REVIEW AND ASSESSMENT OF THE SCIENTIFIC BASIS
FOR DIETARY GUIDELINES FOR CHILDREN,
INCLUDING THOSE LESS THAN TWO YEARS OF AGE

January 1999

Prepared for

UNITED STATES DEPARTMENT OF AGRICULTURE
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LIFE SCIENCES RESEARCH OFFICE
AMERICAN SOCIETY FOR NUTRITIONAL SCIENCES
9650 Rockville Pike
Bethesda, MD 20814-3998
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UNIVERSITY OF CALIFORNIA, BERKELEY
DEPARTMENT OF PEDIATRIC CLINICAL RESEARCH
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FOREWORD

The Life Sciences Research Office (LSRO), an office of the American Society for Nutritional Sciences (ASNS), provides scientific assessments of topics in the biomedical sciences. This report is the product of a project developed for the Agricultural Research Service (ARS) of the U.S. Department of Agriculture (USDA) in accordance with provisions of Research Agreement 59-0790-6-113.

The project was initiated in October, 1996, and LSRO held two meetings. The first meeting, with representatives of those agencies and organizations involved in the generation and promotion of the Dietary Guidelines for Americans (DGFA), provided LSRO staff with insights and background about the processes involved in the development of this publication and its anticipated applications. Individuals who attended this meeting are listed with their affiliations in Appendix A. A second meeting in April 1997 included two USDA representatives and six consultants who provided input about the scope and organization of the report (see Appendix B).

The LSRO expresses its appreciation to all these people for guidance but is responsible for the report’s contents, conclusions, and overall accuracy. LSRO also thanks the American Society for Nutritional Sciences for subsidizing this undertaking. The individuals listed in Appendices A and B did not review the final report and their endorsement should not be inferred. The final report was reviewed and approved by the LSRO Scientific Advisory Committee. Upon completion of these review procedures, the report was approved and transmitted to USDA. This report does not necessarily reflect the views of members of the LSRO Scientific Advisory Committee or of individual ASNS members.

1/7/99
Date

Michael Falk, Ph.D.
Director
Life Sciences Research Office
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EXECUTIVE SUMMARY

A new Dietary Guidelines Advisory Committee was recently established to assist the Secretaries of the U.S. Department of Agriculture (USDA) and Department of Health and Human Services (DHHS) in preparing the 5th edition of the Dietary Guidelines for Americans (DGFA) report, scheduled for publication in the year 2000. The DGFA, published every 5 years since 1980, summarizes the federal government’s advice to healthy consumers on making food choices to promote health and active lives and reduce the risks of chronic disease. The current dietary guidelines are:

- Eat a variety of foods;
- Balance the food you eat with physical activity—maintain or improve your weight;
- Choose a diet with plenty of grain products, vegetables, and fruits;
- Choose a diet low in fat, saturated fat, and cholesterol;
- Choose a diet moderate in sugars;
- Choose a diet moderate in salt and sodium;
- If you drink alcoholic beverages, do so in moderation.

In partial response to a recommendation from a previous Dietary Guidelines Advisory Committee that consideration be given to developing dietary recommendations specifically for children (i.e., infants, children, and adolescents), the Agricultural Research Service of USDA, in collaboration with the Office of Disease Prevention and Health Promotion of DHHS, asked the Life Sciences Research Office (LSRO) independently to review the research basis for dietary guidelines for children. LSRO was asked to provide a report containing the following:

- A review of current knowledge of the dietary and nutritional needs of infants, children, and adolescents;
- A definition of the variables to be used to distinguish the developmental milestones that separate the dietary and nutritional needs of infants, children, and adolescents from those of the general population;
- A definition of the points where the needs of infants, children, and adolescents differ from those of the general population;
- A definition of the points where the nutritional needs of infants, children, and adolescents might differ prior to adulthood, thereby necessitating the need for not only different nutrient requirements between adults and children but also during different points throughout childhood, e.g., 0-2 yr versus > 2 yr versus adolescence, considering gender and ethnic differences where appropriate;
- Documentation of the evidence for or against the application of the current Dietary Guidelines for Americans to infants, children, and adolescents and for or against the need for specific dietary guidelines for infants, children, and adolescents; and
- Identification of gaps in knowledge and needs for additional information and/or new research.

GROWTH, DEVELOPMENT, AND NUTRITIONAL NEEDS

As described in Chapter II, children have energy and nutrient requirements that reflect their unique needs for support of growth, development, maintenance, and normal physiological function. Physical growth is most rapid during the first 3 to 4 months of life, and by the end of the first year, most normal infants have tripled their birthweight and increased their length by 50%. The digestive and renal systems of newborns are not fully developed, so easily digested and excreted products are required to provide for their special nutrient needs. At this time, nutritional needs are adequately supplied by human milk or infant formula. By about six months of age, the digestive and absorptive capability of the gastrointestinal tract is near that of the adult, and the ability to metabolize, utilize, and excrete the absorbed products of digestion is also near adult capacity. These changes in physiological maturation have implications for the introduction of solid foods.

In the second year of life, the rate of physical growth slows down considerably, but brain growth continues, with myelination occurring throughout this period. Between the ages of two and five years, physical growth continues to
be slow but steady. Body proportions and composition change from that of early childhood, with the abdomen flattening and the body becoming leaner. Growth continues to be generally slow between the ages of five and twelve years (Hamill et al., 1979). Head circumferences increases by only 2-3 cm throughout this entire period, reflecting a slowing down of brain growth. Percent body fat gradually decreases during the early school years and reaches a minimum at about age 6. Thereafter, it increases in preparation for puberty (Rolland-Cachera et al., 1987). Sex differences in body and fat mass become apparent, but these differences do not become pronounced until adolescence. The changes in physical growth that occur during adolescence are as dramatic as those of early childhood. Physiological development is characterized by substantial increases in height and weight, changes in body composition, and enlargement of major organ systems. Psychosocial and cognitive development is also rapid at this time.

In general, children eat diets that supply adequate amounts of energy, macronutrients, and most vitamins and minerals. Several nutritional issues pertain to energy, specific nutrients, and other substances in food as follows:

**Energy**
Most children consume adequate dietary energy from food to support basal metabolism, physical activity, and growth. Only during early infancy is a sizeable amount of energy required for growth. Energy intakes have remained relatively steady for most children over the past several decades, except for older adolescents. This suggests that the growing prevalence of overweight and obesity among U.S. schoolchildren and adolescents is largely related to reduced energy expenditures.

**Carbohydrate**
The majority of children obtain at least half of their caloric intake from carbohydrates, although a greater proportion than generally recommended comes from added sugars. The only established direct relationship between sugar and disease pertains to dental caries. The American Health Foundation recommends that children older than age 2 years consume a “safe and tolerable” amount of dietary fiber ranging from “age plus 5” to “age plus 10” grams/day. Younger children are more likely to meet this recommendation than older ones. Foods rich in both carbohydrates and dietary fiber include whole grains, vegetables, and fruits.

**Protein**
Mean protein intakes of most American children at all ages are well above actual needs, though approximately one out of four adolescent girls do not meet the Recommended Dietary Allowance (RDA) for this nutrient. Protein requirements may be overestimated for infants 2-5 months of age.

**Fat**
Newborn infants change from carbohydrate as their primary energy source in utero to fat supplied by breast milk or commercial infant formula. Linoleic acid and α-linolenic acid are essential fatty acids of the n-6 and n-3 classes, respectively; they are converted into long-chain polyunsaturated fatty acids (LCPUFAs) that appear to affect infant development, particularly growth, neurophysiology, and visual and cognitive competency. Because of the high energy requirements of children <2 years of age relative to body weight, fat should not be restricted in their diets. The current DGFA report recommended that children aged 2 years and over gradually adopt a diet by age 5 years that contains no more than 30% of calories from fat, less than 10% of calories from saturated fat, and less than 300 mg of cholesterol per day. Most children ages 2-19 years exceed these recommendations for total fat and saturated fat, with most adolescent boys exceeding the cholesterol recommendation. However, considerable debate surrounds the application of these recommendations to children and adolescents.

**Iron**
Iron is involved in growth, cognitive development, psychomotor function, behavior, and intellectual performance. Infants are generally born with substantial iron reserves, proportional to birth weight. Breast milk and infant formula help the infant maintain good iron status, as does introducing iron-rich solid foods beginning at 4 to 6 months of age. Use of cow milk by infants increases the risk of iron deficiency because it is not a good source of iron, inhibits iron absorption, and increases gastrointestinal blood loss. The groups most prone to iron deficiency and anemia are toddlers and adolescent girls. In the Third National Health and Nutrition Examination Survey (NHANES III, 1988-1994),
approximately 9-11% in both groups were iron-deficient, with 2-3% having anemia. It is not known whether iron deficiency with or without anemia can lead to long-term, irreversible functional changes in behavior and cognition. Almost three out of four adolescent girls do not meet the RDA for iron, in part because their iron needs are high to replace iron loss resulting from menstruation.

**Calcium**

More than 99% of body calcium is bound to the structural matrix of bone. Milk products are the main dietary source of calcium among Americans. However, beyond infancy, fewer than half of American children obtain the RDA for calcium (excluding boys 6-11 years, 56% of whom meet or exceed the RDA). Over time, poor calcium nutriture caused by inadequate intakes and/or inadequate absorption is one important factor leading to reduced bone mass and osteoporosis. Peak calcium accretion occurs at an average age of 13 years in girls and 14.5 years in boys. Yet fewer than 15% of teenage girls and only about 1/3 of teenage boys meet recommended intakes of this nutrient. African-American adolescents may absorb calcium more efficiently than Caucasian teenagers and excrete less in their urine, which could explain the higher bone mass in black children and their lower bone-fracture rates as adults.

**Zinc**

Zinc is required for growth and sexual maturation, as shown in studies in the 1960s where zinc-deficient Middle-Eastern adolescent males experienced severe growth retardation and delayed sexual development. Although fewer than half of American children (excluding infants) eat diets that supply the RDA for zinc, there is little evidence for inadequate zinc nutriture in this country. This may in part reflect the difficulty of assessing zinc status and the very limited data available from well-controlled trials.

**FOOD CONSUMPTION PATTERNS AND THEIR DETERMINANTS**

Chapter III presents selected data on children’s food consumption patterns at various stages of development. It also identifies some of the important determinants of children’s food choices and preferences and how they change throughout childhood. The findings in this chapter are organized by age group.

**Infants 0-12 Months**

Exclusive breastfeeding is recommended for the first six months of life, and breastfeeding is best continued at least until the infant is 12 months old. Human milk provides high-quality nutrition, promotes maternal/child bonding, and may favorably influence the development of the immune system and help to protect the nursing infant against infections (e.g., otitis media) and allergic diseases. Iron-fortified formula is the appropriate alternative to human milk. Solid foods should be gradually introduced beginning at 6 (or perhaps as early as 4) months of age, when the infant is developmentally ready for them. At this time, the infant is able to sit with support, has good neuromuscular control of the head and neck, and has adequate motor control of the trunk. The tongue-extrusion reflux disappears and the ability to chew follows. The eruption of teeth at about 5 months of age also has implications for eating solids. As development continues, tongue flexibility increases, enabling greater manipulation of food in the mouth before swallowing. Soon after, infants can make definite chewing movements, take small bites of soft foods, show an interest in feeding themselves, and drink unassisted from a bottle or cup; they may begin to bring small pieces of food to their mouth. Many parents introduce solid foods to ease the hunger of their infants and to help them sleep through the night. Introduction of solid foods usually begins with pureed, iron-fortified, single-grain infant cereals, followed gradually over time by a variety of more textured foods. Over time the purees are thicker, and finally the infant can handle lumpy and bite-sized solid foods. Infants appear to be born with an innate preference for the sweet taste and an unlearned dislike for sour and bitter tastes.

**Children 1-2 Years**

During this period, children become developmentally ready for self-feeding. Hand and finger coordination are well controlled and precise, and skills in using a spoon and drinking from a cup are refined. With the continued eruption of teeth and growing manual dexterity, children of this age are able to handle and manipulate small pieces of food. In addition to taste, the sight, smell, and texture of foods become important determinants of food acceptance. By the time
they reach their second birthday, most children have made the transition from dependent to independent feeding and are typically eating a wide variety of foods.

**Children 2-5 Years**
Most young children eat breakfast and snacks everyday. They are also eating more foods away from home than in previous decades. Primary sources of away-from-home foods are day-care settings, fast-food restaurants, and stores. A substantial proportion of children fail to consume at least one serving of fruits, vegetables, and dairy products per day. Young children tend to prefer foods that are familiar and dislike foods that are unfamiliar, a neophobia that can be modified by providing them with repeated opportunities to taste new foods under favorable conditions. They also learn to like foods associated with positive contexts and consequences and to dislike foods associated with negative ones. Parents shape the eating habits and food preferences of their young children by the foods they make available in the home, by role-modeling, and by the way they interact with their children in eating contexts. Day-care providers also shape eating habits of children for these reasons. Other influences include peers and the promotion of foods to children on television.

**Children 5-12 Years**
Like preschool children, most schoolchildren eat breakfast and snacks everyday. Eating outside the home is common, most often in schools and fast-food restaurants, so that such eating contributes about one-third of the daily intakes for energy and most nutrients. When children start school, food choices are increasingly determined by influences outside of the family environment, including peers, the kinds of foods available at school, and advertising. Increasing access to money enables children to purchase food products independently.

**Adolescents 12-20 Years**
Adolescents’ growing independence, increased participation in social life, and generally busy schedules have a strong impact on their eating behaviors. Meal skipping, snacking, and away-from-home eating are common. Gender differences in food consumption patterns are becoming apparent, boys consuming more food than girls. Intakes of fruits, vegetables, and dairy products are often less than recommended, particularly among girls. The use of soft drinks is high (often displacing milk consumption), and a large proportion of adolescents drink alcoholic beverages. Food habits are influenced less by family and more by peers. With ready cash, adolescents have easy access to food, much of it of limited nutritional value. Internal factors such as personal values and beliefs, health motivations, search for self-identity, and body-image concerns play a role in determining their eating behaviors. Dissatisfaction with body weight, shape, or size frequently results in unnecessary food restrictions, particularly among girls.

**ACHIEVEMENT OF HEALTH AND RESISTANCE TO DISEASE**

Chapter IV addresses a variety of issues related to the dietary, nutritional, and health status of children, including controversies pertaining to diet and disease relationships. Many health-care professionals believe that prudent dietary patterns and active lifestyles established in childhood are likely to continue into adulthood and reduce the risks of developing a variety of chronic diseases.

**Diet and Disease—Dietary Fat**
Many public-health authorities and professional organizations urge Americans to limit their intakes of total fat, saturated fat, and cholesterol to reduce the risks of developing cardiovascular disease (CVD) and some types of cancer in later life. This guidance commonly applies to children beginning at age 2 years. However, not all authorities agree with this recommendation and are concerned that children following lower-fat diets are at increased risk for nutrient inadequacies and growth retardation if the diet is too restricted. They note that there is no direct evidence suggesting that childhood diet is related to CVD and that intervention studies in which children reduced their fat intakes produced only very modest reductions in blood cholesterol levels. They question whether the fatty streaks found in the arteries of children uniformly progress into fibrous plaques that increase CVD risk. Proponents of moderate-fat diets contend that such diets are nutritionally adequate and quite safe when appropriately applied. Such a dietary pattern adopted early in life may be more likely to be maintained into adulthood, when such a pattern is widely agreed to be prudent.
In contrast to authorities in the United States, the Canadian Pediatric Society/Health Canada advocates moderate-fat diets when the child has achieved the end of linear growth.

**Diet and Disease—Dietary Sodium**
The current DFGA recommends that children beginning at age 2 years begin to moderate their salt and sodium intakes to reduce the risks for developing hypertension, a risk factor for CVD in adults. Sodium intakes of children are generally higher than needed, but no conclusive evidence shows that this is detrimental to their health. Short-term studies demonstrate that decreasing sodium intake lowers blood pressure in children and adolescents, and salt sensitivity has been detected in adolescents. But there is no clear evidence that sodium restriction lowers blood pressure in children with mild hypertension. To date, the only dietary interventions shown to have a beneficial effect on blood pressure in children are those that control or reduce obesity.

**Overweight and Obesity**
Dietary and activity patterns established during childhood may begin to set the stage for the development of weight problems. Classifying children as overweight or obese is difficult because there are no generally accepted definitions for these conditions. The 85th and 95th percentiles of body mass index have been used as the basis for such estimates. It is generally agreed that the prevalence of excess weight and body fat among children is increasing, possibly more as a result of a decrease in physical activity than from an increase in food intake. Being characterized as overweight or obese in childhood can lead to undue attention to body size and thereby increase the potential for eating disorders.

**Physical Activity**
The health benefits of regular physical activity include improved strength, endurance, flexibility, weight control, body composition, and cardiorespiratory fitness; increased self-esteem; and perhaps reduced risks of becoming overweight or developing osteoporosis or CVD in adulthood. A minimum of 30 minutes of moderate activity on most or preferably all days of the week is recommended. There is a lack of valid instruments for measuring physical-activity patterns in children, and few data exist on the activity patterns of children. Yet it appears that activity levels decrease from childhood through adolescence. Children spend much time in sedentary activities such as watching television and playing computer and video games. A decrease in physical activity as part of the school curriculum may also be responsible for these decreases. Safety issues may also play a role, especially for children living in urban areas.

**Dieting and Weight Control**
Although reducing the prevalence of obesity among children is important, the weight-control practices of children are a concern when they are unwarranted. Restricting dietary intakes unnecessarily during childhood denies the growing body essential nutrients at a time when needs are relatively high. Concerns about weight and eating are apparent as early as the preadolescent years, having more to do with perceived rather than actual body weight. Dissatisfaction with body weight is especially widespread among adolescent girls, much of it fueled by cultural ideals of thinness. Typically, even normal-weight and underweight girls want to lose weight. Many reports have shown that white female adolescents are less satisfied with their body weight, are less accepting of being overweight, and experience more social pressure to be thin than their black counterparts.

**Eating Disorders**
Anorexia and bulimia nervosa are eating disorders that occur most frequently in young females. Anorexia is the more serious, estimated to affect from 1-10% of middle- and upper-middle-class adolescent girls, with a mortality rate estimated at 1-5%. Anorexics are substantially underweight and have an intense fear of gaining weight and a very distorted body image. Bulimia is characterized by recurrent episodes of binge eating, feelings of lack of control over eating, and recurrent inappropriate compensatory behavior after binging to prevent weight gain. About 10% of adolescent females may induce vomiting to control weight, and up to 45% of teenage girls and 35% of teenage boys participate in binge eating. Medical treatment plans for anorexia and bulimia nervosa include medical, nutritional, and psychological or psychiatric therapy.
Vegetarianism
Appropriately planned vegetarian and vegan diets are nutritionally adequate for children of all ages and promote normal growth and development. Inappropriately planned vegetarian or vegan (no animal products) diets, however, can create nutritional problems, especially among children <2 years of age. Nutritional concerns center around adequate intakes of vitamins B12 and D, calcium, iron, and zinc. Vegetarian diets typically contain liberal amounts of dietary fiber, phytates and oxalates, some of which may form insoluble compounds with minerals and may reduce their absorption. The high bulk and low energy density of some vegetarian diets, combined with a limited stomach capacity, restricts the amount of food that young children can consume.

Adolescent Pregnancy
Pregnant adolescents have especially high nutritional needs because they are continuing to grow and develop while supporting the needs of the fetus. Compared with infants born to adult women, infants born to adolescent mothers are more likely to be premature and of low birth weight, require intensive hospital care, suffer physical problems, or die in the neonatal period. Generally, pregnant women should try to gain approximately 25-40 lbs. Over the course of their pregnancy, they should also consume adequate amounts of nutrients (especially folic acid, iron, and calcium) and avoid alcoholic beverages.

DIETARY ISSUES FOR CHILDREN
Children are not simply adults in miniature. They have nutritional requirements that differ from those of adults, and factors that influence their food consumption patterns vary as well. This is especially true for children <2 years of age, a group not addressed in the current DGFA. In infancy, nutrition issues of concern include the use of human milk and infant formula, timing the introduction of solid foods into the diet and their nature, and appropriate nutritional supplement use. During the second year of life, the nutrition issues relate to the transition from dependent to independent feeding and to ensuring that toddlers have opportunities to try, accept, and enjoy a wide variety of foods.

For children ages 2 years and older, the current DGFA appear reasonable, with the possible exception of the guideline to “Choose a diet low in fat, saturated fat, and cholesterol.” The applicability of this guideline to growing children has been questioned by those who are not convinced that the prevention of cardiovascular disease by limiting fat intake needs to begin in childhood and are concerned that adhering to the guideline too closely would limit the intake of especially nutritious animal foods such as meat and dairy products. The guideline pertaining to alcohol consumption in the current DGFA—“If you drink alcoholic beverages, do so in moderation”—would also need to be adapted for a pediatric population by recommending that children and adolescents not drink alcohol (a statement made in the DGFA text). Specific dietary guidelines might also be considered in support of adequate intakes of iron and calcium, nutrients that are frequently underconsumed by children. Adequate folate intakes are also important for adolescent girls.

RESEARCH RECOMMENDATIONS
There is a tremendous need for nutrition-related research on infants, children, and adolescents. In Chapter V, several broad areas are described in which research is needed that has specific relevance to developing dietary guidelines for children.

Improve Understanding of Micronutrient and Macronutrient Requirements Throughout the Various Life Stages of Children
Nutrient intakes vary by life stage as reflected in different Recommended Dietary Allowances (RDAs) for children by age and gender. Often, however, recommended nutrient intakes for children are based on extrapolations from adults. Better identification is required of the specific transitions in the growth and development of children that have a significant impact on their nutritional needs. Furthermore, more research is needed on the differences in nutritional needs, and the consequences to health from varied dietary and activity patterns, among children of different racial and ethnic groups.
Improve Understanding of How Food Preferences and Dietary Patterns Develop and Are Shaped from Birth Throughout Adolescence

Over the course of childhood, dietary patterns evolve from consuming a single food (typically human milk or infant formula) to eating a wide variety of foods based on personal preferences and the influence of a wide variety of factors (e.g., friends and the media). Addressing this research need in all its complexities will require investigators from a wide variety of disciplines, including genetics, physiology, psychology, sociology, and anthropology.

Better Understand How Dietary and Activity Patterns at Various Stages of Childhood Affect Overall Health and Resistance or Susceptibility to Disease in the Short Run and into the Adult Years and Old Age

Most chronic, degenerative diseases that kill and handicap most Americans—such as cardiovascular disease, some types of cancer, stroke, and diabetes mellitus—are caused and exacerbated, at least in part, by lifestyle factors. There are many questions as to whether diet and activity patterns in childhood—especially early childhood—are related to the development of these diseases. Additionally, this general area of need will require research in improving the accuracy of measuring the dietary intakes, physical activity levels, and fitness of children and adolescents. Better definitions of overweight and obesity in these groups are also needed.

Develop Better Approaches That Lead More Children and Adolescents to Adopt and Maintain Healthy Eating Patterns and Engage in Regular Physical Activity

Many efforts have been and continue to be made to influence children’s diet and activity patterns. They range from relatively small efforts in schools to improve the food choices in the cafeteria to national initiatives that encourage greater consumption of fruits and vegetables. Yet despite these programs, the lifestyle patterns of many children fall short of those recommended for health. Much more attention should be given to understanding the factors and social dynamics that influence health-related behaviors and the conditions under which they operate. Such knowledge should guide the development of future health-promotion programs.
I. INTRODUCTION

A new Dietary Guidelines Advisory Committee was recently established to assist the Secretaries of the U.S. Department of Agriculture (USDA) and Department of Health and Human Services (DHHS) in preparing the 5th edition of the Dietary Guidelines for Americans (DGFA) report, scheduled for publication in the year 2000. The DGFA, published every 5 years since 1980, summarizes the federal government’s advice to healthy consumers on making food choices to promote health and active lives and reduce the risks of chronic disease. The current dietary guidelines (U.S. Department of Agriculture (USDA) and U.S. Department of Health and Human Services (HHS), 1995) are:

- Eat a variety of foods;
- Balance the food you eat with physical activity—maintain or improve your weight;
- Choose a diet with plenty of grain products, vegetables, and fruits;
- Choose a diet low in fat, saturated fat, and cholesterol;
- Choose a diet moderate in sugars;
- Choose a diet moderate in salt and sodium;
- If you drink alcoholic beverages, do so in moderation.

In partial response to a recommendation from a previous Dietary Guidelines Advisory Committee that consideration be given to developing dietary recommendations specifically for children (i.e., infants, children, and adolescents), the Agricultural Research Service of USDA, in collaboration with the Office of Disease Prevention and Health Promotion of DHHS, asked the Life Sciences Research Office (LSRO) independently to review the research basis for dietary guidelines for children. LSRO was asked to provide a report containing the following:

- A review of current knowledge of the dietary and nutritional needs of infants, children, and adolescents;
- A definition of the variables to be used to distinguish the developmental milestones that separate the dietary and nutritional needs of infants, children, and adolescents from those of the general population;
- A definition of the points where the needs of infants, children, and adolescents differ from those of the general population;
- A definition of the points where the nutritional needs of infants, children, and adolescents might differ prior to adulthood, thereby necessitating the need for not only different nutrient requirements between adults and children but also during different points throughout childhood, e.g., 0-2 yr versus > 2 yr versus adolescence, considering gender and ethnic differences where appropriate;
- Documentation of the evidence for or against the application of the current Dietary Guidelines for Americans to infants, children, and adolescents and for or against the need for specific dietary guidelines for infants, children, and adolescents; and
- Identification of gaps in knowledge and needs for additional information and/or new research.

The term children is used generically throughout this report to refer to individuals from infancy to the end of adolescence. The following specific terms are used to refer to children at particular stages of life:

- Infants in first 12 months of life,
- Toddlers between ages 1 and 2 years,
- Preschool children to the point where they begin their formal education (age 2 to approximately age 5),
- School-aged (prepubescent) children to the point where they begin their adolescent development (age 5 to approximately age 12), and
- Adolescent (postpubescent) children, age 12 to approximately age 20, the period when puberty begins to the point where growth and development have largely been achieved and the adolescent is said to have become an adult.

The time periods delineated above are social conventions and were selected somewhat arbitrarily. They are not necessarily based on physiological or biological events.
II. GROWTH AND DEVELOPMENT, NUTRIENT NEEDS, AND NUTRIENT INTAKES

Children have energy and nutrient requirements that reflect their unique needs for support of growth, development, maintenance, and normal physiological function. As a result, their nutritional needs differ in relation to their body weight from those of adults who require nutrients mainly for maintenance (Heird, 1994). The question to be addressed in this chapter is to what extent the demands of growth and development have an impact on the nutritional needs of infants, children, and adolescents that might differ from those for adults. This chapter presents information on the nutritional needs of infants, children, and adolescents and the milestones that mark these needs at various stages of development. Data from nationally representative surveys on nutrient intakes are also presented and compared to recommended intakes.

GROWTH AND DEVELOPMENT

In preparing this report, the following definitions were used (Pipes & Trahms, 1993a):

- Growth: an increase in the physical size of the body as a whole or in any of its parts associated with an increase in cell number (hyperplasia) or cell size (hypertrophy).
- Development: the acquisition of function associated with cell differentiation and maturation of individual organ systems or as a change from a lower to a more advanced stage of complexity or greater facility in functioning.

Growth and developmental patterns are influenced by an interaction among genetic, hormonal, and behavioral factors (Woteki & Filer, 1995). Environmental factors such as sanitation, health-care delivery (e.g., vaccinations), and physiological stress can also influence these patterns. However, there are critical periods in growth and development of individual organs and systems that may distinguish the nutritional needs of children from those of adults. To distinguish how those critical periods might affect the nutritional needs of children, the following presentation is divided arbitrarily into five age categories: 0-12 months, 1-2 years, 2-5 years, 5-12 years, and 12-20 years.

Infants 0-12 Months

Physical growth is most rapid during the first 3 to 4 months of life (Fomon, 1993b). In the second 6 months, growth and weight gain slow down considerably compared to the first six months. By age one, most normal infants have tripled their birthweight and increased their length by 50% (Hamill et al., 1979; Heird, 1996). Growth charts and reference data for heights and weights at various ages during infancy are a convenient way to evaluate the size of infants in relation to their peers and to identify potential problems in growth.

Many developmental milestones occur between the ages of 6 and 12 months (Needelman, 1996). Among them is the ability to sit unsupported and crawl and often to walk with or without support. The teeth begin to erupt, with the central incisors appearing at 5 to 8 months and the lateral incisors at 7 to 11 months (Needelman, 1996). Cognitively, infants become increasingly curious, inspecting and mouthing objects, particularly novel ones. They also become more adept at nonverbal communication, and their babbling becomes more complex.

Digestion, absorption, and excretion. The digestive system of newborns is not fully developed, so easily digested and absorbed products are required to provide for their special nutrient needs (Franklin, 1989; Heird, 1996; Lebenthal & Leung, 1989). Human milk, the ideal first food, is readily digested and absorbed (American Academy of Pediatrics, Work Group on Breastfeeding, 1997). At birth, the renal system can perform all of its normal functions, but with limited concentrating ability (Hendricks & Badruddin, 1992). At about 4 months of age, the functional capacity of the kidneys increases rapidly, allowing them to handle an increased renal solute load. By 12 months of age, kidney size has almost doubled, permitting a wider variety of foods to be tolerated.
Lactose, the predominant carbohydrate in human milk and in most commercial infant formulas in the U.S., is hydrolyzed in the term infant by lactase, located in the brush border membrane of enterocytes of the small intestine (Life Sciences Research Office, 1998). To digest starch, young infants require salivary amylase, an enzyme present in low levels at birth but increasing to about one-third of adult levels by 3 months of age (Hendricks & Badruddin, 1992). Pancreatic amylase, another enzyme needed for starch digestion, is not detected in the duodenal fluid until 4 to 6 months of age (Shulman et al., 1983). Most infants appear to compensate for a lack of pancreatic amylase activity through the presence of salivary amylase and glucoamylase. As a result, clinical evidence of starch intolerance is low in most infants (Hendricks & Badruddin, 1992).

Protein digestion begins in the stomach through the action of pepsin, formed from pepsinogen I and II in the presence of hydrochloric acid (Fomon, 1993c; Meyer, 1994). Pepsin secretion is high in the first days after birth. Levels decline between 10 and 30 days of life and slowly increase thereafter, paralleling weight gain, but remain well below adult values for the first 3 months (Agunod et al., 1969). Gastric acid secretion increases shortly after birth but does not reach an optimal level for pepsin activity (Agunod et al., 1969). This suboptimal proteolytic activity in the stomach may allow intact immunoglobulins in colostrum to be absorbed (Hanson et al., 1989; Sampson & Fomon, 1993). Large polypeptides, oligopeptides, and amino acids are the main byproducts of gastric digestion (Fomon, 1993c). In the small intestine, smaller peptides are formed through the action of pancreatic trypsin, chymotrypsin, and elastase (Hendricks & Badruddin, 1992). These enzymes are all present in sufficient amounts at birth.

Fat absorption is 85-95% efficient in the first weeks of life (Anderson, 1991; Franklin, 1989; Lebenthal & Leung, 1989). Ingested triglycerides begin to be hydrolyzed in the stomach by lingual lipase, secreted by serous glands in the tongue. Pancreatic lipase functions in the intestine, its activity increasing five-fold in the first weeks of life and more in the following months (Hamosh et al., 1984). Human milk lipase is active in the duodenum, facilitating digestion of milk fat by hydrolyzing the monoglycerides formed from the actions of pancreatic lipase. For optimal absorption, the products of lipase action must be incorporated into mixed micelles with bile salts, which in turn requires that bile salts reach a critical concentration (Jensen et al., 1982). Both the bile-salt pool and bile-salt concentrations increase dramatically during the first month of life. Human milk appears to enlarge the bile-salt pool, helping to enhance the efficiency of fat absorption (Jensen et al., 1982).

The efficiency of absorption of micronutrients varies by vitamin and mineral and differs between human milk and formula (Life Sciences Research Office, 1998). For example, iron is present in human milk at lower concentrations but is significantly more bioavailable than iron in infant formula (Lönnerdal, 1997).

Fat and lipoprotein metabolism. Endogenous cholesterol synthesis in infants is inversely related to the cholesterol content of their diets (Cruz et al., 1994; Wong et al., 1993). Breast milk is rich in saturated fatty acids and cholesterol, so nursing infants usually have higher plasma- and LDL-cholesterol concentrations than infants fed commercial formulas that contain little cholesterol but are rich in unsaturated fatty acids (Innis & Hamilton, 1992). The possibility that the cholesterol in human milk may have long-term health benefits for the infant by enhancing the ability to metabolize dietary cholesterol later in life has been raised (Reiser & Sidellman, 1972). However, most studies comparing the relative impact of breast milk and formula on serum lipids have found no long-term effects on cholesterol concentrations (Fomon et al., 1984; Friedman & Goldberg, 1975; Hamosh, 1988; Wagner & von Stockhausen, 1988).

Children 1-2 Years
Compared to the first year of life, the rate of physical growth slows down in the second year (Birch & Fisher, 1995; Heird, 1994). Birth weight triples in the first year of life but does not quadruple until the end of the second year (Hamill et al., 1979). Brain growth continues, with myelinization occurring throughout this period (Widdowson, 1994).

Children 2-5 Years
During this period, children gain an average of 2 kg (4-1/2 lb) of weight and 7 cm (3 in) in height per year (Hamill et al., 1979). Body proportions and composition change significantly. For example, the prominent abdomens of toddlers flatten, and their bodies becomes leaner. The preschool years are a time of substantial social, cognitive, and emotional development (Crockett & Sims, 1995).
**Children 5-12 Years**

Between the ages of 5 and 12 years, growth is generally slow and steady, with average annual gains of about 3-3.5 kg (7 lb) in weight and 6 cm (2.5 in) in height (Hamill et al., 1979). Head circumference increases by only 2-3 cm throughout this entire period, reflecting a slowing down of brain growth (Hamill et al., 1979). Deciduous (baby) teeth begin to be lost at about age 6 years and are replaced with adult teeth at a rate of about 4 per year (Needlman, 1996). Percent body fat gradually decreases during the early childhood years and reaches a minimum at approximately 6 years of age, and then increases in preparation for puberty (Rolland-Cachera et al., 1984, 1987). Sex differences in body and fat mass become apparent, with girls having a higher percentage of body fat and boys having more lean body mass per centimeter of height. These differences, however, do not become large until adolescence (Booth et al., 1997; Pipes & Traxler, 1993a). School-age children begin to realize that eating nutritious foods can help them to grow and be healthy, but they do not appear to understand why or how this occurs (Contento, 1981; Michela & Contento, 1986). It is during this period that many young girls begin to think that they are overweight and may restrict food intake to attain an abnormally thin cultural ideal (Hill & Oliver, 1992; Maloney et al., 1989; Richards et al., 1990; Striegel-Moore et al., 1995).

**Adolescents 12-20 Years**

Adolescence is a period of rapid physiological development, characterized by substantial increases in height and weight, changes in body composition, and enlargement of major organ systems (Gong & Heald, 1994). Psychosocial and cognitive development is also rapid. Following the period of slow growth in the prepubertal years, the changes in physical growth that occur during adolescence are as dramatic as those of early childhood (Mahan & Escott-Stump, 1996).

Although linear growth continues throughout the 5 to 7 years of pubertal development, most of this height will be gained during the 18-24-month period commonly known as the “growth spurt.” The average U.S. female experiences the most rapid spurt in linear growth between 10 and 13 years of age, whereas the growth spurt in males occurs between 12 and 15 years (Gong & Heald, 1994). Because great variability in the rate of linear growth and sexual development is evident among adolescents of the same age, it is difficult to evaluate pubertal growth status by age alone (Mahan & Escott-Stump, 1996; Spear, 1996). Tanner’s Sexual Maturity Ratings is commonly used to describe the stage of development of individual adolescents (Tanner, 1962).

Differences in the rate, quantity, composition, and distribution of tissue emerge between the sexes during adolescence. Males are inclined to gain weight at a faster rate than females, and their skeleton continues to grow for a longer period of time than that of females (Gong & Heald, 1994). Between the ages of 10 and 20 years, males add lean body mass at twice the rate of females (Forbes, 1995). Females deposit more total body fat than males (Gong & Heald, 1994).

Bone mass increases throughout adolescence, and peak bone mass is achieved between 19 and 30 years of age, depending on the skeletal site (Institute of Medicine, 1997). Peak bone mass appears to be related to the intake of calcium and other nutrients, although sex hormones and physical activity also affect bone development and metabolism (National Research Council. Subcommittee on the Tenth Edition of the RDA's. Food and Nutrition Board, 1989a).

Age of menarche among girls is affected by body composition and possibly fat intake. In a group of girls in Texas studied by Wellens et al. (1992), those who began menstruating before 12 years of age were significantly heavier and had higher BMIs than girls who achieved menarche later. Although other studies have noted this relationship as well, investigation of its association with energy-adjusted dietary fat intakes has yielded contradictory results (Macleure et al., 1991; Merzenich et al., 1993). Girls active in school and in leisure-time sports have been reported to experience a delay in menarche (Merzenich et al., 1993).

**NUTRIENT NEEDS AND INTAKES**

A knowledge of the unique growth and development processes at each of the different stages of childhood development is essential in understanding the special nutritional issues of each stage. The nature of physical growth that occurs at each stage forms a foundation upon which nutritional needs are determined.
Since 1941, the Food and Nutrition Board (FNB) of the National Academy of Sciences has periodically issued Recommended Dietary Allowances (RDAs), defined as "levels of intake of essential nutrients...judged...to be adequate to meet the known nutrient needs of practically all healthy persons" (National Research Council, 1989a). Estimates of the nutrient allowances for infants have usually been derived from the average amount of nutrients consumed by healthy infants breast-fed by healthy, well-nourished mothers (National Research Council, 1989a). RDAs for infants in the first six months of life are based mainly on the amounts of nutrients supplied by 750 ml of human milk, plus an additional 25% (2 SDs) to allow for variance, whereas RDAs for infants in the second six months of life are consistent with nutrient intakes achieved by the continued consumption of human milk or formula, supplemented by the addition of solid foods to the diet. RDAs for children and adolescents have generally been based on extrapolations of data obtained from adults.

