Nutritional Management of Pediatric Food Hypersensitivity

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ABSTRACT. The diagnosis and management of food allergy requires attention to several important dietary issues. Successful exclusion of identified dietary allergens requires extensive education regarding the interpretation of ingredient labels of commercial products and an appreciation for issues of cross-contact in settings such as restaurants and commercial manufacturing. Once a food or food group is eliminated, attention must be focused on potential dietary insufficiencies resulting from these exclusions. These dietary issues are also central to the successful use of diagnostic elimination diets and physician-supervised oral food challenges. This review provides a framework for the dietary management of food hypersensitivity in infants and children both for short-term diagnostic and long-term therapeutic purposes. In addition, approaches for maternal dietary restriction for breastfed infants with food allergy and the introduction of solid foods to atopic infants are reviewed. ***Pediatrics*** **2003;111:1645–1653;** ***food allergy, food hypersensitivity, nutrition, failure to thrive, elimination diet.***

ABBREVIATIONS. RDA, Recommended Dietary Allowance; DRI, Dietary Reference Intake; EFA, essential fatty acid; DHA, docosahexaenoic acid; AAP, American Academy of Pediatrics.

Virtually all facets of the diagnosis and treatment of food allergies require careful consideration for nutritional and dietary issues. Accurate identification of the allergenic food(s) is the first step. This involves obtaining an accurate dietary history that includes very specific details about foods in relation to symptoms, a process with many nuances. The second step involves the removal of the identified allergen(s) from the diet. This step may be undertaken for a prolonged period as a therapeutic intervention or more briefly as a diagnostic intervention to determine whether the disorder under consideration resolves with the intervention. This step requires detailed education about allergen avoidance and consideration for alternative sources of nutrition. Finally, it is essential in the long-term management to provide a diet that is adequate for appropriate growth and development despite the removal of particular foods from the diet. Some of the intricacies involved in these diagnostic and therapeutic maneuvers have been reviewed in other articles in this supplement. Specific issues related to the nutritional management of the child with food allergy are discussed here.

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APPROACH TO GROWTH ASSESSMENT AND NUTRITION

Nutritional Assessment

Assessment of growth and nutrition is fundamental to the care of children with or without food allergy. Growth is assessed primarily by comparing values for weight, length, weight-to-length ratios, and head circumference against National Center for Health Statistics growth standards for boys and girls.[1] However, these measurements alone have limitations.[2–5] Although absolute size is important, a more sensitive index of growth is growth velocity, the increase in height per unit of time. For a pediatrician, reviewing the growth chart with an emphasis on growth velocity is probably the easiest way to monitor infants and children for the possibility of nutritional deficiency. Height velocity and weight-to-length ratios are excellent measures of stature. Recumbent length should be used in infants younger than 2 years. This is performed by having the infant lie supine on a flat surface and using a length board fitted against the soles of the feet and the crown of the head. Body mass index is useful after 2 years of age and should not be used for infants.

Failure to achieve normal growth rates or growth velocity suggests the need to assess a child's nutritional intake. For infants younger than 6 months, this can be accomplished by a 24-hour recall of the dietary intake. A 3-day diet record is necessary for a child 6 months and older because day-to-day intake is more varied.

Dietary Needs

Nutrient requirements for infants and children with food allergies are similar to the requirements for healthy children based on age and can be obtained from the Recommended Dietary Allowances (RDAs) and, since 1998, Dietary Reference Intakes (DRIs).[6,7] These published guidelines are updated periodically on the basis of the current scientific research by The Food and Nutrition Board of the National Academy of Sciences. The DRI has been divided into 7 nutrient groups, and so far, DRIs have been established for the first 3 groups, which include vitamins, minerals, and some trace elements. Currently, the panel is working on establishing guidelines for macronutrients, including protein.

A number of dietary issues are pertinent to all

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children, which are of particular importance for food-allergic children on potentially nutritionally suboptimal diets. Particular attention should be paid to calories, protein, and fat intake in addition to particular vitamins, minerals, and trace elements for children with food allergies. When applying suggested intakes for children on age-appropriate diets, care should be taken with children who have food allergies and are restricting some common dietary staples. In addition, children with moderate to severe atopic dermatitis may have higher calorie and protein needs based on the degree of skin involvement.

