Do Foods or Additives Cause Behavior Disorders?

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Attention-deficit/hyperactivity disorder (ADHD) is the most commonly diagnosed behavioral disorder in childhood, with a prevalence of 4% to 12% of elementary school population, affecting three boys to every girl.[1] Children with ADHD often have poor scholastic performance, impaired family and peer relationships, and other co-existing developmental and psychiatric disorders. With the shortage of mental healthcare providers, pediatricians and other primary care physicians provide the majority of care for such children. In a recent study of pediatric practices in North Carolina, 15% of children were found to have behavioral disorders, with ADHD the most frequent diagnosis.[2] Another recent survey reported that about half of pediatricians conduct three or more new evaluations for ADHD per month.[3]

ADHD has gained much popularity among parents and schoolteachers and periodically is highly publicized by the media. In fact, many children are labeled "hyperactive" based merely on the personal impression of a parent or a teacher. The diagnosis should be based on specific standardized criteria published in the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM*) by the American Psychiatric Association (Sidebar, see page 748).[4]

Multiple etiologies have been proposed for childhood behavioral problems, including ADHD. It is generally accepted that ADHD is a complex, multifactorial disorder. Underlying factors include any or combination of genetics, perinatal events, environmental causes, neurobiological mediators, and psychosocial influences. An association between food additives and behavior disorders in children was suggested many years ago and continued to gain momentum, par-

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ticularly in the 1970s, after a publication by Benjamin Feingold.[5] The introduction of this hypothesis generated conflicting reactions from health care professionals and the public. The purpose of this article is to provide a balanced review of the literature, both in support and against the possibility of such a relationship (Table, see pages 750-751).

HYPERACTIVITY AND DIET

Feingold[6] postulated that some children have a genetic predisposition to hyperactivity, triggered by certain food components. He proposed that such children improve on a diet free of artificial flavors and colors and natural salicylates, which he used in his pediatric practice. He reported dramatic improvement in about 50% of children with hyperactivity who followed his proposed diet. Even though Feingold's hypothesis was based on anecdotal evidence, his proposed diet received wide publicity. Supported by certain groups of parents of hyperactive children, "Feingold Associations" were formed throughout the United States. A positive corollary was the generation of interest by several investigators to study the relationship between diet and childhood behavior.

REPORTS THAT MAY SUPPORT THE RELATIONSHIP

A few studies reported that food dyes, preservatives or other additives could adversely influence behavior in children. In such studies, the children's behavior was assessed primarily by parents, school teachers, or other professionals.

In a double-blind study, Conners et al.[7] studied 15 hyperactive boys (ages 6 to 12) who met *DSM-II* criteria and were given either the Feingold diet or a control diet for 4 weeks. The teachers reported significant reduction in hyperkinetic symptoms on the Feingold diet. Such an apparent improvement was neither observed by the parents nor reproduced when the order of giving the two diets was reversed. The authors concluded that further studies were required before definite recommendations were made.

In further testing the Feingold hypothesis, 36 school-age boys (ages 6 to 12) and 10 of preschool age (ages 3 to 5) were randomly assigned in a double-blind, crossover study to either the Feingold diet or a control diet for 3 to 4 weeks.[8] The participants were selected on the basis of a physician's diagnosis of hyperkinetic behavior or according to a Conners Parent-Teacher Score of 15 or greater, indicative of moderate to severe behavioral disruption. Only four of the 36 school-age children showed improvement on the Feingold diet by both parent and teacher behavior ratings. No chang-

SIDEBAR.

Diagnostic Criteria for Attention-deficit/Hyperactivity Disorder*

- **Six or more of the following symptoms of inattention and/or hyperactivity–impulsivity persisting at least 6 months and inconsistent with the developmental level of the child:**

Inattentive

- Often fails to give close attention to details, makes careless mistakes
- Often has trouble sustaining attention in tasks/activities
- Often does not seem to listen
- Often does not follow through on instructions
- Often has trouble organizing tasks
- Often avoids/dislikes tasks requiring sustained mental effort
- Often loses important things
- Often easily distracted by extraneous stimuli
- Often forgetful in routine activities

