Atypical Diets in Infancy and Early Childhood

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The nutritional adequacy of atypical diets for infants and young children may be a concern for the health care professional. These diets are thought to provide potential health benefits for infants and children, but may also lack nutrients needed for normal growth and development. They include vegetarian diets, prolonged breastfeeding, and low-fat diets. High juice intake, pica, and finicky eating are not "diets" per se, but are practices that may cause concern regarding diet adequacy. We discuss the background, the proposed health benefits, and the potential concerns related to the nutritional adequacy of these diets and eating practices.

Vegetarian Diets for Children

Vegetarianism is a major dietary practice in the United States today and vegetarian parents often raise their children on a vegetarian diet. Data from the U.S. Department of Agriculture 1994-1996 Continuing Survey of Food Intake by Individuals (CSFII) showed that approximately 6% of adults consume a vegetarian diet defined as no intake of meat, poultry, or fish. Individuals may follow a vegetarian diet as part of their personal beliefs, culture, or religion, or for health benefits. Regardless of why they choose this diet, vegetarian parents, similar to most parents, want the best for their children. So, it is important for them to understand that the nutritional requirements of a growing child are different from those of an adult. These differences may require modifications for the child’s diet, but such modifications must be reasonable to ensure cooperation with the individuals providing the meals. Radical changes that disrupt the general basis of the diet are likely to be rejected by the parents, especially if the diet is associated with religious practices. The pediatrician should be knowledgeable about the different types of vegetarian diets, their health benefits, and the areas of potential concern regarding them.

Types of Vegetarians

Because caring for vegetarian children means interacting with vegetarian parents, it is beneficial for the pediatrician to understand the reasons a vegetarian diet is followed. Typical reasons include religious practices, ethical or economic concerns, and health concerns.

The term “vegetarian” is broad and includes several subgroups, all of which vary in the degree of animal products consumed in the diet. Some vegetarians are raised in cultures and societies where a vegetarian diet is the norm. They are termed traditional vegetarians and typically avoid most animal foods to varying amounts depending on their ethnic or cultural beliefs. Because they avoid pork, religious groups such
as the Muslims would be considered traditional vegetarians. Lacto-ovo-vegetarians consume dairy products and eggs in addition to plant foods, but abstain from animal flesh, such as red meat, poultry, and seafood. Lacto-vegetarians drink milk and eat other dairy products, but do not include eggs or animal flesh in their diets. Vegans follow a strict vegetarian diet that excludes any food that comes from an animal source. Alternative vegetarians have become vegetarians due to personal beliefs. They do not necessarily belong to a particular dietary group, but tend to live a lifestyle revolving around the person as a whole. The Zen macrobiotic diet is one of these lifestyles that revolves around the Chinese dualism of yin and yang, in which the individual tries to find an appropriate balance among foods.

Some individuals who consider themselves vegetarians will occasionally consume some types of meat products, such as chicken or fish. These meat products may supplement the nutritional needs of the individual to ensure health.

Possible Health Benefits

The health benefits of a vegetarian diet during early childhood are not well known, but the advantages of an adult vegetarian diet have been proposed for years. A vegetarian diet may play a role in reducing coronary heart disease by decreasing consumption of saturated fats typically found in animal products and increasing consumption of monounsaturated and polyunsaturated fats generally found in plant foods. It has been suggested that eating habits formed during childhood have a lifelong effect on serum lipid levels, and therefore an indirect effect on risk for adult coronary heart disease. Lower blood pressure and a decreased incidence of obesity have been observed in adult vegetarians. These may be related to lower caloric intake and a high amount of fiber in the diet. The high amount of fiber also could help to decrease the risk of diseases of the lower gastrointestinal tract, including diverticular disease, appendicitis, and perhaps colon cancer.

Seventh-Day Adventists are a religious group that typically avoids tobacco and alcohol. Approximately half of the members also consume a lacto-ovo-vegetarian diet. Several studies have assessed health aspects for Seventh-Day Adventists.

One of the largest and longest examined all causes of mortality. This study surveyed and observed 27,530 vegetarian and nonvegetarian Seventh-Day Adventists for 21 years. At the 21-year follow-up, those with more vegetarian food habits had lower age-specific mortality rates than did those with more omnivorous eating practices.

Due to the increased intake of high-fiber foods and decreased intake of simple sugars, particularly sticky sweets and snacks high in sugar, vegetarian children may have a decreased risk of dental caries compared with omnivorous children. In 2,000 Asian Indian children between the ages of 1 and 14 years, the prevalence of dental caries was lower in those consuming a vegetarian diets (33%) compared with those consuming a nonvegetarian diet (38%). However, others have concluded that a vegetarian diet had no advantage over a nonvegetarian diet for preventing dental caries, noting that a vegetarian diet is high in acid fruits, juices, and other foods that erode enamel.

