Nutrition and ADHD in children from ages 6-12: Can nutrition make a difference?

A Literature Review

By

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M.P.H., Emory University, 2011
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A literature review submitted to the
Career Master of Public Health Program
The Rollins School of Public Health of Emory University
in partial fulfillment of the requirements of the degree of
Master of Public Health
2011

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Degree to be awarded: M.P.H.
Career MPH

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ACKNOWLEDGEMENTS

I would like to thank Dr. Kathy Miner and Ann Duttera Council for their guidance, encouragement and especially, their patience. The gentle prodding will always be appreciated and although I didn't believe that I could accomplish this, both Dr. Miner and Ann believed in me and for this, I will always be grateful.

I would also like to thank my parents, my husband and my two sons, all of whom have been patiently watching as I persued this feat. I am grateful that my family has been willing to take on some of my "mom" duties while I worked through this part of my Masters. Everyone's help has been wonderful.

I also want to thank my two sons, Charlie and James, for being a part of our own experiment with nutrition. I know that it wasn't always easy to consume the particular foods I asked of them and I appreciate their tolerance. I realize that children with ADHD are unique and creative people that are challenged with both strengths and weaknesses and who benefit from emotional and physical health in a multitude of environments. Thank you for the invaluable knowledge!

Abstract

Attention Deficit/Hyperactivity Disorder (ADHD) is a prevalent and chronic childhood disorder for which no specific origin has been identified. If left untreated and undiagnosed, ADHD can have devastating effects on both the children and their families. To date, public health agencies have not implemented a population wide intervention to address the health consequences associated with ADHD. Some of the health threatening behavior includes alcohol and drug abuse, risky sexual behavior involving multiple partners and/or contraceptive nonuse. Adolescents diagnosed with ADHD are more likely to utilize the health care and mental health care systems and it is estimated that children with ADHD have ten times more health care costs than children without ADHD (Rowland, Lesesne & Abramowitz, 2002). Furthermore, individuals with ADHD have approximately 50% more driving violations and are three times more likely to have accidents that result in severe vehicle damage (Barkley, Murphy & Kwasnik, 1996). If unrecognized and untreated, children with ADHD have consistent academic impairment that can continue into high school, resulting in leaving school before graduation. Sears and Thompson (1998) report that 20-30% of adolescents diagnosed with ADHD have problems with the law and preschoolers diagnosed with ADHD have extensive social problems that can last throughout life.

It is assumed that early intervention can reduce the high risk behaviors and consequences associated with ADHD but long term public health studies are needed in order to address and possibly reduce health threatening behaviors associated with ADHD in the population by intervening with successful treatment options. Because of the diverse nature of the disorder, variables like prevalence and how that might vary by socio-

economic status, race, gender and age have yet to be investigated thoroughly. Other questions unanswered include how effective are current treatment options, is there a subset of children who respond better to some treatment options than other children and are there other nongenetic risk factors that can be prevented. Furthermore, prevention efforts can be developed to reduce risk and to improve the health of children, adolescents and adults with ADHD.

Treatment strategies for children with ADHD can be far reaching and controversial. Restrictive diets, fatty acid supplementation, chiropractors, biofeedback therapy, and central nervous stimulants are a few such strategies. Special diets and nutritional supplementation are among the most popular alternative methods to treat ADHD. The following literature review will describe the historic and current nutrition related interventions associated with the treatment of children, aged 6-12 who have been diagnosed with ADHD by reviewing published empirical findings that explore the effectiveness of diet and nutritional management of children with ADHD.

Table of Contents

List of Tables

Introduction

Attention-Deficit/Hyperactivity Disorder (ADHD), as defined by the fourth edition of the Diagnostic and Statistical Manual of Mental Disorder-Text Revision (DSM-IV-TR) appears in early childhood and results in difficulties with inattention, impulsivity and hyperactivity (Table 1). The problem is usually diagnosed at around age seven, the time when children are expected to sit still and pay attention in school. The most commonly observed and reported signs include inattention (not paying attention while being taught or spoken to, nor sticking with an assigned task), hyper focus (becoming overly engrossed in self-selected activities such as watching television or playing video games), distractibility (attending to too many activities at one time, moving from one idea to another without completing any one of them), impulsivity (acting and speaking without thinking), and hyperactivity (the constant movement that has become the most frequently recognized signal that a child may have ADHD).

According to the DSM-IV, there are three subtypes of ADHD: (a) predominantly impulsive/hyperactive type, (b) predominately inattentive type, and (c) combined type (both inattentive symptomatology and hyperactivity/impulsivity). According to the DSM-IV, a child's symptoms must be "present before the age of seven, must create impairment in two or more settings (for example, school, home and/or neighborhood) and must cause clinically significant impairment in social, academic, or occupational functioning" (American Psychiatric Association, [APA], 2000). Additionally, the inattention and/or hyperactivity must not be due to any other diagnosis or other disorder since such symptoms can be accompanied by other conditions such as a learning disability, conduct disorder and anxiety disorder. Impulsiveness and difficulty with delay of gratification are

behavioral components of children under the age of seven and are also symptoms of ADHD and thus, diagnosis of ADHD is difficult (Young, Friedman, Miyake, Willcut, Corley & Haberstick, 2009).

Until recently, ADHD was not diagnosed through laboratory testing, but through observations made by teachers, parents, and medical professionals. The 1990s saw an increase in sophisticated brain scans, molecular genetic studies and neuroimaging which can currently diagnose ADHD, but results from these tests are considered preliminary. The newer technologies are still in an infancy stage and because of expense; the sample population is too small to be considered significant (Castellanos, 2001). The DSM-IV defines ADHD as a collection of traits that needs to be present for at least six months, must have begun before age seven, and be severe and persistent enough to be considered inconsistent with a child's developmental level. Furthermore, DSM-IV requires six of its nine characteristics of inattention or six of its nine characteristics of hyperactivity and impulsivity to be met. The behaviors must be exhibited at home and at school and be causing "significant distress or impairment in functioning" (Diller, 2000 p. 56).

Pediatricians, psychiatrists, and psychologists use these criteria when making a diagnosis although individuals may add selected, individualized criteria to their evaluations. The Conners Behavioral Rating Scale (Table 2) is an example of the type of observations which parents and classroom teachers are asked to note and record during the diagnostic phase of treatment. It is available only through licensed psychologists and therefore, only the short form is available for the public.

In May 2000, the American Academy of Pediatrics (AAP) issued its first guidelines for diagnosing ADHD, intended for children ages 6 to 12. The guidelines were

the same as those already in place from the DSM-IV but were significant in that it was the first time pediatricians had their own set of standards to follow and the first time they have been called upon to take on a leadership role in ADHD treatment. The issuance was also timely due to the increasing number of children being referred for diagnosis, and their parents' growing tendency to seek diagnosis and advice from a pediatrician rather than from a psychiatrist. The requirement for the behavior to be recognized both at home and at school may make it less likely that naturally overactive preschoolers will be misdiagnosed, while ensuring that children who truly need help will get it.

The current estimate of children diagnosed with ADHD is approximately 3-5% of the population but without a standardized surveillance system to monitor prevalence, there is discrepancy with this estimate. The ADHD combined type appears more frequently than the predominantly hyperactive-impulsive type in clinic samples, whereas the inattentive type occurs more frequently than the other two subtypes in community samples (Anastopoulos, Klinger & Temple, 2001; DSM-IV-TR, 2000). In examining differences between boys and girls, studies have suggested that males are approximately three times more likely than females to have ADHD (Barkley, 1998). Simple attention deficits, however, may occur with equal frequency in both boys and girls. Research has revealed that boys out number girls in diagnosed cases of ADHD across all subtypes with estimated ratio of 3:1 (Anastopoulos et al, 2001).