Hyperactive–impulsive

- Often squirms and fidgets
- Often can't stay seated
- Often runs/climbs excessively
- Often has difficulty remaining quiet during play or leisure activities
- Often blurts out answers before questions are finished
- Often "on the go," acts as if "driven by a motor"
- Often talks excessively
- Often has difficulty awaiting turn in play/activity
- Often interrupts/intrudes on others

- **Onset of symptoms that cause impairment present before age 7.**
- **Presence of symptoms in two or more settings (eg, home, school, work).**
- **Evidence for significant impairment in social, academic, or occupational functioning.**
- **Symptoms that do not occur exclusively during a course of pervasive developmental disorder, schizophrenia, or other psychotic disorder and are not better accounted for by another mental disorder (eg, mood, anxiety, dissociative, or personality disorder).**

**Adapted from the* Diagnostic and Statistical Manual of Mental Disorders, *fourth edition.*[4]

es were noted by neuropsychological testing or in observer ratings. In the 10 preschool boys, however, all 10 mothers and four of the seven fathers reported improvement in behavior in response to the Feingold diet.

In another study of 13 hyperkinetic children ages 3 to 10, parent ratings were recorded within 3 hours after the children ate cookies containing artificial colors or cookies without colorings.[9] The parents reported that the children's behavior was worse following eating cookies with the colorings compared with the placebo.

A study from Australia investigated the possible role of tartrazine in 34 children (ages 2 to 14) referred for hyperactivity (23 strongly suspected reactors and 11 uncertain reactors) and 20 controls.[10] The children were maintained on a dye-free diet and then each morning for 21 days were given a placebo or tartrazine in a capsule or added to orange juice. After a 3-day placebo administration, tartrazine was given in one of six doses (1, 2, 5, 10, 20, or 50 mg), with at least 2 days between doses. Each child was his or her own control regarding change in behavior. The investigators identified consistent behavioral changes in 24 of the 54 participants: 82.6% of the suspected reactors, compared with 27.3% of the uncertain reactors and 10% of controls. The changes observed in younger children (ages 2 to 6) were constant crying, irritability, restlessness, and disruptiveness. The changes in the older children (ages 7 to 14) were irritability, aimless activity, whining, and unhappiness. Interestingly, all 24 reactors were atopic, with a history of asthma, eczema, or allergic rhinitis. Therefore, the change in behavior cannot be directly attributed to the change in diet.

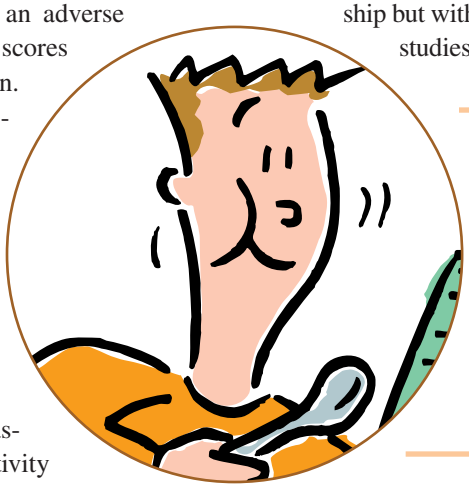
Some investigators used a mixture of multiple food colorings for challenge rather than single agents. Swanson and Kinsbourne[11] investigated 40 children; 20 were considered as hyperactive, with an average score of 16.2 on the Conners Rating Scale (CRS) and a favorable response to stimulant medications, and the other 20 had a lower average CRS score of 12.3 and were considered not hyperactive. After 3 days of a diet free of dyes and other additives, oral challenges with either a blend of nine food dyes (total 100 or 150 mg) or placebo were administered to 10 children of each group on days 4 and 5. The findings suggested that food dyes (in this large dose) decrease attention span in hyperactive children. However, CRS showed no difference between the dye and placebo intake periods. The performance of the nonhyperactive group was not affected by the food dye challenge.

Pollock and Warner[12] evaluated 39 children (ages 2 to 15) whose behavior was reported by parents to improve on an additive-free diet. The children were challenged with a capsule containing a

12.5 mg dye mixture (tartrazine, sunset yellow, carmoisine, and amaranth) given daily for a week on two occasions, separated by 3-week daily intake of placebo capsules. In the 19 children who completed the trial, the intake of food dyes was associated with an adverse effect on daily CRS scores in 17 (89.5%) children.