The last complete edition of the RDAs was published in 1989 (National Research Council, 1989a). More recently, the FNB developed a new approach to dietary recommendations known as Dietary Reference Intakes (DRIs). This approach broadens the concept of adequacy to include, when possible, the role of a nutrient in reduction of disease risk (Institute of Medicine, 1997). The DRIs are a set of reference values that, for a given nutrient, includes either an RDA (a daily intake level sufficient to meet the needs of 97.5% of individuals in a given age-sex group) or an Adequate Intake (AI; a daily intake level that appears to be adequate based on current experimental or epidemiological data). The FNB issued new RDAs and AIs for calcium, phosphorus, magnesium, vitamin D, and fluoride in 1997 (Institute of Medicine, 1997) and for thiamin, riboflavin, niacin, vitamin B6, folate, vitamin B12, pantothenic acid, biotin, and choline in 1998 (Institute of Medicine. Food and Nutrition Board, 1998). The FNB intends to update recommendations for other nutrients over the next several years. For most people, both the RDAs and AIs provide a margin of safety above actual requirements for a nutrient, so nutrient intakes somewhat below RDAs or AIs do not necessarily lead to deficiencies.

RDAs and DRIs have served, and will continue to serve, as a standard to guide many aspects of national food policy. The following is a brief review of the nutrient requirements of infants, children, and adolescents that utilizes the RDAs and DRIs as reference points.

**Energy**

Dietary energy, measured in kilocalories (kcal), comes from the breakdown of carbohydrate, fat, and protein in food. Children’s energy requirements are determined by basal metabolism, level of physical activity, and growth rate (Holliday, 1986). Total energy expenditure is the sum of the resting energy expenditure, energy expended in physical activity, and the thermic effect of food (also known as diet-induced thermogenesis). Only during early infancy is a sizeable amount of energy required for growth (Joint FAO/WHO/UNU Expert Consultation, 1985).

Recommended energy intakes reflect mean population requirements for each age-sex group (see Table II-1) (National Research Council. Subcommittee on the Tenth Edition of the RDAs. Food and Nutrition Board, 1989a). Energy needs vary depending on activity and other factors, but the allowances do not cover this variation because to do so might lead to excessive energy intakes in some and deficits in others.

**Infants 0-12 months.** Normal newborn infants require 3 to 4 times more energy per unit of body weight than adults (Heird, 1994, 1996). Up to 40% of the energy requirement supports their growth (Holliday, 1986). At least 5.0 g/kg/day of carbohydrate are needed to avoid ketosis and hypoglycemia, and a minimum of 0.5 to 1.0 g/kg/d of linoleic acid plus smaller amounts of linolenic acid are required to prevent deficiency of essential fatty acids (Heird, 1996).

The World Health Organization (WHO) used data from healthy infants in developing countries to estimate energy requirements as follows: 118 kcal/kg at 0-3 months of age, 99 kcal/kg at 3-6 months, 95 kcal/kg at 6-9 months, and 101 kcal/kg at 9-12 months (Joint FAO/WHO/UNU Expert Consultation, 1985). The FNB used these figures to recommend 108 kcal/kg for infants from birth to 6 months of age and 98 kcal/kg for infants 6-12 months of age (National Research Council. Subcommittee on the Tenth Edition of the RDAs. Food and Nutrition Board, 1989a). However, the appropriateness of these recommendations has been questioned. Prentice et al. (1988) determined that the WHO recommendations were approximately 15% greater than estimates derived from measurements of energy expenditure that included an allowance for the theoretical amount of energy deposited as tissue added in growth. Based on this discrepancy, the energy requirements for infants in the first six months of life would be 95 kcal/kg/d and in the second six months of life would be 84 kcal/kg/d. The FNB noted that these alternative estimates "can be taken as equal
<table>
<thead>
<tr>
<th>Age Group</th>
<th>Survey¹</th>
<th>Mean Energy Intake (kcal/day)</th>
<th>Daily Recommended Energy Intakes (kcal)²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants under 1 yr²</td>
<td>CSFII 1994-96</td>
<td>838</td>
<td>108/kg or 650/day (0-6 mo)</td>
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<td>NHANES III 1988-91</td>
<td>877</td>
<td>98/kg or 850/day (6-12 mo)</td>
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<td></td>
<td>NHANES II 1976-80</td>
<td>996</td>
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<td>NHANES I 1971-74</td>
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<tr>
<td>Children 1-2 yr</td>
<td>CSFII 1994-96</td>
<td>1,312</td>
<td>102/kg or 1,300/day</td>
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<tr>
<td></td>
<td>NHANES III 1988-91</td>
<td>1,289</td>
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<td>NHANES II 1976-80</td>
<td>1,287</td>
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<td>NHANES I 1971-74</td>
<td>1,350</td>
<td></td>
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<tr>
<td>Children 3-5 yr</td>
<td>CSFII 1994-96</td>
<td>1,577</td>
<td>1,300 (2-3 yr)</td>
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<td>NHANES III 1988-91</td>
<td>1,591</td>
<td>1,800 (4-5 yr)</td>
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<td>NHANES I 1971-74</td>
<td>1,676</td>
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<td>Children 6-11 yr</td>
<td>CSFII 1994-96</td>
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<td>1,800 (5-6 yr)</td>
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<td>1,807 (females)</td>
<td>2,000 (7-10 yr)</td>
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<td>NHANES III 1988-91</td>
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<td>2,500 (males 11-12 yr)</td>
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<td>1,753 (females)</td>
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<td>NHANES II 1976-80</td>
<td>1,960 (combined)</td>
<td>2,200 (females 11-12 yr)</td>
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<td></td>
<td>NHANES I 1971-74</td>
<td>2,045 (combined)</td>
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<td>Adolescents 12-19 yr</td>
<td>CSFII 1994-96</td>
<td>2,766 (males)</td>
<td>2,500 (males 12-14 yr)</td>
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<td>1,910 (females)</td>
<td>3,000 (males 15-18 yr)</td>
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<td>NHANES III 1988-91</td>
<td>2,578 (males 12-15 yr)</td>
<td>2,900 (males 19-20 yr)</td>
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<td>3,097 (males 16-19 yr)</td>
<td>2,200 (females 12-20yr)</td>
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<td>1,838 (females 12-15 yr)</td>
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<td>1,958 (females 16-19 yr)</td>
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<td>NHANES II 1976-80</td>
<td>2,490 (males 12-15 yr)</td>
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<td>3,048 (males 16-19 yr)</td>
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<td>1,821 (females 12-15 yr)</td>
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<td>1,687 (females 16-19 yr)</td>
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<td>NHANES I 1971-74</td>
<td>2,625 (males 12-15 yr);</td>
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<td>3,010 (males 16-19 yr);</td>
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<td>1,910 (females 12-15 yr)</td>
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<td></td>
<td></td>
<td>1,735 (females 16-19 yr)</td>
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¹ Data are from the CSFII and NHANES surveys: CSFII 1994-96 (Continuing Survey of Food Intakes by Individuals) is conducted by the Agricultural Research Service of the U.S. Department of Agriculture. Data are the combined results from the 1994, 1995, and 1996 surveys based on respondents' intakes on the first surveyed day (U.S. Department of Agriculture (USDA), Food Surveys Research Group, Agricultural Research Service, 1997a). NHANES III 1988-91 (Third National Health and Nutrition Examination Survey, Phase I), NHANES II 1976-80 (Second National Health and Nutrition Examination Survey), and NHANES I 1971-74 (First National Health and Nutrition Examination Survey) are conducted by the National Center for Health Statistics, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services (Lifesciences Research Office, 1995). Nutrient intakes are based on a single 24-hour dietary recall.

² Data exclude breast-fed infants.

³ Source: Food and Nutrition Board of the National Academy of Sciences (National Research Council, Subcommittee on the Tenth Edition of the RDAs, Food and Nutrition Board, 1989a).
to dietary requirement if the metabolizable energy value of foods consumed (human milk, formula, beikost) is estimated correctly" (National Research Council. Subcommittee on the Tenth Edition of the RDAs. Food and Nutrition Board, 1989a).

Energy intakes of breast-fed and formula-fed infants have been shown to differ after the first few months of birth (Butte et al., 1984, 1990a; Dewey et al., 1989; Krebs et al., 1994). Formula-fed infants have higher intakes than breast-fed infants (Butte et al., 1990b). Greater energy deposition and weight gain have also been reported in formula-fed infants than in infants fed human milk (Butte et al., 1990b). The rapid weight-gain of breast-fed infants in early life, despite energy intakes lower than the RDA, suggests that energy requirements are lower than current recommendations (Garza & Butte, 1990). No functional advantage has been reported for the faster gains in weight and in lean body mass among formula-fed infants (Heimig et al., 1993a) complete accounting for the differences in total energy expenditures among breast-fed and formula-fed infants cannot be provided at present (Life Sciences Research Office. 1998).

The mean energy intakes of formula-fed infants under 1 year of age determined from nationally representative surveys are presented in Table II-1. Skinner et al.(1997a) found that the daily energy intakes of breast-fed and formula-fed infants increased with age. At ages 2, 4, 6, 8, 10, and 12 months, intakes were 549, 566, 690, 757, 870, and 1,173 kcal/day, respectively. Energy intakes nearly doubled between 4 and 12 months of age.

Children 1-2 years. Energy needs to support growth decrease substantially by 1 year of age, with less than 5% of the total energy requirements of the 1-year-old needed for this purpose (Holliday, 1986). Mean energy intakes of toddlers have remained static since the early 1970s (see Table II-1).

Children 2-5 years. Less than 3% of the total energy requirement is used to sustain growth of children after the age of 2 years (Holliday, 1986). Energy intakes of 3-5-year-old children have remained relatively constant since the early 1970s (see Table II-1).

Children 5-12 years. Through age 10, RDAs for energy are not based on gender. After age 10 years, separate energy allowances are provided for boys and girls because of differences in the age of onset of puberty and activity patterns (National Research Council. Subcommittee on the Tenth Edition of the RDAs. Food and Nutrition Board, 1989a). Mean energy intakes of children 6-11 years of age were generally below the 1989 RDAs, particularly for girls, and were essentially the same as in the early 1970s (see Table II-1). Nevertheless, the prevalence of overweight among U.S. children of this age range is increasing (National Center for Chronic Disease Prevention and Health, 1997). (See Chapter IV for a discussion of overweight in childhood.)

Adolescents 12-20 years. Energy needs increase during adolescence to accommodate increases in body size. Energy RDAs during adolescence are approximations in that they are based on median energy intakes, assume only light to moderate activity, and do not take into account individual variability in rates of physical growth, timing of the growth spurt, physiologic maturation, and physical activity patterns (National Research Council. Subcommittee on the Tenth Edition of the RDAs. Food and Nutrition Board, 1989a).

Since the early 1970s, energy intakes of 12-15-year-old adolescents have been static while those of 16-19-year-olds have increased (see Table II-1). Nutrient-intake data show that mean energy intakes of adolescent girls are generally below recommended allowances. Nevertheless, as with younger children, the prevalence of overweight among U.S. adolescents is increasing (National Center for Chronic Disease Prevention and Health, 1997; Troiano et al., 1995). (See Chapter IV for a discussion of overweight in childhood.)

Macronutrients
Carbohydrate. Carbohydrates are classified as either simple (sugars) or complex (polysaccharides). The sugars include monosaccharides such as glucose and disaccharides such as sucrose (table sugar). Complex carbohydrates include starches and dietary fiber. Surveys show that the majority of infants, children, and adolescents obtain at least half of their caloric intake from carbohydrates (see Table II-2) as recommended by the FNB (National Research Council, 1989a). These surveys do not distinguish between simple and complex carbohydrates.
Table II-2. Carbohydrate intakes of children 0-19 years of age

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Survey¹</th>
<th>Mean Carbohydrate Intake in g/day (percentage of energy intake)</th>
<th>Mean Dietary Fiber Intake in g/day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants under 1 yr</td>
<td>CSFII 1994-96</td>
<td>106.8 (50.8%)</td>
<td>3.4</td>
</tr>
<tr>
<td></td>
<td>NHANES III 1988-91</td>
<td>115 (52.5%)</td>
<td>4.73 (males)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>4.10 (females)</td>
</tr>
<tr>
<td>Children 1-2 yr</td>
<td>CSFII 1994-96</td>
<td>175.9 (54.2%)</td>
<td>8.8</td>
</tr>
<tr>
<td></td>
<td>NHANES III 1988-91</td>
<td>170 (53.1%)</td>
<td>9.01 (males)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>8.00 (females)</td>
</tr>
<tr>
<td>Children 3-5 yr</td>
<td>CSFII 1994-96</td>
<td>215.6 (55.0%)</td>
<td>10.7</td>
</tr>
<tr>
<td></td>
<td>NHANES III 1988-91</td>
<td>215 (54.6%)</td>
<td>11.18 (males)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10.24 (females)</td>
</tr>
<tr>
<td>Children 6-11 yr</td>
<td>CSFII 1994-96</td>
<td>276.3 (54.8%); males 247.3 (54.9%); females 272 (53.5%); males 229 (52.9%); females</td>
<td>13.6 (males)</td>
</tr>
<tr>
<td></td>
<td>NHANES III 1988-91</td>
<td>272 (53.5%); males 229 (52.9%); females</td>
<td>12.2 (females)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>13.14 (males)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11.81 (females)</td>
</tr>
<tr>
<td>Adolescents 12-19 yr</td>
<td>CSFII 1994-96</td>
<td>367.0 (53.6%); males 260.1 (54.7%); females 346 (54.0%); males 12-15 yr 243 (54.4%); females 12-15 yr 238 (54.5%); males 16-19 yr 254 (52.4%); females 16-19 yr</td>
<td>17.4 (males)</td>
</tr>
<tr>
<td></td>
<td>NHANES III 1988-91</td>
<td>346 (54.0%); males 12-15 yr 243 (54.4%); females 12-15 yr 238 (49.6%); males 16-19 yr 254 (52.4%); females 16-19 yr</td>
<td>15.09 (males 12-15 yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>17.44 (males 16-19 yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>11.45 (females 12-15 yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>12.57 (females 16-19 yr)</td>
</tr>
</tbody>
</table>

¹ Data are from CSFII 1994-96 and NHANES III 1988-91. CSFII (Continuing Survey of Food Intakes by Individuals) is conducted by the Agricultural Research Service of the U.S. Department of Agriculture. Data from CSFII 1994-96 are the combined results from the 1994, 1995, and 1996 surveys based on respondents' intakes on the first surveyed day (U.S. Department of Agriculture (USDA), Food Surveys Research Group. Agricultural Research Service, 1997). NHANES III 1988-91 (Third National Health and Nutrition Examination Survey, Phase I) is conducted by the National Center for Health Statistics, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services (Life Sciences Research Office, 1995). Nutrient intakes presented are based on a single 24-hour dietary recall.

² Data exclude breast-fed infants.

The 1995 DGFA recommended that sugars be used in moderation by children 2 years of age and older (U.S. Department of Agriculture (USDA) and U.S. Department of Health and Human Services (HHS), 1995). The Food Guide Pyramid also recommended that sugars be used sparingly because they contribute little nutritive value to the diet (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997b). Sugars such as fructose and lactose occur naturally in such foods as fruit and milk, respectively. "The Pyramid suggests that Americans try to limit their added sugars to 6 teaspoons a day if they eat about 1,600 kcal [e.g., children 2-5 years], 12 teaspoons at 2,200 calories [e.g., children 6-11 years and adolescent girls], or 18 teaspoons at 2,800 calories [e.g., adolescent boys]" (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997b). Food consumption survey data indicate that American children consume approximately twice the recommended limit of added sugars (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997b). Simons-Morton et al. (1990) found that the diets of children in grades 3-5 consisted of many foods rich in added sugars (e.g., soft drinks, cakes, cupcakes, pies, hard candy, and candy bars).

To date, the only established direct relationship between sugar and disease pertains to dental caries. Although any fermentable carbohydrate is cariogenic, sucrose is the most cariogenic for children because it is the major fermentable sugar in their diets (American Academy of Pediatrics. Committee on Nutrition, 1993a). Frequent snacking and the persistence of sucrose-
containing food on the teeth contribute to dental caries by influencing the length of time the teeth are exposed to an acidic environment conducive to tooth decay. Studies in animals and humans show that malnutrition during infancy is linked to an increased prevalence of caries (Alvarez, 1995).

Dietary fiber, an indigestible complex carbohydrate, promotes normal bowel function by increasing fecal bulk and promoting regularity; it also reduces the energy and protein density of the diet (Giovannini et al., 1996; Hillemeier, 1995; Williams, 1995). However, excess fiber, especially in the diets of young children, may lead to inadequate energy intakes because of the low caloric density of high-fiber foods combined with small stomach capacities (Williams, 1995; Williams & Bolllela, 1995; Williams et al., 1995). Diets very high in fiber may also reduce the bioavailability of essential minerals, which may be a problem when mineral intakes are low (Williams & Bolllela, 1995).

The American Health Foundation has suggested that a "safe and tolerable" range of dietary fiber intake for healthy children older than 2 years of age is between "age plus 5" and "age plus 10" g/day (Williams & Bolllela, 1995; Williams et al., 1995). Younger children are more likely to meet this recommendation than older children and adolescents (see Table II-2) for example, 53% of preschoolers ages 2-5 years, but only 11% of adolescent girls ages 12-17 years and 24% of adolescent boys (Lin & Guthrie, 1996). Among the foods richest in dietary fiber are fruits, vegetables, and whole grains. Children consuming nutritionally inadequate vegan diets should pay special attention to meal planning to avoid the potential adverse effects of high fiber intakes (Dwyer, 1995a; Williams, 1995; Williams & Bolllela, 1995).

Infants 0-12 months. **Total carbohydrate.** Mature human milk provides about 40% of total energy from carbohydrate (Mietus-Snyder et al., 1993; Newberg & Neubauer, 1995) and standard milk protein-based formula for term infants provides about 42 to 44% of total energy from carbohydrate (Life Sciences Research Office, 1998). In comparison, whole cow milk provides only about 30% of energy from carbohydrate (Newberg & Neubauer, 1995). Lactose, a disaccharide, is the principal carbohydrate found in human milk and in most commerical infant formulas in the U.S. (Life Sciences Research Office, 1998).

A minimum of 5 g of carbohydrate per kg body weight is required in the infant's diet to prevent ketosis and hypoglycemia (Heird, 1996). Moreover, a diet with inadequate carbohydrate would make it difficult to meet the infant's high energy demands (Lifschitz, 1988) and would place additional metabolic demands on the infant if energy compensation was achieved by increasing administration of fat and protein (Fomon, 1993a). Toxicity from excessive carbohydrate intake is unknown in normal term infants; however, excessive dietary intakes have been implicated as a contributor to diarrhea in formula-fed infants (Lifschitz, 1988).

**Dietary fiber.** Complex carbohydrates are introduced into an infant's diet with solid foods such as cereals, fruits, and vegetables. Soluble fiber in particular helps in the establishment of the resident intestinal flora (Giovannini et al., 1996). There are no dietary guidelines for fiber consumption in infancy. Agostoni et al. (1995) recommended that weaning diets should gradually come to supply 5 g fiber/day through a gradual introduction of plant-based foods. Older infants can easily obtain this amount of fiber by consuming one-half cup each of fruits, vegetables, and infant cereal daily (Johnson, 1997).

**Protein.** Proteins provide structure to cells and tissues, catalyze biochemical reactions, serve as energy sources, and are essential components of the immune system, among other functions (U.S. Department of Health and Human Services [HHS], 1988). They are composed of approximately 20 amino acids, some of which are termed "essential," meaning that they are not synthesized by the body and must be ingested. Protein in food is broken down into its constituent amino acids, which are then used by cells to make human proteins and other nitrogen-containing compounds such as creatine and some neurotransmitters. Mean protein intakes of most American children at all ages are well above actual needs, although approximately one out of four adolescent girls do not meet the RDA (see Table II-3).

Infants 0-12 months. Infants in the first six months of life have higher protein needs relative to body weight than at any other period of life, given the high rate of protein synthesis and breakdown in tissues (Young & Steinke, 1992). Young infants require the same essential amino acids as adults (leucine, isoleucine, valine, threonine, methionine, phenylalanine, tryptophan, lysine, and histidine) but also appear to require cysteine and tyrosine (Heird, 1996).
Table II-3. Protein intakes of children 0-19 years of age and percentages meeting 1989 RDAs

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Mean protein intake (g/day)</th>
<th>Percentage meeting 100% of the 1989 RDA</th>
<th>1989 RDA (g/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants under 1 yr²</td>
<td>21.6</td>
<td>80.1</td>
<td>13 (6-12 mo)</td>
</tr>
<tr>
<td>Children 1-2 yr</td>
<td>49.2</td>
<td>98.8</td>
<td>16</td>
</tr>
<tr>
<td>Children 3-5 yr</td>
<td>55.4</td>
<td>98.9</td>
<td>16 (3 yr)</td>
</tr>
<tr>
<td>Children 6-11 yr</td>
<td>70.3 (males)</td>
<td>97.4 (males)</td>
<td>28 (6-10 yr)</td>
</tr>
<tr>
<td></td>
<td>62.4 (females)</td>
<td>95.1 (females)</td>
<td>45 (males 11 yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>46 (females 11 yr)</td>
</tr>
<tr>
<td>Adolescents 12-19 yr</td>
<td>97.5 (males)</td>
<td>90.4 (males)</td>
<td>45 (males 12-14 yr)</td>
</tr>
<tr>
<td></td>
<td>65.3 (females)</td>
<td>76.3 (females)</td>
<td>59 (males 15-18 yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>58 (males 19 yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>46 (females 12-14 yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>44 (females 15-18 yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>46 (females 19 yr)</td>
</tr>
</tbody>
</table>

¹ Data are from CSFII 1994-96. CSFII (Continuing Survey of Food Intakes by Individuals) is conducted by the Agricultural Research Service of the U.S. Department of Agriculture. Data presented above are the combined results from the 1994, 1995, and 1996 surveys based on respondents' intakes on the first surveyed day (U.S. Department of Agriculture (USDA). Food Surveys Research Group. Agricultural Research Service, 1997a).

² Data exclude breast-fed infants.

³ Data are based on respondents' 2-day average intakes.


Protein concentrations in human milk decline over the course of lactation (Butte et al., 1984; Fomon, 1991; Nommensen et al., 1991). Human milk also supplies non-protein nitrogen compounds such as urea, uric acid, creatine, creatinine, and amino acids, with an estimated 27% of this nonprotein fraction available for protein synthesis (Lønnerdal et al., 1976). Between the ages of 2 and 5 months, protein intakes of infants fed human milk have been found to be lower than those of formula-fed infants (Akerblom et al., 1992; Fomon, 1993c; Järvenpää et al., 1982a,b; Räihä, 1985). In the first two months of life, protein intakes are similar to estimated requirements, but are substantially lower than requirements at 2-5 months of age, leading Fomon (1993c) to conclude that the protein requirement is underestimated.

Fat. Dietary fats provide the fatty acids needed for the structure and function of cell membranes and serve as precursors for bioactive metabolites such as eicosanoids. Energy in the form of fat spares protein for tissue synthesis. Dietary fats also facilitate the absorption, transport, and delivery of fat-soluble vitamins, add flavor and texture to food, and play a role in satiety (American Academy of Pediatrics. Committee on Nutrition, 1993a; Fomon, 1993d; Hamosh, 1988). Fat is a concentrated energy source, providing 9 kcal/g compared with 4 kcal/g for both protein and carbohydrate.

The American Academy of Pediatrics has recommended that fat intakes should not be restricted in the diets of children less than 2 years of age, given that they have high energy requirements relative to body weight to support rapid growth and development (American Academy of Pediatrics. Committee on Nutrition, 1998a). Both the American Academy of Pediatrics (1998a) and the 1995 DGFA (U.S. Department of Agriculture (USDA) and U.S. Department of Health and Human Services (HHS), 1995) have recommended that children aged 2 years and over gradually adopt a diet that contains no more than 30% of total energy from fat, less than 10% of energy from saturated fat, and less than 300 mg of cholesterol per day by the age of 5 years (see Tables II-4, II-5, and II-6). The Food Guide Pyramid also has recommended that foods high in fat be used sparingly and that the diet provide no more than 30% of calories from fat (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997b). Not all nutrition scientists agree that fat intakes should be limited during childhood as a public health strategy. This controversy is discussed in Chapter IV.

Most children between the ages of 2 and 19 years have higher total fat and saturated fat intakes than recommended by the DGFA and the Food Guide Pyramid (see Tables II-4 and II-5). Approximately two-thirds consume diets supplying >30%
of total energy as fat, and between two-thirds and three-fourths consume diets containing ≥10% of total energy as saturated fat. Eighty percent or more of 3-19-year-old children, with the exception of adolescent males consume ≤300 mg cholesterol per day (see Table II-6). Similar results were found in the NHANES III 1988-91 (Life Sciences Research Office, 1995).

Newborn infants must change from carbohydrate as their primary energy source in utero to fat after birth (Anderson, 1991). Breast milk supplies about 45-58% of energy as fat, and current milk-based infant formulas provide about 48% of energy from fat (Fomon, 1993d). Fat as a concentrated energy source has advantages after birth when energy requirements per unit of body weight are higher than at any other time of life (Fomon, 1993b). As solid foods are introduced, the percentage of total energy from fat in the diet decreases.

Many clinical trials have shown that diets providing 30 to 55% of total energy from fat result in appropriate growth rates among young infants (Fomon, 1993b). Markedly higher or lower intakes of fat are regarded as physiologically inappropriate (Fomon, 1993b). A recent study by Skinner et al. (1997b) found that the percentage of energy from fat in the diets of breast-fed and formula-fed infants ranged from 47 to 49% between 2 and 4 months of age. The percentage decreased to 42% at 6 months of age and to 32% at 12 months of age, reflecting the introduction of solid foods.

Essential fatty acids, including long-chain polyunsaturated fatty acids. Linoleic acid (LA) is an essential fatty acid of the n-6 family that must be obtained from the diet. Arachidonic acid (AA) becomes essential when linoleic acid deficiency exists (National Research Council, 1989a). α-Linolenic acid (ALA) has traditionally been classified as an essential fatty acid of the n-3 family, found primarily in storage and transport lipids (Life Sciences Research Office, 1998; National Research Council, 1989b). The American Academy of Pediatrics (1993a) has recommended that essential fatty acids comprise at least 3% of caloric intake. Providing <1% of total energy intake from LA in the diet can result in deficiency signs and symptoms, including scaly skin, hair loss, diarrhea, and impaired wound healing.

LA from human milk or formula is metabolized into long-chain polyunsaturated fatty acids (LCPUFAs; fatty acids containing 20 or more carbon atoms) such as AA. Human milk also supplies ALA, which is metabolized into LCPUFAs such as eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA). Variable amounts of ALA are found in infant formulas, depending on the polyunsaturated oils used in their manufacture. LCPUFAs, many of which are found in breast milk, serve as precursors for the synthesis of a variety of biologically active metabolites including eicosanoids, which are important factors in second-messenger systems and are crucial for normal cell function. The concentration of many n-6 and n-3 fatty acids in human milk is greatly influenced by maternal diet (Finley et al., 1985; Jensen, 1996; Sanders & Reddy, 1992).

A growing body of studies have investigated the role of n-3 fatty acids and the LCPUFAs DHA and AA in infant development, particularly on growth, neurophysiology, and visual and cognitive competency (Life Sciences Research Office, 1998). In the brain, DHA and AA are present in substantial amounts in non-myelin membranes, particularly in the cortical synaptic terminals and the retina (Clandinin & Van Aerde, 1992).

These studies were recently reviewed by an Expert Panel of the Life Sciences Research Office (Life Sciences Research Office, 1998). The Expert Panel recommended that LA should continue to be added to term infant formulas. The Panel also recommended that ALA should be added to commercial term infant formulas to reduce the possibility of delayed development of visual function and lower levels of DHA in the brain. It was concluded that the ratio of LA:ALA should not exceed 16 to 1 nor be less than 6 to 1, because a balance of n-3 and n-6 fatty acids is needed to ensure formation of LCPUFAs from both fatty acid families. The Expert Panel did not recommend the addition of AA and DHA to infant formulas at this time (Life Sciences Research Office, 1998). The available evidence was found to be inconsistent, given the paucity of data, inconclusive results of available studies, and the continuing complexity of the issue. It did not conclusively support the benefit, dietary essentiality, or effect on growth or neurological development of LCPUFA fortification.
### Table II-4. Total fat intakes of children 0-19 years of age

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Mean total fat intake (g/day)</th>
<th>Percent kcal from total fat</th>
<th>Recommended intakes of total fat</th>
<th>Percentage of individuals meeting recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants under 1 yr</td>
<td>36.4</td>
<td>39.7</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Children 1-2 yr</td>
<td>47.9</td>
<td>32.2</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Children 3-5 yr</td>
<td>57.4</td>
<td>32.4</td>
<td>Maximum of 30% of total kcal</td>
<td>32.5</td>
</tr>
<tr>
<td>Children 6-11 yr</td>
<td>74.3 (males) 66.1 (females)</td>
<td>32.5 (males) 32.6 (females)</td>
<td>Maximum of 30% of total kcal</td>
<td>30.3 (males) 33.9 (females)</td>
</tr>
<tr>
<td>Adolescents 12-19 yr</td>
<td>102.8 (males) 69.3 (females)</td>
<td>33.1 (males) 32.2 (females)</td>
<td>Maximum of 30% of total kcal</td>
<td>30.3 (males) 35.3 (females)</td>
</tr>
</tbody>
</table>

1 Data are from CSFII 1994-96. CSFII (Continuing Survey of Food Intakes by Individuals) is conducted by the Agricultural Research Service of the U.S. Department of Agriculture. Data presented above are the combined results from the 1994, 1995, and 1996 surveys based on respondents' intakes on the first surveyed day (U.S. Department of Agriculture (USDA). Food Surveys Research Group. Agricultural Research Service, 1997a).

2 Data exclude breast-fed infants.

3 Sources: (National Research Council, 1989a) and (U.S. Department of Agriculture (USDA) and U.S. Department of Health and Human Services (HHS), 1995).

4 Data are based on respondents' 2-day average intakes.

### Table II-5. Total saturated fat intakes of children 0-19 years of age

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Mean saturated fat intake (g/day)</th>
<th>Percent kcal from saturated fat</th>
<th>Recommended intakes of saturated fat</th>
<th>Percentage of individuals meeting recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants under 1 yr</td>
<td>36.4</td>
<td>39.7</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Children 1-2 yr</td>
<td>47.9</td>
<td>32.2</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Children 3-5 yr</td>
<td>57.4</td>
<td>32.4</td>
<td>Below 10% of total kcal</td>
<td>23.0</td>
</tr>
<tr>
<td>Children 6-11 yr</td>
<td>74.3 (males) 66.1 (females)</td>
<td>32.5 (males) 32.6 (females)</td>
<td>Below 10% of total kcal</td>
<td>24.9 (males) 23.2 (females)</td>
</tr>
<tr>
<td>Adolescents 12-19 yr</td>
<td>102.8 (males) 69.3 (females)</td>
<td>33.1 (males) 32.2 (females)</td>
<td>Below 10% of total kcal</td>
<td>27.5 (males) 33.5 (females)</td>
</tr>
</tbody>
</table>

1 Data are from CSFII 1994-96. CSFII (Continuing Survey of Food Intakes by Individuals) is conducted by the Agricultural Research Service of the U.S. Department of Agriculture. Data presented above are the combined results from the 1994, 1995, and 1996 surveys based on respondents' intakes on the first surveyed day (U.S. Department of Agriculture (USDA). Food Surveys Research Group. Agricultural Research Service, 1997a).

2 Data exclude breast-fed infants.

3 Sources: (National Research Council, 1989a) and (U.S. Department of Agriculture (USDA) and U.S. Department of Health and Human Services (HHS), 1995).

4 Data are based on respondents' 2-day average intakes.
Table II-6. Total cholesterol intakes of children 0-19 years of age

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Mean cholesterol intake (mg/day)</th>
<th>Recommended intakes of cholesterol (mg/day)</th>
<th>Percentage of individuals meeting recommendation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants under 1 yr²</td>
<td>46</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Children 1-2 yr</td>
<td>189</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Children 3-5 yr</td>
<td>183</td>
<td>≤300</td>
<td>87.8</td>
</tr>
<tr>
<td>Children 6-11 yr</td>
<td>228 (males) 200 (females)</td>
<td>≤300</td>
<td>80.1 (males) 85.4 (females)</td>
</tr>
<tr>
<td>Adolescents 12-19 yr</td>
<td>323 (males) 216 (females)</td>
<td>≤300</td>
<td>55.8 (males) 80.7 (females)</td>
</tr>
</tbody>
</table>

¹ Data are from CSFII 1994-96. CSFII (Continuing Survey of Food Intakes by Individuals) is conducted by the Agricultural Research Service of the U.S. Department of Agriculture. Data presented above are the combined results from the 1994, 1995, and 1996 surveys based on respondents' intakes on the first surveyed day (U.S. Department of Agriculture (USDA); Food Surveys Research Group. Agricultural Research Service, 1997a).
² Data exclude breast-fed infants.
³ Sources: (National Research Council, 1989a) and (U.S. Department of Agriculture (USDA) and U.S. Department of Health and Human Services (HHS), 1995).
⁴ Data are based on respondents' 2-day average intakes.

Trans fatty acids. Most fatty acids in nature are of the cis configuration. Trans fatty acids are produced by the industrial hydrogenation of unsaturated oils and occur in small amounts in animal fats. Levels of trans fatty acids have been found to be substantially higher in human milk than in formula (Koletzko & Bremer, 1989), probably reflecting the trans fatty acid content of the maternal diet (Carroll, 1989). Trans fatty acids have no known nutritional value. Concerns have been raised that trans fatty acids may adversely affect fetal growth and infant development. At the cellular level, for example, trans fatty acids may impair microsomal desaturation and chain elongation of LA and ALA to their LCPUFAs metabolites (Mahfouz et al., 1980, 1981). They also reputed to have deleterious effects on cholesterol metabolism by increasing serum lipoprotein [a] (Mensink et al., 1992; Mensink & Katan, 1993). In a recent review, Carlson et al. (1997) concluded that concerns about trans fatty acids center around observations of an inverse association between the percentage of trans fatty acids and n-6 LCPUFAs in the plasma lipids from premature infants, and a negative correlation between trans fatty acids in the plasma and the birth weight of premature infants. Although these observations suggest that trans fatty acids may inhibit the desaturation of essential fatty acids, this concern is difficult to investigate because of the many factors that can influence development and maturation. Carlson et al. (1997) concluded that no causal relationship has been established between trans fatty acid intake and changes in early development, but called for further research in this area.

Micronutrients
In general, children eat diets that supply adequate amounts of most vitamins and minerals. Data from CSFII 1994-95 and NHANES III 1988-91 indicate that the mean intakes from food of most micronutrients exceeded the 1989 RDA among children across racial and ethnic groups (Life Sciences Research Office, 1995; Wilson et al., 1997). Nevertheless, many children have intakes of minerals such as iron and calcium and perhaps zinc that may be less than adequate. Data from NHANES III 1988-91, CSFII 1989-91, and CSFII 1994-95 also indicate that many adolescent females fail to meet RDA levels for vitamins A and B6 (Life Sciences Research Office, 1995; Wilson et al., 1997). The low reported energy intakes of teenage girls may also contribute to nutritional inadequacies. Concerns over body weight and body image are major preoccupations of teenage girls that often lead to restrictions in food intake, even when it is not necessary (see Chapter IV).

Iron. Iron is critical for normal growth and development throughout childhood, with infancy and adolescence being the times of greatest need. Children need iron to maintain hemoglobin concentrations and to increase their total iron mass (National Research Council. Subcommittee on the Tenth Edition of the RDAs. Food and Nutrition Board, 1989a). Iron also appears to be involved in cognitive development, psychomotor function, behavior, and intellectual performance, with the most complex postnatal neural developmental changes in the human brain occurring in the first two years of life (Pollitt, 1993; Yip & Dallman, 1996).

Absorbed iron is derived from two pools: the heme pool in which iron is complexed with hemoglobin, myoglobin, and other heme-containing proteins, and the nonheme pool comprising the major part of dietary iron intake (Yip & Dallman, 1996).
Nonheme iron absorption is inhibited by calcium, milk proteins (particularly those in cow milk), phytates, and tannins (Fomon, 1993e; Hallberg et al., 1992, 1996; Lönnander, 1997). Enhancers of nonheme iron absorption include vitamin C (Davidsson et al., 1994a; Gilloy et al., 1984; Stekel et al., 1986; Hallberg, 1981) and an unidentified component of meat and fish (Hallberg, 1981; Heinig et al., 1993b).

**Infants 0-12 months.** Infants are born with substantial iron reserves that are sufficient to maintain iron adequacy through at least the first four months of life without supplementation (Dallman, 1992; Stekel, 1984). This endowment is essentially unaffected by maternal iron status under all but the most extreme circumstances (Stekel, 1984).

Mean iron concentrations reported for mature human milk are relatively low, ranging from 0.2 to 0.8 mg/L (Anderson, 1992; Feeley et al., 1983; Hirai et al., 1990; Lönnander, 1984; Picciano & Gutherie, 1976; Siimes et al., 1979, 1984). Concentrations of iron in human milk are highest in early lactation, diminish throughout about five months, and gradually rise thereafter (Casey et al., 1995). Currently available commercial iron-fortified formulas provide about 12 mg iron/L (Life Sciences Research Office, 1998). Data from CSFII 1994-96 indicated that the mean daily iron intakes of formula-fed infants exceed the 1989 RDA for infants 0-12 months of age (see Table II-7).

**Iron deficiency: incidence and functional changes.** Data on the incidence of iron deficiency in infants less than one year of age are limited, but data are available for older children. Recent data from NHANES III 1988-94 indicated that 9% of 1-2-year-old children were iron-deficient, with 3% having iron deficiency anaemia (Looker et al., 1997). (See Table II-8 for cutoff values used to define iron deficiency and iron-deficiency anaemia). Because overt iron deficiency develops over a period of months, these data provide insight into the incidence of these conditions in infants less than one year old.