In general, it appears that boys exhibit more behavioral problems than girls, which may, in part, explain why they are diagnosed with ADHD at greater rates. While girls are less likely to demonstrate symptoms of ADHD, varying estimates of the ratio of boys to girls have been described. Reported difference estimates of ADHD diagnoses have

ranged from 2:1 to 9:1 boys to girls, with gender differences less obvious for the inattentive subtype of ADHD (APA, 2000): "Boys are five to nine times more likely to be affected with ADHD than girls" (Williams, Wright & Partridge, 1999, p. 565). This suggests the possibility that hyperactivity is a more common reported symptom in boys, which may have implications for treatment strategy acceptability and selection for ADHD. Likewise, it may be possible that teachers or parents would be more accepting of more restrictive treatments, such as medication for children who are more hyperactive than inattentive. Therefore, since boys demonstrate more of the hyperactivity than girls in general, more boys may be selected as candidates for treatment.

Why nutrition? It is widely accepted that all cells in the human body need minute amounts of vitamins and minerals. Colby and Morley (1983) noted that some vitamins and minerals are vital structural and functional components of enzymes that allow cells to function properly. If the appropriate amounts of vitamins and minerals are not available, then the cell will not perform at its highest level. To ensure proper performance of cells and organs, the body and brain require the correct amount and type of nutrients.

So how does nutrition relate to brain and cognitive functioning? Linus Pauling (1968) had an article published in the journal *Science* that stated that by varying the concentrations of substances (vitamins and minerals) normally present in the human, it might be possible to improve how the brain functions. He called this orthomolecular therapy. The chemical composition of the brain is dependent on the vitamins and minerals in the diet as well as the rate of chemical reactions that are influenced by both genetics and diet. Pauling believed that vitamin therapy could restore the optimum molecular environment of the brain. An increased rate of metabolism of a vital substance

in the brain may cause low concentration in the brain while at the same time the concentration in the blood and lymph are normal. A mentally ill person may not have a vitamin deficiency according to the recommended dietary allowances but may have far from optimum concentrations necessary for normal brain functioning. Pauling believed that mentally ill patients could be treated with vitamin therapy to restore the optimum molecular environment of the brain and thus, the ability to function at a higher level. Pauling stated that this was a very difficult area to research because every person's needs of vitamins and minerals are unique due to differences in the way they metabolize food, the variety of foods and different amount they eat, and different genetic constitutions. Pauling's article advanced the controversial idea that our brain chemistry is altered by the kind and amount of foods, vitamins, and minerals we consume.

There is some support to Pauling's idea that what is digested affects the chemistry in the brain. A study by Yokogoshi and Nomura (1991) using rats on a low protein diet found sharp decreases in the concentration of brain tryptophan, serotonin, and 5-hydroxyindole acetic acid. An experimental group of rats was given amino acid supplementation while the control group was not given any. The experimental group of rats significantly outperformed the control group. It was concluded that learning ability is correlated with nutritional state and thus, diet is correlated with cognitive functioning in humans while malnutrition may be related to poor learning performance.

Method

The PubMed database was searched for articles that refer to treatments, alternative and conventional, regarding pediatric ADHD. Private data bases such as the Journal of the American Medical Association Journal (JAMA), Children and Adults with Attention Deficit/Hyperactivity Disorder website (CHADD) and Science Direct were also utilized. Search terms included: nutrition management as an alternative treatment for ADHD males (ages 6-12), alternative and/or complementary medicine and ADHD, nutrition use, diet management and ADHD children, nutritional supplementation for male children with ADHD, and various other combinations of these terms. Limits used for Pub Med searches were: human subjects, English language, males, aged 6-12, publication date within the last twenty years (1990-2010). Because ADHD is associated with other mental disorders and/or learning disabilities, articles were omitted when referring to ADHD and another diagnosis.

Hyperactivity and/or restless children was described as early as 1902 by Dr. George Still and the first stimulant used to treat this symptom (amphetamine) was prescribed in 1937 (Williams et al. 1999). Although the Pub Med limits were for research within the past 20 years, there were pertinent studies that were utilized in this review that date to the early 1960s. Furthermore, most of the research obtained includes both males and females subjects and thus, the limit of "males" was dropped and this review instead refers to research of both females and males or, children, with ADHD. To meet the selection criteria, interventions must have had a component that specifically addressed school aged children and therefore, articles containing preschool (ADHD is diagnosed before the age of seven), elementary/middle school aged and a few articles involving adolescent aged (12-18) children were included as well.

All articles were placed in chronological order according to publish date with the earliest (1968) being first and the most current (2009) being last. Once the articles were placed into chronological order, they were then divided up according to which alternative treatment was addressed. For example, a number of articles referred to multivitamin supplementation and therefore, all articles citing any study that utilized multivitamin therapy were also organized chronologically by publish date. This organization continued with each type of alternative treatment having to do with diet and/or nutrition and ADHD symptoms. Therefore, all articles were ordered according to publish date and then again regarding intervention strategy utilized. Research dealing with medication as a treatment was reviewed but omitted. For the case of this review, the meaning of diet and nutrition are interchangeable and the definition of hyperkinesis is in regard to ADHD hyperactivity.

Research

At least 50 years of research and anecdotal recording of observation suggest a link between nutrition and the effective treatment, management, or control of ADHD. The following review will address the research that implies that nutrition might have an effect on ADHD symptoms. Any literature review that addresses diet and ADHD would not be complete without first discussing the Feingold diet.

Diet and Behavior

It was Doctor Benjamin Feingold, M.D., who brought national attention to the dietary treatment of ADHD. Writing in his now classic, *Why Your Child is Hyperactive*, Feingold traced his realization of the relationship between diet and behavior to the year 1965, when a patient with acute hives sought his treatment. He placed her on an elimination diet to control the hives, but during the two week treatment period, an unexpected and unsolicited result occurred. Her normally aggressive and hostile behavior, for which she had undergone psychotherapy for two years, seemed to disappear along with the hives. Feingold had been completely unaware of the psychological difficulties the woman had experienced. She reported to him that as long as she remained on the prescribed diet, one that eliminated artificial food colors and flavors, the giant hives disappeared as well as the negative behaviors. Any infraction of the diet "brought back the full constellation of previous complaints" (p. 2).

Scientific research regards one case such as Feingold reported to be a mere coincidence. Pure science does not accept observation and case history as definitive evidence, and so the scientific community largely dismissed Feingold's theory.

Nevertheless, Feingold's curiosity was now aroused and he documented observations and case histories collected from his pediatrics practice in San Francisco, California, and published them in *Why Your Child is Hyperactive*, (1974). His book chronicles cases of both children and adults who suffered from allergies, learning disabilities, and a host of erratic and difficult behaviors who were helped through his elimination diet.

Feingold's revolutionary hypothesis purported that diet could control allergy and attention deficit disorder (the addition of hyperactivity to the syndrome's description did not exist at the time and was not added until the revised version of the DSM-IV in 2000). Feingold continued his study, specifically with artificial food colors, stating that they "can behave in the human body in the same manner as a 'drug' used for medication" (p. 6). He was also concerned about acetylsalicylic acid, known as aspirin, because so many of his patients used it to treat minor medical ailments at the time: colds, headache, arthritis, etc. He knew that like any drug, aspirin could have both beneficial and unwanted reactions.

Eventually, Feingold designed a salicylate free diet that not only eliminated aspirin, but naturally occurring salicylates as well, including foods such as tomatoes, prunes, apricots, plums, peaches, raspberries, oranges, grapes and cucumbers (Table 3). With so many popular and otherwise nutritious foods on the list, it was easy to see why so few people were willing to try his radical approach, but Feingold held fast: "patients afflicted with salicylate sensitivity usually prefer diet to agony" (p. 7). Feingold, contemplating retirement before this discovery, now threw himself full tilt into what has remained a controversial issue for over fifty years. He believed that behavior could be controlled through diet. Feingold theorized that problem behaviors in his patients could

be relieved, controlled, or totally eliminated by removing salicylates, synthetic flavorings, preservatives, and synthetic colorings from the diet. In 1974, Feingold wrote of food additives: “Aside from basic toxicity tests, no one knows very much about the long-term effects, the possible residuals of many of these individual chemicals, let alone the mixing of a half dozen or more” (p. 125).

The use of prescription medication has been proven to be the most effective short term method to control ADHD symptoms, is simple to administer, and is widely accepted by the scientific and medical communities as well as by the American public. Feingold believed that long-term use of methylphenidate hydrochloride, (marketed today as Ritalin, and referred to in the shortened form, methylphenidate), could cause as many problems for children when used over a long period of time as it might solve short term. He claimed that 50% of his patients exhibited improved behavior and relief of symptoms when using his elimination diet. He is considered a pioneer in the natural treatment of ADHD, and an organization named in his honor and devoted to his treatment philosophy, Feingold Association of the United States, has worldwide affiliates and continues his work today.