A recent double-blind, placebo-controlled crossover challenge was conducted on 277 children (ages 3.2 to 4.1) in England.[13] The children were divided into four groups based on assessment of hyperactivity and presence or absence of atopy, then randomly assigned to fruit juice with 20 mg of artificial colorings (sunset yellow, tartrazine, ponceau, and carmoisine) plus 45 mg of sodium benzoate or to placebo fruit juice for 1 week each. Behavior was assessed weekly by research psychologists using validated tests, as well as daily by the parents using the Weiss-Werry-Peters Activity Scale.[14] There was significant reduction in hyperactivity during the initial elimination of dyes and benzoates. In addition, the parents reported greater increases in hyperactivity during the active challenge than the placebo. These effects were not related to the initial presence or absence of hyperactivity or atopy. The investigators concluded that there seems to be a general adverse effect noticed by parents of artificial food dyes and benzoate on the behavior of preschool children.

A widespread belief is that sweeteners (natural or artificial) cause hyperactivity in some children. Our literature search revealed very few studies that might support this belief. In a retrospective study, dietary records of 28 hyperactive children (ages 4 to 7) were reviewed and compared with the child's behavior as observed by an independent professional.[15] It was noted that the amount of sugar consumed correlated significantly with increased aggressive–destructive and restless behaviors. The literature contains a few additional anecdotes about such a relationship but without any systematic studies.[16,17]



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Bradstock et al.[18] analyzed 231 consumer complaints of adverse effects of aspartame, 69% of which were neurobehavioral in nature. However, the authors found no definite symptom complex that suggests a health hazard to aspartame.

DATA THAT REFUTE THE RELATIONSHIP

Several double-blind, placebo-controlled studies do not support the relationship between food additives and behavior disorders. In 1978, Harley et al.[19] studied nine hyperactive boys who were the most responsive to the Feingold diet in a previous study.[8] The food of the entire family was limited to the Feingold diet for 11 weeks. Following a 4-week baseline period, the children were subjected to multiple double-blind, placebo-controlled crossover challenges with cookies or candy bars that contain a mixture of artificial food colors or placebo. No adverse effects on behavior were observed according to parent or teacher ratings, classroom observation, or psychological testing. One child exhibited extreme behavior disruption but was discovered to be receiving the placebo cookie during that period.

Levy et al.[20] conducted a double-blind, placebo-controlled, crossover study on 22 hyperactive children, ages 4 to 8, using a tartrazine challenge (5 mg in biscuits). They found no significant differences in the children's behavior by Conners parent–teacher ratings or by standard neuropsychological testing.

In 1980, Weiss et al.[21] reported a study on 22 children, ages 2.5 to 7, with behavior problems and histories of marked improvement on the Feingold diet. The children were challenged in a double-blind, placebo-controlled fashion with 35.6 mg/day of a mixture of seven artificial food dyes in a soft drink on 8 separate days. There was no overall effect of the challenge in 21 of the 22 children, based on parental observation. One 34-month-old child seemed to react consistently to food coloring but not to the placebo.

In another series, 11 hyperactive children (ages 4 to 13) with histories of remarkable response to the Feingold diet underwent double-blind, placebo-controlled crossover challenge with cookies containing food coloring mixture (13 mg/cookie) or placebo cookies for 1 week each.[22] The children received one cookie the first day with an additional cookie each day to a maximum of six cookies on days 6 and 7. No change in behavior was noted by parents, teachers, or psychiatrists.

TABLE.

