provided conclusive evidence. The conclusion of the systemic review was that this intervention requires more research, and that currently GFCF diets cannot be supported for the treatment of ASD. Therefore, GFCF diets should only be followed in ASD children, if the child is diagnosed with a gluten-intolerance or Celiac disease.[29]

The Academy of Nutrition and Dietetics released a statement regarding the current status of research based on GFCF diets for children with autism in January of 2009. In the article,

attention is brought to the drawbacks of the GFCF diet: intricacy for parents to follow the diet modifications for meal preparation, higher cost of food, and increased time for meal preparation. Following a GFCF diet could result in decreased nutrition in the form of essential amino acid deficiencies and bone loss noted in children of past studies. The Academy agrees with all of the studies previously discussed that more research is needed to determine the efficacy of this dietary intervention in autism. In conclusion, they call on food and nutrition professionals to ensure the health and safety of autistic children whose parents have decided to start this dietary regimen.[30]

Interview with Corrine Bieber

To gain further insight into the effectiveness of a gluten-free diet on autism associated behaviors, a supplemental interview has been included. This individual has had direct experience working with ASD diagnosed children following a GFCF diet. She researched the efficacy of a gluten-free, casein-free diet and agreed to offer her personal experience and knowledge about the issue. Utilizing the opinion of an unbiased third party aware of the research offers a general perspective rather than one simply based on experimentation or parental reports.

Q: What experience have you had working with children diagnosed with ASD?

A: I have had countless experiences over the past two years working with children on the spectrum. I work direct care with them, assisting with their unique needs. From supervision and guidance, to help with all ADL's (activities of daily living.) This entirely depends on the child and can vary from day to day.

Q: Where has this experience taken place? How long? How in-depth were your interactions?

A: I work for Family and Children Services and have for the past two years. I was a lead direct care staff on shifts with the children. During the shifts all interactions are very in-depth. Myself and the other staff provide all care to the kids during the time we are on shift. As a lead staff, I was also the one responsible for passing their medications and helping out with anything the staff needed.

Q: At what end of the spectrum are these children? Please describe behavioral, communicative, developmental, and social characteristics.

A: This varies from child to child. Some children are very high functioning and may just be a little shy or socially awkward. Other children are non-verbal, exhibit physically aggressive behaviors, become over stimulated easily, and need help with all ADL's including toileting, etc.

Q: Are you familiar with the concept of a GFCF diet being used for autism?

A: I have vast understanding of both the gluten-free, casein-free diet and autism. Many parents are trying this diet in the hopes to improve the behaviors in their children.

Q: Where/how did you gained your knowledge of this topic? Has this past knowledge made you bias on this issue in any way?

A: I have gained this knowledge while working with the kids, talking to the parents, and through my schooling. I have a bachelor's of science degree in dietetics, and as a dietetic intern I have spent time researching this topic on my own out of pure personal interest. Because of this interest, I read the book: *Eating for Autism*.

Q: Are you aware of any ASD children you interacted with being treated with a GFCF diet?

A: Not a huge percentage, but multiple kids in our program are on a GFCF diet. Some of these children are on the autism spectrum and others have been diagnosed with ADHD.

Q: From your standpoint, do you see any difference in the behavior of the ASD children following this diet?

A: I personally have not seen any changes in the behavior of the children. They are very particular about food and often refuse to eat the gluten free foods that are offered. They have become agitated at meal times because of this.

Q: In what ways are they following a GFCF diet?

A: Another issue is compliance. Parents often have the best intentions, but for most of our staff and most of the parents, the necessary knowledge is not there. Some kids are on "gluten-free, casein-free" diets, but are then allowed to eat things that I happen to know have gluten in them. The parents will talk about behavioral improvements, but will allow their kids to

eat breaded chicken nuggets, fruit snacks that are not gluten free etc. Whether they realize it or not, compliance is typically not occurring.

Q: Have you noticed any inconsistencies in their faithfulness to this diet?

A: Due to behaviors and a lack of knowledge of parents and other direct care staff there are many inconsistencies.

Q: What is your opinion of parents' knowledge of what constitutes a GFCF diet?

A: Parents seem to think that gluten-free means no normal bread, noodles, cereal, etc. They are completely forgetting about those hidden ingredients on food labels.

Q: From your perspective, is it possible that a lack or skewed understanding of a gluten-free diet is the reason it has had no effects on behavioral symptoms of ASD?

A: This may very well be the case, however we have also had children strictly follow gluten-free, casein-free diets and still no behavioral changes can be noted. Much more research needs to be done at this point.

Q: From your standpoint, do you see any difference in the behavior of the ASD children following this diet?

A: None at all. I am not their parent, but in the two years of working with the kids, I have not seen changes that can be attributed to diet.

Q: Overall, what is your personal opinion of the effectiveness of this treatment, if any?

A: More research needs to be done and the lack of education parents have makes it nearly impossible to judge.

Conclusion

While some research studies support the use of a GFCF diet to assist in treating autism, no substantial evidence has been found. The current studies are conflicting and suffer from design flaws. An interview with an unbiased individual and an examination of up-to-date research trials concludes there is no relationship between the GFCF diet and an amelioration of ASD core symptoms. More high-quality research is needed on the subject. Even though the logic behind its potential makes sense, there is no substantial evidence of any beneficial results. For autistic children with food selectivity or gastrointestinal disorders caused by certain foods, a restricted diet could help gradually introduce new foods and heal the inflamed villi in the intestine. These both have the capacity to decrease the occurrence and event of behavioral episodes at meal times. If the autistic child also has Celiac Disease, a GF diet would be a necessary and beneficial lifestyle change, but may not affect the core autism symptoms. A major flaw with the proposed potential cures and treatments for autism is the lack of a defined etiology. No one has discovered a genetic link or single or multi-factorial cause of autism; therefore, no foolproof cure can be prepared. All that exist is a general understanding of the coinciding behaviors and developmental characteristics that occur. As a result, treatments like the GFCF diet are aimed at the characteristics associated with autism.

Some studies have reported promising findings on a GFCF diet. Unfortunately, most of the published studies that reported beneficial findings were of the lowest level of certainty. Furthermore, many studies based positive outcomes on biased parental reports. All of the studies reported were done on autistic children. Symptoms of autism especially repetitive behaviors, problems with non-verbal and verbal communications, lack of empathy, need for routine do not

disappear completely with age. More research is needed on the efficacy of the GFCF diet and autistic adults.

Additional studies are required to provide solid evidence on the usefulness of the GFCF diet in autism in general. An ideal study would be a randomized, double blind, controlled study with a follow-up greater than four years. The sample size would be greater than 100 participants between the ages of 3 and 15 years old, who fit the inclusion criteria of 1) diagnosis of an ASD, 2) diagnosis of a gastrointestinal disease based on biopsy results, 3) proof of misbehaving at mealtimes or in the presence of food. For the experimental group receiving the GFCF diet, researchers would have to fully understand what foods can and cannot be administered. If beneficial results were discovered after 2 years, the control group would also be switched to the GFCF diet. At baseline and one year into the study, a biopsy should be completed on the experimental group, with consent of the child and parents, to confirm the improved condition of the small intestine. All children would be monitored closely by a Registered Dietitian, who would provide additional supplements if needed.

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