Calories and Protein

Recommended intakes of protein and energy for normal healthy individuals based on the 1989 RDAs are provided in Table 1. For children with food allergy, provision must be made to provide adequate essential amino acids by ensuring sufficient intake of complete proteins and/or complementary proteins, in addition to sufficient calories. In this regard, it is worth noting that the protein requirements established in the 1985 Food and Agriculture Organization/World Health Organization/United Nations University committee report based the RDAs largely on nitrogen balance data from studies using high-quality, highly digestible sources of protein with presumably adequate energy intake.[8] Indeed, factors such as the state of health, the form and quantity in which nitrogen is administered, and energy intake all affect nitrogen balance. Nitrogen retention and ureagenesis are affected by the quality of the protein source; indeed, Jones et al[9] reported increased nitrogen losses in individuals who received L-amino acids as their source of protein in comparison with individuals who received intact whole protein. Hence, intake of adequate protein equivalent to cover nitrogen losses as a result of poor utilization of amino acid and protein hydrolysates, in addition to sufficient energy intake, should be recommended for children with food allergies. Use of protein hydrolysates and/or amino acid-based formulas may be necessary for children older than 1 year, if sufficient intake of good-quality protein is compromised.

Fats

Appropriate fat intake may become compromised in allergen-restricted diets. The worry is not only because of loss of total calories but also because essential fatty acid (EFA) requirements may not be met. The fatty acids essential for humans are linoleic (C18:2n-6) and α-linolenic (C18:3n-3) acids. Linoleic acid and its derivative, arachidonic acid (C20:4n-6), function as precursors for eicosanoids, which include prostaglandins and leukotrienes involved in cell signaling mechanisms. α-Linolenic acid and its derivatives, eicosapentaenoic acid (C20:5n-3) and docosahexaenoic acid (DHA; C22:6n-3), are important for neuronal development. The optimum requirements for EFA of the n-3 and n-6 families for infants are still not known, although normal growth of infants depends on an adequate supply of EFAs. The Committee on Nutrition of the American Academy of Pediatrics (AAP) recommends that 2.7% (range: 1%–4.5%) of energy intake be linoleic acid and 1% of energy intake be linolenic acid.[10] This should ensure an adequate supply of EFA for tissue proliferation, membrane integrity, and eicosanoid formation. Vegetable oils, except for coconut oil, are predominantly unsaturated with high content of linoleic acid and small amounts of linolenic acid. Major sources of linolenic acid are fish, fish oils, and oil extracted from seeds of *Oenothera biennis* (evening primrose).

Dietary fat should be varied so that an equivalent blend of saturated, monounsaturated, and polyunsaturated fats are provided. Typically, animal proteins provide adequate amounts of saturated fats. Use of vegetable oils such as safflower, canola, corn, soybean, and olive oil is recommended to supply monounsaturated and polyunsaturated fats and the necessary EFAs to the allergic individual.[11] Because fish and fish oils are the ones most commonly re-

TABLE 1. Recommended Intakes of High-Quality Reference Protein and Calories for Normal Healthy Individuals Based on 1989 RDA

Age (Years)	Weight (kg)	Protein (g/kg/day)	Energy (kcal/kg/day)
Infants			
0–0.5	6	2.2	108
0.5–1	9	1.6	98
Children			
1–3	13	1.2	102
4–6	20	1.1	90
7–10	28	1.0	70
Males			
11–14	45	1.0	55
15–18	66	0.9	45
19+	72–79	0.8	40
Females			
11–14	46	1.0	47
15–18	55	0.8	40
19+	58–65	0.8	38
Pregnancy		Add 10 g/d	Add 300 kcal/d
Lactation, 1st 6 mo		Add 15 g/d	Add 500 kcal/d
Lactation, 2nd 6 mo		Add 12 g/d	Add 500 kcal/d

Adapted from Food and Nutrition Board, National Research Council. *Recommended Dietary Allowances*. 10th ed. Washington, DC: National Academy Press; 1989.

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stricted in the diet of allergic children, the addition of vegetable oils to meals is recommended. The quantity of the oils required in the diet of a child will need to be individualized on the basis of the type of foods allowed in the diet and the quantity consumed daily. This approach ensures intake of sufficient quantities of both linoleic and linolenic acid necessary to avoid EFA deficiency and also to promote growth.