Potential Concerns

A vegetarian diet, if properly monitored and supplemented, can provide all of the nutrients required for the health of an infant. Problems arise when individuals consuming strict vegetarian diets shun nutritional supplements. Children consuming a strict vegan diet are at increased risk of deficiencies in vitamin D, vitamin B12, and iron, as well as growth failure.

Vitamin D. The body can naturally synthesize vitamin D with adequate exposure to sunlight. Thus, a dietary source may not be necessary. However, latitude, seasonal differences, and skin pigmentation all play a role in the body’s ability to synthesize vitamin D. High latitudes receive less exposure to sunlight than do low latitudes, especially during the winter months. A decrease in serum levels of 25-hydroxyvitamin D (25-OHD), the major storage form of vitamin D, has been shown to occur during the winter months. This is due to less sunlight and the skin being covered because of the cold weather. Children with increased skin pigmentation, such as those of African or Asian descent, may have lower concentrations of vitamin D. Melanin may hinder the production of vitamin D by blocking ultraviolet light. Children who consume vegan diets and
other diets that do not include milk or other dairy products fortified with vitamin D need to receive sufficient amounts of ultraviolet light to maintain adequate levels of vitamin D.

The classic manifestation of vitamin D deficiency during infancy and childhood is rickets. A high prevalence of rickets has occurred in infants consuming a macrobiotic diet. Such infants were found to have lower serum 25-OH12 concentrations throughout the year compared with infants without rickets; 25-OH12 concentrations were also significantly lower following the winter months.

The amount of exposure to sunlight required for a breastfed infant to maintain adequate 25-OH12 concentrations has been estimated to be 2 hours per week with only the face exposed or 30 minutes per week wearing only a diaper. The infants in this study did not use sunscreen, which may hinder the production of vitamin D. Despite regular use on infants, most sunscreens are not recommended for infants younger than 6 months without consulting a physician. The recent Dietary Reference Intakes (DRI) state that if an adequate amount of vitamin D is not provided in the diet and a sufficient amount of sunlight exposure cannot be obtained due to high latitudes, long winter months, or dark skin pigmentation, 200 IU/d of vitamin D supplementation should be encouraged for infants and young children.

**Vitamin B12.** Because there is no high-quality source of vitamin B12 in plant foods, almost all vegetarians who do not consume eggs or dairy products are at risk of vitamin B12 deficiency unless a supplement is provided. Microorganisms that are part of the normal intestinal flora produce vitamin B12, but the body is unable to absorb the vitamin because it is synthesized distal to the site of major absorption. Some vegetarians may consume tempeh, a fermented soy product, or spirulina, a blue-green algae, believing that these are quality sources of vitamin B12. Tempeh does not contain substantial amounts of vitamin B12, and spirulinas contain analogs of vitamin B12 that are inactive in humans.

If initial body stores of vitamin B12 are adequate, deficiencies may take a long time to develop in adults (sometimes up to 4 to 5 years). This is due to the small requirements for and relatively large stores of the vitamin, and the efficient enterohepatic circulation that reabsorbs most of the vitamin B12 in the bile before it is excreted from the body, resulting in a small daily turnover. However, the initial vitamin B12 stores of an infant may be inadequate for normal development if the mother consumed a vegetarian diet during pregnancy and was vitamin B12 deficient herself. Regardless of initial stores, vitamin B12 deficiency is likely unless some source is provided in the diet or through supplementation.

Vitamin B12 deficiency can lead to megaloblastic anemia, methylmalonic acidemia, and severe and irreversible neuropathy that may impair the cognitive development of a growing infant. Megaloblastic anemia may or may not be present with vitamin B12 deficiency, depending on folate levels. If folate levels are high enough, which may be likely with a vegetarian diet, megaloblastic anemia may not be apparent.

Vitamin B12 is needed for the normal metabolism of methylmalonic acid, and its deficiency is typically diagnosed by an increase in either urine or serum methylmalonic acid concentrations. Methylmalonic acidemia is a physiologic indication of vitamin B12 deficiency. Levels of urinary methylmalonic acid are high in infants whose mothers were found to have low concentrations of vitamin B12 in breast milk (Fig. 1).