Hersey, continuing Feingold's work, wrote in 1996, “even more surprising was the discovery that the same food or chemical which could bring about a case of hives in one patient could result in distractibility for another, and unprovoked anger in a third. In other words, substances that cause a reaction on one organ, our skin, can also affect another organ, our brain” (p. 84). Hersey provided a list of approximately 200 additives, both natural and chemical, that are commonly found in foods; of these, 50 are either forbidden or suspect by the Feingold program for chemically sensitive individuals.

The food and drug industries routinely rely on additives for the palatability, eye appeal, and shelf life of their packaged products, and most consumers are unaware that potential problems are associated with frequently used abbreviations such as BHA (butylated hydroxyanisole) or BHT (butylated hydroxytoluene). Chemically sensitive individuals continually wrestle with the problems these additives cause. What does scientific evidence tell us concerning behavior and the additives used in packaged foods?

Chronological description of nutritional intervention studies

In 1976, Conners, Goyette, Southwick, Lees, and Andruionis performed a double-blind crossover trial on 15 hyperkinetic (hyperactive) children between the ages of 6 and 12 who had exhibited symptoms of the disorder for at least two years. They remained on a controlled diet for twelve weeks, with their teachers unaware of when the children were on either the experimental or control program. Both teachers and parents observed fewer hyperkinetic symptoms during the additive free diet phase than during baseline, with the teachers noting the most significant reduction. Conners et al. offered the explanation that teachers are able to compare the children's behavior over many months to others with normal behavior, and because of the structured situation, specific task requirements, expectation for attention, and goal orientation are greater in the classroom than at home, improvements in these areas will be more evident to teachers.

In 1980, Swanson and Kinsbourne studied 40 children who were given a diet that was free of additives and artificial food dyes for five days. When these children were challenged with a food dye, they reported a dye-induced impairment of performance on a laboratory learning test. It took approximately ½ hour for the effect of the dose of food

dye to become evident, it reached its maximum by 1½ hours, and lasted at least 3½ hours, the approximate amount of time left in a school day after a child might ingest dyes from his lunch foods. Since a large number of aggressive, problematic behaviors in children occur during the after lunch recess periods, it is possible that this chemical ingestion might be a contributing factor in those problems.

Augustine and Levitan also studied food dyes in 1980, suggesting that the use of the food additive, erythrosine (FD&C No. 3) be reexamined after it showed "an irreversible, dose-dependent increase in neurotransmitter release" (p. 1489). It was determined, therefore, that their findings were consistent with previous studies, suggesting that erythrosine and other food additives can change behavior and its use should be reconsidered. The researchers concluded that the food additive increased activity in a subset of children that was beyond normal physiological stimulation. Their use of the term "subset of children who respond adversely to food additives" (p. 245) was particularly significant, for the medical community concerns itself with the majority population, and although it was becoming obvious that only some children were having difficulty with the additives, it was this population that was having trouble learning and behaving, and it was this population that could be helped by removing offending substances from their diets. In further testing, Augustine and Levitan observed that erythrosine increased neurotransmitter release in the brains of laboratory animals, dramatically and irreversibly altering synaptic transmissions in their brains, and altering the permeability of neuronal membranes and thus, recommended that the dye be eliminated from the diet.

Egger, Carter, Graham, Gumley, and Soothill (1985) tested the effects of colorants and preservatives on 76 children who were labeled as "socially handicapped" due to their defiant behavior and lack of social skills. The children were placed on an oligoantigenic diet (one that contained few foods). Improvement was noted in 62 patients, and completely normal behavior was achieved in 21 children. Their parents deemed the changes in their children's behavior "remarkable" when the offending colorants and preservatives were removed (p. 545). "Symptoms returned or were exacerbated much more often when patients were on active material than on placebo. Forty-eight foods were incriminated. Artificial colorants and preservatives were the commonest provoking substances, but no child was sensitive to these alone" (p. 540).

Kaplan, McNicol, Conte, and Moghdam (1989) gathered evidence from their study of 24 male children who showed 50% improvement in behavior and sleep habits when they received multivitamin supplements at the same time that food dyes, food flavorings, preservatives, monosodium glutamate, chocolate, and caffeine were removed from their diets. "According to the parental report, more than half of the subjects exhibited a reliable improvement in behavior and negligible placebo effects" (p. 7). Thus, he suggested that pediatricians and other practitioners consider dietary modifications.

Ward et al. (1990) looked at the zinc status of 20 hyperactive male children, comparing them with 20 age-matched controls in response to the chemical additive tartrazine, commonly found in commercial orange beverages. Zinc was of interest to Ward because zinc deficiency had been implicated in studies on aggression. The hyperactive children showed a reduction in saliva and serum concentrations and a corresponding deterioration in behavior/emotional responses when the tartrazine was

ingested. When tartrazine was removed from the diet, zinc saliva and serum concentrations normalized and behavioral responses were reported to be less problematic.

Schoenthaler, Moody, and Pankow (1991) reviewed empirical studies from 813 state facilities in California conducted over a period of ten years. Results showed that inadequate vitamin-mineral intake can adversely impact behavior in children and that nutrition needs to be considered in the presence of violence, conduct disorders, poor academic performance, and low non-verbal intelligence. Poor nutritional habits in children can lead to low concentrations of water-soluble vitamins in the blood, impair brain function and subsequently cause violence and other serious antisocial behavior. The authors suggest that a proper amount of nutrient intake, either through a well-balanced diet or low-dose vitamin-mineral supplementation, corrects the low concentrations of vitamins in blood, improves brain function and subsequently lowers antisocial behavior.

Egger, Stolla, and McEwen (1993) replied to a group of researchers who found fault with their suggestion that an allergic mechanism is involved when children react to foods, by referring to four trials which had shown that "in some children the hyperkinetic syndrome is provoked by foods and /or other additives" (p.115). Egger felt that wrangling over use of the term allergy provided no relief to patients, while treatment (removing suspected offending foods) did. Egger concluded: "Our trial was conducted over 3-5 years and demonstrated an unequivocal and consistent response to the active EPD (enzyme potentiated desensitization) formulation" (p.115). Egger found that "… stopping or continuation of provoking food is a simple, unequivocal and realistic outcome measure that answered directly the question that was the aim of the trial" (p. 115).

Boris and Mandel (1994) supported the earlier findings of Egger et al. (1985) and Kaplan et al. (1989) when they studied 26 children and found improvement in nineteen of them through an elimination diet. Their study demonstrated "a beneficial effect of eliminating reactive foods and artificial colors in children with ADHD. Dietary factors may play a significant role in the etiology of the majority of children with ADHD" (p. 462). They suggested that through a simple elimination diet, symptoms can be controlled. "Elimination of the causes of ADHD is preferable to the pharmacologic therapy of this condition" (p. 467). The work of Boris and Mandel supported the assumption that dietary factors affect ADHD symptoms, as well as the premise that natural treatments be considered before conventional drug therapy is employed.

Rowe and Rowe (1994) studied 200 children, 150 of whom improved on an elimination diet and worsened with the reintroduction of synthetic food colorings in the areas of irritability/control, sleep disturbance, restlessness, aggression, and attention span. A second test involved 54 children in a double-blind study for three to six months. All children were within the normal range for behavior when not exposed to the synthetic coloring. "The data identified consistent variations in behavior for at least five of the six dose challenges in 24 of the 54 participating subjects. Moreover, the amplitude and duration of effect increased with increasing dosage levels." (p. 695).

Schmidt et al. (1997) compared the few foods diet to methylphenidate treatment in 49 children, concluding that "dietary treatment cannot be neglected as a possible access to treating hyperactive /disruptive children and merits further investigation" (p. 88). Jacobson and Schardt (1999) compiled a review of 23 relevant studies conducted in the last quarter century for the Center for Science in the Public Interest (CSPI). Their

executive summary captured the ongoing dilemma for affected families, and set the stage for continuing investigations of the problem. The CSPI report recommended that the potential for diet to affect behavior should be acknowledged and that "parents should consider dietary changes (along with behavioral therapy) as the first course of treatment for children with behavioral problems before turning to stimulant drugs" (p. iii).