The development of iron deficiency begins with the depletion of ferritin and hemosiderin—the storage forms of iron. In normal human infants, hemoglobin levels are about 16 to 18 g/dL at birth and fall rapidly to adult levels by about four months of age. The depletion of iron stores leads eventually to reduced concentrations of circulating hemoglobin and to abnormal erythrocytes (microcytic and hypochromic). In healthy term infants, little change occurs in total body stores of iron between birth and four months of age (Dallman, 1993). This is followed by a period of continued rapid growth and an expanding blood volume during which body iron stores decrease in the absence of supplementation to support these needs. In exclusively breast-fed infants, efficiency of iron absorption increases as iron stores become depleted. The incongruity between the relatively low iron content of human milk and the infant’s ability to maintain adequate iron status through the first four to six months of life is thought to be due to the high bioavailability of iron from human milk and physiological compensations that allow for increased iron absorption in the presence of depleted iron stores. Iron from human milk is more bioavailable than the iron in formula, although a large range of values has been reported for percent absorption—11.8% to 48.8% (Abrams et al., 1997; Davidsson et al., 1994b; Hallberg et al., 1992; McMillan et al., 1977; Saarinen et al., 1977; Schulz-Lehl et al. 1987). Fomon (1993e) indicated that the iron in human milk is absorbed more efficiently than the iron in other infant foods, because of the low iron concentration and the absence of iron inhibitors in human milk.

Although iron deficiency rarely occurs before six months of age in exclusively breast-fed infants, it may occur if unfortified solid foods are introduced after this time (Dallman, 1993). Hertrampf et al. (1986) and Pizarro et al. (1991) found that a large percentage of exclusively breast-fed 9-month-old infants had impaired iron status in the absence of iron supplementation. Infants fed unfortified formulas are also at risk for iron deficiency (Lönnander, 1997; Pizarro et al., 1991). Lönnander (1997) indicated that infants fed unfortified formula frequently develop iron deficiency or anaemia by 6-9 months of age. Introducing cow milk before the age of 12 months is also associated with iron deficiency, because cow milk is not a good source of iron (Centers for Disease Control and Prevention [CDC], 1998). Use of cow milk in the first year of life may also promote iron deficiency by inhibiting iron absorption because of its high calcium content (Dallman, 1993). A number of studies have shown that infants fed cow milk are more likely to have poorer iron status and higher gastrointestinal iron losses than infants fed iron-fortified formula (Falkner, 1991; Fomon et al., 1981; Fuchs et al., 1993; Pizarro et al., 1991; Ziegler et al., 1990).

In addition to the hematological changes described above, impaired behavioral and cognitive development may occur with iron deficiency, with or without anemia. However, the precise nature of the relationship between iron intake and developmental outcomes remains unclear. In a review article by Beard et al. (1993), it was indicated that the effects of iron deficiency on neurological function may be attributed to alterations in brain indolamine and catecholamine neurotransmitter concentrations and to changes in brain electrophysiology, based on evidence from animal and human studies. Whether these effects of iron...
Table II-7. Iron intakes of children 0-19 years of age and percentages meeting 1989 RDAs

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Mean iron intake (mg/day)</th>
<th>Percentage meeting 100% of the 1989 RDA</th>
<th>1989 RDA (mg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants under 1 yr</td>
<td>15.7</td>
<td>87.9</td>
<td>6 (0-6 mo)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>10 (6-12 mo)</td>
</tr>
<tr>
<td>Children 1-2 yr</td>
<td>10.5</td>
<td>43.9</td>
<td>10</td>
</tr>
<tr>
<td>Children 3-5 yr</td>
<td>12.4</td>
<td>61.7</td>
<td>10</td>
</tr>
<tr>
<td>Children 6-11 yr</td>
<td>16.6 (males)</td>
<td>79.8 (males)</td>
<td>10 (6-10 yr)</td>
</tr>
<tr>
<td></td>
<td>13.7 (females)</td>
<td>60.9 (females)</td>
<td>12 (males 11-14 yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15 females 11-14 yr</td>
</tr>
<tr>
<td>Adolescents 12-19 yr</td>
<td>19.8 (males)</td>
<td>83.1 (males)</td>
<td>12 (males 11-18 yr)</td>
</tr>
<tr>
<td></td>
<td>13.8 (females)</td>
<td>27.7 (females)</td>
<td>10 (males 19-24 yr)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>15 (females 11-24 yr)</td>
</tr>
</tbody>
</table>

1 Data are from CSFII 1994-96. CSFII (Continuing Survey of Food Intakes by Individuals) is conducted by the Agricultural Research Service of the U.S. Department of Agriculture. Data presented above are the combined results from the 1994, 1995, and 1996 surveys based on respondents’ intakes on the first surveyed day (U.S. Department of Agriculture (USDA), Food Surveys Research Group. Agricultural Research Service, 1997a).

2 Data exclude breast-fed infants. Data are not available on iron intakes at various stages of infancy (e.g., before and after introduction of solids).

3 Data are based on respondents’ 2-day average intakes.


Table II-8. Cutoff Values Used to Assess Iron Deficiency and Iron-Deficiency Anemia

<table>
<thead>
<tr>
<th>Age (yr)</th>
<th>Transferrin saturation (%)</th>
<th>Serum ferritin (µg/L)</th>
<th>Erythrocyte protoporphyrin (µmol/L red blood cells)</th>
<th>Hemoglobin (g/L)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2</td>
<td>&lt;10</td>
<td>&lt;10</td>
<td>&gt;1.42</td>
<td>&lt;110</td>
</tr>
<tr>
<td>3-5</td>
<td>&lt;12</td>
<td>&lt;10</td>
<td>&gt;1.24</td>
<td>&lt;112</td>
</tr>
<tr>
<td>6-11</td>
<td>&lt;14</td>
<td>&lt;12</td>
<td>&gt;1.24</td>
<td>&lt;118</td>
</tr>
<tr>
<td>12-15</td>
<td>&lt;14</td>
<td>&lt;12</td>
<td>&gt;1.24</td>
<td>&lt;126 (males)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;119 (females)</td>
</tr>
<tr>
<td>16-19</td>
<td>&lt;15</td>
<td>&lt;12</td>
<td>&gt;1.24</td>
<td>&lt;136 (males)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;120 (females)</td>
</tr>
</tbody>
</table>

1 Data are from Looker et al. (1997). Iron status was assessed by laboratory tests: free erythrocyte protoporphyrin, transferrin saturation, and serum ferritin. To be considered iron-deficient, at least two of these indicators had to be abnormal. Iron deficiency anemia was defined as having iron deficiency and a low hemoglobin concentration.

deficiency, with or without anemia, lead to long-term irreversible functional changes in behavior and cognition is still unknown.

Several large studies have found that infants with iron deficiency anemia had lower test results of mental development before iron treatment than infants who were not anemic, using the Bayley Scales of Infant Development (Grundilis et al., 1986; Lozoff et al., 1987, 1991; Walter et al., 1989). In some of these studies, the remediation of iron deficiency anemia in infants with the most severe cases of anemia was not associated with full recovery from behavioral and developmental deficits (Lozoff et al., 1987, 1991).
Moffatt et al. (1994) found that the use of iron-fortified formula by high-risk infants was beneficial in preventing anemia and possibly a transient decline in psychomotor development associated with iron deficiency. In this randomized, controlled, double-blinded study, 283 healthy term infants from very low-income families were fed either a commercially available low-iron cow-milk formula (1.1 mg/L) or one that was iron-fortified (12.8 mg/L). Iron status was assessed biochemically, and the Bayley Scales of Infant Development and the Infant Behavior Record tests were administered at 6 (n=225), 9 (n=204), 12 (n=186), and 15 (n=154) months of age. Iron intake from foods other than formula was assessed, with no significant differences in intake identified at any time during the study. Although no differences in growth were found between the two groups throughout the study's duration, infants fed the lower-iron formula had substantially lower hematologic indices after six months and had significantly lower scores on the psychomotor indices of the Bayley Developmental Scales test at 9 and 12 months of age than infants fed the higher-iron formula. Differences in neurodevelopment scores disappeared by 15 months of age.

Idjradinata & Pollitt (1993) indicated that the adverse neurodevelopmental effects of iron deficiency anemia may be reversed with iron repletion. In their randomized, double-blinded trial, developmental measures of 12 18-month-old Indonesian infants were evaluated before and after four months of iron therapy. Infants with iron deficiency anemia (n=50) received either dietary ferrous sulfate or placebo for four months. Similar treatment randomization was conducted in a nonanemic iron-deficient group (n=29) and in an iron-sufficient control group (n=47). At baseline, neurodevelopmental indices were significantly lower in the iron-deficient anemic group than in either of the other two groups. After treatment, developmental deficits were reversed in the iron-deficient anemia group receiving iron supplementation, whereas in the iron-deficient anemia group that did not receive supplemental iron, developmental deficits remained the same. Neither placebo nor iron supplementation resulted in any changes in the non-anemic groups.

Gastrointestinal considerations. Most authoritative organizations agree that iron-fortified infant formula is the best substitute for breast milk for infants who are not breastfed or are partially breastfed in the first year of life (see Chapter III). As indicated in the CON-AAP (Life Sciences Research Office, 1998) statement on iron-fortified formulas (American Academy of Pediatrics. Committee on Nutrition, 1989) concerns that infants fed iron-fortified formula are more likely to experience constipation, colic, diarrhea, and regurgitation than infants fed low-iron formulas are not supported by controlled experiments. As stated previously, currently produced commercial “iron-fortified” formulas contain approximately 12 mg iron/L. Formula products labeled as “low-iron” contain between 1.3 and 4.7 mg iron/L. (Life Sciences Research Office, 1998). The justification for the use of low-iron formulas is that their use will alleviate these gastrointestinal problems presumed to be associated with the iron content of conventional infant formulas. These presumptions have been tested empirically in a number of controlled studies, but none of these studies has provided any evidence to support these contentions (Bradley et al., 1993; Hyams et al., 1995; Nelson et al., 1988; Oski, 1980).

One of the most recent studies conducted in this area was done by Hyams et al. (1995). In this prospective, double-blinded study, stool frequency and characteristics and gastrointestinal symptoms were compared between breast-fed infants (n=66) and infants randomly assigned to one of four formulas: whey-casein formula with 1 mg iron/L (n=56), whey-casein formula with 12 mg iron/L (n=47), soy protein formula with 12 mg iron/L (n=58), and casein hydrolysate formula with 12 mg iron/L (n=58). Infants fed breast milk and the protein hydrolysate formula had a significantly higher stool frequency than infants fed the other formulas. The addition of iron to the whey-casein formula resulted in a significantly lower percent of loose or watery stools than the same formula without iron. Infants in the group fed the soy-based formula had the highest frequency of “hard” stools of the four formula groups. Watery stools were more frequent in the protein hydrolysate group. Although infants fed formulas containing 12 mg iron/L had more “green stools” than infants fed formulas with 1 mg iron/L and breast-fed infants, no differences were found in spitting, gassiness, or crying.

In an earlier study, Oski (1980) compared the gastrointestinal symptoms of infants randomly assigned to cow milk-based formulas with 12 mg iron/quart (n=44) or without iron (no concentration provided; n=49). No differences were found in the number, consistency, or quality of stools, or in the incidence of colic, spitting-up, or vomiting. These findings were confirmed by Nelson et al. (1988) who conducted a similar study with infants fed high-iron (12 mg/L) and low-iron (1.5 mg/L) milk-based formulas. In all three phases of their trial, infants receiving the iron-fortified formula had a significantly higher incidence of “green” stools.

Bradley et al. (1993) conducted a different type of study, but their results were similar to those of Oski (1980) and Nelson et al. (1988). In this study, comparisons were made among infants receiving milk-based formulas containing two different levels of iron (7.4 mg/L; n=106 or 12.7 mg/L; n=106) and infants receiving breast milk (n=51). Infants who were discontinued
from breastfeeding between one and eight weeks of age were randomly assigned to receive one of the two formulas; 40 received the 7.4 mg/L formula and 44 received the 12.7 mg/L formula. In the final analyses (n=86), no significant differences in rates of or reasons for attrition were noted among the three groups. Infants were assessed at 1, 2, 3, 4, 6, and 12 months of age for possible intolerance symptoms (vomiting, diarrhea, perianal irritation, colic, gas, eczema, and hunger). During the first six months of the study, parents completed daily records on formula intake and the number of bowel movements and weekly records on stool characteristics, formula tolerance and symptoms, diaper area irritation, the introduction of new foods, and any medications given. Statistically significant differences were not observed in stool number. No apparent differences in stool characteristics or formula tolerance were noted, although these differences were not analyzed statistically because "of the very small number of symptoms reported." "Green" was reported as the most common stool color in the formula-fed infants, and "yellow" was reported as the most common stool color in the breast-fed infants.

 Appropriateness of using lower iron concentrations in iron-fortified formulas. Concerns about current iron levels in infant formulas have resulted in the conduct of a number of studies that have investigated whether the use of lower concentrations of iron in formulas is appropriate during infancy (Bradley et al., 1993; Fomon et al., 1997; Haschke et al., 1993; Löönerdal & Hernell, 1994; Hernell & Löönerdal, 1996; Walter et al., 1998).

 Löönerdal & Hernell (1994) showed that whey-predominant formulas containing 4 or 7 mg iron/L were equally effective in maintaining iron status during the first six months of life. The formula fed in each of the 5 groups (n=10 for each group) studied was supplemented as follows: group A: 4 mg iron/L (ferrous sulfate), group B: 4 mg iron/L (ferrous sulfate) and 10 μg selenium/L (Na₄SeO₄), group C: 4 mg iron/L (1.4 mg as bovine lactoferrin and 2.6 mg as ferrous sulfate) and 10 μg selenium/L (Na₄SeO₄), group D: 4 mg iron/L (ferrous sulfate) and 0.4 mg copper/L (copper sulfate), and group E: 7 mg iron/L (ferrous sulfate). A control group of exclusively breast-fed infants (n=10) was also included. No iron supplements or solid foods were given during the test period, with the exception of limited amounts of fruit purées (without iron) between 4 and 6 months of age. Blood samples were taken at baseline and at 6 months. At 6 months of age, no statistically significant differences were observed for any of the hematological indices studied among the groups, and all infants had satisfactory iron status.

 In a subsequent paper, Hernell & Löönerdal (1996) compared the results from their previous study (Löönerdal & Hernell, 1994) to preliminary data from studies in which experimental formulas containing 2 or 4 mg iron/L were fed to healthy term infants over the first six months of life. Infants were fed their respective formulas between 4 and 6 weeks of age through six months of age. Although much of the detail of these protocols was unclear (e.g., the number of subjects in each treatment group), no differences in hematologic measures were found in either of the two formula groups and a group of exclusively breast-fed infants. At 6 months of age, none of the infants fed the 4 mg/L formula and only one of the infants fed the 2 mg/L formula were found to be iron-deficient, as defined by multiple criteria (i.e., serum ferritin < 12 μg/L, serum Fe < 10 μmol/L, and mean corpuscular volume < 70).

 In another recent study with infants less than 6 months of age, Fomon et al. (1997) used stable isotope ⁵⁷Fe to assess iron absorption in infants fed formulas with an iron concentration of 8 mg or 12 mg/L. No statistically significant differences were found at day 168 and 196 of age in the quantity of iron incorporated into erythrocytes by infants fed either formula. Because their results were unable to show that iron absorption was greater by infants fed formulas providing 12 mg iron/L than by those fed formulas providing 8 mg iron/L, the authors concluded that "pending the results of further studies, it is reasonable to decrease the iron concentration of iron-fortified infant formulas."

 Haschke et al. (1993) compared the iron intakes and iron status of three groups of healthy, term infants to determine whether infant formulas providing 3 or 6 mg iron/L might result in adequate iron status in the first nine months of life. Infants were assigned to receive either a whey-predominant formula fortified with 3 mg iron/L (n=27) or the same formula fortified with 6 mg/L (n=24). Infants were admitted to the study at 90 days of life and continued with their respective formulas through day 274 of life. A comparison group of exclusively breast-fed infants (n=30) whose mothers intended to continue breastfeeding beyond 6 months of age were also studied until 274 days of age. All infants received infant foods and cereals according to European Community feeding guidelines. Haschke et al. (1993) reported that mean iron intakes of infants fed formula with 3 mg iron/L were significantly lower at 183 and 274 days of age than intakes of infants fed formula with 6 mg iron/L. None of the infants fed the formula with 3 mg/L met the RDA for infants between 6 and 12 months of age (10 mg). At 183 and 274 days of age, no statistically significant differences in iron indices (hemoglobin, hematocrit, mean corpuscular volume, free erythrocyte protoporphyrin, and serum ferritin levels) were apparent between formula groups, and none of the infants had depleted iron stores. In comparison, 13% of the breast-fed infants had depleted iron stores at 183 days of age. Only 3% of the
breast-fed infants had depleted iron stores at 273 days of age, a time when iron-fortified foods were included as a regular part of the diet.

In a recently published paper, Walter et al. (1998) compared the hematologic effects of low-iron formulas (2.3 mg/L; n=405) and high-iron formulas (12.7 mg/L; n=430) in a randomized double-blinded study with healthy Chilean infants followed between 6 and 18 months of age. At the time of enrollment, all infants had been breast-fed for the first six months of life and were either partially or totally weaned, with no signs of iron-deficiency anemia (defined as hemoglobin levels <10 g/L and two out of three other measures in the deficient range—mean cell volume <70 fl, erythrocyte protoporphyrin >100 µg/dL RBC, or serum ferritin <12 µg/L). Average daily consumption of formula was similar between the two groups during the initial test period (6 to 12 months of age), and no data were provided with regard to the intake of solid foods. At 12 months of age, no differences were apparent in the prevalence of iron-deficiency anemia between the high- and low-iron formula groups, 2.8% and 3.8%, respectively; however, the high-iron group had significantly higher hemoglobin levels, mean cell volume, and serum ferritin and lower erythrocyte protoporphyrin levels than the low-iron formula group. Furthermore, 39% of the low-iron group at 12 months were classified as iron-deficient compared with 20% of the high-iron group. Walter et al. (1998) indicated that solid foods typically are a poor source of iron in Chilean infants’ diets in the first year of life. After infants with anemia at 12 months of age were excluded from the 18-month follow-up, iron status of infants in the low-iron group had improved at 18 months and anemia was virtually absent. The amount of formula consumed or the contribution of iron from the solid foods consumed by the children was not indicated; however, the authors noted that the amount and variety of supplemental foods increased in the second year of life, particularly in regard to the intake of iron-fortified wheat products.

Walter et al. (1998) expressed concern that the results of their study would be used to justify the continued use of unfortified formula throughout infancy. They countered this concern by noting that the infants in this study were all healthy, large (>3 kg at birth) term infants who had been breast-fed for an average of four months or more, and thus were better able to tolerate the low-iron formulas in terms of their iron endowment than smaller infants who were not in optimal health. Moreover, the selection process eliminated any infants who had or might have been at risk of developing anemia. Walter et al. (1998) cautioned against using the results of their study to infer that the use of unfortified formulas in the absence of any other iron supplementation is appropriate for infants during the first year of life. They concluded that “high-iron formula continues to provide the best insurance that infants will have normal iron status.”

Excessive intakes and interactions. Another concern related to the routine use of iron-fortified formula is the potential that the iron in the formula will adversely affect the absorption of other minerals (Lönnerdal & Hernell, 1994). Iron has been presumed to interact with the absorption of zinc, copper, and manganese, because these minerals compete for similar intestinal absorption sites (Lönnerdal, 1989, 1991, 1997; Solomonos. 1986). Lönnerdal (1989, 1997) noted that the presence of these minerals in foods at a meal lessens concerns about bioavailability. Data from Sandström et al. (1985) support this conclusion. Their findings showed that excessive levels of iron (iron: zinc ratio >25:1) taken in a water solution resulted in significantly lower zinc absorption in adults, but no effect was found when given with a meal. The effect of iron-fortified formulas on mineral balance has been addressed in numerous studies with infants (Abrams et al., 1997; Bradley et al., 1993; Craig et al., 1984, Fairweather-Tait et al., 1995; Haschke et al., 1986, 1993; Lönnerdal & Hernell, 1994; Yip et al., 1985). To date, no evidence supports the contention that iron fortification of formulas impairs the absorption of zinc and copper at current levels present in infant formula.

Several studies have demonstrated that the use of iron-fortified formulas by infants adversely affects mineral balance. An early study by Craig et al. (1984) investigated the effect of two cow milk-based formulas with (14.4 mg/L) and without additional iron (1.9 mg/L) on zinc and copper concentrations. A third group of infants received iron-fortified soy formula with an iron content of 16.6 mg/L. The respective mean iron:zinc ratios for the three formulas were 2.2, 0.3, and 2.6.1. Plasma zinc concentrations were found to be significantly lower among the infants fed the two iron-fortified formulas than among those fed the low-iron formula, with concentrations being lowest among those fed the soy formula. A similar but not statistically significant lowering of serum copper concentrations was also noted in the two iron-fortified formulas.

In a study by Haschke et al. (1986) the impact of differing levels of iron in cow milk-based formula (2.5 and 10.2 mg/L) on mineral balance was compared in seven healthy term infants aged 43 to 322 days old. Infants less than 120 days old (n=2) consumed their assigned formulas as their sole source of nutrition. Older infants (n=5) consumed commercial baby foods in addition to the formulas, and attempts were made to restrict their intake of baby foods to those that would not interfere with the absorption of the minerals under investigation. The relative ratios of minerals in the high- and low-iron formulas were:
iron: zinc ratio, 5.4:1 and 1.3:1, and iron: copper ratio, 34:1 and 8.3:1, respectively; the zinc: copper ratio in both formulas was 6.3:1. Urine and feces were collected over the 72-hour balance periods and analyzed for iron, calcium, magnesium, phosphorus, zinc, copper, and manganese content. At the conclusion of the study, no statistically significant effects were noted for any mineral, with the exception of phosphorus and copper. For phosphorus, absorption was significantly lower among the infants fed the high-iron formula than among those fed the low-iron formula. Significant reductions in copper absorption and retention and increases in fecal excretion were observed with the high-iron formula, but not with the low-iron formula. Lønnerdal & Hernell (1994) also observed that the lowest serum copper concentrations were associated with the intake of higher iron-containing formulas (7 mg/L) than with the intake of lower iron-containing formulas (4 mg/L).

In contrast, findings from other studies have suggested that iron supplementation has no effect on mineral balance in infants. Bradley et al. (1993) found no differences in serum iron, zinc, or copper concentrations or in hematologic indices at 6 and 12 months of age among healthy term infants fed either human milk or cow milk-based iron-fortified formula containing 12.7 mg/L or 7.4 mg/L. Furthermore, no differences in hematologic parameters or mineral concentrations were observed between the two formula-fed groups. Haschke et al. (1993) found no effects on copper or zinc concentrations in infants fed formulas containing 3 or 6 mg iron/L when given with solid foods. Fairweather-Tait et al. (1995) found no statistically significant differences in zinc absorption in 9-month-old infants (n=11) fed a commercial vegetable-based weaning food with supplemental iron (6.6 mg/test meal; iron: zinc ratio=4.7) or without supplemental iron (iron: zinc ratio=0.7). The study by Yip et al. (1985) differed from the others noted above in that it included older infants and the use of a sole source supplement rather than diet as the iron source. In their study, 1-year-old infants (n=291) were randomly assigned to receive either 30 mg iron (ferrous sulfate) or a placebo daily before breakfast for three months. No statistically significant differences in serum zinc or copper concentrations were found when iron was supplemented at this level.

Dallman (1989) indicated that the amount of iron required to decrease zinc and copper absorption is higher than the amount of iron ordinarily found in commercially available iron-fortified infant formulas. Nonetheless, the results from several of the above described studies suggest that reduced absorption of copper and zinc is possible in infants consuming iron-fortified formulas. The functional consequence(s) of such alterations, however, are still unclear.

Other potentially deleterious effects have been attributed to excessive iron intakes. Iron acts as a catalyst for free radical generating reactions, whereby an excess of free iron through the enhancement of cellular oxidative reactions such as lipid peroxidation can lead to oxidative damage (Halliwell, 1994). To our knowledge, no in vivo or clinical studies have been conducted to address this issue in infants, with the exception of the study by Almas et al. (1997) on the impact of vitamin C on hydroxyl radical formation in iron-fortified formulas. Dallman (1989) presented other possible adverse effects of excess iron, including a reduction of the host response to infection. This effect is believed to be caused by the saturation of transferrin, thereby making the unbound iron available to enhance the growth of pathogenic organisms. Wharton et al. (1994) speculated that the advantageous microflora associated with breast milk might be associated with lactoferrin-bound iron, presumed to be unavailable for iron-dependent pathogens.

**Children 1-2 years.** The rapid growth rate of children less than 2 years of age accompanied by their generally low iron intakes places them at higher risk of iron deficiency anemia than any other age group (Centers for Disease Control and Prevention [CDC], 1998). Fewer than half of toddlers meet the RDA for iron (see Table II-7). Iron deficiency is common in the second year of life (Wood et al., 1993). Recent data from NHANES III 1988-94 indicated that 9% of the 1-2 year-old children tested were iron deficient, with 3% having iron-deficiency anemia (Looker et al., 1997). For this analysis, iron deficiency was defined based on the results of three laboratory tests of iron status—free erythrocyte protoporphyrin, transferrin saturation, and serum ferritin (see Table II-8). Looker et al. (1997) indicated that the prevalence of anemia has decreased over the past several decades, probably because of the increased use of iron-fortified formula and better absorbed iron compounds added to infant foods.

**Children 2-5 years.** After the age of 18-24 months of age, children are at lower risk of iron deficiency because their growth rates are slower and their diets typically are more varied and consist of more iron-rich foods (Dallman, 1992; Looker et al., 1997; Yip and Dallman, 1996). Data from NHANES III 1988-94 showed that 9% of 1-2-year-olds were iron-deficient, with 3% of 1-2-year-olds having iron deficiency anemia (Looker et al., 1997). In comparison, 3% of 3-5-year-olds presented with iron deficiency and less than 1% presented with anemia (see Table II-8 for cutoffs). Data from CSFII 1994-96 showed that the mean iron intakes of children 3-5 years old exceeded the RDA; however, 38% still had iron intakes below the RDA (see Table II-7).
Iron-deficiency anemia has been associated with lower IQ and learning scores among preschool children (Pollitt, 1993; Pollitt et al., 1986; Seshadri & Gopaldas, 1989; Soewondo et al., 1989). Beard (1995) noted that because unresolved issues remain concerning the timing, severity, duration, and reversibility of iron’s detrimental effects on mental development, it is still unclear whether iron deficiency, with or without anemia, can lead to long-term, irreversible functional changes in behavior and cognition.

**Children 5-12 years.** As in the preschool years, iron deficiency is not common during the school years because growth rates have slowed and children of this age typically eat a varied diet containing ample iron (Yip & Dallman, 1996). In the NHANES III 1988-94 surveys, 2% of children ages 6-11 were found to be iron-deficient, with less than 1% presenting with anemia (Looker et al., 1997). Although mean iron intakes of 6-11-year-old children were found to exceed the RDA in CSFII 1994-96, approximately 20% of boys and 40% of girls had intakes below the RDA (see Table II-7).

**Adolescents 12-20 years.** With the onset of puberty, iron demands increase to support accelerated growth and sexual maturation (Dallman, 1992; Yip & Dallman, 1996). Males experience many physiological changes during pubertal development that increase their need for iron, including rapid growth of body size and muscles and increases in testosterone concentrations (Anttila et al., 1997). According to Dallman (1992), demands for absorbed iron increase during peak growth from about 1.0 to 2.5 mg/day, reflecting an expanding blood volume and an increase in hemoglobin concentrations that occur with male sexual maturation. As noted earlier, the growth spurt in U.S. males occurs between the ages of 12 and 15 years (Gong & Heald, 1994), with sexual maturation (Tanner stages 2 to 5) beginning about two years before the period of peak growth (Dallman, 1992). After the growth spurt and sexual maturation have been achieved, the rate of growth and the need for iron decrease.

In females, the growth spurt occurs earlier than in males, between 10 and 13 years of age (Gong & Heald, 1994) and is not as great as that for males (Dallman, 1992). Sexual maturation (Tanner stages 2 to 5) begins about one year before peak growth and lasts about 4 years, with menstruation beginning about one year after peak growth (Dallman, 1992). Dallman (1992) indicated that the mean requirement for absorbed iron in females reaches a maximum of about 1.5 mg/day at peak growth and remains at about 1.3 mg/day thereafter to replenish blood iron losses in menses. The RDA for iron is higher for adolescent females (15 mg) than for adolescent males (12 mg, 11-18 years; 10 mg, 19-24 years) because of their need to replace menstrual iron loss (see Table II-7).

Because of increased iron demands during adolescence, the risk of iron deficiency increases, particularly in females (Centers for Disease Control and Prevention [CDC], 1998). The NHANES III 1988-94 reported that 9% of 12-15-year-old females and 11% of 16-19-year-old females were iron-deficient, with 2% and 3% respectively being anemic (Looker et al., 1997). Only 1% of males 12-15 years of age and fewer than 1% of males 16-19 years of age were iron-deficient, with fewer than 1% being anemic in both age groups (Looker et al., 1997) (see Table II-8 for cutoffs). Girls with heavy menstrual blood losses (>80 ml/month) are more likely to become anemic without extra iron from foods or supplements than girls with lighter menstrual blood losses (Dallman, 1993). The method of contraception used influences menstrual blood losses and subsequent risk of iron deficiency; use of oral contraceptives decreases blood loss by about half, and use of intrauterine contraceptive devices doubles the loss (Bothwell & Charlton, 1981; Hallberg et al., 1996). The increase in the prevalence of iron deficiency that occurs among adolescent females may be attributed not only to their high iron requirements, but also to their tendency to consume less food than male adolescents (see Chapter III). In the CSFII 1994-96, only 28% of females 12-19 years of age consumed diets meeting 100% of the RDA for iron compared with 83% of their male counterparts (U.S. Department of Agriculture [USDA].Food Surveys Research Group. Agricultural Research Service, 1997).

**Calcium.** More than 99% of body calcium is bound to the structural matrix of bone (Arnaud & Sanchez, 1996; Pomson & Nelson, 1993). The remainder is found in the extracellular fluid and within cells where it constitutes the physiologically active pool of free calcium. Ionic calcium is involved in many physiologic processes throughout the body, including blood coagulation, muscle contraction, regulation of nerve electrical conduction, and control of many enzyme reactions. Vitamin D has as its primary function the maintenance of serum calcium and phosphorus concentrations within a normal physiologic range, which it accomplishes by stimulating the absorption of both minerals from the small intestine (Holick, 1994).

Milk products are the main dietary source of calcium among Americans (Institute of Medicine, 1997). Beyond infancy, a large percentage of U.S. children and adolescents do not consume diets meeting the RDA for calcium (see Table II-9). Intakes are particularly low among adolescents, with only 36% of males and 14% of females consuming diets meeting the RDA for
calcium in CSFII 1994-96. Over time, poor calcium nutriure caused by inadequate intakes and/or inadequate absorption may lead to reduced bone mass and osteoporosis (Institute of Medicine, 1997). Regular physical activity is also important to bone health and development (Anderson & Metz, 1993).

**Infants 0-12 months.** Total body calcium in a healthy term infant increases from approximately 30 g at birth to 80 g by 1 year of age (Institute of Medicine, 1997). Abrams et al. (1992) found that calcium accretion to bone was approximately the same in infants aged 10-11 months and adults 23-33 years of age, but the infants had a net calcium retention that exceeded that of the adults by more than 300 mg/day on average.

The FNB derived the Adequate Intake (AI) of calcium in infancy based on mean intakes of this nutrient from human milk (Institute of Medicine, 1997) (see Table II-9). Infants fed human milk absorb considerably more calcium that those fed formula (Southgate et al., 1969; Widdowson, 1965; Williams et al., 1970). Mean absorption of calcium by breast-fed infants is 58% of intake and 38% by formula-fed infants (Fomon & Nelson, 1993). However, total retention of calcium is at least as good from formula as from human milk because of the higher calcium content in formula (Fomon & Nelson, 1993).

**Adolescents 12-20 years.** Calcium absorption increases in early puberty. Abrams & Staff (1994) found that fractional calcium absorption averaged 34% in early puberty in Caucasian girls consuming about 925 mg calcium/day, up from 28% in previous years, and then decreased to 25% two years later. Martin et al. (1997) using dual-energy X-ray absorptiometry (DXA) to measure bone mineral content, found that the mean daily calcium retention of boys and girls aged 9.5-19.5 years was 282 mg and 212 mg, respectively. Peak calcium accretion occurs at an average age of 13 years in girls and 14.5 years in boys (Institute of Medicine, 1997). In a metabolic study by Weaver et al. (1995), white adolescent girls were found to absorb and retain calcium more efficiently than young adult women.

Racial differences appear to exist in calcium metabolism during adolescence. Black adolescents may absorb calcium more efficiently and excrete less calcium in their urine than white adolescents (Abrams et al., 1996; Bell et al., 1993), which could explain the higher bone mass found in black children (Bell et al., 1991) and their lower bone-fracture rates as adults (Institute of Medicine, 1997). One study found that calcium retention in black girls did not decline after menarche as it does in white girls (Abrams & Staff, 1994). In the judgment of the FNB, the implications of these differences in calcium metabolism for calcium requirements are not clear, so race-specific recommendations for this nutrient have not been made (Institute of Medicine, 1997). The calcium AIs for adolescent boys and girls are based on the achievement of maximal calcium retention, which is derived largely from studies on white girls aged 11-14 years (Institute of Medicine, 1997). Peak bone mass is achieved at different ages at various sites (Anderson & Metz, 1993).

**Zinc.** Zinc, a constituent of more than 200 enzymes, participates in most metabolic pathways involving the synthesis and degradation of proteins, lipids, carbohydrates, and nucleic acids (Czajka-Narins, 1996; National Research Council. Subcommittee on the Tenth Edition of the RDAs. Food and Nutrition Board, 1989a). It is necessary for proper growth in children (Favier, 1992), as was first demonstrated in studies with adolescent males in Iran and Egypt in the early 1960s (Prasad et al., 1963). Zinc also has important functional roles in cellular immunity and wound healing (Cousins, 1996) and may play a role in cognitive development (Black, 1998).

Knowledge of the role of zinc in human nutrition has grown considerably in recent years, leading to a greater appreciation of its importance for young children (Hambidge, 1997). Animal products are the richest sources of bioavailable zinc (Allen, 1998). It can be difficult for children eating plant-based diets high in phytates to obtain recommended amounts of this mineral. The assessment of zinc status has been hampered by a lack of a sensitive index (Hambidge et al., 1998). The little evidence for inadequate zinc nutriure among children in the United States to date may in part reflect the difficulty of assessing zinc status and the very limited data available from well-controlled trials. Nonetheless, fewer than half of U.S children (excluding infants) consume diets that supply 100% of the RDA for zinc (see Table II-10).

**Infants 0-12 months.** Zinc deficiency is rare in breast-fed term infants, except in cases when the zinc concentrations of human milk are unusually low (<0.37 mg/L) (Bye et al., 1985; Glover & Atherton, 1988; Heinen et al., 1995; Kuramoto et al., 1986, 1991; Lee et al., 1990; Roberts et al., 1987). Thus, it has been assumed that human milk is an adequate source of zinc for infants, particularly in the first six months of life. However, whether exclusive breastfeeding supplies adequate zinc in the second 6 months of life is still unclear (Krebs et al., 1994; Prasad, 1996; Walravens et al., 1992). Concerns have been raised about the impact of marginal zinc intakes on growth in exclusively breast-fed older infants. The decline in zinc concentrations
### Table II-9. Calcium intakes of children 0-19 years of age and percentages meeting 1989 RDAs

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Mean calcium intake (mg/day)</th>
<th>Percentage meeting 100% of the 1989 RDA (%)</th>
<th>1989 RDA and 1997 AI (mg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants under 1 yr</td>
<td>664</td>
<td>72.4</td>
<td>RDA: 400 (0-6 mo) 600 (6-12 mo)  AI: 210 (0-5 mo) 270 (6-12 mo)</td>
</tr>
<tr>
<td>Children 1-2 yr</td>
<td>848</td>
<td>48.7</td>
<td>RDA: 800  AI: 500</td>
</tr>
<tr>
<td>Children 3-5 yr</td>
<td>819</td>
<td>43.5</td>
<td>RDA: 800  AI: 500 (3 yr) 800 (4-5 yr)</td>
</tr>
<tr>
<td>Children 6-11 yr</td>
<td>970 (males) 857 (females)</td>
<td>55.5 (males) 42.5 (females)</td>
<td>RDA: 800 (6-10 yr) 1,200 (11 yr)  AI: 800 (6-8 yr) 1,300 (9-11 yr)</td>
</tr>
<tr>
<td>Adolescents 12-19 yr</td>
<td>1,145 (males) 771 (females)</td>
<td>36.3 (males) 13.5 (females)</td>
<td>RDA: 1,200  AI: 1,300 (12-18 yr) 1,000 (19 yr)</td>
</tr>
</tbody>
</table>

1 Data are from CSFII 1994-96. CSFII (Continuing Survey of Food Intakes by Individuals) is conducted by the Agricultural Research Service of the U.S. Department of Agriculture. Data presented above are the combined results from the 1994, 1995, and 1996 surveys based on respondents' intakes on the first surveyed day (U.S. Department of Agriculture (USDA). Food Surveys Research Group. Agricultural Research Service, 1997a).

2 Data exclude breast-fed infants.

3 Data are based on respondents' 2-day average intakes.

4 RDAs (National Research Council. Subcommittee on the Tenth Edition of the RDAs. Food and Nutrition Board, 1989a) and AIs (Institute of Medicine, 1997) are issued by the Food and Nutrition Board of the Institute of Medicine, National Academy of Sciences.

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### Table II-10. Zinc intakes of children 0-19 years of age and percentages meeting 1989 RDAs

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Mean zinc intake (mg/day)</th>
<th>Percentage meeting 100% of the 1989 RDA (%)</th>
<th>1989 RDA (mg/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants 0-12 mo</td>
<td>6.4</td>
<td>73.0</td>
<td>5</td>
</tr>
<tr>
<td>Children 1-2 yr</td>
<td>7.4</td>
<td>15.2</td>
<td>10</td>
</tr>
<tr>
<td>Children 3-5 yr</td>
<td>8.6</td>
<td>25.4</td>
<td>10</td>
</tr>
<tr>
<td>Children 6-11 yr</td>
<td>11.2 (males) 9.5 (females)</td>
<td>45.2 (males) 30.4 (females)</td>
<td>10 (6-10 yr) 15 (males, 11 yr) 12 (females, 11 yr)</td>
</tr>
<tr>
<td>Adolescents 12-19 yr</td>
<td>14.5 (males) 9.9 (females)</td>
<td>34.7 (males) 23.9 (females)</td>
<td>15 (males) 12 (females)</td>
</tr>
</tbody>
</table>

1 Data are from CSFII 1994-96. CSFII (Continuing Survey of Food Intakes by Individuals) is conducted by the Agricultural Research Service of the U.S. Department of Agriculture. Data presented above are the combined results from the 1994, 1995, and 1996 surveys (U.S. Department of Agriculture (USDA). Food Surveys Research Group. Agricultural Research Service, 1997a).