Carbohydrates

Carbohydrates are the primary source of metabolic energy and provide between 40% and 60% of the caloric requirement. Grains, fruits, and vegetables all are good sources of carbohydrates. Consumption of whole grains and fresh fruits and vegetables should be emphasized not only for the nutrient contribution but also to provide fiber to the diet. Cooked forms of fruits and vegetables may not provide the same quality of nutrients in comparison with their fresh counterparts but do supply fiber.

Vitamins, Minerals, and Trace Elements

The adequacy of vitamins, minerals, and trace elements is dependent on the variety of the foods in the diet. When 1 food or food group is eliminated, alternative sources of nutrients that are consequently lost need to be identified. The RDAs and DRIs for vitamins, minerals, and trace elements can be used as guidelines for children with food allergies. However, specific nutrient needs of children with food allergies are not known. Recently, Salman et al[12] reviewed the nutritional intake of a group of children (1–9 years of age) with known food allergies. Several nutrients, including calcium, iron, vitamin D, vitamin E, and zinc, were noted to be low, provided at <67% of the RDA.

FOOD ELIMINATION DIETS

General Overview

Strict elimination of the offending food allergen(s) is the only proven therapy for food hypersensitivity.[13,14] Dietary allergen elimination may be used as a brief trial to determine the impact of food allergy on a disease state or for a longer period for treatment. Elimination diets should be undertaken with caution, especially if a significant number of foods or food groups are avoided, because several reports have documented inadequate caloric intake and failure to thrive.[15–20] With these issues in mind, it is important to identify exactly which foods need to be eliminated and to consider nutritional issues of a diet composed of the allowed foods over the long term.

Prescription of Diets

Education about issues that arise in undertaking dietary elimination, such as label reading, cross-contact, and selection of substitute foods, is crucial for successful elimination. A review of these same points is needed for periodic reassessment and to determine whether there are indiscretions in the diet, especially if symptoms fail to respond or symptoms recur. It is helpful to have the family bring in labels and keep food/symptom diaries to help identify foods/ingredients that are common in time to symptoms or that may be identifiable as tolerated. Details such as the time of the meal or snack, brand name if commercially prepared, specific ingredients if homemade, amount consumed, and symptoms should be recorded. Such a list, along with ingredient labels, may reveal hidden sources of the food allergen or unknown sources of contamination. Using alternative foods similar to what is recorded in the diet diary can also significantly enhance adherence to the restricted diet. For example, rice or corn pasta would be a helpful substitution for a child who frequently eats wheat pasta and is to be placed on a trial of a wheat-free diet.

A tremendous amount of information must be given to families to afford them the tools needed for successful dietary elimination. The information spans label reading (understanding nonstandard terms such as "casein" or "whey" that mean cow milk), concerns about cross-contact of food allergens in commercial processing and in food service such as restaurants, and the nutritional issues.[21,22] Particular allergens may be hidden in unsuspected foods such as milk or egg proteins in bread products; milk or soy protein in canned tuna; peanut flour in cakes, sauces, or chili; and peanut butter as the glue that holds egg rolls together.[23] In many cases, it is necessary for families to call the manufacturers to determine the safety of the products, although improved labeling laws are under consideration. The potential confusion is illustrated by the use of kosher symbols that may inadvertently be misleading to patients. Kosher dietary laws prohibit use of milk or milk products in combination with meat. Therefore, a product labeled with a "D" for dairy should not contain any meat, and a product labeled "Pareve" (neutral) should contain no milk or meat products. Under most kosher supervision agencies, any product that contains any material derived from milk as an ingredient that is intentionally put into a product that is dairy would be marked with a "D" next to the kosher symbol. Some agencies allow products that are made on equipment that contains no intentionally added dairy to be marked with a "DE" for dairy equipment. Under Jewish law, a food product may contain a very small amount of milk and still be considered Pareve. There have been several reports in the literature[24–27] and also several alerts from the Food Allergy & Anaphylaxis Network yearly regarding contamination of Pareve-labeled items resulting in a reaction in an individual with milk allergy. Although food manufacturers adhere to "good manufacturing practice" guidelines, there are reports of adverse reactions after ingestion of products either specifically intended to be nondairy or not labeled to have milk as an ingredient. In addition, "How to read a label" cards are available from The Food Allergy & Anaphylaxis Network (800–929-4040; www.foodallergy.org) to help parents with the various difficulties caused by labeling inadequacies.