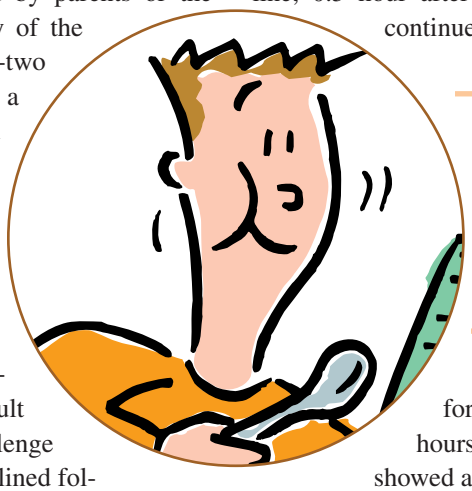
Summary of Studies on the Relationship Between Food Additives and Behavior

Author	Year	Design	Subjects
Conners et al.	1976	Double-blind, crossover challenge	15 hyperkinetic boys (ages 6 to 12)
Goyette et al.	1978	Double-blind, crossover challenge	13 hyperkinetic children (ages 3 to 10)
Harley et al.	1978	Double-blind, crossover challenge	36 school-age boys (ages 6 to 12) and 10 preschool boys (ages 3 to 5)
Harley et al.	1978	Multiple DBPC, crossover challenge	Nine hyperactive boys who were most responsive to Feingold diet from a previous study
Levy et al.	1978	DBPC, crossover challenge	22 hyperactive children (ages 4 to 8)
Weiss et al.	1980	DBPC, repeated crossover challenge	22 children (ages 2.5 to 7) with behavior problems and a history of response to elimination diet.
Swanson and Kinsbourne	1980	DBPC challenge	40; 20 considered hyperactive (mean CRS=16.2), 20 nonhyperactive (average CRS=12.3)
Mattes and Gittelman	1981	DBPC, crossover challenge	11 hyperactive children (ages 4 to 12) with improvement on Feingold diet per history
Gross	1984	DBPC, crossover challenge	50 hyperactive children (ages 5 to 17) whose mothers were convinced that sugar caused the child's symptoms
Wolraich et al.	1985	DBPC, crossover challenge	Two separate groups of 16 hyperactive boys (ages 7 to 12)
David	1987	DBPC challenge	24 children (ages 1.6 to 12.4) with history of adverse behavior reaction to tartrazine or benzoic acid
Pollock and Warner	1990	DBPC challenge	39 children (ages 2 to 15); 19 completed trial
Wender and Solanto	1991	DBPC, crossover challenge	17 children with ADHD (ages 5 to 7) and nine age-matched normal control subjects
Rowe and Rowe	1994	DBPC, crossover challenge	54 children (ages 2 to 14); 23 suspected reactors, 11 uncertain reactors, 20 controls
Wolraich et al.	1994	DBPC, three-way crossover challenge	23 children (ages 6 to 10) described to respond adversely to sugar; 25 normal children (ages 3 to 5)
Shaywitz et al.	1994	DBPC, crossover challenge	15 children (ages 5 to 13) with ADD
Bateman et al.	2004	DBPC, crossover challenge	277 children (ages 3.2 to 4.1); divided into four groups based on presence or absence of hyperactivity and atopy

DBPC = double-blind, placebo-controlled; CRS = Conners Rating Score; ADHD = attention-deficit/hyperactivity disorder; ADD = attention deficit disorder.