Discussion

Questions have been raised about whether nutrition treatment options provide better benefit than prescription medication for ADHD children. It is important from a health prevention stand point to try to find long-term solutions to the problems associated with ADHD. The theoretical framework for dietary interventions or strategies focuses on the idea that ADHD individuals are receiving either too much or too little of a particular substance, which results in an imbalance, which ultimately leads to the manifestation of symptoms. The therapeutic approach is to eliminate or supplement with, the substance or substances that are causing the symptoms to occur.

Sinha and Efron (2005) found that the most common interventions for ADHD were modified diets, vitamins/mineral therapy, and other dietary supplements. Stubberfield, Wray and Parry (1999) conducted a survey with parents of ADHD children and found that diet therapies were utilized with 60% of the respondents. The study found that the most commonly utilized treatment was restricted dietary therapies, vitamin supplementation, and occupational therapy. Varley (1984) found that 80% of clinic patients had implemented a specialized diet for ADHD. Diet modification, although time consuming, is appealing to parents as it promotes their own sense of control (Rojas & Chan, 2005).

CSPI reviewed more than 20 controlled studies of diet and behavior in an effort to improve understanding of the diet/behavior relationship for American children which is now organized into a meaningful body of literature, available to the public under the title *Diet, ADHD, & Behavior*. Results of studies conducted for the last quarter century are condensed and concisely explained in clear and readily understandable language, and the

information is scientific and statistically significant. It is a concrete testament to the efficacy of this treatment approach, and provides an excellent starting point for parents exploring the dietary management format.

Sugar-free Diet

The idea that refined sugars have a strong impact on behavior is a popular belief (Rojas & Chan, 2005). Historically, there have been a few studies to report that sugar has an adverse effect on behavior (Prinz & Riddle, 1986). Most research studies, however, have not supported this notion (Spring, Chiodo, & Bowen, 1987). Wolraich, Wilson, and White (1995) reviewed a study that looked at the effect of sugar on behavior in children diagnosed with hyperactivity. In their review, Wolraich et al. concluded that overall sugar appeared to have no effect on the behavior or cognition of children. It could not be ruled out that sugar did affect specific subsets of children, though which subsets or why could not be determined from their research.

In 1994, Dr. Richard Milich gave 31 boys a sugar free drink but only told half the mothers that the drink was not sugar free. The mothers, who thought their son had sugar, reported a high level of hyperactivity. Milich concluded that parental expectations about the effects of sugar perpetuate the assumption that sugar makes children more hyperactive. There is no concrete evidence that sugar exacerbates ADHD symptoms. "Anecdotally implicated substances such as sugar have not been shown to be significant causes of ADHD-related difficulties in controlled trials" (Williams et al., 1999, p.566).

Essential Fatty Acids Supplementation

Essential fatty acids influence various neurotransmitters such as serotonin, catecholamines, and acetylcholine (Haag, 2003; Richardson, 2003). Yehuda, Rabinovitz, and Mostofsky (1999) revealed that a correct balance of fatty acids is crucial to proper mental functioning. Given the importance of fatty acid metabolism in the healthy functioning brain, Chen, Hsu, Hsu, Hwang, and Yang (2004) hypothesized that ADHD children have altered dietary patterns and atypical fatty acid metabolism. Their study evaluated the blood fatty acid composition in 58 children with ADHD and 58 children without ADHD (control group). Although the two groups only differed slightly in nutritional intake (amounts of iron and vitamin C), their fatty acid composition was significantly different between the ADHD group and normal controls. This finding suggests that these differences in fatty acid composition are not related to diet but to some other factor, possibly ADHD.

Other studies assessing the fatty acid metabolism of ADHD children found reduced levels of fatty acids as well (Mitchell, Aman, Turbott, & Manku, 1987). This leads to the question of whether fatty acid supplementation would reduce the symptoms of attention and hyperactivity in ADHD subjects. Similar studies have looked at pure fatty acid supplementation, some have assessed fatty acids added to foods, and others have compared fatty acid supplementation to other supplements. All of these differing methodologies contribute to varying results and thus, the reason for low fatty acid concentrations in some children with ADHD is not clear (Richardson, & Puri 2000).

Horrocks and Young's (1999) findings were supported in the work of William Lands, researcher for the National Institute of Health, who said,"Americans suffer an

imbalance in fatty acids; too much omega-6, found in vegetable oils, deep fried foods, dressing, and margarines, and too little omega-3, found in fish and some vegetables" (p. 212). He explained that omega-3 has a calming effect on hormone production which may help relieve some immune system diseases as well as mental conditions ranging from depression to attention deficit. Bell and Peiper (1997), Sears and Thompson (1998), Conners (1989), Crook (1991), and Stanway (1995) all wrote substantiating opinions on the role of fatty acids and ADHD, suggesting an improvement in all ADHD related symptoms. Given the safety and tolerability of this simple treatment, the case for further investigation is strongly supported.

Additional Nutritional Supplements

In addition to fatty acid supplementation, combined supplements have been studied in the treatment of ADHD. Harding (1999) assessed the effects of a nutritional supplement consisting mostly of amino acids, vitamins, and minerals and found that treatment with the nutritional supplement was equivalent to treatment with Ritalin in terms of attention and self-control. In 1991, Schoenthaler, Moody and Pankow reported on double-blind, placebo-controlled trials showing "that children placed on vitamin-mineral supplements exhibited significantly less violence, less non-violent antisocial behavior, higher gains in non-verbal intelligence and higher academic achievement than children on placebos" (p. 31).

Harding, Judah, and Gant (2003) compared a dietary supplement regimen to medication administration on the symptoms of ADHD. According to the authors, ADHD appears to have, “multiple, heterogeneous, biochemical etiologies” (p. 320). Further

investigation is needed to ascertain the best method of determining specifically which nutrients are lacking in each specific child before such treatments can be utilized with any certainty. Research in this area looks promising and treatments appear to be logically based on what is known about biochemistry (Biederman, & Faraone, 2002). Nutritional supplements, such as those described earlier, offer little risk and would be beneficial to the body regardless of effects on ADHD symptomatology (Harding 1999).

Salicylates, food dyes, flavors and preservatives

The Feingold hypothesis states that many children are sensitive to dietary salicylates and artificially added colors, flavors, and preservatives, and that these sensitivities lead to difficulty with learning and behavior (Feingold, 1975). As mentioned earlier, learning and behavioral difficulties are primary diagnostic criteria for ADHD. According to Feingold, by eliminating the offending substances from the diet, the problems in learning and behavior would improve. He had anticipated hypersensitivity to thousands of different substances among different children and suggested food colorings as a good place to begin studying because of their prevalence in the market place and ease of control of eliminating them completely from the diet (Feingold, 1981).

Swanson and Kinsbourne (1980) tested the theory that food dyes impair performance on certain learning tasks on a group of children divided into two groups. One group of children had been diagnosed with ADHD from scores on the Conners Rating Scale and were also reported to have favorable responses to stimulant medication for their ADHD behavior. The second group included a control group of non-hyperactive children. For five days, both groups received a diet free of artificial dyes and other

additives. On days 4 and 5, all children received either a placebo or oral dose of approved dye blend totaling between 100 and 150 milligrams. The findings from this tudy supported the Feingold`s hypothesis in regards to symptoms associated with ADHD. The individual symptoms that improved were not listed but regardless, the researches, like Feingold, claimed that a diet free of artificial flavors, salicylates and artificial colors "results in remission of symptoms in 30-50% of children diagnose with ADHD" (p. 172).

Williams and Cram (1978) report that a series of clinical studies investigating the Feingold hypothesis have produced mixed results indicating that small subgroups of ADHD children, estimated to include between 10 and 25%, respond favorably to the restrictive diet. Few of the early studies reviewed, however, give unqualified support for the hypothesized diet effect on ADHD. In addition, Kavale and Forness (1983) reported that there are controlled studies which refute the Feingold hypothesis stating that improvements occurred in accordance to parental reports but were rarely validated by laboratory measures. The lack of conclusive, consistent evidence dictates the need for additional research to test the hypothesis (Conners, 1989; Kavale et al).