Thought must also be given to substitutions for eliminated foods. Teaching parents how to replace the egg in the diet to provide an alternative source of nutrients lost through the elimination of egg from the

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diet is one example. The Food Allergy & Anaphylaxis Network's Cookbook has many recipes that do not use milk, egg, soy, wheat, peanuts, and tree nuts. Most of the "egg substitutes" available are made with egg whites, which would still pose a problem to the egg-allergic child. There are ways to replace the egg with baking powder, oil and water, or apricot puree to resemble the function or the color of egg in baked products.[28] A potato-based egg substitute that can be used in place of eggs in baked goods is also available.

Nutritional Consequences of Elimination Diets

When a food or a food group is eliminated, one must consider the types of nutrients that are potentially lost, whether other components of the diet are adequate to fulfill nutritional needs, and whether additional dietary alterations are needed to fulfill the lost nutrients. Table 2 shows which vitamins and minerals may be reduced by specific restrictions. For example, if the allergy is to a food group that is a major contributor to the diet, such as in cow milk allergy, then all dairy products will be avoided. Therefore, calcium, phosphorus, riboflavin, pantothenic acid, vitamin B_{12}, vitamin A, and vitamin D will need to be supplied from other sources. Supplementation with appropriate amounts of calcium and vitamin D are important to individuals with milk allergy at any age. It is difficult to obtain adequate calcium from nondairy foods. There are, however, alternative drinks (soy and rice) and juices that are enriched with calcium. Milk-free calcium supplements can also be considered for use with milk-allergic children. Use of calcium-fortified juices that come in "juice box" form could result in unexpected problems because contamination with milk protein has been noted in several different products in juice box form, presumably from cross-contact during processing (H. A. Sampson, personal communication, June 2002). Juices that are from bottles, cans, and/or frozen concentrates are not as commonly contaminated. Intake of residual foods must be considered to determine whether an adequate amount of, for example, vitamin A, is provided and whether it is necessary to increase the intake of foods high in vitamin A. Another issue of concern for children with multiple food allergies is the distribution of carbohydrates, protein, and fats in the diet. Modifications in food choices should be made to ensure sufficient macronutrient and energy intake. For example, a grain-allergic child should be evaluated to ensure adequate intake of carbohydrates from alternative foods because sufficient intake of carbohydrates is necessary to prevent ketosis.

TABLE 2. Vitamins and Minerals That Are Provided by Different Food Allergens

Allergen	Vitamins and Minerals
Milk	Vitamin A, vitamin D, riboflavin, pantothenic acid, vitamin B_{12}, calcium, and phosphorus
Egg	Vitamin B_{12}, riboflavin, pantothenic acid, biotin, and selenium
Soy	Thiamin, riboflavin, pyridoxine, folate, calcium, phosphorus, magnesium, iron, and zinc
Wheat	Thiamin, riboflavin, niacin, iron, and folate if fortified
Peanut	Vitamin E, niacin, magnesium, manganese, and chromium

Success of elimination diets depends on adherence and nutritional adequacy, and both can be affected unless intelligent and creative choices are made to allow diversity of taste and texture in addition to nutrition. Sometimes the removal of even a single food protein requires that a large number of products with diverse nutritional and social advantage be excluded from the diet. For example, if the allergy is to wheat, then all commercial breads, cereals, baked goods, and pastas would be eliminated. Wheat is not only a main ingredient for a large number of products, it is also one of the common starches used in many processed foods. In this situation, the use of alternative grains (eg, rice, oat, potato, barley) as flour in baked goods may provide a solution. Use of commercial products with alternative grains such as crackers, cakes, and pastas made of rice, corn, potato, or quinoa can also provide normalcy and convenience to the diet of the allergic child on a wheat-restricted diet.

Long-Term Management of Restricted Diets

The duration of the restricted diet also becomes an important factor in management. If the diet is modified for a short period for diagnostic purposes, then a complete evaluation may not be necessary. If the elimination diet is long-term, then a full nutritional assessment is essential.