	Diet/Challenge	Evaluation	Apparent Relationship
	Feingold diet or control diet	Parent and teacher behavior rating	Feingold diet more effective than control diet on teacher ratings. Improved parent and teacher ratings on Feingold diet compared to baseline.
	Challenge (artificial colors) and placebo cookies	Parent ratings	Significant effect of challenge cookies 3 hours after challenge.
	Feingold diet or control diet	Parent and teacher behavior rating, neuropsychological data, classroom and laboratory observation	Four of 36 school-age boys improved on Feingold diet in parent and teacher ratings. Mothers of all 10 preschool boys reported improvement on Feingold diet.
	Cookies or candy bars with artificial colors or placebo	Parent and teacher ratings, classroom observations, neuropsychological tests	No adverse effects on all parameters.
	Tartrazine in biscuits or placebo	Parent and teacher ratings, objective tests of attention, perceptual-motor tests and subtests from Wechsler Intelligence Scale for Children	No differences between challenge and placebo periods in parent and teacher ratings or in standard tests.
	Soft drink with mixture of seven artificial food dyes or placebo	Parent rating scale	No overall effect in 21/22 subjects on parent ratings.
	Capsule containing nine food dyes or placebo	Paired-associate learning test, CRS	Increase in errors on the learning tests in the hyperactive children. No difference in CRS between food dye and placebo.
	Cookies with food coloring mixture vs placebo	Parent and teacher ratings, psychiatric evaluation/rating, psychological tests	No evidence of food coloring effect on all evaluation parameters.
	Lemonade containing sucrose or placebo (saccharin) with equal sweetness	Parent behavior rating	No consistent response to sucrose.
	Challenge drink with sucrose or placebo (aspartame) Group 1: challenge given 1 hour after lunch. Group 2: challenge given in the morning after overnight fast.	Behavioral measures (playroom observation and examiner ratings), cognitive measures (learning and memory tasks)	Neither group showed a difference between sucrose and aspartame effect on behavior.
	Tartrazine in orange juice/blackcurrant drink or placebo. Challenge with benzoate on a separate day.	Parent and nursing staff observation. No specific scoring system employed.	No changes in behavior as reported by the parents and the nursing staff.
	Capsule containing a mixture of four food dyes or placebo	Parent ratings	17/19 with higher behavioral scores on food color challenge.
	Orange drink either with sucrose, saccharin or aspartame on 3 separate days	Playroom observation, cognitive performance tasks	No significant effect of sugar, saccharin, or aspartame on aggressive behavior of either group. Increase inattention on cognitive tasks in the ADHD group following sucrose.
	Capsule containing different doses of tartrazine given randomly over 3 weeks	Parent ratings on Behavior Rating Inventory devised by the authors	24/54 with consistent variations in behavior to tartrazine challenge.
	Diets: high in sucrose, with no artificial sweeteners; low in sucrose and with aspartame; low in sucrose with saccharin	Behavioral and cognitive measures	No significant differences among the three diets in any variables for the school-aged children. No consistent pattern of difference observed in the preschool group.
	Capsules containing aspartame or placebo (microcrystalline cellulose)	Parent and teacher ratings, cognitive tests	Aspartame at 10 times usual consumption has no effect on behavior and cognitive status.
	Fruit juice with artificial colors plus sodium benzoate or placebo fruit juice	Parent ratings using Weiss-Werry-Peters Activity Scale, objective testing by research psychologists	Increase in hyperactivity during active challenge compared to placebo on parent ratings. No difference on objective testing.

David[23] studied 24 children (ages 1.6 to 12.4) whose parents reported that tartrazine caused severe, immediate behavioral change, with six having a similar reaction to benzoic acid. The children underwent a double-blind, placebo-controlled challenge in the hospital with tartrazine or benzoic acid in pure orange juice or a blackcurrant drink. The first challenge dose was 50 mg, followed by 250 mg 2 hours later. No change in behavior was noted by parents or the nursing staff to any of the challenges. Twenty-two patients returned to a normal diet without any food related problems. The parents of one patient, who was only taking three foods at the time of investigation, refused to accept the negative result of their child's challenge test. One family declined follow-up and also insisted on continuing with the diet.



A meta-analysis by Kavale and Forness of 23 published studies indicated that diet modification had negligible effects on hyperactivity.[24] They concluded that the existing research at that time had not validated the Feingold hypothesis and that diet modification be questioned as an efficacious treatment for hyperactivity.

The claimed association of sugar and hyperkinesis has been refuted by several studies. Fifty hyperkinetic children (ages 5 to 17) described by their mothers as having behavioral reactions to natural sugar were challenged blindly to lemonade containing sugar (sucrose) or saccharin as a placebo sweetener.[25] None showed consistent response to sugar and the parents could not differentiate between the two challenges. Subsequently, 49 of the participants were given pharmacotherapy for hyperkinesis, with good response.

Wolraich et al.[26] studied 32 hyperactive boys in a double-blind, placebo-controlled crossover challenge in a clinical research center. While on a sucrose-free diet, the children were challenged with a drink containing either sucrose or placebo (aspartame). In 16 of the group, the challenge drink was given 1 hour after lunch and in the other 16 in the morning after an overnight fast. Behavioral and cognitive evaluation were done at baseline, 0.5 hour after the challenge and continued every 0.5 hour for approximately 2.5 hours. Neither group showed a difference between sucrose and aspartame effects on behavior. The conclusion remained the same when the analysis was limited to 20 children whose parents claimed that sugar adversely affected their behavior.