The concerns that have been raised about the Feingold diet or an elimination diet in general, include the potential for the diets to be nutritionally damaging, low response rates and high placebo response rates (Whalen, Henker & Henshaw, 1985). Feingold`s hypothesis continues today to be challenged but Feingold and his advocates refute the arguments on several grounds. These grounds include but were not limited to (a) narrow restrictions of tests to food dyes; (b) arbitrary ignoring of positive findings in certain subgroups; (c) dosage levels of dyes used in challenges too low; and (d) ignoring of animal tests (Feingold, 1981).

Oligoantigenic Diet Influence

Oligoantigenic, which means few foods diet, was first proposed by Feingold for the purpose of eliminating food flavorings that might be causing a reaction in his allergic patients. Success with this treatment program led him to explore its potential for relief from hyperkinesis, as some of the patients were school children who were experiencing difficulties in school as well as allergic reactions to foods. So he eliminated various bakery goods, some ice creams, chewing gums, soft drinks, gelatin products and anything synthetically enhanced with mint flavors, and he began to receive reports that the patients' behavior problems in school were decreasing at the same time as their allergic reactions were subsiding. With this study, research on the effectiveness of the elimination diet at university medical centers throughout the world escalated.

Kaplan et al. (1989) studied 24 preschool-aged boys with ADHD at the Alberta Children's Hospital, and the Learning Centre, Calgary, Alberta, Canada. Foods that were eliminated included those with artificial colors and flavors, chocolate, monosodium glutamate, preservatives, and caffeine, as well as any a particular food that the family reported as a problem for a specific child. According to parental reports, more than 1/2 of the boys exhibited an improvement in behavior and on several non behavior variables such as night time awakenings, bad breath and sleep onset.

Egger, et al. (1985) placed 76 children with hyperactivity on an oligoantigenic diet that consisted of "two meats, two carbohydrate sources, two fruits, a vegetable, water, calcium and multivitamins" (p. 172). Patients who improved moved into the second phase of the diet, where some of the foods were reintroduced, and 52 patients began to show problems once again. At the end of the testing, "the degree of

improvement was not trivial. Forty-seven children ceased having headaches, and 13 who previously had seizures became free of them. Our hyperactivity checklist (filled out by parents) was significantly improved by the diet" (p. 180).

Conners et al. (1976) treated 185 children with established hyperkinetic syndrome through the oligoantigenic diet, 116 of whom responded to provoking foods. Forty patients then took part in a hypo sensitization trial (similar to allergy shots), with 20 of those receiving active treatment (with provoking foods). Sixteen became tolerant toward provoking foods. Stanway (1995) stated "the diet is one factor affecting behavior and the ability to learn" (p. 32). She had given instructions on how to follow a regimen of an oligoantigenic diet, noting that both a craving for and a dislike of a food can indicate sensitivity. She also had given a complete list of the salicylate family first suspected by Feingold, and advised that a time period of one day to three weeks might be required in order to notice an improvement in behavior. Stanway cautioned that symptoms might worsen for a few days due to the withdrawal effect when a child is placed on an elimination diet.

Mary Ann Block (1996) decided to attend medical school because of her dissatisfaction with the medical community's lack of answers in regards to her chronically ill child. Upon graduation, she opened the Block Center for children with chronic health problems. The author of *How to Raise a Healthy Child*, Lendon Smith, M.D. and one of the first pediatricians to believe in natural health management, praised Block's work in the introduction to her book, *No More Ritalin.* Smith wrote that Block "looks for the cause of poorly functioning children rather than using drugs as a Band-Aid to suppress the symptoms" (unnumbered page). Block wrote "it is very common for

children labeled with ADHD to also have allergies" (p. 83). Block told of a mother who noticed her child's behavior becoming worse after eating sugar. Since the family doctor told her that sugar does not affect behavior, however, the mother decided she must be wrong, continued to allow the child to eat refined sugar, and witnessed continued poor behavior. "She was denying her own experience, her own common sense, in deference to someone else's opinion, someone she had put in an authoritative position" (p. 70). Block advised parents to find a physician who would work with them, rather than at them, and to trust simple, cost-effective remedies like food selection before turning to expensive drug treatments.

Like Stanway, Block provided step-by-step instruction in the elimination process: elimination of suspected foods; notation of behavioral change, which may include temporary worsening of behavior; the challenge, where one offending food is selected and fed to the child on an empty stomach, and reaction is noted; continuation of challenge, one food per day; rotation: allowable foods, to which there has been no reaction, are eaten once every four days. Although time consuming and detailed, an oligoantigenic diet has been suggested as a successful intervention for children with ADHD in regards to behavior.

Breakey (1997) noted that the issue of food sensitivity was conceptualized between 1975 and 1985, and that by the mid-1980s the complexity of the issue was recognized, with investigators beginning to monitor a wider range of suspect foods and behaviors. He summarized the research to find out the relationship between nutrition and behavior and concluded that, "research has shown that diet definitely affects some children. Rather than becoming simpler the issue has become demonstrably more

complex. The range of suspect food items has broadened" (p. 190). Further, he wrote of improvements in methodology which in turn provided clearer research results. "The most important finding was that in almost all studies there was a statistically significant change in behavior with dietary intervention" (p. 191). Investigations of grain, dairy foods, natural and medicinal salicylates, natural and added monosodium glutamate, natural amines and added color as well as flavor and preservatives concluded that most children responded to more than one additive and that "the symptom most affected by diet is mood, especially irritability" (p. 192).

Crook (1991) suggested diet as one alternative to Ritalin, and admonished, "as a first step, clean up your child's diet and get rid of junk foods" (p. 14). He gave a generalized recommendation for foods that are minimally processed, low in sugar, low in fat, and which contain no hydrogenated oils. Zeisel (1986) reviewed what was known at the time about how the brain is nourished. He suggested the need for amino acids from protein for neurotransmitter synthesis, stating that, "Children with a documented hospitalization for protein-calorie malnutrition during the first year of life performed worse in eight out of nine academic subjects, had lower IQs and had more behavioral problems than did carefully matched controls" (p. 27).

Pyridoxine, calcium and magnesium

Bell and Peiper (1997) discussed the neurotransmitter serotonin, which requires both pyridoxine, known commonly as Vitamin B6, and tryptophan, for its formation. The best natural sources for Vitamin B6 are wheat bran, wheat germ, liver, soybeans, cantaloupe, cabbage, oats, unmilled rice, eggs, peanuts, and walnuts. They suggested raw

dairy products, bananas and turkey in order to derive enough tryptophan from the diet and that 48 supplements may be necessary, positing that modern American foods are raised in soil that has been depleted of essential nutrients, intake of fresh foods is down, and intake of highly processed foods containing additives is significant.

Bhagavan, Coleman, and Coursin (1975) studied serotonin levels in the blood samples of hyperactive patients, finding a noteworthy decrease as compared to controls. "Oral doses of pyridoxine resulted in an appreciable increase in the serotonin content" (p. 437). In a double-blind study, Bhagavan et al. compared pyridoxine to methylphenidate, and although both controlled hyperkinesis, "[p]yridoxine elevated wholeblood serotonin levels, [while] methylphenidate did not" (p. 741). Bell and Peiper also discussed the calcium-magnesium connection in relation to serotonin, explaining that calcium releases insulin, which lowers serotonin levels, while magnesium inhibits the release of insulin. "Most children with ADD/ADHD show low magnesium levels at the cellular level, and high calcium" (p. 17). Stanway wrote that a good balance of calcium-magnesium will prohibit learning problems and act as a natural tranquilizer (a support of serotonin's role in calming the hyperactive brain).

Kozielec and Starobrat-Hermelin (1997) contributed two articles on magnesium supplementation. The first investigation was comprised of 116 children with disruptive behavior, 95% of whom showed magnesium deficiency. In their second study, 50 hyperactive children who had a recognized deficiency of magnesium were selected. "In the group of children given 6 months of magnesium supplementation, a significant decrease of hyperactivity of those examined has been achieved" (p. 149). Dietary sources of magnesium would include nuts, grains, green leafy vegetables, cereals, and seafood.