2 Data exclude breast-fed infants.

3 Data are based on respondents' 2-day average intakes.

in human milk that occur over the course of lactation is compensated for by an apparent concomitant increase in absorption rates (Krebs & Hambidge, 1986).

**Children, 2-5 years.** Although it was believed in the 1960s that growth impairment from zinc deficiency was limited to children in less developed countries, studies in the United States have described marginal forms of zinc deficiency, resulting in poor growth among apparently healthy preschool children. Hambidge et al. (1972) found a correlation between low levels of zinc in hair and poor appetite and low growth percentiles in children less than 4 years of age from families of upper and middle socioeconomic status in Denver. A subsequent study showed a correlation between short stature and low hair zinc levels in low-income preschool children (Hambidge et al., 1976). More recently, Vanderkooy & Gibson (1987) found a significant correlation between low hair zinc levels and low height-for-age in preschool-aged boys, but not in girls.

Consumption of meat, a food high in zinc content, is often low in the diets of preschool children because of personal preferences (Czajka-Narins, 1996). Data from CSFII 1994-95 showed that 3-5-year-old children consumed, on average, only about 1 oz/day of beef and poultry (Wilson et al., 1997). Hambidge et al. (1976) similarly found that preschool children ate only about 1 oz/day of meat.

**Adolescents, 12-20 years.** Zinc is essential for adolescent sexual development (Gong & Heald, 1994; Thompson et al., 1986). Studies in the 1960s first described cases of severe growth retardation and delayed sexual development resulting from zinc deficiency in Middle Eastern adolescent males (Prasad et al., 1963). Zinc retention increases significantly during the adolescent growth spurt (Thompson et al., 1986). This increase is related to the increase of lean body mass which occurs at this time (Sandstead, 1973).

**Sodium.** Sodium is essential to the regulation of extracellular fluid volume, the membrane potential of cells, and the body's osmolality and acid-base balance (National Research Council. Subcommittee on the Tenth Edition of the RDAs. Food and Nutrition Board, 1989a). Sodium, especially in the form of salt (sodium chloride) is plentiful in the food supply and is often added in food processing, so inadequate intakes among healthy persons are extremely rare (see Table II-11). Intakes are usually well above requirements, and there is evidence that sodium intakes among schoolchildren and adolescents have increased since the 1970s (Life Sciences Research Office, 1995). Sodium depletion may occur with heavy and persistent sweating or when trauma, chronic diarrhea, or renal disease lead to excessive sodium loss (National Research Council. Subcommittee on the Tenth Edition of the RDAs. Food and Nutrition Board, 1989a).

Beginning at age two years, the FNB recommends that the total daily intake of salt be limited to a “moderate” 6 g (2,400 mg sodium) or less (National Research Council, 1989a). The rationale for limiting salt and sodium intake is to prevent high blood pressure, a risk factor for coronary heart disease and cerebrovascular disease in adults (Gillman & Ellison, 1993; National Heart, Lung and Blood Institute, 1991). Whether young children or even all adults benefit from a reduction in sodium intake remains a topic of continued debate. This issue is discussed in Chapter IV.

**NUTRITIONAL SUPPLEMENTS**

Use of vitamin and mineral supplements is common among U.S. children and adolescents (see Table II-12). Most users of supplements take a multivitamin with or without iron or other minerals. Adolescents 12-19 years of age are more likely to take single vitamins and minerals than children less than 12 years of age.

**Infants, 0-12 Months**

According to the American Academy of Pediatrics. Committee on Nutrition, (1993c), there is no evidence that healthy full-term infants fed commercial formula require vitamin or mineral supplements, because the vitamins and minerals in infant formulas supply all known essential nutrients in amounts required by the infant. Furthermore, there is little conclusive evidence that any specific vitamin or mineral supplements are required by healthy breast-fed term infants of well-nourished mothers, with the exception of vitamin K at birth (American Academy of Pediatrics. Committee on Nutrition, 1993c) and perhaps supplemental vitamin D and iron (American Academy of Pediatrics. Work Group on Breastfeeding, 1997) Vitamin D was noted as being possibly needed by infants not exposed to adequate sunlight or by infants whose mothers are vitamin D-deficient; iron was noted as being possibly needed by infants with low iron stores or anemia. In the second six months of life, the AAP (American Academy of Pediatrics. Committee on Nutrition, 1993c) indicated that iron deficiency can occur in exclusively breast-fed infants, and deficiencies of vitamin K, fluoride, and perhaps zinc are also possible. Nevertheless, it was
### Table II-11. Mean sodium intakes of children 0-19 years of age from selected national surveys, 1 day, 1988-91 and 1994-96

<table>
<thead>
<tr>
<th>Age Group</th>
<th>Survey¹</th>
<th>Daily Mean Sodium Intakes (mg/day)²</th>
<th>Estimated Minimum Requirements (mg/day)⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infants under 1 yr²</td>
<td>CSFII 1994-96, NHANES III 1988-91</td>
<td>458, 575</td>
<td>120 (0-5 mo), 200 (6-11 mo)</td>
</tr>
<tr>
<td>Children 1-2 yr</td>
<td>CSFII 1994-96, NHANES III 1988-91</td>
<td>1,946, 1,938</td>
<td>225 (1 yr), 300 (2 yr)</td>
</tr>
<tr>
<td>Children 3-5 yr</td>
<td>CSFII 1994-96, NHANES III 1988-91</td>
<td>2,468, 2,531</td>
<td>300</td>
</tr>
<tr>
<td>Children 6-11 yr</td>
<td>CSFII 1994-96, NHANES III 1988-91</td>
<td>3,186 (males), 2,805 (females)</td>
<td>400 (6-9 yr), 500 (10-11 yr)</td>
</tr>
</tbody>
</table>


² Data exclude breast-fed infants.

³ These figures do not include sodium from salt added at the table.


### Table II-12. Percentages of children using vitamin and mineral supplements, 1994-95¹

<table>
<thead>
<tr>
<th>Age Group</th>
<th>% of Individuals Using Vitamin and Mineral Supplements²</th>
<th>% Using Multivitamin</th>
<th>% Using Multivitamin with Iron or Other Minerals</th>
<th>% Using Single Vitamins/Minerals</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-2 yr</td>
<td>46.2</td>
<td>21.5</td>
<td>20.6</td>
<td>3.9</td>
</tr>
<tr>
<td>3-5 yr</td>
<td>58.9</td>
<td>31.4</td>
<td>23.4</td>
<td>4.3</td>
</tr>
<tr>
<td>6-11 yr</td>
<td>46.9 (males), 40.6 (females)</td>
<td>24.7 (males), 20.2 (females)</td>
<td>17.7 (males), 14.1 (females)</td>
<td>4.1 (males), 5.2 (females)</td>
</tr>
<tr>
<td>12-19 yr</td>
<td>31.3 (males), 40.6 (females)</td>
<td>16.2 (males), 17.5 (females)</td>
<td>6.4 (males), 11.2 (females)</td>
<td>9.3 (males), 11.3 (females)</td>
</tr>
</tbody>
</table>

¹ Data are from CSFII 1994-95. CSFII (Continuing Survey of Food Intakes by Individuals) is conducted by the Agricultural Research Service of the U.S. Department of Agriculture. Data presented above are the combined results of the 1994 and 1995 surveys (Wilson et al. 1997).

² Individuals who reported taking a vitamin or mineral supplement "every day," "almost every day," or "every so often."
concluded that the greater nutrient requirements in the latter half of infancy can be met with continued use of human milk or iron-fortified formula supplemented by a variety of solid foods, especially cereals and meats.

The Food and Nutrition Board (FNB) has recommended that breast-fed term infants receive supplemental iron at 4 months of age either from iron-fortified infant cereals, meat, or iron supplements (1 mg/kg/day) (Earl & Woteki, 1993). The FNB advised that because formula-fed term infants should only be fed iron-fortified formula, iron-fortified cereals or iron supplements were not required. Similar recommendations on iron supplement use have been provided by the Subcommittee on Nutrition During Lactation of the FNB (Institute of Medicine, 1991). The Canadian nutrition guidelines for healthy term infants do not indicate that extra iron is needed by breast-fed infants; however, recommendations on supplemental use of vitamin D are included. Their guidelines state that Canadian breast-fed infants should be given vitamin D supplements because vitamin D deficiency is a health problem in Canada and that infants who are fed formula do not require supplements because formula is fortified with vitamin D (Canadian Paediatric Society. Dietitians of Canada and Health Canada, 1998).

Children 1 Year and Older

The American Academy of Pediatrics (1993c) has concluded that after infancy there is little evidence suggesting that properly nourished healthy children require nutritional supplements, with the exception of fluoride if insufficient amounts are present in drinking water (American Academy of Pediatrics. Committee on Nutrition, 1993c; U.S. Department of Agriculture [USDA] and U.S. Department of Health and Human Services [HHS], 1995). The AAP (1993c) noted that children at particular risk of nutritional inadequacies may benefit from supplementation:

- Children from disadvantaged families or those who suffer from parental neglect or abuse;
- Children with anorexia or poor appetites or those consuming fad diets;
- Children with chronic diseases such as cystic fibrosis, inflammatory bowel disease, or liver disease;
- Children on weight control regimens to manage overweight; and
- Children following vegetarian diets containing few, if any, dairy foods.

The 1995 DGFA noted that supplements of vitamins, minerals, or fiber should not be used to replace improper food choices, but indicated that supplement use may be appropriate in certain circumstances (see Appendix C). Although these recommendations were not specifically targeted to children or adolescents, several circumstances when supplement use may be appropriate that are relevant to children and adolescents were given: use of vitamin D supplements by persons with little sunlight exposure, iron supplementation by pregnant women, and use of folate supplements (or consumption of folate-rich food) by women of childbearing years. The Surgeon General's Report on Nutrition and Health, Healthy People 2000, and the NRC Diet and Health report have also provided recommendations regarding supplement use that are relevant to children and adolescents (see Appendix C). Specific recommendations for iron supplementation have been provided by the CDC (Centers for Disease Control and Prevention [CDC], 1998) for adolescent girls and boys with iron deficiency anemia. For adolescent girls with anemia, treatment should include an oral dose of 60-120 mg of iron daily, and for adolescent boys, two 60 mg iron tablets were recommended each day.
III. FOOD CONSUMPTION PATTERNS AND THEIR DETERMINANTS

The establishment of healthy eating behaviors in the first two decades of life helps children achieve proper growth and development and may serve as a foundation for healthier eating habits in adulthood (Nakhiyan-Nehs, 1997; Sigman-Grant, 1992; Williams et al., 1998). This chapter presents information on the various factors that influence children's food choices and food preferences and on how these influences change throughout childhood. It also reviews current dietary recommendations for children from infancy through adolescence and presents selected data on children's food consumption patterns at various stages of development.

FOOD CONSUMPTION PATTERNS

Infants 0-12 Months

Current recommendations. Human milk. Increasing the incidence and duration of breastfeeding is a national health objective of the U.S. Department of Health and Human Services (DHHS) as part of its "Healthy People 2000" goals. The target is to "increase to at least 75 percent the proportion of mothers who breastfeed their babies in the early postpartum period and to at least 50 percent the proportion who continue breastfeeding until their babies are 5 to 6 months old" (U.S. Department of Health and Human Services [HHS], Public Health Service, 1990). The Centers for Disease Control and Prevention (CDC) recently issued recommendations that exclusive breastfeeding be encouraged for 4-6 months after birth to reduce iron deficiency in infants (Centers for Disease Control and Prevention [CDC], 1998). The Surgeon General's Report on Nutrition and Health (U.S. Department of Health and Human Services [HHS], 1988) promoted breastfeeding or the use of iron-fortified formula as the most important safeguard against iron deficiency in infants. The American Dietetic Association (ADA) (1997) also promotes human milk as the preferred source of nourishment for rapidly growing young infants because of its benefits to both infant and mother.

In its policy statement on breastfeeding issued in late 1997, the AAP recommended exclusive breastfeeding as the ideal source of nutrition to support optimal infant growth and development for approximately the first six months of life (American Academy of Pediatrics. Work Group on Breastfeeding, 1997). AAP also recommended that breastfeeding begin as soon as possible after birth and that the newborn remain with the mother throughout the recovery period whenever possible. It further recommended that the newborn be nursed about 8 to 12 times every 24 hours until satisfied, usually 10 to 15 minutes on each breast, and that breastfeeding be initiated whenever the infant shows signs of hunger.

The AAP recommended that breastfeeding continue at least until the infant is 12 months old and for as long thereafter as mutually desired (American Academy of Pediatrics. Work Group on Breastfeeding, 1997). Gradual introduction of iron-fortified solid foods should complement breastfeeding in the second six months of life, and, if the infant is weaned from the breast before 12 months of age, an iron-fortified infant formula should be given as a substitute for breast milk (American Academy of Pediatrics. Work Group on Breastfeeding, 1997). Whole cow milk, reduced-fat milk, and fat-free milk were indicated as being inappropriate substitutes for human milk or formula in the first year of life (American Academy of Pediatrics. Committee on Nutrition, 1992).

In most cases, adequate intakes of human milk from well-nourished women provide for all the known nutritional requirements of infants up to age six months (Fomon, 1993f). The AAP noted that some infants may need supplemental vitamin D and iron before this time. Vitamin D might be needed by infants who are not exposed to adequate sunlight or by infants whose mothers are vitamin D-deficient, and iron might be needed by infants with low iron stores or anemia (American Academy of Pediatrics. Work Group on Breastfeeding, 1997).

The AAP further advised that healthy breast-fed infants generally do not need supplemental water, juice, or other foods in the first six months (American Academy of Pediatrics. Work Group on Breastfeeding, 1997). Supplements of water can decrease blood sodium concentrations, posing the risk of water intoxication characterized by hypothermia, edema, seizures, and altered mental status. Infants in the first month of life are especially susceptible to this condition because they have a lower glomerular filtration rate and cannot eliminate excess water as rapidly as older infants (Scariati et al., 1997).
In 1998, the Canadian Joint Working Group, consisting of Canadian Paediatric Society Nutrition Committee, Dietitians of Canada, and Health Canada issued a statement on breastfeeding for healthy term infants that was similar to the AAP statement (Canadian Paediatric Society. Dietitians of Canada and Health Canada, 1998). However, some differences were apparent. In the Canadian statement, for example, exclusive breastfeeding was encouraged for at least the first four months of life rather than six. Because vitamin D deficiency is a health problem in Canada, the Canadian statement recommended that the nation’s breast-fed infants be given vitamin D supplements (Canadian Paediatric Society. Dietitians of Canada and Health Canada, 1998). It did not address the need for extra iron by nursing infants, as did the AAP statement.

Breastfeeding promotes maternal-infant bonding in addition to contributing to the general health, growth, and development of infants (Fomon, 1993f). Breastfeeding may also influence favorably the development of the immune system and help to protect the nursing infant against infections (Hanson et al., 1996, 1997). For example, breastfeeding may reduce the incidence or severity of gastrointestinal illnesses (Burr et al., 1989; Dewey et al., 1995; Howie et al., 1990), respiratory tract infections and other respiratory illnesses (Burr et al., 1993; Wilson et al., 1998; Wright et al, 1989, 1995), otitis media (Dewey et al., 1995; Duncan et al., 1993; Owen et al., 1993), and allergic diseases (Halken et al., 1992; Saarinen & Kajosaari, 1995) in the nursing infant. Breastfeeding has also been linked with improved cognitive development (Horwood & Fergusson, 1998; Wang & Wu, 1996).

Infant formula. Commercial infant formula plays an important role in meeting the nutritional requirements of many infants in the United States (American Academy of Pediatrics. Committee on Nutrition, 1993c). Human milk is used as the model for the nutritional composition of infant formula. Because the bioavailability of some nutrients in human milk is generally greater than their bioavailability in infant formula (Lönnrender, 1997), most formulas contain higher concentrations of many nutrients.

The U.S. Food and Drug Administration (FDA) is responsible for ensuring the safety and nutritional quality of formulas intended for healthy term infants and for defining their nutrient content and labeling requirements (Vanderveen, 1991). AAP has been the primary source of recommendations to FDA for nutrient levels in formula. Current regulations include minimum specifications for 29 nutrients and maximum specifications for 9 nutrients (Life Sciences Research Office, 1998). At the request of FDA, the Life Sciences Research Office (LSRO) developed a new, updated set of recommendations for the nutrient composition of term infant formula (Life Sciences Research Office, 1998).

According to the AAP (American Academy of Pediatrics. Work Group on Breastfeeding, 1997), iron-fortified infant formula is the only appropriate alternative to breast milk. Commercial iron-fortified formulas provide approximately 12 mg/L of iron, whereas formulas labeled as “low-iron” contain between 1.3 and 4.7 mg/L (Life Sciences Research Office, 1998). The AAP (American Academy of Pediatrics. Committee on Nutrition, 1989) reviewed concerns that infants fed iron-fortified formula are more likely to experience gastrointestinal problems such as constipation, colic, diarrhea, and regurgitation than infants fed low-iron formulas. Several controlled studies found no basis for these concerns (Bradley et al., 1993; Hyams et al., 1995; Nelson et al., 1988; Oski, 1980). Furthermore, no evidence has supported the contention that iron fortification of formulas impairs the absorption of their zinc and copper (Abrams et al., 1997; Bradley et al., 1993; Craig et al., 1984; Haschke et al., 1986, 1993; Fairweather-Tait et al., 1995; Lönnrender & Hennell, 1994; Yip et al., 1985).

The CDC (Centers for Disease Control and Prevention (CDC), 1998) has also recommended iron-fortified formula as the only substitute for breast milk for infants less than 12 months of age who are not breastfed or are partially breastfed. A similar position was taken by a Canadian Joint Working Group (Canadian Paediatric Society. Dietitians of Canada and Health Canada, 1998). Recommendations advocating the use of iron-fortified formulas and foods were also included in the Healthy People 2000 (U.S. Department of Health and Human Services [HHS], Public Health Service, 1990) and The Surgeon General’s Report on Nutrition and Health (U.S. Department of Health and Human Services [HHS], 1988) (see Appendix C).

An LSRO Expert Panel recently concluded that infants are at risk of iron deficiency if they are fed a formula with 1.3 mg iron/L for most of the first year of life and do not receive medicinal iron supplementation or are not fed foods (such as meats) with substantial bioavailable iron (Life Sciences Research Office, 1998). It endorsed the use of iron-fortified formulas for infants of all ages, but acknowledged that some pediatric-nutrition authorities believe that low-iron formulas should remain available.

While cow milk-based infant formula is generally recommended as a substitute for or supplement to human milk, the AAP (American Academy of Pediatrics. Committee on Nutrition, 1998b) and the Canadian Joint Working Group (Canadian...
Paediatric Society. Dietitians of Canada and Health Canada, 1998) noted that soy protein-based formula is an appropriate alternative for infants with galactosemia or who do not tolerate dairy-based products. Soy formula is also appropriate for term infants raised as vegetarians (American Academy of Pediatrics. Committee on Nutrition, 1998b; Canadian Paediatric Society. Dietitians of Canada and Health Canada, 1998). A variety of isoflavones called phytoestrogens are naturally found in soy foods (Cruz et al., 1994; Setchell et al., 1997). Their potential beneficial and deleterious health effects are an active area of research (Cruz et al., 1994; Messina et al., 1997; Setchell et al., 1997). For example, some animal studies suggest that short-term exposure to phytoestrogens neonatally or prepubertally decreases breast cancer risk (Murrill et al., 1996), supporting epidemiological observations that the protective value of soy foods consumed by Southeast Asians occurs early in life (Colditz & Frazier, 1995).

Cow milk. Nutrient intakes of infants fed whole cow milk are not optimal (Heird, 1996). For example, protein and sodium intakes are excessive and intakes of iron and linoleic acid are inadequate (Heird, 1996). Infants fed skim milk have even higher protein and sodium intakes, with iron intakes being equally low and intakes of linoleic acid being even lower (Heird, 1996).

The CDC issued recommendations discouraging use of low-iron milks (such as cow, goat, and soy milk) until age 12 months (Centers for Disease Control and Prevention [CDC], 1998). Cow milk is not only a poor source of iron, but it may further promote iron deficiency by inhibiting iron absorption because of its high calcium content (Dallman, 1993). Several studies have shown that infants fed whole cow milk had poorer iron status and higher gastrointestinal blood loss (Fomon et al., 1981; Fuchs et al., 1993; Pizarro et al., 1991; Ziegler et al., 1990. Based on some of this evidence and concerns over displaced nutrient intakes, the AAP (American Academy of Pediatrics. Committee on Nutrition, 1992) recommended that cow milk should not be used as a substitute for human milk or formula in the first year of life. The Food and Nutrition Board (FNB) of the National Academy of Sciences also recommended that infants not be given cow milk during the first year (Earl & Woteki, 1993).

In contrast to these U.S. recommendations, the Canadian Joint Work Group advised that pasteurized whole cow milk may be introduced at 9 to 12 months of age though iron-fortified follow-up formula is preferred (Canadian Paediatric Society. Dietitians of Canada and Health Canada, 1998). It added that reduced-fat and fat-free milks and vegetarian beverages (except for soy formula) are inappropriate alternatives to pasteurized whole cow milk or to breast milk or formula in the first year of life.

Solid foods. It is widely acknowledged that an exclusive diet of human milk can meet the nutritional requirements of healthy term infants during the first six months of life and that non-milk foods should subsequently be introduced (American Academy of Pediatrics. Work Group on Breastfeeding, 1997; American Dietetic Association, 1997a; Institute of Medicine, 1991). For breast-fed infants, supplemental foods provide additional calories and nutrients, particularly iron, that human milk may no longer be able to supply in adequate amounts (Fomon, 1993c). For formula-fed infants, supplemental foods introduce a variety of tastes into the diet that breast-fed infants were exposed to via breastfeeding (Mennella, 1997).

Timing. The AAP recommended that solid foods for formula-fed babies be introduced between 4 and 6 months of age (American Academy of Pediatrics. Committee on Nutrition, 1992). It also recommended that iron-fortified solid foods be gradually introduced into the diet of breast-fed term infants at approximately 6 months of age (American Academy of Pediatrics. Work Group on Breastfeeding, 1997). The FNB recommended that breast-fed term infants be given supplemental iron at 4 months of age either from iron-fortified infant cereals, meat, or iron supplements (1 mg/kg/day) (Earl & Woteki, 1993). It advised that formula-fed term infants be given iron-fortified formula, in which case iron-fortified cereals would not be needed. The FNB also recommended that iron-fortified foods, supplemental foods with bioavailable iron, or a low-dose iron supplement be provided at 6 months of age, or earlier if solid foods were introduced before this time (Institute of Medicine, 1991). The Canadian Joint Working Group (Canadian Paediatric Society. Dietitians of Canada and Health Canada, 1998) recommended that iron-fortified cereals be introduced as the first solid foods between 4 and 6 months of age.

Little data are available on the effect of solid foods on mineral bioavailability from human milk in older infants (Abrams et al., 1997). Abrams et al. (1997) measured the absorption of calcium, zinc, and iron in 14 healthy, nonanemic 5-7-month-old breast-fed infants whose mother’s milk was extrinsically labeled with stable isotopes of these minerals. The researchers found that minerals were well-absorbed from human milk after solid foods were introduced.
Sequence of introduction. The AAP (American Academy of Pediatrics. Committee on Nutrition, 1993d) advised that single-ingredient foods be introduced one at a time at weekly intervals to allow possible food intolerances to be identified. Iron-fortified, single-grain infant cereals were suggested for the first supplemental foods, especially the well-tolerated precooked, partially hydrolyzed cereals (particularly rice). After that time, other single-ingredient pureed foods such as fruits, vegetables, and meats could be added gradually; the sequence of introduction not being important. The AAP (American Academy of Pediatrics. Committee on Nutrition, 1993d) further recommended that mixes of individual foods could be offered after tolerance to each had been demonstrated, and that juices may be introduced when the infant was able to drink from a cup.

The Canadian Joint Working Group (Canadian Paediatric Society. Dietitians of Canada and Health Canada, 1998) also recommended that single-ingredient pureed foods be initially introduced into the infant’s diet to allow potential allergic reactions to be identified. Single-grain rice cereal was suggested as the preferred first food followed by barley and oat cereals. The Canadian group recommended, without justification, the order of introduction of other single foods: vegetables, fruits, and meat and meat alternatives. Subsequently, single-food combinations, more textured purees, finger foods, and table foods could be provided.

Several researchers have found that the absorption of nonheme iron (e.g., the form found in cereals) is enhanced by vitamin C (Davidsson et al., 1994; Gillooly et al., 1984; Hallberg, 1981; Stekel et al., 1986) and by an unidentified component of meat and fish (Hallberg, 1981). The FNB, in recommending that iron-fortified infant cereal and meat be introduced after age 4 months, noted that meats and foods rich in vitamin C improve iron absorption (Earl & Woteki, 1993).

Food consumption patterns. The recent Ross Laboratories Mothers’ Survey (Ryan, 1997) found that 60% of mothers across sociodemographic groups initiated breastfeeding in the hospital in 1995, up from 52% in 1989. Rates of breastfeeding at six months of age also increased, from 18% in 1989 to 22% in 1995.

Skinner et al. (1997a) followed the food-related behaviors of healthy term infants from white families of middle and upper socioeconomic status. Between 4 and 6 months of age, the percentage of infants breastfeeding decreased from 59% to 24%. Many infants were fed solids in the first few months of life. At 2 months of age, 12% of the infants were being fed rice cereal, and at 6 months most were eating cereal and many were eating fruit and/or vegetables. The diets of these infants increased in variety in the second six months of life. Many different baby foods were eaten, and some table foods were introduced. Bananas, toasted oat cereal, crackers, and potatoes of all kinds were the most popular foods, and vegetables and meats were the least liked. By 12 months of age, about one-third of the infants were eating more table foods than baby foods.

According to the 1994-96 Continuing Survey of Food Intakes by Individuals (CSFII) conducted by the U.S. Department of Agriculture (USDA), 6% of formula-fed infants were given whole cow milk before their first birthday (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997a). The food consumption habits of breast-fed infants were not collected in this survey. Skinner et al. (1997a) found that 40% of the infants studied were drinking whole cow milk by 1 year of age, with about one-third consuming reduced-fat (1% or 2%) milk.

Children 1-2 Years
During the second year of life, it is important that developmentally appropriate, nutritious foods are served in a positive mealtine environment so that toddlers can continue to achieve normal growth and development and begin the transition from dependent to independent feeding (Glinsmann et al., 1996). Learning to accept and enjoy a variety of foods is critical at this time.

Current recommendations. According to the AAP, toddlers may be weaned to whole cow milk or may continue to be fed breast milk or formula (American Academy of Pediatrics. Committee on Nutrition, 1992). The AAP (American Academy of Pediatrics. Committee on Nutrition, 1992) and the Canadian Joint Working Group (Canadian Paediatric Society. Dietitians of Canada and Health Canada, 1998) agreed that whole milk was the only appropriate type of cow milk for children in the second year of life. They also agreed that toddlers should be encouraged to eat a variety of foods from the major food groups and that small, frequent meals consisting of energy- and nutrient-dense foods should be offered each day. The AAP discouraged introduction of foods such as hot dogs, nuts, grapes, raw carrots, and round candies, which may present a choking hazard (American Academy of Pediatrics. Committee on Nutrition, 1993c). It also urged that toddlers not be given diets restricted in fat, since high-fat, energy-dense foods help them, despite small stomach capacities, to meet energy needs during a period of rapid growth and development (American Academy of Pediatrics. Committee on Nutrition, 1998a).
The CDC (1998) recommended that 1-2 year-old children consume no more than 24 oz/day of milk, which is low in iron, to reduce the risk of iron deficiency. In addition, several studies suggest that toddlers may be at nutritional risk if they overconsume fruit juice. Smith & Lifschitz (1994) reported that consumption of 12 to 30 fl oz/day of fruit juice was a contributing factor among eight very young children aged 14 to 27 months. These children gained weight when they began eating a more balanced, varied diet and drinking less juice. Dennison et al. (1997) found that daily consumption of 12 fl oz or more of fruit juice by 2-year-old children was associated with short stature and obesity.

**Food consumption patterns.** Food-consumption data from the 1994-96 Continuing Survey of Food Intakes of Individuals (CSFII) show that toddlers eat a wide variety of foods (see Table III-1). French fried potatoes were the most frequently consumed vegetable, and juices, bananas, and apples were among the most popular fruits. Virtually all children consumed grain products daily, especially breads and ready-to-eat cereals. Cakes, cookies, and other baked goods were also commonly eaten. Almost all children also consumed milk and milk products every day, although about half drank whole milk and one-third drank low-fat or fat-free milk. Skinner et al. (1997b) collected similar food-consumption data in a longitudinal study of 1-2-year-old children. Bananas, toasted oat cereal, crackers, cheese, yogurt, chicken, and potatoes (including french fried potatoes) were among the most popular foods reported.

The CSFII 1994-96 data show that almost all toddlers eat breakfast (97%) and snacks (90%) every day and that these eating occasions contribute substantially to their energy and nutrient intakes (see Tables III-2 and III-3). More young children today are eating foods away from home than in previous years, a phenomenon largely related to the increase in working parents (mainly mothers) and placement of children in child-care settings (Borrud et al., 1996). Between 1977-78 and 1994-95, the greatest increases in away-from-home eating among children ≤ 5 years of age were from day-care, fast-food restaurants, and stores (see Table III-4). Away-from-home foods contribute 11-15% of total daily energy and nutrient intakes of toddlers (see Table III-5).

**Children 2-5 Years**
Children 2-5 years of age experience slow gradual growth ((Pipes & Trahms, 1993b; Sigman-Grant, 1992). Their fine motor skills are being refined and they are now able to feed themselves and help with food preparation.

**Food consumption patterns.** CSFII 1994-96 data show that most children aged 3-5 years eat breakfast (97%) and snacks (87%) every day and that these eating occasions contribute substantially to their energy and nutrient intakes (see Tables III-2 and III-3). In addition, young children today are eating more foods away from home than in previous decades (see Table III-4). This increase in away-from-home eating results from the increase in the number of women who work outside the home and leave their young children in day-care settings (Borrud et al., 1996). Eating at fast-food restaurants is also more common today (see Table III-4). Overall, away-from-home foods contribute about one-fifth of the total energy and nutrient intakes of 3-5-year-old children (see Table III-5).

Two-day data from CSFII 1996 show that average intakes of fruits, vegetables, milk and milk products, and grains meet or approach the Food Guide Pyramid recommendations (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997b). Nevertheless, a substantial proportion of children still fail to consume even one daily serving of fruits, vegetables, and dairy products. Selected findings are summarized below by food groups.

**Fruits and vegetables.** Boys and girls ate an average of 2.2 and 2.3 servings of fruits each day, respectively, about one-third of them from citrus fruits and juices, melons, and berries (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997b). Almost one-half consumed at least the minimum two servings/day, but about 30% failed to eat even one serving. Children consumed an average of 2.2 servings/day, with almost one-half coming from potatoes, primarily as french fries. Only 23% of boys and 28% of girls consumed at least the minimum three servings, while 26% of boys and 16% of girls consumed less than one serving.

**Dairy products.** In CSFII 1996, 39% of boys and 43% of girls consumed the minimum recommended two servings/day, and about 20% consumed less than one serving (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997b). Boys and girls consumed similar amounts of dairy foods, with 1.4 and 1.5 of these servings, respectively, from milk and 0.4 and 0.3 servings from cheese.
<table>
<thead>
<tr>
<th>Commodity Group</th>
<th>Survey Data</th>
</tr>
</thead>
</table>
| Fruits and Vegetables | 78% reported consumption of fruits and fruit juices:  
- 22% drank citrus fruit juices;  
- 40% drank non-citrus juices and nectars;  
- 23% consumed apples;  
- 22% consumed bananas.  
Higher percentages of toddlers consumed dried fruit (5%) than any other age group, with the exception of adults ≥70 years of age.  
75% reported consumption of vegetables:  
- 28% consumed french fried potatoes;  
- 24% consumed tomatoes and tomato products;  
- 16% consumed corn, green peas, and lima beans;  
- 13% consumed green beans;  
- 12% consumed deep-yellow vegetables;  
- 7% consumed dark-green vegetables. |
| Milk and milk products| 94% reported consumption of milk and milk products:  
- 53% drank whole milk;  
- 32% drank low-fat milk;  
- 4% drank skim milk;  
- 30% consumed cheese;  
- 16% consumed milk desserts;  
- 8% consumed yogurt. |
| Grain Products        | Virtually all children consumed grain products:  
- 53% consumed yeast breads or rolls;  
- 50% consumed ready-to-eat cereals;  
- 47% consumed mixtures consisting mainly of grains, a category including such items as pizza, enchiladas and egg rolls;  
- 45% consumed cakes, cookies, pastries, and pies;  
- 36% consumed crackers, popcorn, pretzels, and corn chips;  
- 26% consumed quick breads, pancakes, and french toast. |
| Meats and Meat Alternatives | 80% consumed meat, poultry, and fish:  
- 29% consumed frankfurters, sausages, and luncheon meats;  
- 24% consumed chicken;  
- 14% consumed beef;  
- 6% consumed fish and shellfish.  
Among meat alternatives:  
- 26% consumed eggs;  
- 15% consumed nuts and seeds (including peanut butter);  
- 12% consumed legumes. |
| Fats and Sugars       | 27% consumed table fats (e.g., butter and margarine);  
- 12% consumed salad dressings;  
- 12% consumed candy and chocolate;  
- 8% consumed table sugars (white, brown, maple, and raw sugar, fructose; and sugar substitutes). |

<table>
<thead>
<tr>
<th>Nutrient (% total intake)</th>
<th>Males and Females 1-2 years</th>
<th>Males 6-11 years</th>
<th>Males 12-19 years</th>
<th>Females 6-11 years</th>
<th>Females 12-19 years</th>
</tr>
</thead>
<tbody>
<tr>
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<td>19.9</td>
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<td>23.9</td>
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</table>

Data are the combined results from the 1994, 1995, and 1996 surveys based on respondents’ intakes on the first surveyed day (U.S. Department of Agriculture (USDA), Food Surveys Research Group, Agricultural Research Service, 1997a).
Table III-3. Mean percentages of energy and nutrients contributed by snacks (including beverage breaks), by sex and age, CSFII 1994-96, 1 day\(^1\)

<table>
<thead>
<tr>
<th>Nutrient (%) total intake</th>
<th>Males and Females</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-2 years</td>
<td>3-5 years</td>
<td>6-11 years</td>
</tr>
<tr>
<td>Energy</td>
<td>24.1</td>
<td>21.3</td>
<td>20.5</td>
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<tr>
<td>Total fat</td>
<td>22.5</td>
<td>20.1</td>
<td>19.3</td>
</tr>
<tr>
<td>Saturated fat</td>
<td>23.7</td>
<td>20.6</td>
<td>19.2</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>16.0</td>
<td>13.2</td>
<td>12.3</td>
</tr>
<tr>
<td>Protein</td>
<td>18.0</td>
<td>13.9</td>
<td>13.0</td>
</tr>
<tr>
<td>Total carbohydrate</td>
<td>26.7</td>
<td>24.1</td>
<td>23.2</td>
</tr>
<tr>
<td>Dietary fiber</td>
<td>20.3</td>
<td>20.7</td>
<td>19.3</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>17.4</td>
<td>14.4</td>
<td>14.5</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>22.3</td>
<td>20.5</td>
<td>19.0</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>26.0</td>
<td>20.8</td>
<td>17.9</td>
</tr>
<tr>
<td>Thiamin</td>
<td>19.2</td>
<td>14.9</td>
<td>14.2</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>22.0</td>
<td>17.2</td>
<td>15.9</td>
</tr>
<tr>
<td>Niacin</td>
<td>14.8</td>
<td>12.3</td>
<td>12.8</td>
</tr>
<tr>
<td>Vitamin B-6</td>
<td>19.4</td>
<td>15.3</td>
<td>14.0</td>
</tr>
<tr>
<td>Folate</td>
<td>18.1</td>
<td>15.3</td>
<td>14.8</td>
</tr>
<tr>
<td>Vitamin B-12</td>
<td>19.8</td>
<td>14.2</td>
<td>11.8</td>
</tr>
<tr>
<td>Calcium</td>
<td>24.9</td>
<td>18.7</td>
<td>16.8</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>21.7</td>
<td>17.0</td>
<td>15.7</td>
</tr>
<tr>
<td>Magnesium</td>
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<td>19.5</td>
<td>18.6</td>
</tr>
<tr>
<td>Iron</td>
<td>16.8</td>
<td>14.2</td>
<td>14.5</td>
</tr>
<tr>
<td>Zinc</td>
<td>18.0</td>
<td>14.2</td>
<td>14.1</td>
</tr>
<tr>
<td>Copper</td>
<td>21.7</td>
<td>20.7</td>
<td>19.5</td>
</tr>
<tr>
<td>Sodium</td>
<td>16.3</td>
<td>14.1</td>
<td>14.0</td>
</tr>
<tr>
<td>Potassium</td>
<td>23.6</td>
<td>19.2</td>
<td>16.8</td>
</tr>
</tbody>
</table>

\(^1\)Data are the combined results from the 1994, 1995, and 1996 surveys based on respondents' intakes on the first surveyed day (U.S. Department of Agriculture (USDA). Food Surveys Research Group. Agricultural Research Service, 1997a).
Table III-4. Percentage of children ≤5 years of age reporting sources of food obtained and eaten away from home, NFCS 1977-78 and CSFII 1994-95, 1 day¹

<table>
<thead>
<tr>
<th>Away-from-home source</th>
<th>1994-95</th>
<th>1977-78</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fast-food restaurant</td>
<td>26</td>
<td>17</td>
</tr>
<tr>
<td>Day-care</td>
<td>20</td>
<td>5</td>
</tr>
<tr>
<td>Store</td>
<td>19</td>
<td>2</td>
</tr>
</tbody>
</table>

¹ Data from NFCS (Nationwide Food Consumption Survey) 1977-78 represent one-day data for children ≤5 years (Wilson et al., 1997). Data from CSFII 1994-95 are the combined results from the 1994 and 1995 surveys based on respondents' responses on the first surveyed day (Wilson et al., 1997).