Wender and Solanto[27] evaluated the response of 17 children with ADHD and nine age-matched normal controls to the ingestion of orange drink of the same taste using either 35 gm of sucrose, 175 mg of saccharin, or 175 mg of aspartame on three separate days. Stimulant medications were discontinued for at least 2 days prior to testing. Cognitive attention and aggressive behavior were assessed for 4 hours: hourly in the playroom for behavior, and every 2 hours on performance task. No significant effect of sugar, saccharin or aspartame on the aggressive behavior of either group was observed.

Another study examined the effects of a diet high in sucrose or aspartame on the behavior of two groups: 23 children (ages 6 to 10) who were described by their parents as adversely affected by sugar and 25 children (ages 3 to 5) without such a history.[28] The children and their families followed three different diets for 3 weeks each in a blinded, three-way crossover fashion. One diet was high in sucrose with no artificial sweeteners; a second diet was low in sucrose and contained aspartame; and the third was low in sucrose and contained saccharin as a placebo. The children were assessed by a standard set of behavioral and cognitive variables, 39 for school-age children and 31 for preschool children. The alleged sugar-sensitive school children showed no significant differences regarding the three diets. In the preschool group, four of the 31 behavioral variables differed significantly among the three diets, but there was no consistent pattern.

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Aspartame has been implicated to cause behavioral changes in anecdotal reports.[18] Shaywitz et al.[29] studied 15 children (ages 5 to 13) with attention-deficit disorder who were challenged in a double-blind, placebo-controlled crossover design to aspartame (at greater than 10 times the usual intake) or placebo (microcrystalline cellulose) for 2-week periods. Parents and teachers assessed the children's behavior. The children were also admitted for 2 days in a study center for cognitive tests, complete blood count, and several biochemical tests. No significant differences were noted in behavior and cognitive evaluation or in any biochemical test.

PARENT BELIEFS

Despite the very limited scientific ev-

idence to support a relationship between food additives and behavioral changes, many parents continue to believe the relationship exists. With the increasing acceptance of natural and homeopathic therapies, some parents may seek dietary management instead of pharmacologic agents. Foods devoid of food additives appeal to parents who may be averse to commercial food processing. Media sources, especially the wide use of the Internet, unfortunately tend to perpetuate information that may appeal to the public without scientific evidence.

It also may be easier for the parents to accept the idea that their child's behavioral problem is due to a dietary factor rather than to psychosocial issues that are often difficult to evaluate and tackle. The perceived favorable effect of certain elimination diets might be attributed to the fact that it gives the family a sense of solving the problem and provides the child with substantial attention.

CASE REPORTS

We evaluated one 8.5-year-old girl with a history of allergic rhinitis who, according to the mother, had behavioral disorder since age 6. The family repeatedly noticed that, within minutes to less than an hour after eating chocolate, the child becomes "aggressive, nasty, talks back, refuses to follow directions, bully both physically and verbally." Skin prick testing, primarily for allergic rhinitis, was done to aeroallergens, as well as to cocoa, at the mother's request. The child showed positive tests to several aeroallergens, but not to cocoa. To further assure the mother, cocoa-specific IgE antibody was obtained and was also negative. Two double-blind, placebo-controlled challenges to cocoa caused no abnormal behavior during observation for 3 hours in the clinic or later at home. After the child was assured of the absence of chocolate "allergy," she was openly challenged with three types of chocolate, without any adverse effects. The result was reinforced to the mother and the child, who subsequently continued to eat chocolate without any problems.

We also evaluated an 11-year-old boy with behavior problems for several years that the mother believed to be food-related. He was diagnosed with ADHD at age 9, but his mother refused giving him specific medications. The child had cochlear implants and attends a special program in school for the hearing-impaired. The mother reported that, within 30 minutes to an hour of ingesting red dye or artificial sweeteners in soft drinks, he becomes "hyperactive, defiant, angry, wild, beats the dog and on three occasions pulled a steak knife at his mother and older sister." The school was not offering him foods or drinks with red dye or artificial sweeteners, yet the teachers reported that he "ignores requests, refuses directions, pushing, hitting, tripping, cries or gets angry when being corrected." Double-blind, placebo-controlled challenges[30] were done with red dye #3 (erythrosine), red dye #40 (allura red), yellow dye #5 (tartrazine), aspartame, saccharin, and placebo (glucose). During each of these visits, no misbehavior was noted during a 3-hour observation in the clinic, or later at home.