Assessment of the quality of the diet and also the degree of compliance with restriction is necessary to prevent future problems with growth. Use of protein hydrolysates and/or amino acid-based elemental formulas is encouraged if sufficient intake of good-quality protein is compromised. Several studies have evaluated protein hydrolysates or elemental formulas in infants and children with food allergies. Protein hydrolysate formula (extensively hydrolyzed) is efficacious in infants with cow milk allergy.[29–37] Amino acid-based formulas have been reported to effectively alleviate residual symptoms that do not respond to hydrolysates.[31,38–40] Two studies recently addressed growth in children with multiple food allergies.[39,41] Isolauri et al[41] evaluated growth in children with cow milk allergy. In a group of 100 infants (<12 months of age), length and weight-for-length indexes were noted to be decreased compared with age-matched healthy controls. The age at the onset of symptoms and the length of the elimination diet were major contributors to growth problems. Niggeman et al[39] evaluated the efficacy of amino acid-based formula compared with extensively hydrolyzed cow milk formula in children with cow milk allergy and found improved growth (length) on amino acid-based formula despite similar intakes of calories.

Substitutes for cow milk are commonly sought during elimination diets. There are a number of pitfalls with the common substitutes. Goat milk is commonly recommended but is a poor choice. In a study of children with confirmed cow milk allergy, 24 of 26

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reacted to goat milk in a double-blind, placebo-controlled, oral food challenge.[42] Rice milk is another alternative that may not be adequate nutritionally. Enriched rice milk is a good source of calcium and vitamin D; however, it lacks protein, fat, and other nutrients that are necessary for growth. Continued use of commercially prepared complete formulas beyond infancy is sometimes recommended for children with multiple food allergies on very limited diets. Use of formula as a supplement to table foods is even more critical for children who are avoiding the major contributors of protein to the diet at that age (milk, egg, and soy) and also for those restricting meats. Even if meats are allowed in the diet, unless the child can consume 2 servings (2–3 oz = meat serving) in a day, the diet may not provide sufficient protein and other nutrients. Reviewing the intake of infant foods/table foods with the family before discontinuing use of commercial formula is strongly recommended. The situation can be reassessed at 3-month intervals during the child's regular checkups to ensure adequate intake and growth. This slow transition from formula can also prevent a common situation in which failure to thrive is noted on switching from a combination of formula/breast milk/infant foods to only table foods.

A multivitamin and mineral supplement can also offer a nutritional safety net. Unfortunately, most supplements, even those marketed as milk-free, may be contaminated with milk and create problems for the milk-allergic child. Care should be taken in choosing a supplement that meets the child's needs. It may be necessary to contact the manufacturer to address concerns regarding the possibility of presence of food allergens. Use of fortified infant cereals is another way to supplement the diets of children with multiple food allergies. Several brands are fortified with vitamins and minerals to provide 25% calcium, 45% iron, 25% zinc, and 25% vitamin B_{12} in addition to several other vitamins in a one fourth-cup serving (15 g). Addition of even a single serving of this cereal to the restricted diet of the food-allergic child can provide several of the needed nutrients.

Provision of an adequate diet to a food-allergic child can seem daunting. Tables 3 and 4 list food sources for vitamins, minerals, and trace elements. Table 5 is a sample menu eliminating all major food allergens. The Food Guide Pyramid for young chil-