Table III-5. Mean percentages of energy and nutrients contributed by foods away from home, by sex and age, CSFII 1994-96, 1 day¹

<table>
<thead>
<tr>
<th>Nutrient (% total intake)</th>
<th>Males and Females</th>
<th>Males</th>
<th>Females</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1-2 years</td>
<td>3-5 years</td>
<td>6-11 years</td>
</tr>
<tr>
<td>Energy</td>
<td>13.7</td>
<td>21.8</td>
<td>27.0</td>
</tr>
<tr>
<td>Total fat</td>
<td>14.6</td>
<td>23.4</td>
<td>28.5</td>
</tr>
<tr>
<td>Saturated fat</td>
<td>13.8</td>
<td>23.4</td>
<td>29.2</td>
</tr>
<tr>
<td>Cholesterol</td>
<td>13.7</td>
<td>23.1</td>
<td>27.8</td>
</tr>
<tr>
<td>Protein</td>
<td>13.8</td>
<td>21.9</td>
<td>27.1</td>
</tr>
<tr>
<td>Total carbohydrate</td>
<td>13.3</td>
<td>20.9</td>
<td>26.3</td>
</tr>
<tr>
<td>Dietary fiber</td>
<td>14.6</td>
<td>20.9</td>
<td>27.1</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>11.0</td>
<td>17.5</td>
<td>22.3</td>
</tr>
<tr>
<td>Vitamin E</td>
<td>14.6</td>
<td>21.4</td>
<td>26.2</td>
</tr>
<tr>
<td>Vitamin C</td>
<td>11.5</td>
<td>17.5</td>
<td>22.6</td>
</tr>
<tr>
<td>Thiamin</td>
<td>12.5</td>
<td>18.9</td>
<td>22.7</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>11.3</td>
<td>18.8</td>
<td>24.0</td>
</tr>
<tr>
<td>Niacin</td>
<td>14.0</td>
<td>19.9</td>
<td>23.5</td>
</tr>
<tr>
<td>Vitamin B-6</td>
<td>12.2</td>
<td>18.2</td>
<td>22.2</td>
</tr>
<tr>
<td>Folate</td>
<td>11.9</td>
<td>17.5</td>
<td>20.9</td>
</tr>
<tr>
<td>Vitamin B-12</td>
<td>12.2</td>
<td>20.5</td>
<td>26.4</td>
</tr>
<tr>
<td>Calcium</td>
<td>11.6</td>
<td>20.1</td>
<td>27.2</td>
</tr>
<tr>
<td>Phosphorus</td>
<td>12.8</td>
<td>21.0</td>
<td>26.4</td>
</tr>
<tr>
<td>Magnesium</td>
<td>12.6</td>
<td>20.1</td>
<td>25.6</td>
</tr>
<tr>
<td>Iron</td>
<td>12.7</td>
<td>18.9</td>
<td>23.0</td>
</tr>
<tr>
<td>Zinc</td>
<td>12.8</td>
<td>20.3</td>
<td>25.4</td>
</tr>
<tr>
<td>Copper</td>
<td>14.0</td>
<td>21.1</td>
<td>26.6</td>
</tr>
<tr>
<td>Nutrient (% total intake)</td>
<td>Males and Females</td>
<td>Males</td>
<td>Females</td>
</tr>
<tr>
<td>--------------------------</td>
<td>-------------------</td>
<td>-------</td>
<td>---------</td>
</tr>
<tr>
<td></td>
<td>1-2 years</td>
<td>3-5 years</td>
<td>6-11 years</td>
</tr>
<tr>
<td>Sodium</td>
<td>14.6</td>
<td>22.2</td>
<td>27.1</td>
</tr>
<tr>
<td>Potassium</td>
<td>13.2</td>
<td>21.1</td>
<td>27.3</td>
</tr>
</tbody>
</table>

Data are the combined results from the 1994, 1995, and 1996 surveys based on respondents' intakes on the first surveyed day (U.S. Department of Agriculture (USDA), Food Surveys Research Group, Agricultural Research Service, 1997b).

**Grain products.** CSFII 1996 data showed that 59% of boys and 52% of girls consumed at least the minimum recommended six servings/day (U.S. Department of Agriculture [USDA], Food Surveys Research Group, Agricultural Research Service, 1997b). Boys ate an average of 6.7 servings and girls ate 6.3 servings, but only about one of them came from whole grain products.

**Meat and meat alternatives.** Boys and girls consumed an average of 2.6 and 2.5 ounces, respectively, with 0.8 ounces from meat; 0.6 ounces from poultry, frankfurters, and luncheon meats; 0.2 ounces from fish and eggs; and 0.1 ounces from nuts, peanut butter, and seeds (U.S. Department of Agriculture [USDA], Food Surveys Research Group, Agricultural Research Service, 1997b). Fewer than 9% met the minimum daily recommendation of five ounces of cooked lean meat or its equivalent.

**Children 5-12 Years**
The school-age period is characterized by a slow but consistent rate of growth with increases in appetite and food intake (Lucas, 1993). Few feeding problems arise, although some may still persist in the early years.

**Current recommendations.** According to USDA's Food Guide Pyramid (U.S. Department of Agriculture [USDA], Food Surveys Research Group, Agricultural Research Service, 1997b), schoolchildren should consume each day 3 servings of fruits, 4 servings of vegetables, 2.5 servings of dairy, 9 servings of grain products, and at least six ounces of cooked lean meat, poultry, or fish or an equivalent amount of meat alternative. Health Canada developed similar food-group recommendations for schoolchildren (Health Canada, 1998b). The CDC recommended that school-age children who have low dietary iron intakes or a history of iron deficiency anemia be screened for anemia, with the treatment for anemia including counseling on iron-containing foods (CDC, 1998).

The AAP (American Academy of Pediatrics. Committee on Nutrition, 1993c) encouraged parents and caregivers to ensure that their children eat breakfast despite hectic morning activities (Vaisman et al., 1996). It also advised that snacks be eaten to replenish energy when children get home from school and to satisfy hunger until the evening meal is served. However, AAP urged parents to control the type and amount of snacks eaten and discourage snacking while watching television.

**Food consumption patterns.** Breakfast contributes substantially to the total energy and nutrient intakes of schoolchildren (see Table III-2). Data from CSFII 1994-96 show a tendency to skip this meal over time; approximately 8% of children aged 6-11 years skipped breakfast compared to 3% of 1-5-year-olds (U.S. Department of Agriculture [USDA], Food Surveys Research Group, Agricultural Research Service, 1997a). About 82% eat snacks, which also contribute substantially to energy and nutrient intakes (see Table III-3). Schoolchildren eat food away from home, often from school cafeterias and fast-food restaurants (see Table III-6). These foods contribute about one-third of total daily intakes for energy and most nutrients (see Table III-5). Schoolchildren are less likely to eat the recommended number of servings of fruits and vegetables from the Food Guide Pyramid than they are from the dairy, grain, or meat groups. The following section provides selected findings from CSFII 1996 on children 6-11 years of age.

**Fruits and vegetables.** Only about one-fifth of children aged 6-11 years consumed the minimum recommended two servings of fruits; 35% of boys and 45% of girls failed to consume even one serving (U.S. Department of Agriculture [USDA], Food Surveys Research Group, Agricultural Research Service, 1997b). Boys averaged 1.8 servings/day, and girls averaged 1.6, with about half coming from citrus fruits, melons, and berries. Only 29% consumed the minimum recommended three servings of vegetables; 17% of boys and 25% of girls ate less than one serving (U.S. Department of Agriculture [USDA], Food Surveys Research Group, Agricultural Research Service, 1997b). Vegetable consumption averaged 2.2 servings for boys and girls, of which 0.9 servings came from potatoes, most as french fries.
Table III-6. Percentage of children 6-11 years of age and adolescents 12-19 years of age reporting various sources of food obtained and eaten away from home, by sex, CSFII 1994-95, 1 day

| Away-from-home source | Males (%) | | | | | Females (%) | | | | | | 6-11 years | 12-19 years | | 6-11 years | 12-19 years |
|-----------------------|-----------|-------------|-----------|-----------|-------------|-----------|-------------|-----------|-------------|-----------|-------------|-----------|-----------|-----------|-----------|-----------|-----------|
| School cafeteria      | 48.4      | 30.7        |           |           | 48.9        | 33.2      |           |           |           |           |           |           |           |           |           |           |           |
| Fast-food restaurant  | 23.1      | 40.4        |           |           | 24.0        | 33.3      |           |           |           |           |           |           |           |           |           |           |
| Restaurant            | 14.2      | 14.1        |           |           | 10.4        | 18.2      |           |           |           |           |           |           |           |           |           |           |
| Store                 | 14.5      | 28.2        |           |           | 17.9        | 26.5      |           |           |           |           |           |           |           |           |           |           |
| Day-care              | 4.1       | 0.5*        |           |           | 5.6         | 0.6*      |           |           |           |           |           |           |           |           |           |           |
| Someone else/gift     | 27.0      | 20.4        |           |           | 32.4        | 33.2      |           |           |           |           |           |           |           |           |           |           |

1 Data from CSFII 1994-95 are the combined results from the 1994 and 1995 surveys based on respondents’ responses on the first surveyed day (Wilson et al., 1997).
* Potentially unreliable statistic.

**Dairy products.** Boys (55%) were more likely than girls (42%) to consume at least two servings/day; 15% of boys and 21% of girls consumed less than one serving (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997b). Boys averaged 2.1 servings and girls 1.8 servings a day, mostly in the form of fluid milk.

**Grain products.** Only 58% of boys and 45% of girls consumed at least the daily minimum recommended six servings (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997b). Boys ate an average of 6.9 servings/day, and females ate 6.1 servings, but only one came from whole grain products.

**Meat and meat alternatives.** Boys consumed 3.4 ounces/day on average and girls 2.9 ounces, primarily as meat, poultry, frankfurters, and luncheon meats (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997b). Only 19% of boys and 9% of girls met the minimum daily recommendation of six ounces of cooked lean meat or its equivalent.

**Adolescents 12-20 Years**
Adolescents' growing independence, increased participation in social life, and generally busy schedules have a strong impact on their eating behaviors (Mahan & Escott-Stump, 1996; Rees, 1993). Meal skipping, snacking, and away-from-home eating are common. Concerns over body weight increase among girls, often resulting in unnecessary restrictions in food intake. Bedinghaus & Doughten (1994) suggested that many teenagers fail to eat well because they lack a sense of urgency about the need to do so and have little orientation to the future.

**Current recommendations.** According to USDA’s Food Guide Pyramid (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997b), adolescents should consume 3 servings of dairy foods for boys and 2.5 for girls, about 11 servings of grain products for boys and 9 for girls, and 7 ounces of cooked lean meat, poultry, fish, or an equivalent amount of meat alternative for boys and 6 ounces for girls. Health Canada developed similar food-group recommendations for adolescents (Health Canada, 1998b).

Concerns about the role of diet in the development of chronic disease in adulthood become more relevant as children pass through the physiological changes associated with adolescence. For example, the 1995 DGFA (U.S. Department of Agriculture [USDA] and U.S. Department of Health and Human Services [HHS], 1995), The Surgeon General's Report on Nutrition and Health (U.S. Department of Health and Human Services [HHS], 1988), and the Diet and Health report of the National Academy of Sciences (National Research Council, 1989b) included specific recommendations for adolescent girls to eat more milk and milk products to get the calcium they need for healthy bones throughout life (see Appendix C).

These reports also recommended that adolescent girls include iron-rich foods in their diets to maintain adequate iron stores and to reduce risk for iron deficiency (see Appendix C), a recommendation that is similar to one more recently issued by CDC.
(CDC, 1998). The risk for iron deficiency increases among teenage girls because of their low dietary iron intakes and high needs. CDC (1998) noted that most adolescent girls do not require iron supplements, but they should be encouraged to increase their intakes of iron-rich foods and foods that enhance iron absorption. It also advised that adolescent boys who have low iron intakes, a history of iron-deficiency anemia, or special health-care needs be screened for anemia.

Federally sponsored reports on diet and health commonly recommend that adolescents not drink alcoholic beverages (see Appendix C). The AAP (American Academy of Pediatrics. Committee on Substance Abuse, 1995) takes a strong position against the use of alcohol by adolescents, emphasizing the role of the parents in fostering healthy attitudes toward alcohol as well as assessing their children's use of alcohol and recognizing signs of possible abuse.

Food consumption patterns. Data from CSFII 1994-96 showed that adolescents are more likely than their younger counterparts to skip breakfast; 22% of boys and 25% of girls 12-19 years of age skipped breakfast compared with 8% of 6-11-year-olds and 3% of 1-5-year-olds (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997a). Breakfast contributes less than one-fifth of their total daily intakes for energy, total fat, and saturated fat and about 20-25% of their intakes for most vitamins and minerals (see Table III-2). Although adolescents are less likely to snack than younger children, 78% reported doing so. Overall, snacks contributed more to their energy, fat, and saturated fat intakes than to their nutrient intakes (see Table III-3).

The CSFII 1994-96 survey found that 72% of adolescent boys obtained and ate at least one food away from home, as did 64% of girls (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997a). Popular sources of away-from-home foods were fast-food restaurants, school cafeterias, and stores (see Table III-6). About one-third of their daily dietary intake of energy and most nutrients was provided by such foods (see Table III-5).

Differences in food consumption patterns between the sexes are apparent during adolescence. Intakes of fruits, vegetables, and milk and milk products are often less than recommended, particularly among girls. Soft drink use is high among both sexes, and a large proportion drink alcoholic beverages. The following section provides selected data on adolescent food consumption habits from the CSFII 1996 survey (12-19 years of age) and from other national surveys.

Fruits and vegetables. Only 22% of boys and girls consumed the minimum recommended two servings of fruits; more than half failed to consume even one serving (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997b). Boys averaged 1.3 servings/day and girls average 1.2. Only 56% of boys and 40% of girls consumed the minimum recommended three servings of vegetables; 10% ate less than one serving. Daily vegetable consumption averaged 3.6 servings for boys and 2.8 servings for girls.

The 1993 Youth Risk Behavior Surveillance System (YRBSS) reported that only 15% of the high school students surveyed ate ≥ 5 servings of fruits and vegetables on the day before the survey (Kann et al., 1995). Boys (18%) were more likely than girls (13%) to meet this goal. Produce consumption was highest among students in grade 9 and tended to decrease at each subsequent grade level.

Dairy products. Boys (29%) were more likely than girls (10%) to consume at least three servings/day; 17% of boys and 40% of girls consumed less than one serving (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997b). Boys averaged 2.4 servings/day and girls 1.5, with two-thirds of these servings from milk and the remainder from cheese. They drank about twice as much carbonated soft drinks as milk. These findings are consistent with earlier ones. The CSFII 1989-91 survey found that as children began secondary school, drinking milk decreased from >11 cups over three days by children aged 6-11 years to <9 cups by adolescent boys and to slightly more than six cups by adolescent girls (Lin & Guthrie, 1996). The decrease in milk consumption was usually related to an increase in soft drink consumption.

Grain products. Boys (83%) were more likely than girls (45%) to consume at least the daily minimum recommended six servings (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997b). Boys ate an average of 9.6 servings/day, and females ate 6.3 servings, but only one came from whole grain products.

Meat and meat alternatives. Only 55% of boys and 19% of girls consumed at least the minimum recommended 5 oz/day (U.S. Department of Agriculture [USDA]. Food Surveys Research Group. Agricultural Research Service, 1997b). Boys ate an average of 5.9 oz and females ate 3.5 ounces, primarily as meat, poultry, frankfurters, and luncheon meats.
Alcoholic beverages. The use and abuse of alcohol by adolescents and its effect on nutritional status is a major concern (Rees, 1993a). Alcohol often decreases appetite and can deplete the body of B-vitamins (Bedinghaus & Doughten, 1994). Furthermore, the long-term effects of alcohol abuse coupled with a poor diet may lead to the development of nutrition-related disorders later in adulthood (Rees, 1993a).

The YRBSS 1993 survey provided data on the drinking behaviors of high school students (Kann et al., 1995). About one-half of the boys (50%) and girls (46%) surveyed reported that they drank alcohol on one or more of the 30 days before the study. Heavy drinking (defined as ≥5 drinks on at least one occasion in the past 30 days) was reported by 34% of boys and 26% of girls. Drinking and heavy drinking increased among both sexes with each subsequent grade level. About 40% of 9th graders reported drinking and 61% of boys and 52% of girls in the 12th grade. Heavy drinking episodes were reported by 24% of boys and 20% of girls in the 9th grade compared with 45% of boys and 33% of girls in the 12th grade.

The YRBSS 1992 survey found that 63% of adolescents who were not in school drank alcohol compared with 55% of those in school (Anonymous, 1994). A higher percentage of adolescents out-of-school (22%) than in-school (17%) reported that they had ≥5 alcoholic drinks of alcohol on at least one occasion in the month before the survey.

The National Longitudinal Study on Adolescent Health found that 18% of students in grades 7 through 12 reported drinking alcohol more than once a month, and 10% reported that they drank at least once a week (Resnick et al., 1997). More frequent alcohol use was associated with easy household access to alcohol, the perception that one appears older than one's peers, a low grade point average at school, and low self-esteem. Variables associated with less frequent use of alcohol included high levels of connectedness to parents, family members, and school; high levels of importance placed on religion and prayer; and more frequent parental presence in the home.

DETERMINANTS OF FOOD CONSUMPTION PATTERNS

Many factors influence the eating patterns and food preferences of children. During early childhood, these patterns and preferences are largely shaped by parents and other caregivers and by experiences with new foods (Birch & Fisher, 1998; Nestle et al., 1998). As children begin formal schooling, food habits learned at home compete with outside pressures from peers and the media and with food available at school and from other sources (Lucas, 1996). This section describes some of the various influential factors that help determine the food choices and preferences of children at various stages of development.

Infants 0-12 Months
This section presents maternal characteristics associated with feeding an infant by breast or bottle and identifies obstacles to the initiation and continuation of breastfeeding. It also addresses the infant's developmental readiness for the introduction of solid foods and maternal traits and beliefs associated with earlier or later introduction of solids.

Breastfeeding. Factors associated with the initiation and continuation of breastfeeding. The Ross Laboratories Mothers' Survey showed that current rates of breastfeeding were increasing as of 1995 (Ryan, 1997), but still fell short of the Healthy People 2000 goal (≥75% of mothers breastfeeding in the early postpartum period and ≥50% continuing until their babies reach 5-6 months) (U.S. Department of Health and Human Services [HHS]. Public Health Service, 1990). Ryan (1997) found increases in breastfeeding across all sociodemographic groups, the largest being among groups that historically tend not to breastfeed: women who were black, <25 years of age, of a lower income level, less than high-school educated, primiparous, living in the South Atlantic area of the United States, employed full-time outside the home, participating in the Women, Infants, and Children (WIC) supplemental foods program, and who had low-birth-weight infants. Nonetheless, higher rates of breastfeeding were observed among women who were white or Hispanic, ≥25 years of age, college educated, multiparous, living in the western states, not employed outside the home, not participating in the WIC program, and who had higher disposable incomes and infants of normal birth weight. Ryan (1997) concluded that continued efforts are needed to instill positive attitudes about breastfeeding in women who are younger, less educated, and from lower-income households.

Obstacles to the initiation and continuation of breastfeeding are common. These include shorter hospital stays that limit professional support and education about breastfeeding for new mothers, the lack of a supportive cultural norm among some demographic groups, more reliance on outside-the-home child-care, short maternity leaves that separate the infant from the new mother and militate against her maintaining a good milk supply, lack of supportive workplace environments for nursing
mothers, media portrayal of bottle-feeding as normative, and aggressive marketing of commercial formulas (American Academy of Pediatrics. Work Group on Breastfeeding, 1997; American Dietetic Association, 1997a; Newberg & Street, 1997). Inadequate training of health-care professionals may also contribute to low breastfeeding rates by making it difficult for them to recognize problems and offer strategies that encourage continued breastfeeding; as a result, a commercial formula is often recommended when breastfeeding problems arise (American Dietetic Association, 1997a). Furthermore, the decline in breastfeeding in the 1960s and 1970s has led to a loss of traditional knowledge and support of breastfeeding, so that today’s grandmothers and mothers often have no experience with the practice and cannot effectively advise new mothers in the family. The AAP Work Group on Breastfeeding (American Academy of Pediatrics. Work Group on Breastfeeding, 1997) and the ADA(1997) recently called for action to overcome these barriers and to establish breastfeeding as a new cultural norm supported by medical, social, and economic practice.

Impact of maternal nutrition on lactation and infant nutrition. The nutrient composition of human milk can be influenced by the diet of the lactating mother. Fomon (Fomon, 1993f) noted that the mother’s diet should provide adequate calories, protein, vitamins, minerals and fluids to ensure adequate milk production of high nutritional quality. Poorly nourished mothers produce less milk than well-nourished ones.

The effect of maternal diet on milk composition varies by nutrient. Although fat concentrations in milk are not affected to a great extent by maternal diet or nutritional status, the fatty acid composition appears to be influenced by the fatty acids in the mother’s diet (Finley et al., 1985; Jensen, 1996; Sanders & Reddy, 1992). Milk concentrations of riboflavin, vitamins B6 and B12, iodine, and selenium reflect recent dietary intakes of the mother (Fomon & Rechouche, 1993). The vitamin D content is influenced by maternal diet and supplementation (Groer et al., 1984a) and extent of maternal exposure to sunlight (Groer et al., 1984b; Specker et al., 1985; Specker & Tsang, 1987). On the other hand, the mother’s diet ordinarily does not affect the amounts in her milk of thiamin, folate, vitamins A and C (Fomon & Rechouche, 1993), zinc (Moser & Reynolds, 1983; Moser-Veillon, 1990), copper (Casey et al., 1995; Haschke et al., 1993) iron, calcium, magnesium, and manganese (Lönnnerdal, 1997). The effect of maternal diet on the vitamin E, nicotinic acid, pantothenate, and biotin concentrations in human milk is not known (Fomon & Rechouche, 1993).

Solid foods. Developmental readiness. At about 6 months of age, changes in infants’ nutritional requirements, particularly for iron, dictate the need for supplemental foods (see Chapter II). Changes in physiological development are also relevant to the introduction of solid foods (Hendricks & Badruddin, 1992). By 6 months of age, the digestive and absorptive capability of the infant’s gastrointestinal tract is near that of the adult, and the infant’s ability to metabolize and utilize the absorbed products of digestion is also near adult capacity (Heird, 1996; Hendricks & Badruddin, 1992). At about 4 months of age, the functional capacity of the kidneys increases rapidly, enabling them to accommodate an increased renal solute load (Hendricks & Badruddin, 1992).

Advances in psychomotor development, including the ability to sit with support and to have good neuromuscular control of the head and neck and adequate trunk motor control, have implications for weaning (Behar, 1987; Johnson, 1997; Kleinman, 1994; Pridham, 1990). At about six months of age, most infants have achieved these developmental milestones. The acquisition of chewing and swallowing skills also influences the schedule for weaning (Schmitz & McNeish, 1987). Young infants exhibit an extrusion reflex, causing them to push out against a spoon placed on the tongue (Schmitz & McNeish, 1987). With the disappearance of this reflex at 4-6 months of age, the ability to chew follows; infants are able to depress the tongue when the spoon touches the lips and then move pureed food to the back of the mouth to swallow (Kleinman, 1994; Schmitz & McNeish, 1987). At about 8 months, tongue flexibility increases and they are able to remove food from a spoon (Pridham, 1990). Greater manipulation of food in the mouth before swallowing is possible, allowing thicker purées to be handled (Hendricks & Badruddin, 1992). Infants can now sit without support and reach for foods. During the latter months of the first year, soft lumpy foods with more complex flavors can be offered (Kleinman, 1994; Pridham, 1990). Infants can make definite chewing movements, take small bites of soft foods, and may begin to bring small pieces of food to their mouth with their thumb and forefinger (i.e., pincer grasp); they show an interest in feeding themselves and can drink unassisted from a bottle or cup (Connolly & Dalgleish, 1989; Hendricks & Badruddin, 1992).

Adverse consequences may occur if solid foods are introduced in the first months of life. These include interference with the sucking reflex; lessening of the frequency and intensity of sucking, resulting in a decrease in breast milk production; and aspiration of ingested solids due to poor swallowing skills (Johnson, 1997). Early introduction of weaning foods may also displace infants’ total energy intakes from milk (Cohen et al., 1994; Heinig et al., 1993b) and may predispose them to
respiratory illness (Forsyth et al., 1993; Wilson et al., 1998), allergic conditions (Fergusson et al., 1990; Forsyth et al., 1993; Marini et al., 1996) and later overweight in childhood (Agras et al., 1990; Wilson et al., 1998).

Excess delay in introducing solid foods to infants can also lead to adverse consequences. Cohen et al. (1994) warned of the potential for faltering growth. Breastfeeding may no longer be able to meet the infant’s needs for energy and nutrients such as iron (Dallman, 1993) and vitamin D (Life Sciences Research Office, 1998). These nutritional issues would not concern infants receiving sufficient amounts of iron-fortified formulas. Ilingworth & Lister (1964) suggested that there may be a “critical period” when normal infants can and must learn to chew. If solid foods were introduced after this period, learning to chew might be much more difficult.

Factors associated with the decision to introduce solid foods. The decision when solid foods should be introduced is more often influenced by social, economic, and cultural factors than by nutritional ones (Parraga et al., 1988). A recent study by Skinner et al. (1997a) with college-educated, older mothers (mean age 31 years) found that they often introduced complementary foods based on their infants’ apparent hunger and sleeping patterns. These results were consistent with those from the Davis Area Research on Lactation, Infant Nutrition and Growth (DARLING) study where subjects were mothers from different sociodemographic groups (Heinig et al., 1993b). In this study, solid foods were introduced most often due to infant hunger and to help the infant sleep through the night. Other reasons included infant interest, appropriate age, and physician advice. Parraga et al. (1988) proposed that in societies where chubby babies are viewed as healthy babies, mothers may be driven to feed their infants solids at an early age to achieve this desired image.

Skinner et al. (1997a) found that mothers who introduced cereals before 4 months of age were more likely to be formula-feeding than breastfeeding their infants when the cereal was added. Introduction of the first complementary food was closely related to the discontinuation of breastfeeding. Earlier studies have confirmed that breastfeeding mothers were more likely to introduce their infants to solid foods later than mothers who bottlefed (Brogan & Fox, 1984; Ford et al., 1995; Heinig et al., 1993b; Parraga et al., 1988). Skinner et al. (1997a) also found that introduction of cereals before 4 months of age was associated with mothers who were primiparous, employed outside the home, and who rejected the advice of a physician in determining their infant feeding practices. Other studies have shown associations between the early introduction of solids and mothers who smoked and were younger, less educated, and from low-income households (Brogan & Fox, 1984; Ford et al., 1995; Persson & Samuelson, 1984; Zive et al., 1992). Cultural factors may account for differences in weaning practices as well (Morrison et al., 1980; Parraga et al., 1988). For example, Zive et al. (1992) reported that Mexican-American mothers tended to introduce solids earlier than white mothers. Other studies found no differences in the timing of solid foods across ethnic groups (Ferris et al., 1978; Hill et al., 1995).

Although it is unclear why parents feed their infants cow milk in the first year of life, the relative costs of cow milk compared with infant formula may be a factor (Heird, 1994). Infant formula is about three times more expensive than cow milk, a difference that may be important to families with limited incomes.

Development of food acceptance patterns. Food likes and dislikes originate in the reflexive facial expressions elicited by the basic tastes of sweet, sour, salty, and bitter (Birch, 1996). Infants appear to be born with an innate preference for the sweet taste and an unlearned dislike for sour and bitter tastes (Beauchamp et al., 1991; Birch & Fisher, 1998; Drewnowski, 1997; Rozin, 1984; Rozin & Vollmecke, 1986). A preference for the salty taste begins to appear at about 4 months of age, perhaps related to the development of the salt-sensitive receptors on the tongue (Beauchamp et al., 1986).

The transition from the exclusive milk diet of early infancy to an omnivorous diet consumed by early childhood is shaped by these unlearned taste preferences (Birch & Fisher, 1998). When supplemental foods are introduced, infants readily learn through experience to accept the new tastes of a variety of foods (Birch, 1996). Building on prior knowledge of foods can help to make the adaptation to new tastes and textures proceed more smoothly (Sullivan & Birch, 1994). For example, when the time comes to introduce a new food, parents can add it to a familiar favorite food.

According to Birch & Fisher (1998), the parents’ decision to breast-feed or formula-feed shapes their infant’s experience with food. Because the flavor of some foods is transferred from the mother’s diet to the infant through her milk, breastfeeding may expose the infant to various flavors long before solid foods are introduced (Mennella, 1997; Mennella & Beauchamp, 1991a,b, 1998). Such exposure might facilitate the transition to a varied diet during the weaning period. Sullivan & Birch (1994) found
that breast-fed infants more readily accepted newly introduced vegetables than formula-fed infants after repeated exposures to these foods. Although more research in this area is needed, these initial findings suggest yet another potential benefit of breastfeeding.

**Children 1-5 Years**

In the second year of life, self-feeding skills are being mastered and the diet is becoming more varied. Continued experiences with food and eating at this age and throughout the preschool years contribute to the development of food acceptance patterns and to the establishment of food preferences (Birch, 1996).

**Developmental progression and implications for feeding.** Toddlers are becoming developmentally ready for self-feeding. Hand and finger coordination become well controlled and precise, and skills in using a spoon and drinking from a cup are refined (Connolly & Dalgleish, 1989; Kleinman, 1994). Independent feeding is fostered by the development of manual dexterity which allows the child to manipulate and handle small pieces of food. As more teeth erupt, a variety of textured foods can be eaten. By the end of the second year, the transition from dependent to independent feeding has been completed for most children (Kleinman, 1994). As toddlers grow older, self-feeding skills are being refined, enabling them increasingly to use their arm, hand, and finger muscles to eat (Hertzler, 1989). Examples of the progression of food handling skills evident during the preschool years are: dipping fruit into yogurt (age 2), pouring beverages (age 3), peeling bananas (age 4), and using a knife (age 5).

As growth rates decrease beginning in the second year, appetite (Bedinghaus & Doughten, 1994; Needlman, 1996; Sigman-Grant, 1992), often reflected by erratic and unpredictable eating behaviors and power struggles with parents (Birch, 1996; Birch & Fisher, 1995; Crockett & Sims, 1995). The young child's increased demand for independence may also contribute to these so-called "temper tantrums."

**Development of food acceptance patterns.** Infants' unlearned reactions to the basic tastes serve as the foundation upon which subsequent food acceptance patterns are formed (Birch, 1996). These include the taste, sight, smell, and texture of foods. Familiarity also influences food preferences (Beauchamp et al., 1991; Birch & Fisher, 1997). Young children tend to prefer familiar foods and dislike unfamiliar ones. According to Birch (1996), a food's familiarity results from the child's experience. Although the infant's unlearned taste preferences suggest that food acceptance patterns may be somewhat fixed and therefore difficult to change, responses to taste can change over time with repeated exposure.

**Neophobia and food acceptance.** The reluctance of many young children to consume new foods, or "neophobia," can be modified by providing them with repeated opportunities to taste new foods under favorable conditions (Birch, 1996; Birch & Fisher, 1995; Nestle et al., 1998). It has been repeatedly shown that changes in food acceptance occur slowly and may require up to ten exposures (Birch et al., 1987; Sullivan & Birch, 1990).

Birch (1996) contended that changes in children's food acceptance patterns may be achieved through "learned safety." If children learn at several occasions that consumption of a new food does not cause unpleasant postdigestive consequences, they regard it as safe to eat and accept it as part of the diet. However, if consumption of a new food leads to problems, a learned food aversion results and the food will be rejected. From this perspective, the rejection of new foods by young children should be viewed as a normal, adaptive reaction (Birch, 1989). According to Birch & Fisher (1995), the fact that early and repeated exposure to new foods can change a child's initial rejection to acceptance underscores the critical role that parents play in shaping their young children's eating behaviors.

**Associative conditioning and social context of eating.** The shaping of children's food acceptance patterns by the repeated association of foods with the social contexts and physiological consequences of eating is referred to as "associative conditioning" (Birch, 1989, 1996; Birch & Fisher, 1995). Research has shown that children learn to like foods associated with positive contexts and consequences and to dislike foods associated with negative ones. Birch et al. (1980, 1984) reported that children prefer foods that are served as rewards or in the context of a positive social interaction, and that restricting access to these foods makes them more desirable. These findings support children's liking of energy-dense foods that are often high in fat and sugar (Birch, 1992). They are frequently served in positive contexts and used as rewards, as desserts at the end of meals, and as part of holidays and special occasions (Birch & Fisher, 1995). Foods rich in calories, fat, and sugar are also preferred because they produce pleasant feelings of satiety (Birch & Fisher, 1995). The social contexts in which food are served can also be negative. Birch et al. (1980, 1984) found that when children were coerced into eating a "nutritious" food to obtain
rewards, their preference for that food was reduced. As suggested by these studies, common child feeding practices may contribute to the formation of food acceptance patterns inconsistent with dietary guidelines (Birch, 1996; Nestle et al., 1998).

Influences on food choices. Studies of the familial, social, and environmental influences on the eating behaviors of young children have largely focused on the effect of parental eating habits and child feeding practices on food preferences, the use of peer modeling to modify food acceptance, and the impact of television advertising on consumption of and requests for advertised foods. Much of this research was conducted by Birch and colleagues.

Family. Parents shape the eating habits of their young children by the foods made available to them in the home, by role-modeling, and by the way they interact with their children in the eating context (Birch & Fisher, 1995, 1998; Nestle et al., 1998; Sigman-Grant, 1992). Parents tend to have foods in the home that they like, and their young children come to include many of these same foods in their diets (Birch & Fisher, 1998). Oliveria et al. (1992) found similarities in nutrient intakes between parents and their 3-5-year-old children, with the children’s nutrient intakes more strongly correlated with the mother than the father. These differences appeared to disappear, however, when both parents frequently ate at home together (Oliveria et al., 1992).

Some evidence suggests that children’s food preferences are shaped by emulating the food selection and dietary behaviors of their parents and siblings. Harper & Sanders (1975) found that children 14 months to 3 years of age were more likely to put new foods in their mouths when they saw their mothers eat those foods than when strangers ate them. Pliner & Pelchat (1986) found that the food preferences of children 2-7 years of age were more likely to resemble the food preferences of their real families than those of similar families in the study. In addition, the children’s food preferences more closely resembled those of their siblings than those of their parents. Skinner et al. (1998) observed a strong relationship between the food preferences of 2-3-year-old children and their family members, with a significant relationship found between foods never offered to the child and the mother’s food dislikes.

Coercive child feeding practices may negatively affect the food acceptance patterns of young children. Various studies have shown that parents who restricted their children’s access to "bad" foods increased their children’s preference for those foods (Birch et al., 1980) and that attempts by parents to encourage consumption of “good” foods caused their children to increase their dislike those foods (Birch et al., 1984). The imposition of controlling parental feeding techniques can also affect a child’s ability to regulate energy intake and to respond to internal hunger and satiety cues. Johnson & Birch (1994) found that parents who exhibited a high degree of control over their children’s eating habits were more likely to have children with poor energy regulation. Differences in energy regulation were associated with differences in children’s adiposity, especially for girls. Johnson & Birch (1994) also observed that parental control over eating was related to mothers’ own problems with dieting and weight control. Mothers with restrictive eating patterns tended to be more controlling over their children’s eating habits and to have daughters with poor control over their energy intake. A subsequent study by Fisher & Birch (1995) found that parental adiposity was strongly related to their children’s preference for and consumption of high-fat foods, and that children with strong preferences for high-fat foods had higher triceps skinfold measurements than those with weak preferences. These studies suggest that familial patterns of obesity are affected by family environmental factors in addition to genetic factors.

Other caregivers. With increasing numbers of young children today eating away from home (see Table III-4, parents are serving fewer meals and snacks. Children who spend up to 10 hours a day in child-care are dependent on that setting for several nutritious meals and snacks (Crockett & Sims, 1995); thus, the influence that day-care providers have on shaping the eating habits of the children they care for becomes important (Pipes & Trahms, 1993b).

Much of the research on eating patterns in child-care centers has focused on evaluating the nutritional adequacy of food served (Birley et al., 1989; Drake, 1991), and few data are available on the role of caregivers in shaping the food preferences and eating behaviors of children. Nahikian-Nelms (1997) attempted to measure caregiver behaviors at mealtimes and to describe the relationship between a caregiver’s attitudes toward nutrition, nutrition knowledge, and behavior. Although most caregivers held beliefs that should have a positive influence on the development of children’s food preferences and healthy eating habits, their observed behaviors did not always support these beliefs. For example, 95% of the caregivers agreed that they should sit with children during mealtime to model good eating habits, but only 69% of them did so. Even though 75% believed that it was important that caregivers consume the same food as the children during meals and snacks, only 53% did so. Overall, caregivers’ nutrition knowledge was low. Positive correlations were found between caregivers’ nutrition knowledge and their behaviors at mealtime.
Peers. Some evidence suggests that peers can help to shape the eating behaviors and food preferences of preschool children. Birch (1980) showed that interaction with other children at mealtimes encouraged young children to eat the same things. In this study, the preference for and consumption of disliked vegetables increased after the children observed other children eating these foods. The change in acceptance of the disliked foods was still apparent several weeks later. The study suggests that day-care could serve as an unique environment for broadening the food preferences of preschool children since it provides repeated opportunities for modeling peer behavior.

Media. Television provides numerous messages about eating that can negatively influence young children’s food selections and preferences (Birch & Fisher, 1998). Cotunga (1988) found that 80% of the food commercials aired during 12 hours of Saturday morning children’s television programming were for food products high in fat, sugar, or salt (e.g., sweetened breakfast cereals, fast-foods, snack foods, and candy). Kotz & Story (1994) reported that 44% of all food advertisements viewed over 52.5 hours of children’s Saturday morning television were for foods classified in the fats, oils, and sweets food group of the Food Guide Pyramid. Taras & Gage (1995) determined that 91% of all foods advertised during children’s television hours were high in fat, sugar, and/or salt.

Healthy eating patterns learned at home must now compete with the heavy promotion of foods of low nutritive value on television. Most preschool children are vulnerable to the persuasive advertising because they are cognitively unable to understand the intention of commercials (Jeffrey et al., 1982).