ROLE OF HEALTHCARE PROFESSIONALS

When parents seek professional help regarding a child's behavioral disorder for possible relationship to foods, additives or sugar, it would be prudent first to establish the diagnosis of ADHD based on specific criteria (Sidebar). Also, relevant practice guidelines have been published by the American Academy of Pediatrics.[31] Therefore, such parents should be counseled with empathy about the limited evidence of such a relationship. The family often expects "allergy testing" to reveal the specific agent. However, routine allergy skin testing or blood tests are primarily for immunoglobulin E-mediated reactions, and there is no evidence for such mechanism in behavioral disorder.

Out of heightened concern by the National Institutes of Health about the widespread belief of diet as a cause of childhood hyperactivity, a Consensus Development Conference was held.[32] A scientific panel listened to presentations by researchers, clinicians, and parents. The panel concluded that there is "a limited positive association between 'the defined diet' and a decrease in hyperactivity. Some hyperactive children demonstrated less evidence of hyperactivity on defined diets, or modifications thereof, than on an appropriate control diet. Such decreases involved only a small proportion of patients; furthermore, the decreases in hyperactivity were not observed consistently." The panel recommended that elimination diets generally should not be instituted in the management of childhood hyperactivity, but that a trial of dietary intervention or continuation of such a diet in children whose parents observe benefits may be reasonable. Nevertheless, consideration of all other traditional therapies should be initiated before any diet is considered.

With continued good relationships among the physician, parents, and patient, the family is likely to be more open to scientific approaches to evaluation and therapy. Although we strive for evidence-based practice, in certain instances, the practitioner may yield to a harmless management claimed by parents as beneficial. It may be reasonable to agree on the avoidance of a specific food or additive that the family strongly believes to be causing behavioral problem in the child, even if it is a placebo effect.

SUMMARY

The possible role of foods or additives in causing behavioral disorders in children, particularly ADHD, has been a controversial subject both among health care providers and the public. However, a critical review of the literature provides very

limited support for such a relationship. On encountering such cases, the healthcare professional should first establish an accurate diagnosis of the suspected "abnormal" behavior based on specific standard criteria. It is important to counsel the family regarding the standard of care practice and about the limited evidence of a role of foods and additives in causing behavior problems. If parents strongly suspect a specific dietary item, a trial of elimination may be warranted. If the child's behavior shows definite improvement, a challenge in a double-blind, placebo-controlled fashion under the supervision of an experienced physician would be necessary to verify the relationship.