Zinc and Iron

Bell and Peiper (1997) wrote of a connection between zinc, aggressive behavior, and hyperactivity. Sears and Thompson (1998) and Stanway (1995) advised adequate zinc intake to ensure fewer learning problems and better behavior. Mindell (1985) listed meat, liver, seafood, wheat germ, pumpkin seeds, and eggs as good dietary sources of the mineral, noting its effectiveness in promoting mental alertness, brain function, and in treatment of mental disorders. Support exists in animal and human studies that suggests a relation between low zinc levels and ADHD symptoms (DiGirolamo & Ramirez-Zea, 1999). Not unlike the studies of essential fatty acids, it is not understood whether low levels of zinc is the cause of ADHD or the effect of having ADHD.

Bell and Peiper (1997) as well as Conners (1989), Crook (1991), and Stanway (1995) advise adequate intake of iron-containing foods when dealing with learning and behavior problems. Sears and Thompson (1998) wrote that insufficient iron contributes to inattention, aggression, irritability, and improper neurotransmitter activity. "[The] best iron foods that children are likely to eat are soybeans, iron-fortified cereals, fish, beef, barley, lentils, clams, beets, tuna, and raisins. Eating or drinking foods high in vitamin C, such as orange juice, with meals enhances the iron absorption from foods" (p. 267). Sever, Ashkenazi, Tyano, and Weizman (1997) looked at the role of iron in regulating dopamine activity by studying 14 boys with ADHD. After 30 days of iron supplementation, there was a significant decrease on the parents' Conners Rating Scale scores (indicating improved behavior). The researchers felt that further investigation of iron deficiency was merited.

Nutrients for Maximum Brain Functioning

Harvard Medical School psychologist Richard Bromfield, (Diet, ADHD, & Behavior), spoke of the responsibility in feeding children a healthy diet: “the brain, the neurological seat of the soul and the self, must be treated with the utmost respect” (p. 13). What are the nutritious foods and supplements that are good for all children, and critical for those affected by ADHD? Conners (1989) first discussed the need for amino acids from protein sources in order for the neurotransmitters to function properly. He listed glucose, found in carbohydrates, for providing fuel for the brain's work. It is estimated that from 30 to 50% of calories consumed by children go toward the energy requirements of the brain.

Sears and Thompson (1998) also addressed nourishing the neurotransmitters as the first requirement for ADHD children. They advised that amino acids be derived from a balanced selection of protein foods that jumpstart the brain such as seafood, beans, tofu, lentils, poultry, and meat, and protein foods that relax the brain such as eggs, milk, bananas, dairy, and sunflower seeds. In their discussion of carbohydrate sources, Sears and Thompson specified the following foods: unsweetened cereals, grains with a low glycemic index such as rice and spaghetti (to maintain blood sugar levels), fruits, vegetables, legumes, and plain dairy products. Before considering nutritional and alternative medicine therapies to mitigate symptoms of ADHD, it is important to emphasize that the child with ADHD is not just an experiment but an individual with a set of challenges that is influenced by his or her physical and emotional environment.

Conclusion

Children with undiagnosed and/or untreated ADHD tend to have both social and academic impairments that last into adulthood. Such impairments result in poor school performance, unproductivity in the work place and a lack of connection to others which in turn can lead to high drop-out rates, frequent job loss and depression (Rowland et al, 2002). ADHD puts children and subsequently, adults, at risk for anti-social activity, depression, aggression and specific learning disabilities and therefore children with ADHD are more likely to utilize health care and mental health care systems. Adolescents with ADHD are more likely to engage in health threatening behavior such as smoking, alcohol and drug use, driving accidents and risky sexual behavior (Vierhile, Robb & Krause, 2009). To date, insufficient public policies and few resources exist to care for children and adolescents with ADHD (Polanczyk & Jensen, 2008). Long term community public health studies could result in better intervention strategies, possibly reducing consequences mentioned above.

In 1902, Dr. George Still first described a group of restless children with an "abnormal incapacity for sustained attention and deficits in volitional inhibition" (Williams et al, 1999, p.563). Furthermore, the children's impulsive behavior was described as "a lack of moral control among children without noted physical impairments" (Barkley, 1998, p. 162). Historically there have been a series of labels associated with the disorder including minimal brain dysfunction, minimal brain damage syndrome, hyperkinetic reaction of childhood, and attention deficit disorder. Currently the APA recognizes difficulty with attention, distractibility and impulsivity as ADHD and it is the most common nuerodevelopmental disorder of childhood. Prevalence varies

across gender, race and socio-economic status but it is estimated that in America 4-5% of children are diagnosed with ADHD (Newmark, 2009). Prevalence estimates, however, are contingent on diagnosis which is primarily dependant on parent and teacher reports.

Until recently, there have not been reliable laboratory tests to diagnose ADHD and therefore, estimates are sensitive to who is asked what and how the information is combined. Subsequently, if the results and conclusions of a study are to be considered generalizable and valid, the study must adhere to the principles of good scientific research that are universally agreed upon. Without adherence to such guidelines (controlled studies), the results obtained not only are deceptive but also will ultimately mislead the public (Dreyer, 2006). This is not to indicate that there is a total absence of well-constructed studies that offer some degree of confidence in their conclusions. However, since they did not compromise the majority of data, it is difficult to generalize from their findings.

Although difficult to diagnose, treatments for ADHD are controversial and contentious. Conventional treatment is base on a combination of stimulant medication, behavioral modification and educational intervention. Despite the effectiveness and safety of the medications, parents are concerned about the long term use of stimulants and as with many chronic diseases, are turning to alternative treatments (Stubberfield, Wray & Parry, 1999). Feingold suggested that eliminating certain substances from the diet such as food coloring, flavorings and preservatives would result in improved ADHD symptoms. His work was the first of many theories about specific food elimination and/or supplementation.

Clinicians need to exercise caution when making treatment recommendations and not trust treatment approaches based on single findings. The weight of opinion in the literature must be considered as conclusive in and of itself. There is a need for additional studies in these promising areas with control groups, placebo, and comparisons using traditional treatments (e.g. Ritalin). Consequently, many of the studies suffer inadequate methodology in terms of factors such as the population under study, statistical measurements employed to define the independent variables, and the reliability, validity and generalizability of the conclusive data (Rowland et al, 2002).

The literature reviewed for the present study revealed that much more information must be gathered before the public becomes sufficiently knowledgeable regarding potential use of nutrition interventions for ADHD in children. The relationship between diet and the brain's functioning is an unexplored area that may impact ADHD. Future research may look at whether adequate nutrition meets the needs for optimal brain functioning. Public and private health organizations should consider sponsoring research that determines which foods and food additives provoke behavioral problems and what subset of children are susceptible. Methods could be developed to indentify children who are sensitive to foods and additives. In addition, more research is needed to understand the efficacy of nutritional supplements in treating ADHD. Long term, Epidemiologic studies might help address prevention efforts in order to reduce risky behaviors and improve the health of children, adolescents and adults with ADHD. The expanding body of literature emphasizes the idealistic possibilities associated with nutritional treatments methods but further empirical research is needed to validate positive claims.

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Glossary

Diagnostic and Statistical Manual of Mental Disorder-IV-TR: The standard diagnostic tool used by mental health professionals worldwide to promote reliable research, accurate diagnosis, and thus appropriate treatment and patient care. Each psychiatric disorder with its corresponding diagnostic code is accompanied by a set of diagnostic criteria and descriptive details including associated features, prevalence, familial patterns, age-, culture-, and gender-specific features, and differential diagnosis. The manual is published by the American Psychiatric Association and covers all mental health disorders for both children and adults. It also lists known causes of these disorders, statistics in terms of gender, age at onset, and prognosis as well as some research concerning the optimal treatment approaches (PsychiatryOnline.com,).

Attention Deficit/Hyperactivity Disorder (ADHD): This is the official name given this condition by the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders* (DSM-IV-TR). ADHD is a neurobiological disorder that is diagnosed in early childhood and is characterized by developmentally inappropriate impulsivity, inattention, and hyperactivity. Science recognizes three subtypes of ADHD (inattentive, hyperactive-impulsive, and combined). A diagnosis of one type or another depends on the specific symptoms (i.e. the "diagnostic criteria") that person has (CHADD, 2011).