Taras et al. (1989) studied the effect of television commercials on preschool children’s food preferences and food consumption patterns. Mothers of 3-8-year-olds were interviewed to determine their children’s television viewing habits and requests for foods advertised on television. Weekly television viewing hours were significantly correlated with the number of food requests by children, purchases by parents of advertised foods, and caloric intake. Similar findings were reported by Galst & White (1976) who observed mother-child interactions in the supermarket and then interviewed mothers on their children’s television viewing patterns. Jeffrey et al. (1982) found that exposure to advertisements for foods of low nutritive value increased the recall and consumption of the advertised foods among children aged 4-5 years. These results were confirmed with 4-5-year-old boys in a follow-up study (Jeffrey et al., 1982).

Children 5-12 Years
When children start school, their food choices are increasingly determined by influences outside of the family environment (Lucas, 1993). They make more independent food decisions as a result of changes in family lifestyles and as socialization with peers and access to money increases (Lucas, 1993; Thomas, 1991). Food preferences are largely established but still can be changed.

Influences on food choices. Family. The family continues to serve as a primary influence on the food choices of school-aged children, although to a lesser extent than for preschool children (Lucas, 1996). Unlike their younger counterparts who depend on their parents to buy and prepare food, schoolchildren are becoming more responsible for these activities because of continued increases in fine and gross motor skills and cognitive growth. In a recent survey, 65% of 9-15-year-olds reported that they decided what to eat for breakfast, 46% decided for lunch, and 74% decided what to eat as snacks (International Food Information Council and the American Dietetic Association, 1991; International Food Information Council, 1995). Younger children aged 6-9 years made fewer decisions about what was consumed at these eating occasions (48%, 36%, and 57%, respectively). Parents were the primary decision makers as to what was served for dinner; only 7% of 6-9-year-olds and 8% of 9-15-year-olds reported that they decided what to eat for dinner. Factors contributing to these patterns include more mothers working today, the increased use of and access to microwave ovens, more money available for buying convenience and prepared foods, and less emphasis on family meals (Crockett & Sims, 1995; Lucas, 1993).

Peers. Peers have considerable influence on the behaviors of children (Crockett & Sims, 1995; O’Brien & Bierman, 1988). Nutritional advice from parents may now be questioned in the face of advice from peers and peers’ parents (Lucas, 1993). Foods that were once eaten may now be refused, and requests for “popular” foods may now become more frequent (Lucas, 1996). Decisions to participate in the school lunch program may be influenced by what friends do and not by what foods are offered (Lucas, 1993, 1996).

Media. As in the preschool years, television advertising reinforces children’s preferences for foods of limited nutritional value. The effect of television commercial messages on schoolchildren’s food choices has been examined in several studies. Signorielli & Lears (1992) surveyed fourth and fifth grade students about their television watching time and asked a number
questions related to their eating habits and nutrition knowledge. There was a statistically significant positive relation between television watching and poor eating habits after controlling for sex, race, reading level, and parent occupational status and educational level. A positive relationship was also found between television viewing time and poor nutrition knowledge and unhealthy conceptions about foods, although this relationship was not as strong as that found for poor eating habits. In another study, Taras et al. (1989) interviewed the mothers of 3-8-year-old children to determine their children's television viewing habits and requests for advertised foods and found that weekly viewing hours were significantly correlated with reported number of food requests by children, purchases by parents of advertised foods, and children’s energy intakes. Jeffrey et al. (1982) found that 9-year-old boys increased significantly their energy intakes after watching television commercials for foods. In particular, energy consumption from foods and beverages of low nutritional value was also significantly higher after watching the commercials. Most of the boys were able to recall what products were advertised, and significantly more of them compared with control subjects stated that the commercials made them want to eat the advertised foods. Although schoolchildren appear to be aware of the intentions of television commercials, several studies have shown that they are still vulnerable to persuasive commercial messages (Jeffrey et al., 1982; Lambo, 1981).

Excessive television viewing may also encourage physical inactivity and excess weight gain (see Chapter IV). The multiple media cues to eat present in television commercials have been implicated as factors contributing to excess weight gain in 6-17-year-old children (Dietz & Gortmaker, 1985). In addition, there are concerns about the potential effect of television advertising for alcoholic beverages on schoolchildren's beliefs and attitudes about alcohol and their use of alcohol during adolescence (Grube & Wallack, 1994).

Food availability at school. When children begin their formal education, the noonday meal is usually eaten at school, and sometimes breakfast may also be eaten away from home (Lucas, 1993). Children may need to adapt to foods that may be considerably different from those served at home.

The National School Lunch Program (NSLP) and the School Breakfast Program (SBP) are available nationwide to approximately 92% and 50% of students in grades 1-12, respectively (Burghardt et al., 1995). Based on recent participation rates (56% in the NSLP and 19% in the SBP) (Gleason, 1995), food programs provide two of the three major meals for one in 10 schoolchildren and one out of three major meals for more than 5 in 10 schoolchildren during the school week (Dwyer, 1995b).

The NSLP must offer lunches that provide one-third of the Recommended Dietary Allowances (RDA) for energy, protein, vitamins, and minerals. The 1992 School Nutrition Assessment Study showed that NSLP lunches offered in elementary and middle schools met or exceeded this requirement for most nutrients, but exceeded the 1990 recommendations in the Dietary Guidelines for Americans for total fat and saturated fat and the NRC recommendation for sodium (Burghardt et al., 1995). SBP breakfasts provided, on average, the program goal of at least one-fourth of the RDA for most nutrients except food energy, the amount of saturated fat and cholesterol exceeded the 1990 DGFA recommendation, but approached the recommended level for total fat. Burghardt et al. (1995) noted that although NSLP and SBP may meet recommended levels for most nutrients, adequate nutrition will not be obtained if the food items served are not consumed. The foods and beverages actually consumed may also differ from the foods offered, because students may be able to choose their meals from alternative foods available at school (Burghardt et al., 1995).

Students who choose not to participate in the NSLP can bring a lunch from home or eat from other food sources available at school (e.g., vending machines and school stores) (Crockett & Sims, 1995). Some cafeterias may allow the sale of some “competitive foods” (defined by USDA as foods of minimal nutritional value, providing less than 5% of the U.S. RDA for eight specified nutrients per serving) (American Dietetic Association, 1991). Inadequate time for eating school meals is a growing problem that encourages the sale of competitive foods (American Dietetic Association, 1991).

Adolescents 12-20 Years

As children enter puberty, psychosocial changes affect the nature of influences determining their food choices. They search for self-identify, develop their own personal values and beliefs, strive for independence, have health motivations, and are concerned about their personal appearance (Barr, 1994; Contenko et al., 1988; Cusatis & Shannon, 1996; Thomas, 1991). Food habits are generally influenced less by family and more by what is considered acceptable by their peers (Mahan & Escott-Stump, 1996; Mahan & Rolls, 1988; Rees. 1993a), The media (Atkin, 1990; Bedingham & Doughten, 1994; Kelly & Edwards, 1998; Miller & Maropis, 1998) and easy accessibility to foods of low nutritional value (Burghardt et al., 1995; Story et al., 1996; Adams, 1997).
Influences on food choices. Peers. Teenagers are strongly influenced by peer group norms, with the peer group determining what is socially acceptable (Barr, 1994; Bedinghaus & Doughten, 1994; Contento et al., 1988; Crockett & Sims, 1995; Miller & Maropis, 1998). The nature of peer-group influence appears to be different than that which occurs in the preadolescent years. O'Brien & Bierman (1988) determined that the influence of peer groups during adolescence was directed toward attitudes and values, personal appearance, and to the use of alcohol, tobacco, and drugs. In preadolescence, peer groups were considered to be most influential in the areas of common activities and social behaviors.

Peer influence may play a role in shaping adolescent food choices, but it is unclear whether this influence has a positive or negative effect on behaviors. A recent study by Evans et al. (1995) suggested that peer influence during adolescence may reinforce poor eating habits. In this study, adolescents’ perceptions of how much their peers valued 11 different health-related behaviors were evaluated. Eating healthy foods was the least-valued behavior and controlling weight (for females) was the most valued behavior. Attractiveness was perceived to be a much stronger motivator for behavioral change than healthfulness. In contrast to these findings, Barr (1994) found that peer modeling had a positive impact on adolescent food choices. In this study with high school students from different ethnic backgrounds, seeing same-sex and opposite-sex friends drinking milk was associated with higher calcium intakes.

Media. Television advertising continues to have a strong impact on eating behaviors during adolescence (Rees, 1993a). Food advertisements targeted at teenagers appeal directly to the strong influence of peer group norms and their need to conform to peer pressure (Bedinghaus & Doughten, 1994; Miller & Maropis, 1998). They are especially vulnerable to advertising for diet fads, drugs, and equipment claiming to provide quick weight loss, because they often have unrealistic attitudes about the amount of time and effort needed for effective weight control (Mahan & Escott-Stump, 1996; Rees, 1993b). Alcohol consumption and smoking are often portrayed as a normal and acceptable part of the adolescent lifestyle (Atkin, 1990; DuRant et al., 1997; Kelly & Edwards, 1998).

Food access. Easy access to unhealthy food choices may reinforce poor eating habits (Adams, 1997; Rees, 1993a). Foods are readily available throughout the day from vending machines, sporting events, fast-food restaurants, convenience stores, and movie theaters, many of them high in calories, fat, sugar, and salt.

Few studies have been published on the accessibility and nutritional value of foods available to high school students. A recent study by Story et al. (1996) found that the high school environment may not promote healthful eating habits. High school students have access to a number of alternative food sources outside of the NSLP such as vending machines, school stores, and a la carte lines or snack bars providing foods which are often high in fat, sodium, and sugar. Of the 55 high schools studied, 47 had vending machines, 17 had a school store, and 53 had an a la carte line or snack bar. The most popular foods offered in vending machines were juice drinks (88%), carbonated beverages (81%), fruit juice (77%), candy bars (60%), cookies (58%), candy (56%), cheese puffs and potato, corn, and taco chips (54%). Only 27% of the vending machines offered pretzels, 8% offered fruit, and 6% offered low-fat or skim milks. Most of the foods available in school stores were high in fat and calories (e.g., candy bars, candy, cookies, doughnuts, and granola bars) with few lower fat alternatives. None of the school stores sold fruit. Although most a la carte menus and snack bars sold healthy food choices such as fruit and fruit juice and low-fat or skim milks, the top-selling foods were higher in fat. The ADA (American Dietetic Association, 1991) has expressed concern over the sale of competitive foods in schools.

Psychosocial factors. Adolescent’s food choices are influenced by internal factors such as health motivations, personal values and beliefs, food meanings, self-concept, and search for self-identity (Barr, 1994; Contento et al., 1988; Cusatis & Shannon, 1996; Traums, 1993). Adolescents may also use food selection to express their independence from parental control and to demonstrate their acquisition of food patterns perceived to be characteristic of adult tastes and the adult lifestyle (Thomas, 1991).

During adolescence, feelings of self-consciousness over changing body size and shape, a distorted body image, inaccurate perceptions of being overweight, and desires to be thinner become evident (particularly among girls) (Blyth et al., 1985; Desmond et al., 1986; Dornbusch et al., 1984). Although these feelings may appear in the preadolescent years (Hill & Oliver, 1992; Maloney et al., 1989; Moore, 1988; Richards et al., 1990), attempts to modify dietary intake to alter body shape or size often do not become apparent until the adolescent years when more freedom over food choice is possible (Rolla, 1988; Thomas, 1991). Dissatisfaction with body weight or body shape or size often results in unnecessary food restrictions, particularly among
girls (Moore, 1988; Rolls, 1988). Restrictive dieting may precede the onset of an eating disorder, but only a small percentage of those who diet develop eating disorders (Hill & Oliver, 1992; Striegel-Moore, 1993). This topic is discussed further in Chapter IV.
IV. CURRENT CONTROVERSIES AND SPECIAL ISSUES

In this chapter, a number of other issues related to the dietary, nutritional, and health status of children are addressed. These issues include several current controversies pertaining to diet and disease relationships of concern during childhood, as well as other diet and nutrition-related matters relevant to children—obesity, physical activity, dieting and weight control practices, eating disorders, vegetarian diets, and adolescent pregnancy. The special nutritional concerns of child and adolescent athletes are also addressed in this chapter.

DIET IN THE PREVENTION AND TREATMENT OF DISEASE

Diet and lifestyle patterns play a major role in the development of many chronic, degenerative diseases in adults, and modifying risk factors associated with these diseases can decrease disease risk (National Research Council, 1989b; U.S. Department of Health and Human Services [HHS], 1988). The causes of cardiovascular disease (CVD), the leading cause of death in the United States, are multifactorial and involve an interplay between genetics and the environment, the latter including lifestyle factors such as diet and physical activity (National Research Council, 1989b). Diets high in total fat, saturated fat, and cholesterol are one of several dietary factors that influence the development of CVD in adults by increasing blood cholesterol levels. High intakes of sodium have been associated in adults with elevated blood pressure, another risk factor for CVD. Other nutrients (such as calcium, potassium, and vitamin E) and certain types of foods (such as fruits and vegetables) have implications for reducing CVD risk as well (National Research Council, 1989b; U.S. Department of Health and Human Services [HHS], 1988). Physical inactivity and obesity have been linked to an increased risk of CVD (see sections on obesity and physical activity). Many health-care professionals believe that prudent dietary patterns and active lifestyles established in childhood form the foundation for healthier eating and physical activity patterns later in life that will help to reduce risk of developing CVD and other diet-related diseases in adulthood.

Dietary Fat

High blood cholesterol levels are a known risk factor for CVD in adults, and lowering elevated levels decreases the risk (National Research Council, 1989b; U.S. Department of Health and Human Services [HHS], 1980, 1988, 1991). The known association of blood cholesterol levels with the development of CVD in adults has resulted in similar dietary recommendations by some authoritative organizations that children 2 years of age and over consume reduced-fat diets to decrease risk of CVD later in life.

Current Recommendations. Many public-health authorities and professional organizations state that one of the most important dietary changes Americans should make, beginning at about 2 years of age, is to reduce the total fat and saturated fat content of their diets to lower their risk of developing chronic, degenerative diseases such as CVD and some types of cancer in later life. The current 1995 Dietary Guidelines for Americans (DGFA) recommend that all healthy children after the age of 2 years should adopt a diet that, by about 5 years of age, provides no more than 30% of total calories from fat (U.S. Department of Agriculture [USDA] and U.S. Department of Health and Human Services [HHS], 1995). Similar dietary recommendations are made by the Surgeon General's Report on Nutrition and Health, the National Research Council, the National Cholesterol Education Program, the American Academy of Pediatrics, and other health organizations (see Table IV-1). However, the American Heart Association (American Heart Association & Committee on Nutrition, 1996) has endorsed a lower limit of 15% of calories from fat, based on evidence that suggests that diets providing less fat increase the risk of nutrient deficiencies in children and have no demonstrated value for most people. The AAP (American Academy of Pediatrics. Committee on Nutrition, 1998a) has recommended a lower limit of 20% of calories from fat. The Canadian Paediatric Society and Health Canada take a more liberal position than their U.S. counterparts, recommending that children's diets be limited in fat only by the end of childhood (Canada and Ministry of National Health and Welfare, 1993).
<table>
<thead>
<tr>
<th>Organization or Report</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary Guidelines for Americans, 4th ed. (U.S. Department of Agriculture (USDA) and U.S. Department of Health and Human Services (HHS), 1995)</td>
<td>Children beginning at age 2 should gradually adopt a diet that, by about 5 years of age, contains no more than 30% of total energy from fat. As they begin to consume fewer calories from fat, children should replace these calories by eating more grain products, fruits, vegetables, and low-fat milk products or other calcium-rich foods, and beans, lean meats, poultry, fish, or other protein-rich foods. Choose a diet low in saturated fat (&lt;10% of total energy) and cholesterol (&lt;300 mg per day).</td>
</tr>
<tr>
<td>Surgeon General’s Report on Nutrition and Health (U.S. Department of Health and Human Services (HHS), 1988)</td>
<td>For most people, reduce consumption of fat (especially saturated fat) and cholesterol. Choose foods relatively low in these substances, such as vegetables, fruits, whole grain foods, fish, poultry, lean meats, and low-fat dairy products. Use food preparation methods that add little or no fat. Infants should consume 3.8 to 6.0 g of fat per 100 calories, or 34-54% of total energy from fat. Three percent of total energy should be provided by linoleic acid.</td>
</tr>
<tr>
<td>Healthy People 2000 (U.S. Department of Health and Human Services (HHS). Public Health Service 1990 ID: 1541)</td>
<td>Reduce dietary fat intake to an average of &lt;30% of total energy and average saturated fat intake to &lt;10% of total energy among people aged 2 and older.</td>
</tr>
</tbody>
</table>
| National Cholesterol Education Program(U.S. Department of Health and Human Services (HHS), 1991) | Recommendations are for healthy children and adolescents. As children over 2 years of age begin to eat with the family, they may safely follow these recommendations:  
  - Total fat: an average of no more than 30% of total energy.  
  - Saturated fat: <10% of total energy.  
  - Dietary cholesterol: <300 mg per day.                                                                                                                                                                                                                                                                                  |
| Diet and Health: Implications for Reducing Chronic Disease Risk (National Research Council, 1989b) | Healthy children over 2 years of age should gradually phase in the recommended diet by slowly limiting their intake of fat and cholesterol, so that by age 5 they are eating the recommended diet like that of the rest of the family:  
  - Reduce total fat intake to <30% of total energy. There is evidence that further reduction in fat intake may confer even greater health benefits.  
  - Reduce saturated fatty acid intake to <10% of calories. It is likely that further reduction, to 8 or 7% of calories or lower, would confer greater health benefits.  
  - Reduce the intake of cholesterol to <300 mg daily. Larger reductions in cholesterol intakes (e.g., 250 or 200 mg or even less per day) may also confer greater health benefits.                                                                                                                                                |
| AAP (American Academy of Pediatrics. Committee on Nutrition, 1998a) | No restriction of fat or cholesterol for children <2 years when rapid growth and development require high energy intakes.  
  After 2 years of age, children should gradually adopt a diet that, by about 5 years of age, contains <30% of total energy from fat but no less than 20% of energy from fat. As fewer calories from fat are consumed, these calories should be replaced by eating more grain products, fruits, vegetables, low-fat milk products or other calcium-rich foods, and lean meat, poultry, fish, beans, or other protein-rich foods. These recommendations are for average intakes over several days. Major emphasis should be placed on reducing saturated fat intake to <10% of total energy because high intakes raise blood cholesterol levels. Another recommendation is to reduce dietary cholesterol to <300 mg per day. |
<table>
<thead>
<tr>
<th>Organization or Report</th>
<th>Recommendations</th>
</tr>
</thead>
</table>
| Canadian Pediatric Society/Health Canada (Canada and Ministry of National Health and Welfare, 1993) | * From the age of two until the end of linear growth, there should be a transition from the high-fat diet of infancy to a diet which includes no more than 30% of total energy as fat and no more than 10% of energy as saturated fat. During this transition, energy intake should be sufficient to achieve normal growth and development. Food patterns should emphasize variety, complex carbohydrates, and lower-fat foods.  
* There is no evidence in children that implementation of a diet providing 30% of energy as fat and 10% of energy as saturated fat reduces illness in later life or provides benefit during childhood.  
* During the preschool and childhood years, nutritious food choices should not be eliminated or restricted because of fat content.  
For children over the age of 4, choose lower-fat dairy products, leaner meats, and foods prepared with little or no fat. |
American Heart Association (American Heart Association & Committee on Nutrition, 1996) | Children between the ages of 2 and 5 can gradually adopt the diet habits of the family. The following guidelines are appropriate for children older than 2 years:  
* <30% of total energy from fat.  
* 8-10% of total energy from saturated fatty acids.  
* Up to 10% of total energy from polyunsaturated fatty acids.  
* Up to 15% of total energy from monounsaturated fatty acids.  
* <300 mg of cholesterol per day.  
The recommended lower limit for total fat is 15% of total energy. |

Evidence relating dietary fat, blood cholesterol, and heart disease. Differences of opinion about limiting total fat and saturated fat intakes by children arise because of inadequate scientific evidence that would lead to consensus in interpretation of the available data. For example, fatty streaks found in the arteries of children have been proposed as evidence that atherosclerosis begins in childhood and adolescence (U.S. Department of Health and Human Services [HHS], 1991). Others question whether these fatty streaks uniformly progress to fibrous plaques, the characteristic lesion of atherosclerosis (Zlotkin, 1996), or sometimes resolve. Moreover, it has been argued that U.S. children are not at risk for clinically significant atherosclerosis because fatty streaks are found in the arteries of children throughout the world regardless of their diets, and because they generally have low serum cholesterol and low-density-lipoprotein (LDL) cholesterol levels (Olson, 1995).

Lower-fat diets beginning in early childhood have been recommended on the basis of evidence that U.S. children and adolescents have higher blood cholesterol levels and higher intakes of saturated fat and cholesterol, and that U.S. adults have higher blood cholesterol levels and higher rates of CVD mortality and morbidity, than their counterparts in many other countries (U.S. Department of Health and Human Services [HHS], 1991). Opponents of this recommendation argue that there is no direct evidence suggesting that childhood diet is related to the etiology of CVD (Olson, 1995). According to Olson (1995), such evidence would be extremely difficult to obtain, because long-term studies would be required to determine the extent to which blood pressure, blood cholesterol, and lipoprotein cholesterol levels correlate with the prevalence of CVD in adulthood. Others have contended that several intervention studies in which children reduced their dietary fat intakes suggest that only very modest reductions in blood cholesterol levels would be expected (Canada and Ministry of National Health and Welfare, 1993; Lifshitz & Tarim, 1996; Newman et al., 1995; Olson, 1995; Zlotkin, 1996). Whether these small reductions in blood cholesterol levels would be of clinical importance is subject to debate. Newman et al. (1995) have indicated that the small decreases seen in total blood cholesterol levels overestimate the benefits of the recommended diet. Their argument claims that reducing saturated fat intakes lowers levels of high-density lipoprotein (HDL) cholesterol by about the same percentage that LDL cholesterol levels are lowered, thereby resulting in unfavorable effects on blood lipid levels (Newman et al., 1995). Newman et al. (1995) expressed additional concerns that the recommended diets could lead to the use of more
restrictive diets or to the inappropriate use of cholesterol-lowering drugs in children unable to achieve desirable blood cholesterol levels through diet.

Critics of modified-fat diets in childhood have pointed out that fat-restricted diets may not provide enough calories or minerals such as iron, zinc, and calcium to support normal growth and development (Kaplan & Toshima, 1992; Lifshitz & Moses, 1989; Lifshitz & Tarim, 1996; Olson, 1995; Pugliese et al., 1987). Lifshitz & Moses (1989) described growth failure among eight hypercholesterolemic children 6-13 years of age whose parents overzealously applied low-fat, low-cholesterol diets. There are also concerns that intakes of fat-soluble vitamins and essential fatty acids will be inadequate on fat-restricted diets (Canada and Ministry of National Health and Welfare, 1993; Olson, 1995). In a cross-sectional sample of 10-year-olds in the Bogulusa Heart Study, Nicklas et al. (1992) found that children who were in the lowest quartile for total fat intake were less likely to meet the RDA for thiamin, niacin, and vitamins B6 and B12 than children following higher-fat diets. Furthermore, intakes of simple sugars tended to be higher among children on lower-fat diets than among children on higher-fat diets.

Several studies, however, have determined that lower-fat diets are safe and nutritionally adequate. A randomized trial in Finland with 1,062 children from age 8 months to 4 years showed that diets lower in fat, saturated fat and cholesterol had minimal effects on micronutrient intakes (Lagström et al., 1997). Shea et al. (1993) studied 215 children ages 3-4 years at baseline with a mean of 25 months of follow-up. Compared with children in the highest quintile of total fat intake (38.4% of calories), children in the lowest quintile (27.1% of calories from fat) had similar statures and rates of growth. They also consumed significantly more carbohydrates, iron, thiamin, riboflavin, and vitamins A and C, and less saturated fat, cholesterol, calcium, phosphorus, and total energy. Two recent randomized, controlled trials—the Dietary Intervention Study in Children (DISC) (The Writing Group for the DISC Collaborative Research Group, 1995) and the Child and Adolescent Trial for Cardiovascular Health (CATCH) (Luepker et al., 1996)—found that diets supplying currently recommended levels of fat, saturated fat, and cholesterol promoted both normal growth and nutritional adequacy.

**Dietary Sodium**

Evidence from population studies suggests that primary hypertension may have its roots in childhood (Geleijse et al., 1996). As a result, determinants of blood pressure in early life have been proposed as being important to the development of hypertension later in life. Although controversy continues as to their etiologic role, diets high in sodium have been often linked in adults with hypertension, a major risk factor for CVD (Gillman & Ellison, 1993). Whether this information is sufficient to recommend that children 2 years and older consume sodium-modified diets to lower their risk for adult hypertension remains controversial.

**Current Recommendations.** Some public health authorities and professional organizations recommend that most Americans, beginning at about age 2 years, should moderate their consumption of sodium and salt (sodium chloride) (see Table IV-2).

The rationale is to reduce the risk for developing hypertension, a risk factor for CVD in adults (Gillman & Ellison, 1993; National Heart Lung & Blood Institute, 1993). Although a Working Group from the National High Blood Pressure Education Program concluded that there is no clear evidence that sodium restriction lowers blood pressure in children and adolescents with mild hypertension, the Working Group recommended that a moderate reduction in dietary sodium can be beneficial, because the sodium intakes of children and adolescents are generally higher than needed (National Heart Lung & Blood Institute, 1996). According to the AAP (American Academy of Pediatrics. Committee on Nutrition, 1993a), no conclusive evidence exists that high sodium intakes are detrimental to the health of children, including the one-fifth of children likely to develop hypertension as adults. Nevertheless, like the Working Group of the National High Blood Pressure Education Program (National Heart Lung and Blood Institute, 1996), the AAP (American Academy of Pediatrics. Committee on Nutrition, 1993a) advised that consumption of foods high in sodium content be avoided because the sodium intakes of U.S. children and adolescents are unnecessarily high.
Table IV-2. Recommendations Pertaining to Sodium/Salt Intake and Children

<table>
<thead>
<tr>
<th>Organization or Report</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary Guidelines for Americans, 4th ed. (U.S. Department of Agriculture (USDA) and U.S. Department of Health and Human Services (HHS), 1995)</td>
<td>Children beginning at age 2 should follow a diet that is moderate in salt and sodium intake.</td>
</tr>
<tr>
<td>Surgeon General’s Report on Nutrition and Health (U.S. Department of Health and Human Services (HHS), 1988)</td>
<td>For most healthy people, reduce sodium intake by choosing foods relatively low in sodium content and limiting the amount of salt added in food preparation and at the table.</td>
</tr>
<tr>
<td>Healthy People 2000 (U.S. Department of Health and Human Services (HHS). Public Health Service, 1990)</td>
<td>Decrease salt and sodium intake so at least 65% of home meal preparers prepare foods without adding salt, at least 80% of people avoid using salt at the table, and at least 40% of adults regularly purchase foods modified or lower in sodium.</td>
</tr>
<tr>
<td>National High Blood Pressure Program (National Heart Lung and Blood Institute, 1996)</td>
<td>No clear evidence supports sodium reduction as beneficial in children or adolescents with mild hypertension. For children and adolescents with elevated blood pressure, moderate sodium reduction may be beneficial. Practical dietary guidance includes increasing fruit and vegetable consumption, eliminating added salt to home-cooked foods in preparation and at the table, and reducing intake of foods with high sodium content.</td>
</tr>
<tr>
<td>Diet and Health: Implications for Reducing Chronic Disease Risk (National Research Council, 1989b)</td>
<td>Recommendations pertain to healthy children over 2 years of age. Limit total daily salt intake (sodium chloride) to ≤5 g. Limit the use of salt in cooking and avoid adding it to food at the table. Salty, highly processed salty, salt-preserved, and salt-pickled foods should be consumed sparingly.</td>
</tr>
<tr>
<td>AAP</td>
<td>Added salt should be used in moderation in second year of life (American Academy of Pediatrics and Committee on Nutrition. 1993c). Although there is no conclusive evidence that high sodium intakes during infancy and childhood are detrimental to the health of even the one-fifth of children likely to develop hypertension as adults, children should avoid foods high in sodium because high sodium intakes are unnecessary (American Academy of Pediatrics. Committee on Nutrition. 1993a).</td>
</tr>
<tr>
<td>Canada’s Food Guide to Healthy Eating (Health Canada, 1998c)</td>
<td>Children over the age of 4 should limit their salt intake.</td>
</tr>
<tr>
<td>American Heart Association (American Heart Association &amp; Committee on Nutrition, 1996)</td>
<td>Guidelines are appropriate for children older than 2 years of age. Between the ages of 2 and 5 years, children can gradually adopt the diet habits of the family. • Use salt and sodium in moderation. • Consume no more than 6 g sodium chloride (2.4 g of sodium) per day.</td>
</tr>
</tbody>
</table>

Evidence relating dietary sodium and blood pressure. Evidence from published clinical trials shows that restricting sodium intake may reduce blood pressure in adults with hypertension (Law et al. 1991), but few data show that decreasing sodium intake lowers blood pressure in children and adolescents (Cooper et al., 1980; Howe et al., 1991; Sinaiko et al., 1993). Most studies investigating the effect of sodium reduction on blood pressure in children have been short-term. In an early study by Cooper et al. (1980), the effect of restricting dietary sodium intake on blood pressure in normotensive adolescents 11-14 years of age was studied using a randomized crossover trial design; no effect on blood pressure was observed after 24 hours of sodium restriction. Howe et al. (1991) investigated the effect of low- and high-sodium intakes on blood pressure in adolescents of the same age range. In this study, individuals representing the top, middle, and bottom deciles of the blood pressure range.
consumed diets providing either &lt;1.7 g or &gt;3.5 g sodium/day for four weeks followed by the other diet for another four weeks. Although urinary sodium excretion differed by &gt;80 mmol between the adolescents consuming the low- and high-sodium diets, no significant differences in blood pressure were observed. More recently, Sinaiko et al. (1993) set out to determine whether adherence to a sodium-restricted diet over an extended period of time resulted in changes in blood pressure or changes in the rate of rise of blood pressure in 13-year-old adolescents who had repeated blood pressures in the top 15% of the population screened. Over the study's three-year duration, subjects were assigned to three interventions (reduced sodium intake, supplemental potassium chloride intake, or placebo supplement). At the conclusion, no differences in blood pressure or blood pressure rate-of-rise and no reduction in urinary sodium excretion were noted in the boys. In the girls consuming the reduced sodium diet, a small decrease in urinary sodium excretion and a slight decrease in the rate of increase in blood pressure were found.

Several studies have shown that sodium intake has a variable effect on blood pressure in children and adults (Gillman & Ellison, 1993; Haddy & Pammani, 1995). In most cases, salt-sensitive persons who respond to sodium restriction with a decrease in blood pressure tend to be older rather than younger (Falkner & Michel, 1997; Haddy & Pammani, 1995). Salt sensitivity, however, has been detected in adolescents and appears to be associated with other risk factors for hypertension such as race, family history of hypertension, and overweight (Falkner & Michel, 1997; Falkner et al., 1981; Rocchini et al., 1989).

**Other dietary considerations.** In addition to sodium, other dietary factors may play a role in the development and maintenance of elevated blood pressure in children and adolescents. To date, the only dietary interventions shown to have a beneficial effect on blood pressure in children are those that control or reduce obesity (Gillman & Ellison, 1993; National Heart Lung and Blood Institute, 1996). A number of studies with children and adolescents have found a relationship between increased body size and blood pressure (Labarthe et al., 1991a,b; Lauer et al., 1991; Lauer & Clarke, 1985; Shea et al., 1994). According to Gillman & Ellison (1993), these data suggest that the prevention of childhood obesity should be emphasized in any discussion of blood pressure control in children.

The role of other minerals (primarily calcium, magnesium, and potassium) in blood pressure regulation has received much attention in recent years, but few such studies have been conducted in children (Geleijnse et al., 1990; Gillman et al., 1992, 1995; Sinaiko et al., 1993). Falkner & Michel (1997) suggested that it is unlikely that sodium acts alone as a contributing factor in hypertension, but that the interaction of sodium with dietary calcium, magnesium, and potassium may account for an effect on blood pressure in some children and adolescents. Gillman & Ellison (1993) indicated that alcohol consumption may be another determinant of blood pressure in adolescence, a time when alcohol use often increases.

**OBESITY**

Overweight in childhood and adolescence has become an important public health concern, because overweight children and adolescents may become overweight adults and overweight adults are at increased risk for adverse health outcomes (Troiano et al., 1995). Dietary and activity patterns established during this period may begin to set the stage for the development of weight problems in adulthood. Excessive body weight and body fat have been associated over time with increased mortality and morbidity from CVD, some forms of cancer, diabetes, and digestive diseases (National Research Council, 1989b; U.S. Department of Health and Human Services [HHS], 1988).

**Current Recommendations**

Specific recommendations for weight regulation in children are included in the DGFA (U.S. Department of Agriculture [USDA] and U.S. Department of Health and Human Services [HHS], 1995). To promote growth and development and to prevent overweight, it is recommended in the DGFA that children and adolescents consume a low-fat, nutritionally varied diet and participate in vigorous physical activity (see Table IV-3). Limiting fat intake was identified as being potentially helpful in preventing excess weight gain, but this strategy was not advised for children younger than 2 years of age. A number of authoritative organizations have similar recommendations (see Table IV-3). Healthy People 2000 has specific goals for reducing overweight prevalence among 12-19-year-old adolescents to no more than 15% (U.S. Department of Health and Human Services [HHS], Public Health Service, 1990). This objective should be achieved through physical activity and a properly balanced diet so that growth is not impaired.
Table IV-3. Recommendations Pertaining to Weight Regulation in Children and Adolescents

<table>
<thead>
<tr>
<th>Organization or Report</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary Guidelines for Americans, 4th ed. (U.S. Department of Agriculture (USDA) and U.S. Department of Health and Human Services (HHS), 1995)</td>
<td>To promote growth and development and prevent overweight, teach children to eat proper foods (grain products; vegetables and fruits; low-fat milk products or other calcium-rich foods; beans, lean meat, poultry, fish or other protein-rich foods) and to participate in vigorous activity. Limit television time and encourage children to play actively in a safe environment. Limiting fat intake may help to prevent excess weight gain in children, but fat should not be restricted in the diet of children younger than 2 years of age. Helping overweight children to achieve a healthy weight and normal growth requires more caution. Modest reductions in dietary fat are not hazardous. Major changes in diet should be accompanied by growth monitoring by a health professional at regular intervals.</td>
</tr>
<tr>
<td>Surgeon General’s Report on Nutrition and Health (U.S. Department of Health and Human Services (HHS), 1988)</td>
<td>To prevent overweight, children and adolescents should be encouraged to maintain appropriate levels of physical activity. Qualified health professionals should provide counseling to most overweight children and their families that helps them plan diets containing adequate but not excessive calories and exercise regimes that include social and physical activities that the child enjoys.</td>
</tr>
<tr>
<td>Healthy People 2000 (U.S. Department of Health and Human Services (HHS). Public Health Service, 1990)</td>
<td>Reduce overweight to a prevalence of no more than 15% among adolescents aged 12-19 years. This objective should be achieved through emphasis on physical activity and a properly balanced diet so that growth is not impaired.</td>
</tr>
<tr>
<td>Diet and Health: Implications for Reducing Chronic Disease Risk (National Research Council, 1989b)</td>
<td>Healthy children should balance food intake with physical activity to maintain appropriate weight.</td>
</tr>
<tr>
<td>AAP (American Academy of Pediatrics. Committee on Nutrition, 1993)</td>
<td>For overweight children, emphasis on energy balance is probably better than specific caloric intake recommendations. The concept of energy for normal growth must be balanced against control of excess weight. Regular physical exercise at home and after school and on weekends should be planned. Television viewing should be limited and monitored.</td>
</tr>
<tr>
<td>Canada’s Food Guide to Healthy Eating (Health Canada 1998a)</td>
<td>For children over the age of 4, achieve and maintain a healthy body weight by enjoying regular physical activity and healthy eating.</td>
</tr>
</tbody>
</table>

Problems of Defining Overweight in Children and Adolescents
Classifying children and adolescents as overweight or obese is difficult because there are no generally accepted definitions for these conditions (Flegal, 1993; Obarzanek, 1993). Recent estimates of overweight prevalence for children and adolescents have used the 85th and 95th percentile of body mass index (BMI, weight in kilograms divided by height in meters squared) as the basis for such estimates. The 95th percentile of BMI clearly represents overweight and is likely to have a high specificity for excess body fat. It has been proposed that a BMI at or above the 85th percentile but less than the 95th percentile be used to identify children and adolescents who are at risk of becoming overweight and who may require further medical assessment (Himes & Dietz, 1994).
Being characterized as overweight or obese in childhood or adolescence can lead to undue attention to body size and thereby increase the potential for eating disorders (DeJong, 1980; Maloney et al., 1989). Because of this potential adverse outcome, Troiano et al. (1995) proposed that the 95th percentile cutoff be used as a criterion of overweight for children and adolescents rather than the 85th percentile. Children and adolescents with a BMI above the 95th percentile are most likely to be obese and at risk for continued weight problems and adverse health outcomes in adulthood. Troiano et al. (1995) further commented that, because heavy younger children are at lower risk of adverse health outcomes in adult life than high-percentile adolescents, additional care must be taken when they are classified as overweight.

**Overweight Prevalence and Trends**

The most recent estimates of the prevalence of overweight among U.S. children and adolescents are from the third National Health and Nutrition Examination Survey (NHANES III 1988-94), a stratified, multistage, probability cluster sample representative of the U.S. noninstitutionalized civilian population. Phase 1 was conducted from 1988 to 1991, with Phase 2 conducted between 1991 and 1994. Trend data on overweight prevalence are available from the second and third National Health Examination Surveys (NHES II 1963-65 and NHES III 1966-70), the first and second National Health and Nutrition Examination Surveys (NHANES I 1971-74 and NHANES II 1976-80), and the NHANES III, Phase 1, 1988-91.