Children consuming vegan diets have been shown to have low serum concentrations of vitamin B12. Louwman et al. found that children consuming macrobiotic diets who had a low or normal vitamin B12 concentration (defined by both serum vitamin B12 and methylmalonic acid concentrations) tended to score lower on intelligence tests than did a control group consuming an omnivorous diet. The former group was 10 to 16 years old and had consumed a macrobiotic diet from birth to an average age of 6 years, at which time a less strict diet was implemented. The macrobiotic group was further divided into subgroups that included subjects who currently had low vitamin B12 concentrations and those with normal vitamin B12 concentrations. A significant association was found between vitamin B12 concentration and performance on tests measuring fluid intelligence, spatial ability, and short-term memory. Both subgroups tended to have levels that were lower than those of the control group, suggesting that mild...
vitamin B12 deficiency with or without hematologic signs of deficiency may be associated with impaired cognitive performance. The authors also suggested that deficits resulting from early vitamin B12 deficiency may be long-term and irreversible.15

Vitamin B12 supplementation should be encouraged among vegan infants and toddlers. Vegetarian mothers who breastfeed may need supplements, because the vitamin B12 content of human milk is related to the mother’s vitamin B12 concentration. In addition, maternal B12 supplements prevent maternal deficiency. Many commercial breakfast cereals are fortified with vitamin B12. The DRI is 0.9 µg/d for children 1 to 3 years old, and 2.8 µg/d for lactating mothers. The latter is higher than the 2.4 µg/d recommended for adults.16 An adequate intake is considered to be 0.4 µg/d for infants 0 to 6 months old and 0.5 µg/d for infants 6 to 12 months old, based on the average vitamin B12 intake of infants fed principally human milk.

Iron. Iron is a concern to vegetarians because the nonheme iron in plants is less bioavailable than the heme iron found in animal meats. Iron absorption from a vegetarian diet can vary, depending on the types of foods that are eaten. Foods high in phytates (eg, spinach) can inhibit iron absorption. Foods containing vitamin C (eg, citrus fruits) may help make iron more available.17 Because of this, it is important for the vegetarian to be knowledgeable about combining foods that are high in iron and vitamin C, and limiting phytate intake when consuming iron-rich foods.

The initial stage of iron deficiency is reflected by decreased serum ferritin concentrations. The second stage involves iron-deficient erythropoiesis. Hemoglobin concentrations may remain within the 95% reference range for age and sex, but red cell protoporphyrin concentrations are elevated and transferrin saturation is reduced. Hemoglobin concentrations then fall below normal values during the third stage of iron deficiency.

Iron deficiency may cause apathy, irritability, lack of concentration, and decreased cognitive processes.18 Many of the developmental delays may be irreversible.19 The 1989 Recommended Daily Allowance for 6 months to 3 years of age was set at 10 mg/d.20 The Food and Nutrition Board should announce the new DRI for iron in the near future.

Energy Intake. Vegetarian diets are generally less dense in energy than omnivorous diets. Although this may be beneficial to an adult who would like to lose weight, it may retard the growth of a child who needs a large amount of calories to ensure proper growth. Several factors must be taken into consideration for a child consuming a vegetarian diet to maintain sufficient energy intake for normal development. Vegetarians tend to eat foods that are bulkier and less energy dense. Because of the small stomach volume of a child, these bulky foods can give the child a feeling of satiety, although nutrition may be insufficient. Vegetarian children may have trouble with, or cannot digest, some bulky high-fiber foods. This can be demonstrated by an increased stool weight in vegetarian children.21

Vegetarian diets are typically high in carbohydrates. Therefore, some vegetarians may more closely approximate the dietary recommendations for the macronutrients set forth by the American Heart Association for adults. However, the energy intake may still be inadequate for their growth and development.

Growth is a major indicator of whether the child is receiving proper nutrition. Several studies have compared the growth of vegetarian and
TABLE