REFERENCES

1. Brown RT, Freeman WS, Perrin JM, et al. Prevalence and assessment of attention-deficit/hyperactivity disorder in primary care settings. *Pediatrics*. 2001;107(3):E43.
2. Williams J, Klinepeter K, Palmes G, Pulley A, Foy JM. Diagnosis and treatment of behavioral health disorders in pediatric practice. *Pediatrics*. 2004;114(3):601-606.
3. Chan E, Hopkins MR, Perrin JM, Herrerias C, Homer CJ. Diagnostic practices for attention deficit hyperactivity disorder: a national survey of primary care physicians. *Ambul Pediatr*. 2005;5(4):201-208.
4. American Psychiatric Association. *Diagnostic and Statistical Manual of Mental Disorders*. 4th ed. Washington, DC: American Psychiatric Association; 2000.
5. Feingold BF. Hyperkinesis and learning disabilities linked to artificial food flavors and colors. *Am J Nurs*. 1975;75(5):797-803.
6. Feingold BF. *Why Your Child is Hyperactive*. New York, NY: Random House; 1975.
7. Conners CK, Goyette CH, Southwick DA, Lees JM, Andrulonis PA. Food additives and hyperkinesis: a controlled double-blind experiment. *Pediatrics*. 1976;58(2):154-166.
8. Harley JP, Ray RS, Tomasi L, et al. Hyperkinesis and food additives: testing the Feingold hypothesis. *Pediatrics*. 1978;61(6):818-828.
9. Goyette GH, Connors CK, Petti TA, Curtis LE. Effects of artificial colors on hyperkinetic children: a double-blind challenge study [proceedings]. *Psychopharmacol Bull*. 1978;14(2):39-40.
10. Rowe KS, Rowe KJ. Synthetic food coloring and behavior: a dose response effect in a double-blind, placebo-controlled, repeated-measures study. *J Pediatr*. 1994;125(5 Pt 1):691-698.
11. Swanson JM, Kinsbourne M. Food dyes impair performance of hyperactive children on a laboratory learning test. *Science*. 1980;207(4438):1485-1486.
12. Pollock I, Warner JO. Effect of artificial food colours on childhood behaviour. *Arch Dis Child*. 1990;65(1):74-77.
13. Bateman B, Warner JO, Hutchinson E, et al. The effects of a double-blind, placebo controlled, artificial food colourings and benzoate preservative challenge on hyperactivity in a general population sample of preschool children. *Arch Dis Child*. 2004;89(6):506-511.
14. Routh D. Hyperactivity. In: Magrab P, ed. *Psychological Management of Pediatric Problems*. Baltimore, MD: University Park Press; 1978:3-8.
15. Prinz RJ, Roberts WA, Hantman E. Dietary correlates of hyperactive behavior in children. *J Consult Clin Psychol*. 1980;48(6):760-769.
16. Rapp DJ. Does diet affect hyperactivity? *J Learn Disabil*. 1978;11(6):383-62.
17. Crook WG. Letter: An alternate method of managing the hyperactive child. *Pediatrics*. 1974;54(5):656.
18. Bradstock MK, Serdula MK, Marks JS, et al. Evaluation of reactions to food additives: the aspartame experience. *Am J Clin Nutr*. 1986;43(3):464-469.
19. Harley JP, Matthews CG, Eichman P. Synthetic food colors and hyperactivity in children: a double-blind challenge experiment. *Pediatrics*. 1978;62:975-983.
20. Levy F, Dumbrell S, Hobbes G, et al. Hyperkinesis and diet: a double-blind crossover trial with a tartrazine challenge. *Med J Aust*. 1978;1(2):61-64.
21. Weiss B, Williams JH, Margen S, et al. Behavioral responses to artificial food colors. *Science*. 1980;207(4438):1487-1488.
22. Mattes JA, Gittelman R. Effects of artificial food colorings in children with hyperactive symptoms. A critical review and results of a controlled study. *Arch Gen Psychiatry*. 1981;38(6):714-718.
23. David TJ. Reactions to dietary tartrazine. *Arch Dis Child*. 1987;62(2):119-122.
24. Kavale KA, Forness SR. Hyperactivity and diet treatment: a meta-analysis of the Feingold hypothesis. *J Learn Disabil*. 1983;16(6):324-330.
25. Gross MD. Effect of sucrose on hyperkinetic children. *Pediatrics*. 1984;74(5):876-878.
26. Wolraich M, Milich R, Stumbo P, Schultz F. Effects of sucrose ingestion on the behavior of hyperactive boys. *J Pediatr*. 1985;106(4):675-682.
27. Wender EH, Solanto MV. Effects of sugar on aggressive and inattentive behavior in children with attention deficit disorder with hyperactivity and normal children. *Pediatrics*. 1991;88(5):960-966.
28. Wolraich ML, Lindgren SD, Stumbo PJ, et al. Effects of diets high in sucrose or aspartame on the behavior and cognitive performance of children. *N Engl J Med*. 1994;330(5):301-307.
29. Shaywitz BA, Sullivan CM, Anderson GM, et al. Aspartame, behavior, and cognitive function in children with attention deficit disorder. *Pediatrics*. 1994:93(1):70-75.
32. Consensus conference: Defined diets and childhood hyperactivity. *JAMA*. 1982;248(3):290-292.
30. Wilson BG, Bahna SL. Adverse reactions to food additives. *Ann Allergy Asthma Immunol*. 2005;95(6):499-507.
31. Clinical practice guideline: diagnosis and evaluation of the child with attention-deficit/hyperactivity disorder. American Academy of Pediatrics. *Pediatrics*. 2000;105(5):1158-1170.