TABLE 3. Functions and Food Sources of Vitamins

Vitamin	Chief Functions in the Body	Significant Sources
Vitamin A	Visual adaptation to light and dark; growth of skin and mucous membrane	Retinol (animal foods): liver, egg yolk, fortified milk, cheese, cream, butter, and fortified margarine Carotene (plant foods): spinach and other dark leafy greens, broccoli, deep orange fruits (apricots and cantaloupe) and vegetables (squash, carrots, sweet potato, and pumpkin)
Vitamin D	Absorption of calcium and phosphorus; calcification of bones	Self-synthesis from sunlight; fortified milk, fortified margarine, eggs, liver, and fish oils
Vitamin E	Antioxidant, stabilization of cell membranes, protection of polyunsaturated fatty acids and vitamin A	Polyunsaturated plant oils, green and leafy vegetables, wheat germ, whole-grain products, nuts, and seeds
Vitamin K	Normal blood clotting	Bacterial synthesis in the digestive tract; green leafy vegetables, milk and dairy products, meats, eggs, and cereals
Thiamin (B_1)	Coenzyme in carbohydrate metabolism; normal function of the heart, nerves, and muscle	Pork, beef, liver, whole or enriched grains, legumes, and nuts
Riboflavin (B_2)	Coenzyme in protein and energy metabolism	Milk, yogurt, cottage cheese, meat, leafy green vegetables, whole or enriched grains and cereals
Niacin (B_3)	Coenzyme in energy production, health of skin, normal activity of stomach, intestines, and nervous system	Meat, peanuts, legumes, and whole or enriched grains
Pyridoxine (B_6)	Coenzyme in amino acid metabolism; helps convert tryptophan to niacin; heme formation	Grains, seeds, liver, meats, milk, eggs, and vegetables
Cyanocobalamin (B_{12})	Coenzyme in synthesis of heme in hemoglobin; normal blood cell formation	Animal products (meat, fish, poultry, shellfish, milk, cheese, and eggs)
Folic acid	Part of DNA; growth and development of red blood cells	Liver, leafy green vegetables, legumes, seeds, and yeast
Pantothenic acid	Part of coenzyme A, which is used in energy metabolism; formation of fat, cholesterol, and heme; activation of amino acids	Meats, cereals, legumes, milk, fruits, and vegetables
Biotin	Part of coenzyme A, which is used in energy metabolism; involved in lipid synthesis, amino acid metabolism, and glycogen synthesis	Liver, egg yolk, soy flour, cereals, tomatoes, and yeast
Vitamin C	Collagen synthesis (strengthens blood vessel walls, forms scar tissue, matrix for bone growth); antioxidant; thyroxine synthesis; strengthens resistance to infection; helps with absorption of iron	Citrus fruits, tomato, cabbage, dark leafy green vegetables, broccoli, chard, turnip greens, potatoes, peppers, cantaloupe, strawberries, melons, papayas, and mangos

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TABLE 4. Functions and Food Sources of Minerals and Trace Elements

Mineral	Chief Functions in the Body	Significant Sources
Calcium	Bone and teeth formation; involved in normal muscle contraction and relaxation, nerve functioning, blood clotting, and blood pressure	Milk and milk products; small fish (with bones); greens; legumes; calcium-fortified tofu; calcium-forti fied juices; calcium-fortified rice, soy, or potato milks
Chloride	Part of hydrochloric acid found in the stomach, necessary for proper digestion	Salt, soy sauce; moderate quantities in whole, unprocessed foods, large amounts in processed foods
Chromium	Cofactor for insulin	Molasses, nuts, whole grains, and seafood
Copper	Cofactor for enzymes; necessary for iron metabolism; cross-linking of elastin	Liver, shellfish, whole-grain cereals, legumes, and nuts
Fluoride	Structural component in calcium hydroxyapatite of bones and teeth	Seafood, meat, fluoridated water
Iodide	A component of the thyroid hormone, thyroxin, which helps to regulate growth, development, and metabolic rate	Iodized salt and seafood
Iron	Structural component of hemoglobin (which carries oxygen in the blood) and myoglobin (which makes oxygen available for muscle contraction) and other enzymes; necessary for the utilization of energy	Red meats, fish, poultry, shellfish, legumes, dried fruits
Magnesium	One of the factors involved in bone mineralization; maintain electrical potential in nerves and muscle membranes; involved in building of proteins, enzyme action, normal muscular contraction, transmission of nerve impulses, and maintenanceance of teeth	Widely distributed in most foods with nuts, fruits, vegetables, and cereals as best sources
Manganese	Cofactor for enzymes	Whole grains, leafy green vegetables, and wheat germ
Molybdenum	Xanthine oxidase, aldehyde oxidase	Legumes, whole grains, and wheat
Phosphorus	Bone and teeth formation; regulation of acid-base balance; present in cell's genetic material as phospholipids, in energy transfer, and in buffering systems	Milk, poultry, fish, meat, and carbonated beverages
Potassium	Regulation of osmotic pressure and acid-base balance; activation of a number of intracellular enzymes; nerve and muscle contraction	All whole foods; meats, milk, fruits, vegetables, grains, and legumes
Selenium	Part of glutathione peroxidase (an enzyme that breaks down reactive chemicals that harm cells); works with vitamin E	Seafood, organ meats, muscle meats, grains, and vegetables depending on soil conditions
Sodium	Regulation of pH, osmotic pressure, and water balance; conductivity or excitability of nerves and muscles; active transport of glucose and amino acids	Salt, soy sauce, seafood, dairy products, and processed foods
Zinc	Part of the hormone insulin and many enzymes; taste perception; wound healing; metabolism of nucleic acids	Red meat; seafood, especially oysters; and beans

dren 2 to 6 years of age can also be used to provide information regarding serving sizes for children younger than 6 years.[43] Some of the items are allergenic, and substitutions should be provided for the family.