Plant Proteins in Human Nutrition: Myths and Realities

<table>
<thead>
<tr>
<th>Myth</th>
<th>Reality</th>
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<tbody>
<tr>
<td>1. Plant proteins are “incomplete” (ie, lack specific amino acids)</td>
<td>1. Usual dietary combinations of proteins are complete; specific food proteins may be low in specific amino acids</td>
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<tr>
<td>2. Plant proteins are not as “good” as animal proteins</td>
<td>2. Quality depends on the source and dietary mixture of plant proteins; it can be equivalent to high-quality animal proteins</td>
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<tr>
<td>3. Proteins from different plant foods must be consumed together in the same meal to achieve high nutritional value</td>
<td>3. Proteins do not need to be consumed at the same time; the balance throughout a day is of greater importance</td>
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<tr>
<td>4. Animal bioassay procedures are satisfactory indices of the human nutritional value of food proteins</td>
<td>4. Animal bioassay procedures can be useful, but they may underestimate plant protein nutritional quality for humans</td>
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<tr>
<td>5. Plant proteins are not well digested</td>
<td>5. Digestibility can vary according to source and food preparation; digestibility can be high</td>
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<tr>
<td>6. Plant proteins alone are not sufficient to achieve an adequate diet (protein intake)</td>
<td>6. The intakes and balance of intakes of indispensable amino acids and nitrogen are crucial and can be adequately met from plant or animal sources</td>
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<tr>
<td>7. Plant proteins are “imbalanced” and this limits their nutritional value</td>
<td>7. There is no evidence that amino acid imbalances per se are important; possible imbalances can be created by inappropriate amino acid supplementation, but this is not a practical problem</td>
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Omnivorous children, with mixed results. Some found growth differences between omnivorous children and vegan or macrobiotic children, whereas another found no such differences. The growth rate of the child is more important than the height and weight of the child at the time of measurement. The pediatrician should monitor the child’s growth rate and steps should be taken if growth falts.

**Protein Intake.** Protein consumption by vegetarian children is not as much of a concern as it once was. We now generally accept that an infant or young child will receive enough protein as long as caloric needs are met in a diet containing a variety of foods. If caloric needs are not being met for the normal growth of a vegetarian child, a protein deficiency also may develop. The table provides a summary of myths and realities of plant proteins.

**Vegetarian Mothers Who Breastfeed.** Vegetarian mothers who breastfeed and totally abstain from meat should supplement their dietary intake with vitamin B12. Vitamin D levels in human milk are low regardless of the vitamin D intake of the nursing mother. Vitamin D supplementation should be incorporated into the infant’s diet if there is inadequate exposure to sunlight for the infant. The simplest means to prevent postsnatal deficiency in vitamins B12 and D and iron is to give infants and children a commercial multivitamin and iron in standard doses.

The calcium content of human milk is the same regardless of the mother’s calcium intake. During breastfeeding, mothers use their own calcium stores by reabsorbing the mineral from bone to ensure that the concentrations in their milk are adequate. This loss of maternal bone mineral during lactation is not due to low maternal calcium intake, but appears to be related more to low estrogen status. After weaning the infant, the mother can restore the bone mineral lost during breastfeeding. Therefore, it is important that the mother have an adequate calcium intake during weaning to ensure appropriate remineralization of her own bones.

**PROLONGED EXCLUSIVE BREASTFEEDING**

Human milk has long been considered the gold standard for infant nutrition. The American Academy of Pediatrics (AAP) strongly encour-
ages mothers of term infants to breastfeed exclusively during the first 4 to 6 months and to continue breastfeeding once solid foods are introduced, until the infant is 12 months old. Human milk is low in vitamin D and iron regardless of the mother’s nutritional status. Mothers who breastfeed their infants exclusively for more than 6 months with no complementary food sources may deprive them of nutrients vital for normal development. Breastfeeding is generally considered prolonged when it is continued past the first year of life.

Health Benefits
Many health benefits have been reported with human milk and are summarized elsewhere.27 Health benefits specific to prolonged exclusive breastfeeding have not been reported.

Potential Concerns
With the exception of certain inborn errors of metabolism (e.g., galactosemia) and other rare defects associated with zinc metabolism, concerns for the use of human milk lie only with prolonged exclusive breastfeeding. These include faltering growth28 and deficiencies of specific nutrients, including vitamin D, zinc, and iron.

Caloric Intake. Mothers who prolong breastfeeding must be aware that breast milk should not be the only source of nutrition for infants older than 6 months. Breastfeeding should complement solid foods after 6 months to ensure proper energy intake and nutrition. The AAP recommends the introduction of solid foods between 4 and 6 months of age,29 and mothers should be encouraged to complement breastfeeding with solid foods at this time.

Vitamin D. Vitamin D is a concern after prolonged breastfeeding. Rickets caused by vitamin D deficiency often becomes evident at approximately 10 to 12 months of age because this is when the infant is able to generate forces on the bone that cause deformities typically seen with rickets.

A recent study concluded that a reemergence of rickets is due to an increase in the numbers of breastfeeding infants who do not receive supplemental vitamin D.29 The study involved 30 children with nutritional rickets, 17 male and 13 female. All were African American and breastfed without supplemental vitamin D. The age at the time of diagnosis ranged from 5 to 25 months, with a mean of 14.9 months.