**Children 5-12 years.** Overweight prevalence, 1988-94. Recent data from NHANES III 1988-94 showed that approximately 14% of children between 6 and 11 years of age were overweight, using the 95th percentile BMI cutoff points (see Table IV-4). Prevalence rates were higher among Mexican-American and non-Hispanic black children than among non-Hispanic white children. An analysis of NHANES III Phase 1 data showed that between 1988 and 1991 overweight prevalence for children 6-11 years of age was 11% based on the 95th percentile BMI cutoff and 22% based on the 85th percentile of BMI (see Table IV-5). Non-Hispanic black and Mexican-American children were also found to have higher overweight prevalence rates than white, non-Hispanic children.

**Trends in overweight prevalence, 1963-91.** Comparisons of NHANES III Phase 1 data with earlier surveys have indicated that overweight prevalence among children aged 6-11 years has increased, with the largest increases occurring since NHANES II (see Table IV-6). These increases were evident using the NHES II 85th and 95th percentiles for BMI as definitions of overweight. Overall, increases in overweight prevalence between NHANES II and NHANES III, Phase 1 were greater for black children than for white children. Findings from the entire NHANES III 1988-1994 indicated generally higher overweight prevalence rates than those from NHANES III, Phase 1 alone (see Tables IV-4 and IV-5), suggesting that the prevalence of overweight among American children has continued to increase. Weight increases occurred in both sexes across all racial and ethnic groups.

**Adolescents 12-20 years.** Overweight in adolescence has been associated with a higher risk of overweight in adulthood and may increase the risk of adverse health outcomes later in life (DiPietro et al., 1994; Guo et al., 1994; Serdula et al., 1993). Guo et al. (1994) reported that the risk that an overweight child will remain overweight as an adult increases with age. The predictive value for overweight during adulthood is excellent for an 18-year-old who is overweight and is good for an overweight 13-year-old. Consistent predictors of adult obesity are low socioeconomic status of a child's parents and school failure in childhood (Pine et al., 1997). In a study by Pine et al. (1997) of 700 youths who were psychiatrically assessed at a mean age of 14 years and again at 22 years, obesity in early adulthood was associated with low social class, poor physical health, smoking, and alcohol use in adolescence. When these factors were controlled, a relationship was found between early adulthood obesity and adolescent conduct disorders characterized by recurrent, impulsive aggression (Pine et al., 1997).
<table>
<thead>
<tr>
<th>Sex and race/ethnicity</th>
<th>Children 6-11 years (%)</th>
<th>Adolescents 12-17 years (^3) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Male</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>13.2</td>
<td>11.6</td>
</tr>
<tr>
<td>Black, non-Hispanic</td>
<td>14.7</td>
<td>12.5</td>
</tr>
<tr>
<td>Mexican American</td>
<td>18.8</td>
<td>15.0</td>
</tr>
<tr>
<td>Total(^2)</td>
<td>14.7</td>
<td>12.3</td>
</tr>
<tr>
<td><strong>Female</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>11.9</td>
<td>9.6</td>
</tr>
<tr>
<td>Black, non-Hispanic</td>
<td>17.9</td>
<td>16.3</td>
</tr>
<tr>
<td>Mexican American</td>
<td>15.8</td>
<td>14.0</td>
</tr>
<tr>
<td>Total(^2)</td>
<td>12.5</td>
<td>10.7</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>13.7</td>
<td>11.5</td>
</tr>
</tbody>
</table>

\(^1\) Adapted from CDC's update report on overweight prevalence in the U.S. (National Center for Chronic Disease Prevention and Health, 1997). Overweight was defined as BMI at or above sex- and age-specific 95th percentile BMI cutoff points calculated at 6-month age intervals at examination, derived from NHES II (children aged 6-11 years) and NHES III (adolescents aged 12-17 years). NHANES III 1988-94 (Third National Health and Nutrition Examination Survey, Phase 1 and 2), NHES II 1963-65 (National Health Examination Survey), and NHES III 1966-1970 are conducted by the National Center for Health Statistics, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services.

\(^2\) Numbers for other racial/ethnic groups were too small for separate reporting but are included in total estimates.

\(^3\) Excludes pregnant females and one person with an outlier sample weight.
Table IV-5. Percentage of children aged 6-11 years and adolescents aged 12-17 years who are overweight, by sex and race/ethnicity, NHANES III 1988-91

<table>
<thead>
<tr>
<th>Age, sex, and race/ethnicity</th>
<th>85th Percentile (%)</th>
<th>95th Percentile (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Both sexes</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-11</td>
<td>22.0</td>
<td>10.9</td>
</tr>
<tr>
<td>12-17</td>
<td>22.3</td>
<td>11.0</td>
</tr>
<tr>
<td>12-17</td>
<td>21.7</td>
<td>10.8</td>
</tr>
<tr>
<td><strong>Males</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-8</td>
<td>21.3</td>
<td>11.7</td>
</tr>
<tr>
<td>9-11</td>
<td>22.7</td>
<td>10.9</td>
</tr>
<tr>
<td>12-14</td>
<td>23.5</td>
<td>12.0</td>
</tr>
<tr>
<td>15-17</td>
<td>20.7</td>
<td>13.5</td>
</tr>
<tr>
<td><strong>Females</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6-8</td>
<td>24.2</td>
<td>13.7</td>
</tr>
<tr>
<td>9-11</td>
<td>21.4</td>
<td>8.2</td>
</tr>
<tr>
<td>12-14</td>
<td>21.5</td>
<td>8.5</td>
</tr>
<tr>
<td>15-17</td>
<td>21.4</td>
<td>9.0</td>
</tr>
<tr>
<td><strong>Males 6-11 years</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>20.5</td>
<td>10.4</td>
</tr>
<tr>
<td>Black, non-Hispanic</td>
<td>26.5</td>
<td>13.4</td>
</tr>
<tr>
<td>Mexican American</td>
<td>33.3</td>
<td>17.7</td>
</tr>
<tr>
<td>Total(^1)</td>
<td>21.9</td>
<td>11.3</td>
</tr>
<tr>
<td><strong>Males 12-17 years</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>23.1</td>
<td>14.4</td>
</tr>
<tr>
<td>Black, non-Hispanic</td>
<td>21.1</td>
<td>9.3</td>
</tr>
<tr>
<td>Mexican American</td>
<td>26.7</td>
<td>12.8</td>
</tr>
<tr>
<td>Total(^1)</td>
<td>22.0</td>
<td>12.8</td>
</tr>
<tr>
<td><strong>Females 6-11 years</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>White, non-Hispanic</td>
<td>21.5</td>
<td>9.8</td>
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<tr>
<td>Black, non-Hispanic</td>
<td>31.4</td>
<td>16.9</td>
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<tr>
<td>Mexican American</td>
<td>29.0</td>
<td>14.3</td>
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<tr>
<td>Total(^1)</td>
<td>22.7</td>
<td>10.6</td>
</tr>
<tr>
<td><strong>Females 12-17 years</strong></td>
<td></td>
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<tr>
<td>White, non-Hispanic</td>
<td>20.3</td>
<td>8.3</td>
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<td>Mexican American</td>
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<tr>
<td>Total(^1)</td>
<td>21.4</td>
<td>8.8</td>
</tr>
</tbody>
</table>

\(^1\) Adapted from Troiano et al. (1995). Table 2. Overweight was defined as BMI at or above sex- and age-specific 85th and 95th percentile cutoff points of NHES II (children aged 6-11 years) and NHES III (adolescents aged 12-17 years) calculated by 6-month age intervals at examination. Values in the table are unadjusted for age. NHANES III 1988-91 (Third National Health and Nutrition Examination Survey, Phase 1), NHES II 1963-65 (National Health Examination Survey), and NHES III 1966-1970 are conducted by the National Center for Health Statistics, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services.

\(^2\) Excludes pregnant females.

\(^3\) Numbers for other racial/ethnic groups were too small for separate reporting but are included in total estimates.
<table>
<thead>
<tr>
<th>Survey</th>
<th>Males</th>
<th>Females</th>
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<tbody>
<tr>
<td></td>
<td>85th Percentile</td>
<td>95th Percentile</td>
</tr>
<tr>
<td>Children 6-11 years</td>
<td></td>
<td></td>
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<tr>
<td>All races³</td>
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<tr>
<td>NHES II 1963-65</td>
<td>15.2</td>
<td>5.2</td>
</tr>
<tr>
<td>NHANES I 1971-74</td>
<td>18.2</td>
<td>6.5</td>
</tr>
<tr>
<td>NHANES II 1976-80</td>
<td>19.9</td>
<td>7.9</td>
</tr>
<tr>
<td>NHANES III 1988-91</td>
<td>22.3</td>
<td>10.8</td>
</tr>
<tr>
<td>White</td>
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<td></td>
</tr>
<tr>
<td>NHES II 1963-65</td>
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<td>5.6</td>
</tr>
<tr>
<td>NHANES I 1971-74</td>
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<td>NHANES II 1976-80</td>
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<td>7.9</td>
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<td>NHANES III 1988-91</td>
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<td>Children 12-17 years</td>
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</tr>
<tr>
<td>All races³</td>
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<tr>
<td>NHANES III 1966-70</td>
<td>15.1</td>
<td>5.2</td>
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<tr>
<td>NHANES III 1988-91</td>
<td>23.3</td>
<td>9.4</td>
</tr>
</tbody>
</table>

1 Adapted from Troiano et al. (1995), Table 3. Overweight is defined as BMI at or above sex- and age-specific 85th and 95th percentile cutoff points of NHES II (children aged 6-11 years) and NHES III (adolescents aged 12-17 years) calculated by 6-month intervals of age at examination. The NHES II and III were selected as the reference population and baseline for trends because their large sample sizes eliminate the need for smoothing and because these surveys provide the earliest source of national data for children’s and adolescent’s heights and weights. Values in the table are age-adjusted to correct for changes in age distribution over time by the direct method to the 1980 U.S. Census population figures based on single years of age. NHANES III 1988-91 (Third National Health and Nutrition Examination Survey, Phase I), NHANES II 1976-80 (Second National Health and Nutrition Examination Survey), NHANES I 1971-74 (First National Health and Nutrition Examination Survey), NHANES II 1963-65 (National Health Examination Survey, Cycle II), and NHANES III 1966-1970 (National Health Examination Survey, Cycle III) are conducted by the National Center for Health Statistics, Centers for Disease Control and Prevention, U.S. Department of Health and Human Services.

2 Data from females in NHANES I, II, and III who reported being pregnant were excluded from analyses. Information on pregnancy was not collected in NHANES II or III.

3 Numbers for other racial groups were too small for separate reporting but are included in estimates for all races combined.

Various psychological variables are associated with adolescent obesity, including emotional disorders, psychopathologies, and troubled parent-child dynamics (Lissau and Sorensen, 1994; Pine et al., 1997). For adolescents whose obesity may be caused by physiological factors, genetics and lower basal energy needs may play a role (Rees, 1993b). Lower energy requirements
for biochemical reactions may result in more energy available for fat storage. In families where food is abundant and physical activity is not encouraged, overweight can result without specific psychological or physiological origins (Rees, 1993b).

**Overweight prevalence, 1988-94.** According to the most recent estimates from NHANES III 1988-94, almost 12% of adolescents 12-17 years of age were overweight using the 95<sup>th</sup> percentile BMI cutoff points (see Table IV-4). Overweight prevalence was similar among males and females, with higher prevalence rates found among Non-Hispanic black and Mexican American adolescents than non-Hispanic white adolescents. In an analysis of NHANES III 1998-91 data using the 95<sup>th</sup> percentile BMI cutoff, 11% of adolescents 12-17 years of age were overweight across race and ethnic groups (see Table IV-5). When overweight was estimated with the 85<sup>th</sup> percentile of BMI, the prevalence of overweight was 22%. Mexican American males had a higher overweight prevalence than non-Hispanic white and black males. Non-Hispanic black females had a higher prevalence of overweight than Mexican-American and non-Hispanic white females.

As suggested by the evidence above, the prevalence of overweight among U.S. adolescents is continuing to increase. The complete NHANES III 1988-94 data indicate generally higher overweight prevalence rates than those found in NHANES III, Phase 1. Increases in overweight prevalence were apparent among males and females across all racial/ethnic groups.

**Trends in overweight prevalence, 1966-91.** Troiano et al. (1995) found that U.S. adolescents have become increasingly overweight since the mid 1960s, with the greatest increases occurring between NHANES II 1976-80 and NHANES III 1988-91 (see Table IV-6). During this time, age-adjusted prevalence rates were higher for black adolescents than for white adolescents using the 85<sup>th</sup> and 95<sup>th</sup> percentile cutoffs. With the 95<sup>th</sup> percentile cutoff, the increase in overweight prevalence was highest among white males (from 5% to 14%) across sex/race groups, and with the 85<sup>th</sup> percentile cutoff, it was highest among black females (from 18% to 30%).

**Energy Balance and Increased Overweight Prevalence**

It has been suggested that the increasing prevalence of excess weight and body fat among U.S. children and adolescents reflects a population shift toward positive energy balance in which energy intake exceeds energy expenditure (National Center for Chronic Disease Prevention and Health, 1997; Troiano et al., 1995). Troiano et al. (1995) indicated that although the reasons for this shift may be difficult to explain, data from national dietary intake surveys suggest that increases in energy intake alone do not explain the increase in overweight prevalence (see Chapter II). It is possible that the increase in the prevalence of overweight among children and adolescents may be more a result of a decrease in physical activity than an increase in energy input (Roberts, 1993).

Nevertheless, current dietary and activity patterns of children and adolescents are believed to contribute to excess weight gain (Christoffel & Ariza, 1998; Troiano et al., 1995; Troiano & Fiegel, 1998). Food is abundant and easily accessible in the United States, thereby increasing the likelihood of overindulgence (Dwyer, 1993). Consumption of fast foods and other away-from-home foods by children and adolescents is frequent and more popular than ever before (see Chapter III). Away-from-home eating is associated with higher energy, fat, and saturated-fat intake than at-home eating (Lin & Guthrie, 1996). Concurrently, contemporary children and adolescents may be more sedentary than those of previous years, leading to energy imbalances (see section on physical activity). This decrease in physical activity may not all be overt. The difference in energy expenditure between sitting and standing is about 0.5 calorie per minute (Mahan & Escott-Stump, 1996). At four hours per day over a 180-day school year, this comes to a difference of more than 21,000 kcal per year, equivalent to 2,400 grams (about 5 lb) of body fat per year.

The increase in overweight prevalence has also been linked with television watching time. It has been difficult, however, to validate that television viewing, as part of a sedentary lifestyle, contributes to the significant overweight problem in children and adolescents today (Robinson, 1998); the contributions of decreased activity, a lower resting metabolic state, and increased caloric intake from snacking during TV watching are difficult to separate. Results from NHANES III 1988-94 indicated that children aged 8-16 years who watched >4 hours of television each day had significantly greater body fat and a greater BMI than those who watched <2 hours per day (Anderson et al., 1998). A similar relationship was reported by Ross & Pate (1987) from a national sample of 6-9-year-old children. Dietz & Gortmaker (1985) found that overweight prevalence increased 2% for each additional hour of television watched per day in adolescents aged 12-17 years. Tucker (1986), on the other hand, found no relationship between television viewing and BMI in a cross-sectional study of high school male adolescents. Robinson et al. (1993) reported only a weak, if any, association between television viewing time and adiposity among females in the sixth and seventh grades.
Klesges et al. (1993) showed that television viewing may increase children's risk for excessive weight by decreasing overall metabolic rates. After watching television for 25 minutes, resting metabolic rates were found to decline by 12% in girls aged 8-12 years of normal weight and 16% in obese girls of this age range.

**PHYSICAL ACTIVITY**

Regular physical activity plays an important role in the health and development of children (Baranowski et al., 1992; Schlicker et al., 1994). The health benefits of regular physical activity during childhood and adolescence are well-documented and include improved strength, endurance, flexibility, weight control, body composition, and cardiorespiratory fitness (Dwyer, 1993; Simons-Morton et al., 1997). Regular exercise also increases self-esteem, helps to maintain appropriate weight, and may lower the risk of osteoporosis and CVD in adulthood (Anonymous, 1996). Physical inactivity is regarded as a major factor contributing to overweight among children and adolescents, and a physically active lifestyle throughout childhood and adolescence may help to establish lifelong patterns of physical activity (Anonymous, 1996).

**Current Recommendations**

A number of reports from federal agencies and other organizations have released guidelines for promoting healthy lifestyles among children and adolescents that include physical activity. In addition, some authoritative organizations have issued dietary recommendations for child and adolescent athletes because they have special nutritional needs.

**General recommendations for physical activity.** There is general consensus among authoritative health organizations that regular physical activity benefits all Americans, including children and adolescents. Most recommendations have emphasized moderate physical activity of at least 30 minutes on most or preferably all days of the week (see Table IV-7). The DGFA (U.S. Department of Agriculture [USDA] and U.S. Department of Health and Human Services [HHS], 1995) have suggested that limiting television watching time may help children to become more physically active. Specific recommendations have been issued by the AAP on the types of activities that will enhance growth and development at various stages of childhood (see Table IV-7). Some authoritative organizations have indicated that parents should regularly provide opportunities for active family play and should serve as role models for their children by participating in regular physical activity themselves.

**Dietary recommendations for child and adolescent athletes.** *Child athletes.* The American Dietetic Association (ADA) (American Dietetic Association, 1996b) has published a timely statement on the specific nutritional needs and concerns of child athletes aged 6-12 years. In this statement, the ADA supports sound dietary practices that promote optimal growth and development while meeting the added requirements of physical activity through organized sports. Among its recommendations are the following:

- Unhealthy nutritional practices (e.g., improper weight management, fluid restriction, and misuse of dietary supplements) should be discouraged.

- Assessment of weight and height should be done regularly by a qualified health professional to ensure that energy and nutrient needs are being met and to determine how growth patterns compare to children of the same age.

- Percent body fat or weight should not be used as a standard for sports participation or to set strict weight requirements. To do so may compromise normal growth and development. The proper use of these measurements is to monitor changes in body composition during training.

- Food choices should provide adequate energy and nutrients to support normal growth and increased energy needs for training. A variety of foods from the major food groups as illustrated in the Food Guide Pyramid should be eaten daily. Food choices should not be restricted because of their energy, sugar or fat content. Complex carbohydrates and moderate amounts of protein and fat should be encouraged to support growth and physical activity.

- Ensuring adequate fluid intake before, during, and after activity is critical. Plain water is the best source of fluid, but sports drinks may be used if exercise lasts more than 90 minutes. Supervision of fluid intake is essential.
<table>
<thead>
<tr>
<th>Organization or Report</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary Guidelines for Americans, 4th ed. (U.S. Department of Agriculture (USDA) and U.S. Department of Health and Human Services (HHS), 1995)</td>
<td>To promote growth and development and prevent overweight, teach children to eat proper foods and to participate in vigorous activity. Limit television time and encourage children to play actively in a safe environment. Try to do 30 minutes or more of moderate physical activity on most, preferably all, days of the week.</td>
</tr>
<tr>
<td>Surgeon General's Report on Nutrition and Health (U.S. Department of Health and Human Services (HHS), 1988)</td>
<td>General recommendations are to participate in 30 minutes or more of moderate physical activity on most, preferably all, days of the week. To prevent overweight, children and adolescents should be encouraged to maintain appropriate levels of physical activity. Qualified health professionals should provide counseling to most overweight children and their families in developing diets that contain adequate but not excessive calories and in suggesting social and physical activities that the child enjoys doing.</td>
</tr>
<tr>
<td>Healthy People 2000 (U.S. Department of Health and Human Services (HHS), Public Health Service, 1990)</td>
<td>• Increase to at least 30% the proportion of people aged 6 and older who engage regularly, preferably daily, in light to moderate physical activity for at least 30 minutes per day (objective 1.3); • Increase to at least 75% the proportion of children and adolescents aged 6-17 who engage in vigorous physical activity that promotes the development and maintenance of cardiorespiratory fitness 3 or more days per week for 20 or more minutes per occasion (objective 1.4); • Reduce to no more than 15% the proportion of people aged 6 and older who engage in no leisure-time physical activity (objective 1.5); • Increase to at least 40% the proportion of people aged 6 and older who regularly perform physical activities that enhance and maintain muscular strength, muscular endurance, and flexibility (objective 1.6); • Increase to at least 50% the proportion of children and adolescents in grades 1-12 who participate in daily school physical education (objective 1.8); and • Increase to at least 50% the proportion of school physical education class time that students spend being physically active, preferably engaged in lifetime physical activities (objective 1.9).</td>
</tr>
<tr>
<td>Diet and Health: Implications for Reducing Chronic Disease Risk (National Research Council, 1989b)</td>
<td>Healthy children should balance food intake with physical activity to maintain appropriate weight.</td>
</tr>
<tr>
<td>NIH Consensus Statement on Physical Activity and Cardiovascular Health (National Institutes of Health Consensus Development Conference on Physical Activity and Cardiovascular Health, 1995)</td>
<td>All Americans should engage in regular physical activity at a level appropriate to their capacities, needs, and interests. Children and adults alike should set a goal of accumulating at least 30 minutes of moderate-intensity physical activity on most and preferably all days of the week.</td>
</tr>
<tr>
<td>Physical Activity and Health: A Report of the Surgeon General (Anonymous, 1996)</td>
<td>People of all ages benefit from regular physical activity. Moderate amounts of daily physical activity are recommended for people of all ages. This amount can be obtained in longer sessions of moderately intense activities, such as brisk walking for 30 minutes, or in shorter sessions of more intense activities, such as jogging or playing basketball for 15-20 minutes. Greater amounts of physical activity are even more beneficial, up to a point. Excessive activity can lead to injuries, menstrual abnormalities, and bone weakening. Weight-bearing physical activity is essential for normal skeletal development during childhood and adolescence and for achieving and maintaining peak bone mass in young adults.</td>
</tr>
<tr>
<td>Organization or Report</td>
<td>Recommendations</td>
</tr>
<tr>
<td>------------------------</td>
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</tbody>
</table>
- All preschool children should participate regularly in a form of physical activity appropriate for their developmental level and physical health status,  
- Emphasis should be placed on promotion of physical activity as a natural and lifelong activity of healthy living.  
- Free play designed to provide opportunities to develop fundamental motor skills and to reach their potential at their own rate is preferable to structured sessions, and,  
- Parents and other family members should be encouraged to serve as role models by participating in regular physical activity themselves. Physical activities that parents can do with young children should be encouraged.  
- Enjoyment of sports and fitness will increase the likelihood of pursuing these activities through adulthood,  
- Children should be allowed to try a variety of sports and to choose those that appeal to them,  
- Unstructured free play should be encouraged to enhance enjoyment of sports and to promote spontaneity and creativity.  
- The preadolescent years should be viewed as a time for teaching fundamental motor skills; developing fitness in a practical, safe, and gradual manner; and promoting desired attitudes and values. |
| American Heart Association (Fletcher et al., 1996) | People of all ages should include physical activity in a comprehensive program of health promotion and disease prevention and should increase their habitual physical activity to a level appropriate to their capabilities, needs, and interests.  
Children must be introduced to the principles of regular physical activity and recreational activities at an early age. Parents must know the health benefits of regular physical activity and how exercise contributes to quality of life, in order to incorporate physical activity into their daily lives and those of their family members. Parents should teach their children that proper physical activity is a fundamental part of normal healthy living. |
| National Association for Sport and Physical Education (National Association for Sport and Physical Education (NASPE), 1998) | Preschoolers  
- An accumulation of more than 60 minutes, and up to several hours per day of age- and developmentally-appropriate activities is encouraged.  
- A variety of physical activities of various levels of intensity is recommended. Some activity each day should last 10-15 minutes or more and include moderate to vigorous activity. This activity will typically be intermittent, involving alternating moderate to vigorous activity with brief periods of rest and recovery.  
- Extended periods of inactivity are not appropriate for normal, healthy children. |

Adolescent athletes. The AAP (American Academy of Pediatrics and Committee on Nutrition, 1993a) and the ADA (American Dietetic Association, 1996a) have issued similar statements on nutritional guidance for adolescent athletes. According to the AAP (American Academy of Pediatrics and Committee on Nutrition, 1993a), a well-balanced diet that provides sufficient nutrients and calories and adequate amounts of foods from the basic food groups is the most effective way to provide optimal nutrition for enhancing athletic performance. Specific guidance was provided that the diet should supply about 55-75% of total energy from carbohydrate, 15-20% from protein, and 25-30% from fat. The ADA (American Dietetic Association, 1996a) encouraged adolescent athletes (aged 13 to 18 years) to follow sound nutrition practices planned around the Food Guide Pyramid that promote healthy growth and development and help to meet the added requirements of sports participation. The training diet should provide about 55-60% of total energy from carbohydrate, 12-15% from protein, and 25-30% from fat. The importance of meeting energy and nutrient needs to achieve maximum performance was emphasized.
Their guidelines also included recommendations to have height and weight measured periodically to assess growth rates and determine adequacy of energy and nutrient intakes.

Adolescent athletes may be at risk of iron deficiency resulting from a cumulative effect of red blood cell destruction, the increased need for red blood cell and tissue synthesis, and poor dietary habits (Spear, 1996). According to the ADA (American Dietetic Association, 1996a), female adolescents are especially susceptible to iron deficiency because they are losing iron through menstruation and may not be eating enough food; thus, it was advised that iron stores be monitored regularly. Further recommendations were given that those with iron-deficiency anemia may require medically supervised supplementation to restore blood values to normal levels. The ADA (American Dietetic Association, 1996a) also emphasized the importance of adequate calcium intake for female athletes to reduce risk of osteoporosis and stress fractures later in life. These recommendations were indicated as being particularly relevant to female athletes who are amenorrheic and have decreased bone mineral content.

Vigorously active adolescent girls may experience delayed menarche or chronic secondary amenorrhea (six or more cycles missed after they are established or no more than one period a year). This results in part from inadequate energy and protein intakes, excessive training, and a thin body type (Dwyer, 1996). Because of these concerns, the AAP Committee on Sports Medicine (American Academy of Pediatrics. Committee on Sports Medicine, 1989) has recommended that, within three years of menarche, amenorrheic female athletes be counseled to decrease activity and improve dietary patterns, especially to obtain more calcium and protein. In addition, the AAP (American Academy of Pediatrics. Committee on Sports Medicine, 1989) advised that all thin female adolescents be counseled to eat a well-balanced diet to avoid amenorrhea.

Another area of nutritional concern is fluid supplementation. The AAP (American Academy of Pediatrics and Committee on Nutrition, 1993a) has recommended that drinking cold water or water with simple sugars or glucose polymers is the best method to restore fluid losses because these liquids are most rapidly absorbed. During exercise, drinking about 100-250 ml every 15 minutes was suggested. The use of salt supplements was discouraged because the diet almost always provides adequate salt to replace these losses. In its recommendation, the ADA (American Dietetic Association, 1996a) advised that active adolescents should consume adequate fluids before, during, and after their activities to avoid dehydration. Plain water was recommended as the best source of fluid replacement for activity lasting less than an hour, and sports drinks were recommended for exercise lasting longer than an hour or performed in high temperature and humidity. The ADA (American Dietetic Association, 1996a) advised against fluid restriction or the use of salt tablets, diuretics, laxatives or any other practices that promote dehydration because these practices may adversely affect electrolyte balance and have serious consequences on health and athletic performance.

The weight-loss strategies used to achieve a perceived “ideal” body weight for competition are of concern to both the AAP and ADA. Fasting and food restriction, practices commonly used to induce rapid weight loss, may cause fatigue, dehydration, nutrient inadequacies, and impaired growth as well as amenorrhea in females. The AAP (American Academy of Pediatrics. Committee on Nutrition, 1993a) has advocated that if weight loss is indicated, it should be achieved by reducing body fat and increasing physical activity, not by restricting food intake. Rapid weight loss may result in loss of muscle mass which will adversely impact performance. Obsessive preoccupations with body weight and food may lead to eating disorders such as anorexia nervosa and bulimia nervosa (see following section). The ADA (American Dietetic Association, 1996a) has indicated that educating coaches, parents, and athletes about the consequences of extreme weight loss practices and recognition of eating disorders should be encouraged.

Both organizations recognize that young athletes are vulnerable to misinformation about nutrition because of their desire to do anything to gain a competitive edge. As a result, they are prone to take dietary supplements for which performance-enhancing properties are claimed. According to the ADA (American Dietetic Association, 1996a), no scientific data exists to support use of ergogenic substances, such as amino acids, protein mixtures, and chromium, to enhance athletic performance. The indiscriminate use of vitamin, mineral, or other dietary supplements may not only impair performance but also result in serious health consequences.

Physical Activity Patterns
There is a lack of valid instruments for measuring physical activity patterns in children and adolescents (Pate, 1993; Simons-Morton et al., 1997). Objective measures such as direct observation, motion sensors, and heart rate monitors are useful for assessing the activity of small numbers of subjects but have limitations. Direct observation is costly in terms of investigator and observer time (Pate, 1993). Motion sensors and heart rate monitors are less costly than direct observation, but are inclined
to have technical problems and provide no information on specific activities or the context in which activities are performed (Pate. 1993). Self-reports or proxy reports are relatively inexpensive to implement and tend to be more practical for assessing the activity levels of large numbers of children; however, their validity is limited by the ability of the subject to recall behavior accurately (Pate, 1993; Sallis, 1991; Simons-Morton et al., 1997).

**Children 5-12 years.** Few data exist on the physical activity patterns of schoolchildren. Using a personal interview format, Simons-Morton et al. (1997) found that an average of 120 minutes per day was spent in sedentary activity in a multi-ethnic group of third graders. About half of this time was spent doing homework, artwork, or reading, and the other half was spent doing leisure activities such as television watching, playing video games, and listening to music. Boys reported significantly more minutes of sedentary activity than girls, and no differences were observed across race and ethnic groups. An average of 55 minutes of moderate activity and 35 minutes of vigorous activity was reported. Boys spent significantly more minutes of vigorous activity than girls, and whites reported more vigorous activity than blacks and Hispanics. About twice as much time was spent in vigorous activity at home than at school. These patterns of physical activity are consistent with findings from the National Children and Youth Study (Ross & Gilbert, 1985).

**Adolescents 12-20 years.** Data from the 1993 Youth Risk Behavior Surveillance System (YRBSS) suggest that participation in vigorous physical activity by high school students nationwide is approaching the goals set in *Healthy People 2000* (Kann et al., 1995). Two-thirds (66%) of the students reported that they exercised vigorously for at least 20 minutes on three or more of the seven days preceding the survey, with males (75%) being more likely to report vigorous physical activity than females (56%). Non-Hispanic white male students (76%) were more likely than non-Hispanic black (71%) and Hispanic (69%) male students to report participation in vigorous physical activity, and non-Hispanic white female students (59%) were more likely than non-Hispanic black (49%) and Hispanic (50%) female students to report such activity. Declines in vigorous activity were noted with each subsequent year of high school; 81% of males and 68% of females in grade 9 reported that they exercised vigorously on 3 or more days in the past week compared with 70% of males and 45% of females in grade 12.

The 1990 YRBSS survey showed that only 50% of male high school students and 25% of female high school students reported vigorous physical activity on three or more days per week (Heath et al., 1994). Similar patterns of vigorous physical activity were found when comparing students by sex and racial/ethnic groups. Declines in vigorous activity were also noted with each advancing grade level.

**Factors Influencing Physical Activity Patterns**

Many waking hours of children in this country are spent in sedentary activities such as watching television and playing computer and video games (Gutin & Manos, 1993; Robinson, 1998; Schlicker et al., 1994). In an analysis of NHANES III 1988-94 data, Anderson et al. (1998) found that 26% of the 4,063 8-16-year-old children surveyed watched 4 or more hours of television per day, with two-thirds watching at least two hours per day. Shannon et al. (1991) found that children who watched more television spent less time exercising than those who watched less television.

A decrease in physical activity as part of the school curriculum may also be responsible for the relatively low physical activity levels of school-age children. Data from the 1990 YRBSS showed that enrollment in high school physical-education classes decreased from 65% in 1984 to 52% in 1990 (Heath et al., 1994). Decreases in enrollment have been attributed in part to budget cuts for school sports programs and for recreational activities in community centers. Furthermore, with two working parents, there may be less time for free or spontaneous play (Gutin & Manos, 1993). Safety issues may also play a role, especially for children living in urban areas (Gutin & Manos, 1993).

**DIETING AND WEIGHT CONTROL**

Although reducing overweight prevalence among U.S. children and adolescents is a public health problem in this country, the weight control practices that children and adolescents follow to lose weight or control weight gain are a major concern, particularly when such practices are unwarranted. Restricting dietary intakes unnecessarily during childhood and adolescence denies the growing body essential nutrients at a time when needs are high (Hill & Oliver, 1992).

**Current Recommendations**

General recommendations are provided in the 1995 DGFA to prevent overweight among children and adolescents (see Appendix C). These recommendations include teaching children to eat proper foods, encouraging them to participate in
regular physical activity, and limiting television time. The DGFA acknowledged that limiting fat intake may help to prevent excess weight gain, but stated that dietary fat should not be restricted in the diets of children younger than 2 years of age. Modest reductions in dietary fat were indicated as being a safe measure to prevent excess weight gain and help overweight children achieve a healthy weight; however, it was recommended that major changes in diet be accompanied by regular monitoring of growth by a health professional to ensure proper growth. In the Surgeon General’s Report on Nutrition and Health (U.S. Department of Health and Human Services [HHS], 1988) it was stated that most overweight children and their families should be provided with counseling to help them follow diets containing adequate but not excessive calories and participate in physical activities that the child enjoys.

Promoting sound weight control practices among overweight adolescents is a national health objective of Healthy People 2000 (U.S. Department of Health and Human Services [HHS], 1997; U.S. Department of Health and Human Services [HHS], Public Health Service, 1990). The goal of this objective is to increase to at least 50% the proportion of overweight people aged 12 and older who have adopted sound dietary practices combined with regular physical activity to attain an appropriate body weight (see Appendix C). To date, no baseline or update data are available to monitor progress toward this goal (U.S. Department of Health and Human Services [HHS], 1997).

**Dieting and Weight Control Practices**

It is well known that dieting is a common practice among adolescent females (Moore, 1988). Increasing evidence, however, suggests that motivations to diet and undue anxiety about body weight and size surface as early as the preadolescent years (Hill & Oliver, 1992; Maloney et al., 1989; Moore, 1988; Richards et al., 1990).

**Children 5-12 years.** A number of studies have reported that concerns about weight and eating are apparent as early as the preadolescent years. Moore (1988) concluded that concerns about weight are already evident by the age of 12 years. Richards et al.(1990) showed that preoccupations with food and dieting begin in the fifth and sixth grades. Maloney et al.(1989) found that 41% of girls and 31% of boys in grades 3-6 reported that they tried to lose weight. Attempts at weight loss were found to increase with grade level for girls but not for boys; 28% of third grade girls reported that they tried to lose weight by dieting compared with 60% of girls in the sixth grade. Maloney et al.(1989) also reported that girls were more likely than boys to aspire to be thinner, and that this desire to be thinner increased with grade level as well; 30% of the third grade girls expressed such desires compared with nearly 80% of the sixth grade girls. Although these desires to be thinner may be apparent, whether prepubertal girls consistently act upon their desires to be thinner by restricting caloric intake is still unclear (Striegel-Moore et al., 1995).

The reasons why preadolescent children are motivated to diet are not well documented. Hill & Oliver (1992) found that some 9-year-old girls, like adults, share discontents with body shape or weight and act upon these dissatisfaction by dieting. The motivation to diet among many of the girls studied appeared to have more to do with their perceived body weight than with their actual weight. Hill & Oliver (1992) proposed that children become exposed to adult prejudices against body fatness and obesity at an early age and adopt them as their own. Feldman et al.(1988) concluded that children acquire a dislike of the obese body by 6 to 9 years of age, and by the age of 7, or possibly earlier, they have acquired some adult cultural perceptions of physical attractiveness. Because the drive for thinness appears to be a common concern among preadolescents, Maloney et al. (1989) concluded that there is a need to investigate the early development of dieting behavior and atypical eating attitudes in young children. Such information will help to understand when to intervene with those who appear to display abnormal eating behaviors and attitudes toward food and weight.

**Adolescents 12-20 years.** Chronic dieting is a common practice among adolescent females in the United States. Preoccupation with dieting and weight increases with age, a relationship believed to be triggered by the rapid increase in body fat occurring during sexual maturation (Kilien et al., 1992; Richards et al., 1990). As a result of the many physiological and psychosocial changes experienced at this time, female adolescents often develop feelings of self-consciousness over their changing body size and shape, a distorted body image, inaccurate perceptions of being overweight, dissatisfaction with body weight, and desires to be thinner (Blyth et al., 1985; Desmond et al., 1986; Dombusch et al., 1984).

Undue attention to body size may increase the incidence of unnecessary weight loss efforts (Maloney et al., 1989). A distortion of body image may contribute, at least in part, to abnormal eating attitudes (Halmi et al., 1977; Horne et al., 1991; Storz & Greene, 1983) and food aversions associated with potentially harmful eating behaviors (Moore, 1993). Given certain emotional
or environmental circumstances, abnormal eating attitudes and behaviors may place adolescents at risk for the development of eating disorders (see section E).

**Self-perception of body weight.** Dissatisfaction with body weight is widespread among adolescent females, with much of it fueled by cultural ideals of thinness (Moore, 1993). Moore (1988) found that more than half of normal-weight and 16% of underweight girls expressed desires to lose weight. Dissatisfaction with body weight is also common among adolescent males, but they are more likely to want to gain weight than lose weight (Moore, 1990).

Results from the 1993 YRBSS have suggested that non-Hispanic white female adolescents tend to be less satisfied with their weight than Hispanic and black, non-Hispanic adolescent females (Kann et al., 1995). Many reports have confirmed these findings and have also shown that white female adolescents are less accepting of being overweight and experience more social pressure to be thin than their black counterparts (Abrams et al., 1993; Desmond et al., 1989; Emmons, 1992; Harris et al., 1991; Rand & Kuldau, 1990; Rucker & Cash, 1992).

**Weight loss practices.** Drive for thinness is a major reason why adolescent females diet (Polivy and Herman, 1993; Striegel-Moore et al., 1995). Aspirations of a thin body ideal, extreme anxiety about becoming fat, and excessive importance placed on thinness are characteristic of this phenomenon (Striegel-Moore et al., 1995). By early adolescence, drive for thinness has been described as a common motivational factor to diet among white adolescent females (Koff & Rierdan, 1991; Paxton et al., 1991; Story et al., 1991; Wardle & Marsland, 1990; Whitaker et al., 1989).