SPECIAL DIETARY CONSIDERATIONS

Maternal Diet Restriction for Breastfed Infants

Prevention of food allergy in infants and children is discussed in great detail elsewhere in this supplement and includes breastfeeding and possibly maternal dietary restrictions. Indeed, the AAP recommends breastfeeding as the optimal source of nutrition for infants through the first year of life or longer.[44] During breastfeeding, greater requirements of calories, protein, vitamins, and minerals are usually met by the mother by consuming a well-balanced diet with a variety of nutritious foods to support lactation. Additional requirements for calories and protein during lactation are noted in Table 1. Although the quality of breast milk is remarkably preserved even at times of poor nutrition, the composition is affected by maternal diet. The quantity of milk produced is decreased in a diet low in calories and/or protein. The fatty acid composition is also potentially altered and mirrors maternal intake. Certain vitamins and minerals are unaffected by the maternal diet, but many are affected.[45] It is interesting that the calcium content of breast milk is unaffected by maternal diet; however, if needed, the calcium is taken from the mother's own calcium reserves.

Several studies have documented the presence of food allergens in breast milk sufficient to induce reactions in infants.[46–48] These studies showed that milk and peanut protein were secreted into breast milk of lactating women after maternal ingestion of these foods. On the basis of this and other observations, the AAP; the European Society for Pediatric Allergology and Clinical Immunology; and the European Society for Pediatric Gastroenterology, Hepatology, and Nutrition all recommend exclusion of identified causal protein from the maternal diet if the infant is affected.[49,50] The AAP specifically suggests restricting milk, egg, fish, peanuts, and tree nuts in the maternal diet if symptoms of food allergy are

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TABLE 5. Sample Menu Eliminating All Major Food Allergens*

Breakfast
Calcium-fortified orange juice or enriched rice milk
Cooked plain oatmeal with sugar and cinnamon
Fruit salad made with apples, grapes, pears, and orange sections
Lunch
Hamburger with ground beef, lettuce, tomato, and milk-free/soy-free bun
French fries with catsup or baked potato with milk-free/soy-free margarine
Green salad made with lettuce, cucumber, tomato, and carrot curls
Homemade vinegar and oil dressing
Enriched rice milk
Banana or apple
Dinner
Baked chicken
White or brown rice
Mixed vegetables made with carrots, broccoli, cauliflower, and zucchini
Milk-free/soy-free margarine
Canned peaches
Enriched rice milk
Snacks
Milk-free/peanut-free rice cakes
Milk-free/wheat-free corn or rice puffs
Fresh fruit (apple, banana, grapes)
Carrot and celery sticks
Applesauce

* Contacting the manufacturer to ensure the safety of the food for the individual child is necessary.
Amounts of food in this sample menu must be individualized to meet the child's nutrient needs.

noted in the infant. In addition, prophylactic restriction of some food allergens is suggested for infants at high risk for allergy.

Lactating mothers who undertake restricted diets may be at nutritional risk. The adequacy of the diets of breastfeeding mothers who are avoiding a number of food allergens has not specifically been studied. The nutrients that are provided in peanuts, tree nuts, and fish can be replaced by modifications of food choices. Such a task is not so simple in relation to milk and egg because both are ubiquitous in foods and limit food choices greatly if excluded. If these foods are restricted, then alternative sources of the nutrients lost must be sought, and this can be a difficult task. The assistance of a dietitian is imperative in these circumstances. In some cases, maternal dietary elimination may not allow sufficient improvement in the infant, and illness and failure to thrive may continue despite good efforts. Isolauri et al[51] studied 100 infants who had atopic dermatitis and were exclusively breastfed. Some improvement was achieved by instituting a maternal elimination diet, but the infant's atopic symptoms resolved completely only after the cessation of breastfeeding. After breastfeeding had stopped, improved growth and nutritional parameters of these infants were noted. They reported that the most important factor contributing to the improved growth and nutrition of these atopic infants was cessation of breastfeeding.[51] It is helpful to emphasize that infants with food allergies are likely to need restricted diets and supplements in the first year of life, and so introduction to bottle feeding, even in exclusively breastfed infants, should be considered to facilitate the introduction of formulas if needed. If commercial formula is needed, then a gradual transition should be made.