Zinc. The zinc in breast milk is more easily absorbed than the zinc in either cow’s milk or formula, because zinc is loosely bound to citrate in human milk. Zinc found in cow’s milk and formula is tightly bound to casein, and the presence of phytates in soy-based formulas inhibits the absorption of zinc from this source. The digestive ability of the infant can release zinc from the citrate in human milk, but have a limited ability to separate the zinc from the casein or phytates. Zinc concentrations in human milk decrease as the postpartum time increases.30,31 Zinc requirements are generally met with exclusive breastfeeding through the first 5 to 6 months, but complementary foods are important to maintain adequate levels of zinc in breastfed infants after 6 months.

Although severe zinc deficiencies are rarely reported, a mild growth-limiting zinc deficiency characterized by normal or slightly low plasma zinc concentrations and a slowing of weight gain, linear growth, or both is more common.32 Walravens et al. found that breastfed infants 4 to 9 months old who received supplements of zinc had greater weight gain and linear growth than did similar infants not receiving zinc supplements.22

Iron. Iron deficiency is a concern among infants who are exclusively breastfed for prolonged periods. Fizarro et al. conducted a study to compare the iron status of infants with different feeding patterns.33 Fifteen percent of the infants who were exclusively breastfed had iron deficiency anemia at 9 months of age compared with fewer than 1% of those who received iron-fortified milk (Fig. 2). It is reasonable to assume that longer exclusive breastfeeding will lead to a higher risk of iron deficiency.

LOW-FAT DIETS
Fats have critical roles in fat-soluble vitamin metabolism and neural maturation. They are also essential for normal growth and development. All infants should receive human milk or infant formula during the first year. Dietary fat intake during the subsequent several years should not be severely restricted.
Health Benefits
A recent study found no difference in growth, body composition, and energy intake for children consuming 2% milk when compared with those consuming whole milk during the second year of life. Consumption of total fat and saturated fat was found to be significantly less in the infants consuming 2% milk. This study suggests that a reduced intake of total fat and saturated fat can be relatively easily achieved in children by substituting lower fat (2%) milk for whole milk. This decreased intake of total fat and saturated fat may have beneficial long-term effects in preventing obesity in later childhood.

Potential Concerns
Because of its relationship with obesity and other chronic health problems, fat is often perceived as negative by the media and the general public. The potential concerns of a modestly limited fat intake in children older than 1 year are minimal, as long as a well-rounded diet is provided. After 1 year of age, cow’s milk is a good source of the essential fatty acid linoleic acid, which is vital for neural development. Concern may arise when parents go to extreme measures to limit fat intake for their child. Parents should be educated on the importance of fat in the child’s diet for normal growth and development.

OTHER ATYPICAL EATING HABITS
Pica
Pica is the regular ingestion of substances not fit as food or with no nutritional value, such as clay, dried paint, and ice. The pathophysiologic basis for pica is not well understood, but it has been associated with iron deficiency, zinc deficiency, mental deficiency, lead poisoning, and developmental delay. These associated factors must be excluded or appropriately treated if present.

High Juice Intake
Children who consume large amounts of juice are at risk of diarrhea, failure to thrive, and nutritional deficiencies. This is especially true if the juice becomes a major source of nutrition. Failure to thrive, or the inability to sustain normal velocity of gain in height and weight during the early years of life, becomes a concern when a child’s weight or weight-for-height is two standard deviations below the gender and age-specific mean. When young children consume excess juice, they are likely to have decreased milk intake, and are thus deprived of a major source of many nutrients, including calcium.

The AAP recommends that fruit juice not be introduced before 6 months of age due to its nutritional inadequacies when compared with human milk or formula. Juice has no nutritional benefits over whole fruits for infants older than 6 months, so whole fruits should be encouraged to meet the recommended daily fruit intake. Because excessive juice consumption may be associated with malnutrition, it is recommended that an infant or young child not exceed half of his or her daily fruit intake from fruit juice. For children 1 to 6 years old, fruit juice intake should not exceed 4 to 6 oz./d. Intake should be limited to 8 to 12 oz./d or 2 servings for children 7 to 18 years old. Infants and young children should consume only pasteurized juice to prevent the introduction of pathogens such as Escherichia coli, Salmonella, and Cryptosporidium.

Picky Eating
Parents may have trouble with children who limit the different foods they will consume. Introducing new foods to a child can be a frustrat-
ing and difficult experience for a parent. The best advice is to be patient. New foods should be offered but not forced on the child. If the child does not want the food, the food should be offered again at a later time. Repeated exposures to a vegetable can significantly increase its intake later.1

REFERENCES

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