.*Conners Behavioral Rating Scale*: Based on more than 30 years of research on childhood and adolescent psychopathology, these widely used rating scales set the standard for assessing Attention-Deficit/Hyperactivity Disorder (ADHD) and related problems in youngsters from 3 to 17 years of age. Combining reports from teachers, parents, and adolescents themselves, the CRS provides a detailed and comprehensive profile of a student's behavior including cognitive, behavioral and emotional problems (National Resource Center on ADHD; A Program of CHADD).

Hyperactive: the constant movement that has become the most frequently recognized signal that a child may have ADHD. The most obvious sign of ADD/ADHD is hyperactivity. While many children are naturally quite active, kids with hyperactive symptoms of attention deficit disorder are always moving. They may try to do several things at once, bouncing around from one activity to the next. Even when forced to sit still, (which can be very difficult for them) their foot is tapping, their leg is shaking, or their fingers are drumming (Smith, Jaffe-Gill, & Segal, 2010).

Symptoms of hyperactivity in children:

- Constantly fidgets and squirms
- Often leaves his or her seat in situations where sitting quietly is expected
- Moves around constantly, often running or climbing inappropriately
- Talks excessively, has difficulty playing quietly
- Is always "on the go," as if driven by a motor

Impulsive: the constant movement that has become the most frequently recognized signal that a child may have ADHD. The impulsivity of children with ADD/ADHD can cause problems with self-control. Because they censor themselves less than other kids do, they'll interrupt conversations, invade other people's space, ask irrelevant questions in class, make tactless observations, and ask overly personal questions. Children with impulsive signs and symptoms of ADD/ADHD also tend to be moody and to overreact emotionally. As a result, others may start to view the child as disrespectful, weird, or needy (Smith, Jaffe-Gill, & Segal, 2010).

Symptoms of impulsivity in children:

- Blurts out answers without waiting to be called on hear the whole question
- Has difficulty waiting for his or her turn
- Often interrupts others
- Intrudes on other people's conversations or games
- Inability to keep powerful emotions in check, resulting in angry outbursts or temper tantrums

Inattentive: not paying attention while being taught or spoken to, nor sticking with an assigned task. Children with ADD/ADHD can pay attention when they're doing things they enjoy or hearing about topics they enjoy. But when the task is repetitive or boring, they quickly tune out. Not paying close enough attention is another common problem. Children with ADD/ADHD often bounce from task to task without completing any of them, or skip necessary steps in procedures. Organizing their schoolwork and their time is harder for them than it is for most children. Kids with ADD/ADHD also have trouble concentrating if there are

things going on around them; they usually need a calm, quiet environment in order to sustain attention (Smith, Jaffe-Gill, & Segal, 2010).

***Symptoms of inattention in children*:**

- Doesn't pay attention to details or makes careless mistakes
- Has trouble staying focused; is easily distracted
- Appears not to listen when spoken to
- Has difficulty remembering things and following instructions
- Has trouble staying organized, planning ahead, and finishing projects
- Frequently loses or misplaces homework, books, toys, or other items

Hyperkinetic: A disorder occurring in children and adolescents, characterized by excessive activity, extreme restlessness, impulsivity, and a short attention span. Hyperkinesis is often used synonymously with ADHD hyperactivity as defined by the DSM-IV criteria (Egger et al., 1993).

Metabolism: Our bodies get the energy they need from food through metabolism, the chemical reactions in the body's cells that convert the fuel from food into the energy needed to do everything from moving to thinking to growing. Specific proteins in the body control the chemical reactions of metabolism, and each chemical reaction is coordinated with other body functions. In fact, thousands of metabolic reactions happen at the same time (all regulated by the body) to keep our cells healthy and working (kidshealth.org).

Nutrition: (Also called *nourishment* or *aliment*) is the provision, to cells and organisms, of the materials necessary to support life in the form of food. Many common

health problems can be prevented or alleviated with a healthy diet (kidshealth.org).

Diet: Also referred to as *nutrition* is the sum of the food consumed by an organism and/or group. Diet is the deliberate selection of food for nutrient intake (kidshealth.org).

Supplementation: Something added to complete a thing, make up for a deficiency, or extend or strengthen the whole. In the case of malnutrition, (lacking certain nutrients), supplementation of the nutrient lacking in order for the body to perform properly (Random House Unabridged Dictionary, 1993).

Chemically sensitive: Also known as Multiple Chemical Sensitivity (MCS) is defined as a chronic medical condition characterized by symptoms the affected person attributes to exposure to low levels of chemicals. Commonly suspected substances include smoke, pesticides, plastics, synthetic fabrics, scented products, petroleum products and paints. Symptoms may be vague and non-specific such as nausea, fatigue and headaches. MCS is a controversial diagnosis, and is not recognized as an organic, chemical-caused illness by the American Medical Association (WebMd).

Adverse reactions to food can be due to several mechanisms. Correct identification of the type of reaction in an individual is important, as different approaches to management may be required. The area of food allergies and intolerances has been controversial and is currently a topic that is heavily researched. It has been characterized in the past by lack of universal acceptance of definitions, diagnosis and treatment (MedicineNet.com).

Food sensitivity: Food sensitivities include many different types of sensitivities to food which may arise for a wide variety of reasons making it a complex, oftentimes confusing and not easily defined area of study. Diagnosis can also be difficult because symptoms may be delayed for up to two days after a food has been consumed. In general, food sensitivities are the result of toxic responses to food and are divided into two categories: allergic responses; and food intolerances (WebMd).

Elimination diet: An *elimination diet* is a method of identifying foods that an individual cannot consume without adverse effects. Adverse effects may be due to food allergies or food intolerance, other physiological mechanisms (such as metabolic or toxins) or a combination of these. Elimination diets typically involve entirely removing a suspected food from the diet for a period of time from two weeks to two months, and waiting to determine whether symptoms resolve during that time

period. In rare cases, a health professional may wish to use an oligoantigenic diet to relieve a patient of symptoms they are experiencing. Common reasons for undertaking an elimination diet include suspected food allergies and suspected food intolerances. An elimination diet might remove one or more common foods, such as eggs or milk, or it might remove one or more minor or non-nutritive substances, such as artificial food colorings. An elimination diet relies on trial and error to identify specific allergies and intolerances. Typically, if symptoms resolve after the removal of a food from the diet, then the food is reintroduced to see whether the symptoms reappear. This challenge-rechallenge approach is useful with inconsistent or vague symptoms. The terms *exclusion diet* and *elimination diet* are often used interchangeably in the literature, and there is no standardized terminology. The exclusion diet can be a diagnostic tool or method used temporarily to determine whether a patient's symptoms are food-related. The term elimination diet is also used to describe a "treatment diet", which eliminates certain foods for a patient (Livestrong.com).

Oligoantigenic diet: An elimination diet removes foods commonly associated with allergy and intolerance. An oligoantigenic diet, or few foods takes the elimination diet further by removing nearly all foods from the diet except a limited number that generally cause no problems. If your symptoms clear up after a determined amount of time, you add more of these well-tolerated foods. If symptoms do not subside, you switch to different foods on the list. Eventually, you can begin

adding other foods back into the diet one by one to gauge if they cause any (Livestrong.com)

Salicylates: Salicylates occur naturally in many plant foods, acting as a plant hormone. The compounds are also manufactured synthetically and used to make painkilling drugs (aspirin and ibuprofen are the most well-known), flavoring, solvents, certain skin care products, perfume fixatives and preservatives (Random House Unabridged Dictionary, 1993).

Erythrosine: Also known as Red No. 3. It is a cherry pink synthetic used primarily as a food coloring but is also used in printing inks, as a biological stain and as a dental plaque disclosing agent. It is used in candies, popsicles and cake-decorating gels (Mayoclinic.com).