Introduction of Foods in Food-Allergic Infants and Children

Introduction of solids before 4 months of life has been associated with a higher risk of atopic dermatitis compared with delayed introduction.[52] Several studies recommend avoidance of solids for the first 6 months of life, with delayed introduction of the allergenic foods.[53–56] The Committee on Nutrition of the AAP also recommends delayed introduction of solids until 6 moths of age.[49]

In a healthy infant, the timing of introduction of solid feedings depends on the neurologic and gastrointestinal maturation of the infant.[45] The infant should be able to sit and to coordinate chewing and swallowing nonliquid foods. The oral-motor skills needed to transfer food from the front of the tongue to the back are also necessary. The ability to digest and absorb proteins, fats, and carbohydrates should be sufficiently mature by 4 to 6 months of age. Usually it is at that time that cereals and pureed fruits, vegetables, and eventually meats are introduced. There is obviously a great variation among infants in the times to achieve these goals. Infants generally indicate their readiness by opening their mouths and leaning forward in the sitting position. Similarly, infants indicate satiety or lack of interest or readiness by turning away. The decision to introduce solid foods should be individualized and based on the infant's developmental ability.

For children with a history of food allergies or a disposition toward them, a modified schedule of food introduction can be used.[49] Solids are delayed until 6 months. Selection of foods is also individualized on the basis of the child's history or family history. Single-ingredient foods should be introduced first with 5 to 7 days between each new food to permit identification of any problems. Infant cereals (rice or oat) are a good first choice because their texture can be manipulated to the tolerance of the infant, but allergy to virtually any food is a possibility and grain allergy is not uncommon. In addition, cereals can play an important role in replenishing the infant's iron stores, which are usually depleted between 4 and 6 months of age.[2] Orange vegetables (squash, sweet potato, and carrots) followed by fruits (apple, pear, banana, plum, peach, and apricot) can subsequently be introduced. Green vegetables (spinach, peas, and green beans) may be added followed by grains (rice or oat, corn, white potato, barley, and wheat) and then meats (lamb, pork, turkey, chicken, and beef). For infants with a high risk for allergy, the AAP recommends delaying the introduction of milk or soy until after 1 year of age; eggs until 2 years of age; and peanuts, tree nuts, fish, and shellfish until after 3 years of age.[49]

Education cannot be emphasized enough because even simple jarred infant foods may contain unexpected ingredients. For example, a brand of jarred "broccoli and cauliflower" infant food mix contains "broccoli, water, cauliflower, brown rice flour, and

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unsalted butter." This vegetable mix may pose a problem for children with milk allergies. Recently, a new line of infant food products have been introduced with added DHA, which use dried egg yolks or cream as the source of the DHA. These infant foods are marketed for use by infants 6 months and older and are inappropriate for children with egg or milk allergies.

For a child who is on only a few foods during infancy, it is critical to provide advancing textures appropriate to the developmental stage to prevent feeding problems. Advancing from pureed sweet potato, for example, to mashed, then diced, then well-cooked chunks, and finally to french-fried sweet potatoes allows the child to experiment and master different textures and finger feeding to achieve appropriate feeding skills.

SUMMARY AND RECOMMENDATIONS

The nutritional management of food allergy in infants and children requires education about dietary avoidance and consideration for nutritional deficiencies that may result. The pediatrician plays a central role in identifying children with food allergy and for continued monitoring of food-allergic patients for growth and development. Indeed, a review of the child's growth chart with emphasis on growth velocity is the most efficient way to monitor children with food allergies. For comprehensive nutritional management, the pediatrician may benefit from the additional assistance of a dietitian and an allergist in many cases:

- For a definitive diagnosis (elimination diets, oral challenge)
- When there are multiple maternal dietary restrictions during breastfeeding
- When food groups or multiple foods are avoided (especially without a complete formula)
- To determine appropriate substitutions of allergenic foods with safe foods
- To determine the nutritional adequacy of the diet in the face of poor growth
- To educate the family regarding the words/terms/indicators that are used on food labels to indicate the presence of an allergen

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