Monosodium glutamate: Monosodium glutamate is the sodium salt of the amino acid glutamate, and is a commonly used flavor enhancer, regarded by the FDA as "generally safe", meaning that food manufacturers can use as much of it as they like. It has been around for many years, and is found not only in take away meals from Chinese restaurants, but many other food sources, in which it is listed as either "monosodium glutamate", "MSG" or "hydrolyzed vegetable protein". These toxic compounds are known to interfere with brain chemistry and have been

implicated in many neurological diseases, such as brain cancers, MS, fibromyalgia, depression and hyperactivity (Mayoclinic.com).

Pyridoxine: Also called Vitamin B6, pyridoxine, is one of 8 B vitamins. All B vitamins help the body convert food (carbohydrates) into fuel (glucose), which is "burned" to produce energy. Pyridoxine is required by the body for utilization of energy in the foods you eat, production of red blood cells, and proper functioning of nerves. It is used to treat and prevent vitamin B_6 deficiency resulting from poor diet, certain medications, and some medical conditions (University of Maryland Medical Center, 2009).

Tryptophan: Tryptophan is one of the 10 essential amino acids that the body uses to synthesize the proteins it needs. It's well-known for its role in the production of nervous system messengers, especially those related to relaxation, restfulness, and sleep (whfoods.org).

Tartrazine: also known as FD&C Yellow Number 5 is an azo dye that produces a yellow color. It is widely used as a food additive (E102) in convenience foods, soft drinks, sweets, medications, cosmetics and dye textiles (whfoods.org).

Essential Fatty Acids (*EFAs*): Two essential fatty acids, linolenic and linoleic acid, cannot be synthesized in the body but can be taken into the diet from plant foods. These basic fats are used to build specialized fats called omega-3 and omega-6 fatty acids. Omega-3 and omega-6 fatty acids are important in the normal functioning of all tissues of the body. Deficiencies are responsible for a host of symptoms and disorders including abnormalities in the liver and kidney, changes in the blood, reduced growth rates, decreased immune function, depression, and skin changes, including dryness and scaliness. Adequate intake of the essential fatty acids results in numerous health benefits. Prevention of atherosclerosis, reduced incidence of heart disease and stroke, and relief from the symptoms associated with ulcerative colitis, menstrual pain, and joint pain have also been documented (Physicians Committee for Responsible Medicine, 2006).

Orthomolecular: Linus Pauling introduced the term *orthomolecular* to refer to the practice of varying the concentration of substances normally present in the body to prevent and treat disease. Often referred to as *megavitamin therapy*, it is an alternative form of medicine that seeks to prevent or treat diseases, with a goal of attaining optimal health, by using nutrients prescribed as dietary supplements or derived from diets (Pauling, 1968).

Orthomolecular medicine focuses on what it sees as the right nutritional molecules in the right amounts for the individual (Pauling, 1968).

Orthomolecular psychiatry: Varying the concentrations of substances normally present in the human body which may control mental disease (Pauling, 1968).

Table 1

DSM-IV Criteria for ADHD

I. either A or B:

A. Six or more of the following symptoms of inattention have been present for at least 6 months to a point that is disruptive and inappropriate for developmental level:

Inattention

1. Often does not give close attention to details or makes careless mistakes in schoolwork, work, or other activities.
2. Often has trouble keeping attention on tasks or play activities.
3. Often does not seem to listen when spoken to directly.
4. Often does not follow instructions and fails to finish schoolwork, chores, or duties in the workplace (not due to oppositional behavior or failure to understand instructions).
5. Often has trouble organizing activities.
6. Often avoids, dislikes, or doesn't want to do things that take a lot of mental effort for a long period of time (such as schoolwork or homework).
7. Often loses things needed for tasks and activities (e.g. toys, school assignments, pencils, books, or tools).
8. Is often easily distracted.
9. Is often forgetful in daily activities.

B. Six or more of the following symptoms of hyperactivity-impulsivity have been present for at least 6 months to an extent that is disruptive and inappropriate for developmental level:

Hyperactivity

1. Often fidgets with hands or feet or squirms in seat.
2. Often gets up from seat when remaining in seat is expected.
3. Often runs about or climbs when and where it is not appropriate (adolescents or adults may feel very restless).
4. Often has trouble playing or enjoying leisure activities quietly.
5. Is often "on the go" or often acts as if "driven by a motor".
6. Often talks excessively.

Impulsivity

1. Often blurts out answers before questions have been finished.
2. Often has trouble waiting one's turn.
3. Often interrupts or intrudes on others (e.g., butts into conversations or games).

II. Some symptoms that cause impairment were present before age 7 years.
III. Some impairment from the symptoms is present in two or more settings (e.g. at school/work and at home).
IV. There must be clear evidence of significant impairment in social, school, or work functioning.
V. The symptoms do not happen only during the course of a Pervasive Developmental Disorder, Schizophrenia, or other Psychotic Disorder. The symptoms are not better accounted for by another mental disorder (e.g. Mood Disorder, Anxiety Disorder, Dissociative Disorder, or a Personality Disorder).

Based on these criteria, three types of ADHD are identified:

1. ADHD, *Combined Type*: if both criteria 1A and 1B are met for the past 6 months
2. ADHD, *Predominantly Inattentive Type*: if criterion 1A is met but criterion 1B is not met for the past six months
3. ADHD, *Predominantly Hyperactive-Impulsive Type*: if Criterion 1B is met but Criterion 1A is not met for the past six months.

American Psychiatric Association: Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition, Text Revision. Washington, DC, American Psychiatric Association, 2000.

Table 2 Conners Parent Teacher Questionnaire

on		CONNERS 3–PARENT				CONNERS 3–TEACHER				CONNERS 3–SELF-REPORT		
		Conners 3–P	Conners 3–P(S)	Conners 3AI–P	Conners 3GI–P	Conners 3–T	Conners 3–T(S)	Conners 3AI–T	Conners 3GI–T	Conners 3–SR	Conners 3–SR(S)	Conners 3AI–SR
Version/Index		Full	Short	ADHD Index	Global Index	Full	Short	ADHD Index	Global Index	Full	Short	ADHD Index
Age Range		6–18 Years				6–18 Years				8–18 Years		
Number of Items		110	43	10	10	115	39	10	10	99	39	10
Empirical Scales	Hyperactivity/Impulsivity	●	●			●	●			●	●	
	Executive Functioning	●	●			●[1]	●[1]					
	Learning Problems	●	●							●	●	
	Aggression	●	●			●	●			●	●	
	Peer Relations	●	●			●	●					
	Family Relations									●	●	
Rational Scale	Inattention	●	●			●	●			●	●	
DSM-IV-TR Symptom Scales	ADHD Hyperactive/ Impulsive	●				●				●		
	ADHD Inattentive	●				●				●		
	ADHD Combined	●				●				●		
	Oppositional Defiant Disorder	●				●				●		
	Conduct Disorder	●				●				●		
Validity Scales	Positive Impression	●	●			●	●			●	●	
	Negative Impression	●	●			●	●			●	●	
	Inconsistency Index	●				●				●		
Indices	Conners ADHD Index	●		●		●		●		●		●
	Conners Global Index	●			●	●			●	●		
Screener Items	Anxiety	●				●				●		
	Depression	●				●				●		
Impairment Items	Schoolwork/Grades	●				●				●		
	Friendships/Relationships	●				●				●		
	Home Life	●								●		
Critical Items	Severe Conduct	●				●				●		

[1] Learning Problems/Executive Functioning Scale

Table 3

Foods not allowed on the Feingold Diet (partial list):*

Almonds, cucumbers, peppers (bell chili), apples, pickles, apricots, currants, plums, prunes, berries (all), grapes, raisins, tangerines, cherries, oranges, peaches, tomatoes, tea, cloves, coffee.

Aspirin (acetyl salicylate), and medications that contain aspirin.

Oil of wintergreen (methyl salicylate; mint flavoring.)

**Reactions to these foods are based on unconfirmed reports, not controlled studies.*

Foods Allowed on the Feingold Diet (partial list):

Fruit

Banana, honeydew, papaya, cantaloupe, kiwi, pears, dates, lemons, pineapple, grapefruit, mangoes, watermelon.

Vegetables

Bean sprouts, cauliflower, peas, beans (all types), celery, potatoes, beets, kale, spinach, broccoli, lentils, squash, brussel sprouts, lettuce, sweet corn, cabbage, mushrooms, sweet potato, carrots, onions, zucchini.