Those who diet usually begin during early adolescence. Whitaker et al. (1989) and Schleimer (1983) found that about half of all the teenage girls studied started dieting by age 15. Maloney et al. (1989) found that 60% of the 12-year-old females they studied reported attempts at weight loss. Adolescent girls who diet are more likely to be white than black (Abrams et al., 1993; Desmond et al., 1989; Emmons, 1992; Harris et al., 1991; Klem et al., 1990; Rand & Kuldau, 1990; Rucker & Cash, 1992; Story et al., 1991), be of a higher rather than lower socioeconomic status (Klem et al., 1990; Story et al., 1991), and have a poor body image and low self-esteem (Grant & Fodor, 1986; Moore, 1993; Richards et al., 1990).

Of special concern is the relatively high percentage of adolescent females who diet but do not need to do so. A small study conducted several decades ago indicated that 46% of adolescent females with below average body fat tried to lose weight (Dwyer et al., 1967). More recently, Moore (1988) found that 31% of adolescent females of average weight had dieted, and Desmond et al. (1986) reported that 55% of normal-weight freshman high school females had attempted to lose weight in the past six months. Richards et al. (1990) found that eighth- and ninth-grade females who reported greater weight and eating concerns spent more time alone and less time with friends and in social activities. These patterns of social isolation are similar to those occurring in persons with eating disorders.

Adolescent males typically have fewer weight and eating concerns than female adolescents, and their attempts at weight loss are also less frequent. Kann et al. (1995) found that only 23% of male high school students were currently trying to lose weight compared with 59% of high school females. Various researchers have found that the most common reasons why adolescent females dieted were that they felt overweight, they wanted to look better, or they felt peer or family pressure to diet (Dwyer et al., 1967; Schleimer, 1983). Whitaker et al. (1989) found that boys were more interested in gaining weight and building muscle mass than in dieting. Regarding the specific methods used by adolescents to lose weight, data from the 1991 YRBSS showed that high school females were more likely than their male counterparts to report that they dieted and exercised to lose weight or to keep from gaining weight, whereas high school boys were more likely to report that they exercised without dieting to lose weight or to keep from gaining weight (Life Sciences Research Office, 1995). Dwyer et al. (1967) found that adolescents frequently reported that they eliminated certain foods or snacks from their diet and sometimes reported that they ate smaller meals, skipped meals completely, eliminated peer-group snacking, or fasted. Crash dieting (Greenfeld et al., 1987), fasting (Whitaker et al., 1989), and the use of diet pills (Greenfeld et al., 1987; Moore, 1988; Whitaker et al., 1989) have been reported as being more common among female than male adolescents. A number of researchers have reported that diuretic and laxative use was uncommon among adolescent girls (1-6%) and boys (1%); however, girls who are overweight and are dissatisfied with their body weight may be more likely to use these drugs than are girls who are not overweight and are satisfied with their body weight (Greenfeld et al., 1987; Moore, 1988, 1990; Whitaker et al., 1989).
EATING DISORDERS

Eating disorders such as anorexia and bulimia occur most frequently in young females, suggesting that physical and emotional changes related to maturation may be involved (Richards et al., 1990). Restrictive dieting typically precedes the onset of an eating disorder, although only a small percentage of those who diet develop eating disorders (Hill & Oliver, 1992; Striegel-Moore, 1993). As stated in the ADA’s position on nutrition invention in the treatment of anorexia nervosa, bulimia nervosa, and binge eating, eating disorders involve “two sets of issues and behaviors: those directly relating to food and weight and those involving the relationships with oneself and with others” (American Dietetic Association, 1994b). Thus, treatment of eating disorders should include both nutritional and psychological therapy.

Anorexia Nervosa

Anorexia nervosa usually occurs in females at the onset of puberty, perhaps because of maturation conflicts or changes in hormonal levels (Crisp, 1984; Garner & Garfinkel, 1980). Its incidence has been estimated to be as high as 1% among middle- and upper-middle-class adolescent girls (Pertschuk, 1993). Approximately 5-10% of anorectics are males (Rees, 1993b). The mortality rate has been estimated at 1-5% (Pertschuk, 1993), although it may be as high as 10% (American Academy of Pediatrics. Committee on Nutrition, 1993b).

Diagnosis. The diagnostic criteria for anorexia nervosa, as defined in the Diagnostic and Statistical Manual of Mental Disorders, are refusal to maintain body weight at or above a minimally normal body weight (e.g., weight loss leading to maintenance of body weight <85% of that expected, or failure to make expected weight gain during period of growth, leading to body weight <85% of that expected); intense fear of gaining weight or becoming fat even though underweight; disturbance in the way one’s body weight or shape is experienced; undue influence of body weight or shape on self-evaluation, or denial of the seriousness of having a low body weight; and amenorrhea in postmenarchal women (i.e., the absence of at least three consecutive menstrual cycles) (American Psychiatric Association, 1994). Self-induced vomiting and use of cathartics may occur, but these practices are usually more common in patients with bulimia (American Academy of Pediatrics . Committee on Nutrition, 1993b).

Treatment recommendations. The AAP (American Academy of Pediatrics. Committee on Nutrition, 1993a, b) has identified anorexia nervosa as a major nutrition-related health problem of adolescents, with psychiatric management recommended as critical in its treatment. The need for nutritional intervention via enteral or parenteral feeding was determined as being essential when further weight loss becomes dangerous to survival (American Academy of Pediatrics. Committee on Nutrition, 1993b).

The ADA (American Dietetic Association, 1994b) has issued a more comprehensive statement for the treatment of anorexia nervosa, although specific treatment guidelines were not provided for adolescents with this disorder. In its position, nutrition education and nutritional intervention should be integrated into a multidisciplinary team approach when treating patients with anorexia nervosa. Psychotherapy and medical nutrition therapy were considered critical throughout the entire recovery process. It was stated that some persons with anorexia nervosa may require hospitalization or residential treatment to provide a safe, controlled environment for initiating or reestablishing medical, psychological, and nutritional intervention. The nutritional care plan should specify parameters of nutritional rehabilitation and may outline such things as daily caloric intake, rate of weight gain, weight range goal for discharge, whether supervision is required during meals and immediately thereafter, and limits on activity.

Bulimia Nervosa and Binge Eating

Bulimia nervosa is another serious eating disorder characterized by recurrent episodes of binge eating, feelings of lack of control over eating, and recurrent inappropriate compensatory behavior after binging to prevent weight gain (e.g., self-induced vomiting, laxative or diuretic abuse, fasting, and excessive exercise) (American Psychiatric Association, 1994). It usually does not lead to severe malnutrition as seen in anorexia nervosa (Mahan & Escott-Stump, 1996). Like persons with anorexia nervosa, those with bulimia experience a distorted body image, isolation, and depression (American Academy of Pediatrics. Committee on Nutrition, 1993b). Weight is generally maintained at close to normal weight. The disorder becomes serious when the bulimic activities become obsessive and interfere with daily living.

Bulimic and binge eating practices. Although the prevalence of bulimia peaks during the early twenties, it may occur from the preteen years to middle age (Pertschuk, 1993). Several studies have reported that about 10% of adolescent females may...
induce vomiting to control weight (Greenfeld et al., 1987; Moore, 1988; Whitaker et al., 1989). The practice is less common among adolescent males (1-2%) (Greenfeld et al., 1987; Whitaker et al., 1989), except among those who are wrestlers (Moore, 1990).

Various reports have indicated that up to 45% of adolescent females and 33% of adolescent males participate in binge eating (Greenfeld et al., 1987; Whitaker et al., 1989). Whitaker et al. (1989) found that males were more likely to participate in large and frequent binges than females. Moore (1990) reported that males who wrestled and played basketball were more likely to engage in binge eating than those who played other sports. Moore (1993) indicated that binge eating may be a normal adolescent behavior when not accompanied by other symptoms; however, if frequent binge eating is accompanied by binge distress (i.e., emotional disturbance following a binge), there may be cause for concern. Johnson et al. (1984) and Moore (1988) reported that almost one-fourth (21-23%) of adolescent females reported weekly binge-eating episodes. Crowther & Cherryk (1986) found that less-heavy girls were more likely than less-heavy boys to binge alone and to report distress after a binge. Moore (1988, 1990) noted that the incidence of binge drinking was greater among adolescent males and females with a history of binge eating. Whether the association between binge eating and binge drinking in both sexes reflects a sign of pathology or normal adolescent behavior is not clear (Moore, 1993).

**Treatment Recommendations.** The AAP (American Academy of Pediatrics. Committee on Nutrition, 1993b) has acknowledged that the nutritional management of bulimia is not as extensive as that for anorexia nervosa unless the two conditions coexist. The ADA (American Dietetic Association, 1994b) has recommended a similar medical, psychological, and nutritional intervention plan for treatment of bulimia nervosa and binge eating to that recommended for anorexia nervosa, although it was indicated that outpatient treatment may be sufficient for the recovery of most persons with these two eating disorders. Neither organization has offered treatment recommendations specific for adolescents with bulimia nervosa or binge eating.

**VEGETARIANISM**

Vegetarians consume a plant-based diet that may or may not include animal products (American Academy of Pediatrics. Committee on Nutrition, 1993b; American Dietetic Association, 1997). Lacto-ovo vegetarian diets, for example, include milk and eggs but not animal flesh. Vegan diets consist of no animal products. In addition, a number of nontraditional vegetarian diets, such as Zen macrobiotic diets, rastafarian diets, and fruitarian diets, have evolved over the years (American Academy of Pediatrics. Committee on Nutrition, 1993e). Although these diets are essentially modified forms of more traditional vegetarian diets, they restrict many foods in their most rigorous forms. Persons following these “new” vegetarian diets often regard vitamin and mineral supplement use as unnecessary and are alienated from or reject the use of orthodox health care (Dwyer et al., 1983; O'Connell et al., 1989).

Children often follow vegetarian diets, sometimes from infancy, because their parents are vegetarian. The greater the restriction of animal products in the diet, the more vegetarian diets must be planned to ensure proper energy and nutrient intake (American Dietetic Association, 1997b). When attention to appropriate meal planning is lacking, as may be the case with extremely restrictive diets, the nutritional consequences can be especially hazardous for children (Sanders & Reddy, 1994). In general, nutritional concerns center around adequate intakes of vitamin B12, vitamin D, iron, calcium, and zinc. Other concerns about vegetarian diets for children are that they typically contain liberal amounts of dietary fiber, are bulky, and are not energy-dense; thus, the potential exists that inadequate energy intake may be consumed. In addition, sufficient amounts of bioavailable minerals such as iron, zinc, and calcium may not be obtained with diets containing excessive dietary fiber. Vegetarian diets also contain large amounts of phytates and oxalates which form insoluble compounds with minerals and reduce their availability for absorption (Institute of Medicine., 1997).

**Current Recommendations**

The 1995 DGFA is the only federally sponsored report that provides specific dietary recommendations for children following vegetarian diets (see Table IV-8). Both the AAP and the ADA identify infants, children, and adolescents who follow vegan or vegan-like diets as a group with special nutritional needs and provide similar dietary guidelines for ensuring nutritional adequacy (see Table IV-8).
<table>
<thead>
<tr>
<th>Organization or Report</th>
<th>Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dietary Guidelines for Americans, 4th ed. (U.S. Department of Agriculture (USDA) and U.S. Department of Health and Human Services (HHS), 1995)</td>
<td>Vegetarians, in general, should pay special attention to the iron, zinc, and B-vitamin content of their diets because these nutrients are not supplied in adequate amounts by plant foods. Vegans must supplement their diets with a source of vitamin B12 because the only food sources of this vitamin are animal products. Vegan diets, particularly those of children, require care to ensure adequacy of vitamin D and calcium, which nonvegetarians obtain from milk products.</td>
</tr>
<tr>
<td>Diet and Health: Implications for Reducing Chronic Disease Risk (National Research Council, 1989b)</td>
<td>No specific recommendations for infants, children, or adolescents.</td>
</tr>
<tr>
<td>AAP (American Academy of Pediatrics. Committee on Nutrition, 1993e)</td>
<td>Providing calorie-dense foods at the time of weaning is critical so the increased bulk of vegetarian diets does not interfere with adequate energy, protein, and nutrient intake. Toddlers must also be given calorically dense foods to ensure adequate caloric, protein, and nutrient intake. Encouraging a wide variety of foods is important. It is important that, as older children and adolescents become more responsible for their own food choices, they understand basic principles of food selection. Areas of nutritional concern are inadequate intakes of energy, protein, vitamin B12, vitamin D, riboflavin, iron, calcium, zinc, and excessive dietary fiber intakes. Appropriate education for families pursuing vegetarian lifestyles is probably the best insurance that the child will receive adequate intake of nutrients to ensure proper growth and development.</td>
</tr>
<tr>
<td>ADA (American Dietetic Association, 1997b)</td>
<td>Vegetarian infants who are exclusively breast-fed should have iron supplements after the age of 4 to 6 months, and, if exposure to sunlight is limited, a source of vitamin D. Breast-fed infants should receive vitamin B12 supplements if the mother’s diet is not fortified. Dietary fat should not be restricted in the diets of children &lt;2 years of age. For older children, include some foods higher in unsaturated fats (e.g., nuts, seeds, nut and seed butters, avocado, and vegetable oils). All vegan children should have a reliable source of vitamin B12, and if sun exposure is limited, vitamin D supplements or fortified foods should be used. Foods rich in calcium, iron, and zinc should be emphasized. Frequent meals and snacks and the use of some refined foods and foods higher in fat can help vegetarian children meet energy needs. For athletic adolescents, special attention should be given to meet energy, protein, and iron needs. To maintain normal menstrual cycles, increase energy and fat intake, reduce fiber, and reduce strenuous training. In general, the diet should consist of a variety of foods, including whole grains, fruits, vegetables, legumes, nuts, seeds, and if desired, eggs and dairy products.</td>
</tr>
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Evidence Relating Vegetarianism and Health

Infants and children 1-5 years. Infants less than 2 years of age who are reared on restrictive vegetarian diets, particularly macrobiotic diets, are at greatest risk for overt nutritional deficiencies and growth faltering caused by inappropriate dietary restrictions and are particularly vulnerable during the weaning period (American Academy of Pediatrics. Committee on Nutrition, 1993e; Van Dusseldorp et al., 1996). Nutritional risk is high during early childhood because this is a period of accelerated growth (Sanders & Reddy, 1994).

Severe malnutrition and low intakes of vitamin D, vitamin B12, iron, calcium, and zinc have been reported in toddlers fed inappropriate vegetarian diets (Campbell et al., 1982). Several studies have found lower growth rates in preschool children on severely restricted vegetarian diets (Dagnelie et al., 1988; Dwyer et al., 1983; Shull et al., 1977). Lower growth rates were also reported by O’Connell et al. (1989) in a group of vegan preschool children living in a collective community in Tennessee. Otherwise, the growth of preschool children following vegan diets has been found to be similar to that of omnivorous children when meal planning is adequate (Hebert, 1985). Sanders & Reddy (1994) attributed lower growth rates observed in some vegetarian children less than 5 years of age to low energy intakes. The high bulk and low-energy density of some vegetarian diets, combined with a limited stomach capacity, restricts the amount of food that very young children can consume, thereby contributing to inadequate energy intakes (American Academy of Pediatrics. Committee on Nutrition, 1993e; American Dietetic Association, 1997b; Sanders & Reddy, 1994).

Children 5-12 years. From a growth standpoint, older vegetarian children do not have the same nutritional risks as younger children (American Academy of Pediatrics. Committee on Nutrition, 1993e). O’Connell et al. (1989) found that vegan children up to 10 years of age who were raised in a commune had similar heights and weights as non-vegetarian children when meal planning was adequate. Although mean heights and weights for age were slightly less than the median of the reference population across age groupings (ages 5-6, 7-8, and 9-10 years), the smallest height and weight differences were apparent among children 9-10-years-old. Similar growth patterns have also been found among Seventh-day Adventist (SDA) lacto-ovo vegetarian schoolchildren (Sabaté et al., 1991; Tayler & Stanek, 1989) and among vegetarian schoolchildren from various Asian ethnic minorities in Britain (Rona et al., 1987) when compared with their meat-eating counterparts. Several studies have shown that children who were raised on nutritionally inadequate vegetarian diets and suffered growth deficits in the first five years of life usually experienced catch-up growth by about age 10 (Dagnelie et al., 1988; Sanders & Manning, 1992). Sanders & Reddy (1994) attributed this rebound in growth to the fact that children at this age are more in control of their food choices and more able to obtain foods on their own than younger children.

Adolescents 12-20 years. Growing adolescents may have difficulties meeting their energy and nutrient requirements because many vegetarian diets are high in bulk and low in fat (Gong & Heald, 1994). Various researchers have found that age of menarche is delayed in Seventh Day Adventist girls raised on vegetarian diets (Kissinger & Sanchez, 1987). Sanders & Reddy (1994) concluded that this would be expected because vegetarian children tend to weigh less than their meat-eating counterparts, and because weight, particularly with respect to body fat, is a good predictor of the time of sexual maturation. Menstrual irregularities may be more common in vegetarian than nonvegetarian premenopausal women in general, and may be attributed to differences in diet and nutrient intakes (Pedersen et al., 1991).

Findings from Neumark-Sztainer et al. (1997) suggest that vegetarian adolescents may be at higher risk for eating disorders than nonvegetarian adolescents. In their study consisting predominantly of white high school students enrolled in public schools in nonurban Minnesota, vegetarians (of which 81% were females) were found to be about twice as likely to report frequent dieting, four times as likely to report intentional vomiting, and eight times as likely to report laxative use than nonvegetarian adolescents. Although similar investigations with adolescents matched for sociodemographic variables have not been conducted to confirm these findings, a recent study by Janelle & Barr (1995) with adult women aged 20-40 years found that vegetarians had lower dietary restraint scores than nonvegetarians, suggesting that vegetarians were not at higher risk for disordered eating behaviors. Neumark-Sztainer et al. (1997) concluded that despite differences between these studies, vegetarian adolescents may be different than adult vegetarians, but that further research would be necessary to confirm this assumption.
ADOLESCENT PREGNANCY

The nutrient needs of pregnant adolescents are particularly high. Pregnant adolescents are not only supporting the nutritional needs of their growing and developing fetus, but are also continuing to grow and develop themselves. According to the ADA (American Dietetic Association, 1994a), pregnant adolescents have unique biological, psychosocial, and developmental vulnerabilities that place them at nutritional risk. Typical female adolescent diets are often inadequate in some essential nutrients, notably iron and calcium, and in total energy (see Chapter II). The nutritional risks to the young woman and her fetus can be further compromised by poverty and by smoking and alcohol and substance abuse (American Dietetic Association, 1994a). Compared with infants born to nonadolescent women, infants born to adolescent females are more likely to be born premature and of low birth weight, require intensive hospital care, suffer physical problems, or die at birth or shortly thereafter (American Dietetic Association, 1994a).

Current Recommendations

A number of federally sponsored reports and professional organizations concerned with maternal and child health have issued recommendations regarding energy and nutrient intake and supplement use during pregnancy (see Table IV-9). Although most statements are targeted to pregnant women in general, some organizations such as the AAP (American Academy of Pediatrics. Committee on Nutrition, 1993a) and the ADA (American Dietetic Association, 1994a) have specific dietary recommendations for pregnant adolescents (see Table IV-9).

Energy requirements increase by approximately 300 kcal per day during the second and third trimesters of pregnancy and by 500 kcal per day during lactation (National Research Council. Subcommittee on the Tenth Edition of the RDAs. Food and Nutrition Board, 1989a). The RDA for protein increases by 10 g per day during pregnancy and increases during lactation by 15 g/day for the first six months and by 12 g/day for the second six months (National Research Council. Subcommittee on the Tenth Edition of the RDAs. Food and Nutrition Board, 1989a). The Adequate Intake (AI) of calcium for pregnant adolescents is 1,300 mg/day (Institute of Medicine, 1997). Some evidence suggests that higher calcium intakes during adolescent pregnancy may be desirable. In a randomized study where pregnant adolescents were given 2,000 mg supplemental calcium or a placebo (in addition to 1,200 mg/day dietary calcium), the supplemented group had a lower incidence of premature deliveries and low-birth-weight babies (Villar & Repke, 1990). The RDA for iron is 15 mg/day for adolescent girls and adult women (National Research Council. Subcommittee on the Tenth Edition of the RDAs. Food and Nutrition Board, 1989a). During pregnancy, the RDA for both groups increases to 30 mg/day, an amount that usually must be obtained through supplementation. In its recently released report on preventing and controlling iron deficiency in the U.S., the CDC (CDC, 1998) issued specific recommendations for primary prevention of iron deficiency during pregnancy (see Table IV-9).

Recommendations for total weight gain during pregnancy have been issued by the Institute of Medicine (Institute of Medicine. Subcommittee on Nutritional Status and Weight Gain During Pregnancy, 1990b). It is recommended that adolescents strive for gains at the upper end of the recommended ranges (see Table IV-9).

Nutrient Intakes and Supplement Use

NHANES III 1988-91 nutrient data from pregnant women showed that mean intakes from food of most vitamins meet at least 100% of the 1989 RDA except for vitamin B6 and folate (Life Sciences Research Office, 1995). For minerals, mean daily intakes of calcium (1,064 mg), magnesium (285 mg), and zinc (11 mg) from food approached the 1989 RDA, and mean iron intakes (14 mg) met about one-half the 1989 RDA. Data on the nutrient intakes of pregnant adolescents were not available from this source.

Vitamin-mineral supplement use appears to be common among pregnant women in the United States. Nearly two-thirds (65%) of the pregnant women in NHANES III 1988-91 reported using a vitamin-mineral supplement in the past month (Life Sciences Research Office, 1995). The 1980 National Natality Survey found that about 92% of the 7,825 married mothers studied took vitamin supplements during pregnancy (Institute of Medicine. Subcommittee on Nutritional Status and Weight Gain During Pregnancy, 1990a).
<table>
<thead>
<tr>
<th>Organization or Report</th>
<th>Recommendations</th>
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| Dietary Guidelines for Americans, 4th ed. (U.S. Department of Agriculture (USDA) and U.S. Department of Health and Human Services (HHS), 1995)                                                                 | In general, iron supplements are recommended during pregnancy. Pregnant women should not drink alcoholic beverages at all.  
No specific recommendations for pregnant adolescents.                                                                                                                                                                                                                                  |
| Surgeon General's Report on Nutrition and Health (U.S. Department of Health and Human Services (HHS), 1988)                                                                 | In general, pregnant women should receive iron supplements when iron stores are low and avoid drinking alcohol.  
No specific recommendations for pregnant adolescents.                                                                                                                                                                                                                                                                 |
| Healthy People 2000 (U.S. Department of Health and Human Services (HHS). Public Health Service, 1990)                                                                 | Increase calcium intake so at least 50% of pregnant and lactating women consume 3 or more servings daily of foods rich in calcium.  
A reduction of iron deficiency can be achieved by adequate supplementation of iron during pregnancy.  
No specific recommendations for pregnant adolescents.                                                                                                                                                                                                                                  |
| CDC (Centers for Disease Control and Prevention (CDC), 1998)                                                                                       | Primary prevention of iron deficiency during pregnancy includes adequate intake of dietary iron and iron supplementation (oral doses of 30 mg/day). Consumption of foods that enhance iron absorption is encouraged.                                                                                                                                                  |
| Diet and Health: Implications for Reducing Chronic Disease Risk (National Research Council, 1989b)                                                                                            | In general, pregnant and breastfeeding women need more of certain nutrients, especially iron, folic acid, and calcium. Alcoholic beverages should be avoided during pregnancy.  
No specific recommendations for pregnant adolescents.                                                                                                                                                                                                                                  |
| Institute of Medicine (Institute of Medicine. Subcommittee on Nutritional Status and Weight Gain During Pregnancy, 1990)                                                                           | Recommended total weight gain ranges for pregnant women by prepregnancy BMI:  
BMI < 19.8, 12.5-18 kg (28-40 lb)  
BMI 19.8-26.0, 11.5-16 kg (25-35 lb)  
BMI > 26.9-29.0, 7-11.5 kg (15-25 lb)  
Young adolescents should strive for gains at the upper end of the recommended ranges.                                                                                                                                                                                                 |
| AAP (American Academy of Pediatrics. Committee on Nutrition, 1993a)                                                                             | Inadequate intakes of calcium, vitamins A and C, folate, iron, and zinc (nutrients most frequently reported to be inadequate in female adolescent diets) may have deleterious effects on pregnancy outcomes. Skipping meals, especially breakfast, should be avoided. Pregnant teenagers who are strict vegetarians may also have less than adequate intakes of protein, riboflavin, vitamin B12, vitamin D, and trace minerals. Vitamin and mineral supplementation is indicated for those who habitually consume poor diets. Folate and iron supplementation should be routinely prescribed.  
Counseling as to proper diet and on the adverse effects of alcohol, smoking, and drugs on pregnancy outcome should be provided. Ensure proper weight gain.                                                                                                                                 |

73
<table>
<thead>
<tr>
<th>Organization or Report</th>
<th>Recommendations</th>
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<tr>
<td>ADA (American Dietetic Association, 1994a)</td>
<td>Iron supplementation during the second and third trimester is recommended as for all pregnant women. Supplementation of calcium, vitamins B6 and C, and folate is recommended for pregnant adolescents at risk for inadequate food consumption. Smoking, alcohol, and other substance abuse, and living in poverty compound nutritional inadequacies. Pregnant adolescents need to consume food with sufficient energy value to support their continuing physical growth and development and the growth of the fetus. Less physically mature mothers are most likely to be still growing and have high energy and nutrient needs. Encourage weight gain at an adequate rate in order to produce healthy optimal-weight infants. Limit weight gain to that needed to achieve adequate birth weight. Nutritional care begins with an assessment of the stage of growth, body size, and activity level of individual pregnant adolescents and making dietary recommendations to ensure optimal nutrition. Social, emotional, and economic stress, psychosocial developmental level, and ethnicity should be taken into consideration when counseling young mothers and their partners on dealing with issues interfering with proper nourishment.</td>
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V. CONCLUSIONS AND RESEARCH RECOMMENDATIONS

In terms of their dietary patterns and nutrient needs, children are not simply adults in miniature. Unique nutrition and food issues exist for children from infancy through adolescence. An obvious difference between children and adults is the physical growth of children, which occurs most rapidly during infancy and adolescence. Secondary sex characteristics appear and mark the beginnings of adolescence. Substantial social, cognitive, and emotional development occurs throughout childhood and adolescence as well.

Development of good eating habits is important for both enjoyment and health in terms of proper growth and development and resistance to disease. Numerous factors influence the eating behaviors of children. Infants and young children depend on their parents and caregivers for sustenance. Infants have an innate preference for the sweet taste and a dislike for sour and bitter tastes. Over time they learn through experience to accept and eat an increasing variety of foods particular to their cultures and cuisines. As children begin formal schooling and their social contacts become more important, their food habits become influenced by other factors such as friends, the media, and available choices at school.

National surveys indicate that children eat diets that supply adequate amounts of many vitamins and minerals. Intakes of some nutrients, however, are low. Calcium intakes in particular are below recommended levels for the majority of children and adolescents, and especially low for teenage girls. As children get older, they tend to drink less calcium-rich milk. Iron intakes are also low, especially among post-menarche girls (who must replace iron losses from their monthly menstrual periods) and toddlers (who are being introduced to new foods, many of them low in iron). Most children and adolescents have zinc intakes below recommended levels, but there is little evidence at this time for inadequate zinc nutriture among them.

The dietary patterns of many children and adolescents fall short of the guidelines of the Food Guide Pyramid. Intakes of fruits and vegetables as well as of whole grains and legumes tend to be low, especially among older children and adolescents, resulting in relatively low fiber intakes. Dietary patterns of teenagers especially tend to be relatively high in sugar and salt. Eating patterns have changed dramatically over the past decades. Children and adolescents eat more frequently and obtain a growing proportion of their nutrients from snacks. They are eating away from home more often, often at school or in fast-food restaurants.

As with dietary patterns, the physical activity patterns of many children and adolescents could be improved. Regular physical activity improves strength, endurance, flexibility, cardiorespiratory fitness, and self-esteem. It may also lower the risks of osteoporosis and cardiovascular disease in adulthood. Yet many children are spending more of their time in sedentary activities.

The growing prevalence of overweight and obesity among children and adolescents in this country indicates a mismatch between food intake and energy expenditure. The risk that an overweight child will remain an overweight adult tends to increase with age. Most children ages 2 years and older have intakes of total fat, saturated fat, and sodium that are thought by many nutrition scientists to increase their risks of developing cardiovascular disease as adults as well as contributing to obesity, which is an independent risk factor for heart and blood vessel disease. At the same time as childhood obesity is increasing, many children, especially girls, are concerned about their weight and are dieting. This concern is apparent even before adolescence. Chronic dieting is a common practice among female adolescents in the United States, and not uncommonly they have a high incidence of eating disorders such as anorexia nervosa and particularly bulimia nervosa.

DIETARY ISSUES FOR CHILDREN

The current edition of Dietary Guidelines for Americans (DGFA) is designed for Americans aged two years and above. Nutritional recommendations for infants and toddlers that are widely supported and are not addressed in the current DGFA include:

- Human milk is the preferred sole source of nutrition for the first several months of a term infant’s life.
- Commercial infant formula, preferably iron-fortified, is the appropriate alternative to human milk during the first nine months of life and possibly to age 12 months.
- In the second half of the first year of life, solid foods should be gradually introduced into the diet. Single foods such as cereals are good first choices.
Specific dietary guidelines might be considered in support of adequate intakes of iron and calcium throughout infancy, childhood, and adolescence. These essential nutrients are frequently underconsumed. Iron is critical, especially during infancy and adolescence. Iron-deficiency anemia, one of the most common nutritional disorders in the pediatric population, can affect growth and both physical and mental development, including cognitive and behavioral performance. Iron deficiency affects approximately 10% of adolescent girls as a result of their menstrual blood loss and inadequate iron intakes. Calcium intakes are typically low in childhood as early as ages 1-2 years, and the majority of adolescents (especially females) fail to consume recommended amounts. Adequate intake of this mineral in childhood is important to achieving the genetically determined peak bone mass, which in turn is inversely related to the risk of developing osteoporosis in the sixth through eighth decades of life.

Specific dietary guidelines may be warranted for infants and toddlers, because the guidelines in the current DGFA are not meant for these groups. For children from age 2 years and older, the current DGFA appear reasonable and relevant with the exception of Guideline 7, “If you drink alcoholic beverages, do so in moderation,” This guideline is inappropriate for children, as it implies the intake of alcoholic beverages is acceptable.

Furthermore, it is unclear whether Guideline 4, “Choose a diet low in fat, saturated fat, and cholesterol,” is appropriate for children from age 2 years. There is significant scientific debate on whether lower-fat diets to reduce the risk of developing chronic, degenerative diseases such as cardiovascular disease (CVD) in later adulthood should be initiated in early childhood (i.e., between ages 2 and 5 years). Critics of implementing lower-fat diets for children argue that there is no direct evidence that levels of dietary fat during childhood are related to the etiology of CVD. They are also concerned that lower-fat diets—especially when overzealously applied by health-conscious parents—may lead to lower intakes of essential nutrients (e.g., iron, calcium, and zinc) found largely in fat-containing animal products and may adversely affect growth and development. They cite for support the Canadian equivalent of DGFA, which recommends limitations in fat intake only by the beginning of adulthood. Others who support lower-fat diets for children beginning at age 2 years point to research showing that moderate restriction of fat, saturated fat, and cholesterol does not adversely affect growth, development, or nutrient intakes. Further, they believe that such diets may lead to lower energy intakes and reduce the risks of obesity (a growing problem in the pediatric population) and that such dietary patterns established in childhood are more likely to persist into adulthood.

RESEARCH RECOMMENDATIONS

So many needs and opportunities for nutrition-related research on children exist that cataloguing them would require a major effort from a diverse group of biomedical scientists. This section describes several broad areas in which research is needed.

Improve Understanding of Micronutrient and Macronutrient Requirements Throughout the Various Lifestages of Children

Nutrient needs vary over infancy, childhood, and adolescence, a fact reflected in the different RDAs for children by age grouping and sometimes gender. Very often, however, recommended nutrient intakes for children are based on extrapolations of data obtained from adults. Better identification is required of the specific points in the growth and development of children that have a significant impact on nutritional needs. Furthermore, more research is needed on the potential differences in nutritional needs and consequences of dietary activity patterns on health among children of various racial and ethnic groups. For example, as described in Chapter II, African-American adolescents absorb calcium more efficiently than Caucasian teenagers and excrete less calcium in their urine, experimental results that may explain their higher bone mass and lower bone-fracture rates as adults. Until further research provides more specific data on the nutrient needs of children at various stages of development, the consumption of a variety of foods remains the best assurance of safe and adequate nutrient intakes.

Improve Understanding of How Food Preferences and Dietary Patterns Develop and Are Shaped from Birth Throughout Adolescence

Over the course of childhood, dietary patterns evolve in a continuum from consuming a single food (human milk or infant formula) to a wide variety of foods based on personal preferences and the influence of various forces (e.g., friends and the media). To address this research need in all its complexities, investigators will be needed from an array of disciplines, including genetics, nutrition, physiology, psychology, sociology, and anthropology. For example, the taste of human milk to the nursing infant is affected by the mother’s diet, suggesting an opportunity to study the relationship of the variety of ingredients in a
mother's diet to the level of neophobia shown by an infant to the new solid foods (particularly meats and vegetables) introduced into his or her diet.

**Better Understand How Dietary and Activity Patterns at Various Stages of Childhood Affect Overall Health and Resistance or Susceptibility to Disease in the Short Run and into the Adult Years and Old Age**

The chronic, degenerative diseases that handicap and kill most Americans—such as cardiovascular disease, some types of cancer, stroke, and diabetes mellitus—are caused or exacerbated, at least in part, by lifestyle factors. There are many questions as to whether diet and activity patterns in childhood—especially early childhood—are related to the development of these diseases. Chapter IV, for example, summarizes the debate as to whether intakes of total fat, saturated fat, cholesterol, and sodium higher than those currently recommended increase the risks for future heart attacks and strokes. For calcium, it is clear that adequate intakes help the bones reach their genetically determined peak bone mass in early adulthood and may delay or substantially reduce the risk of developing osteoporosis in the final decades of life.

Clearly, much research is needed on how the dietary and activity patterns of children from the earliest ages may affect their overall health in middle- and old-age. Additionally, this general area of need will require research in improving the accuracy of measuring the dietary intakes, physical activity levels, and fitness of children and adolescents. Better definitions of overweight and obesity in these groups are also needed.

**Develop Better Approaches That Lead More Children and Adolescents to Adopt and Maintain Healthy Eating Patterns and Engage in Regular Physical Activity**

Many efforts have been and continue to be made to influence children's diet and activity patterns. They range from relatively small efforts made in schools to improve the food choices in the cafeteria to national initiatives that encourage greater consumption of fruits and vegetables. Yet despite these programs, the lifestyle patterns of many children fall short of those recommended for health. Much more attention should be given to understanding the factors and social dynamics that influence health-related behaviors and the conditions under which they operate. Such knowledge should guide the development of future health-promotion programs.
VI. LITERATURE CITED


APPENDIX A

ATTENDEES AT REPORT PLANNING MEETING, OCTOBER 30, 1996

Richard G. Allison
American Society for Nutritional Sciences
Bethesda, MD

Van Hubbard
Division of Nutrition Research Coordination
National Institutes of Health
Bethesda, MD

Sue Ann Anderson
Office of Special Nutritionals
Food and Drug Administration
Washington, DC

Robert Jacobs
Agricultural Research Service
U.S. Department of Agriculture
Washington, DC

Karil Bialostosky
National Center for Health Statistics
Centers for Disease Control and Prevention
Hyattsville, MD

Eileen Kennedy
Center for Nutrition Policy and Promotion
U.S. Department of Agriculture
Washington, DC

Ronette R. Briefel
National Center for Health Statistics
Centers for Disease Control and Prevention
Hyattsville, MD

Nancy F. Krebs
Department of Pediatrics
University of Colorado
Denver, CO

Paul Coates
Division of Nutrition Research Coordination
National Institutes of Health
Bethesda, MD

Ephraim Y. Levin
National Institute for Child Health and Human Development
National Institutes of Health
Rockville, MD

Jacqueline Dupont
Agricultural Research Service
U.S. Department of Agriculture
Beltsville, MD

Bernadette Marriott
Office of Dietary Supplements
National Institutes of Health
Bethesda, MD

Nancy Ernst
National Heart, Lung and Blood Institute
National Institutes of Health
Bethesda, MD

Kathryn McMurray
Office of Disease Prevention and Health Promotion
Department of Health and Human Services
Washington, DC

Tracy Fox
American Dietetic Association
Washington, DC

Linda Meyers
Office of Disease Prevention and Health Promotion
Department of Health and Human Services
Washington, DC

Cuthberto Garza
Food and Nutrition Board,
National Academy of Sciences
Washington, DC

David Schnakenberg
American Society for Clinical Nutrition
Bethesda, MD
LIFE SCIENCES RESEARCH OFFICE

Michael Falk, Ph.D.
Director

Daniel J. Raiten, Ph.D.
Senior Staff Scientist/Project Leader

Gregory J. Downing, D.O., Ph.D.
Senior Staff Scientist

Paul R. Thomas, Ed.D., R.D.
Senior Staff Scientist

John M. Talbot, M.D.
Senior Medical Consultant

Janet H. Waters, M.S., R.D.
Staff Scientist

Donald G. Smith, Ph.D.
Literature Retrieval Librarian

Coleen Kitaguchi
Administrative Secretary

Carol A. Rilley
Administrator
APPENDIX B

CONSULTANTS TO THIS REPORT

Dennis Bier, M.D.
Children's Nutrition Research Center
U.S. Department of Agriculture
Agricultural Research Service
Houston, TX

Johanna Dwyer, D.Sc.
Department of Medicine
Tufts University School of Medicine
New England Medical Center Hospital
Boston, MA

Nancy F. Krebs, M.D.
Department of Pediatrics
University of Colorado
Denver, CO

Theresa Nicklas, Dr.P.H., L.D.N.
Department of Food and Nutrition
North Dakota State University
Fargo, ND

Christine Williams, M.D., M.P.H.
American Health Foundation
Valhalla, NY

Ekhard Ziegler, M.D.
Department of Pediatrics
University of Iowa Hospital and Clinic
Iowa City, IA
# APPENDIX C

Appendix Table. Positions of authoritative organizations regarding dietary guidelines for infants, children, and adolescents.

<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>Dietary Guidelines for Americans¹</th>
<th>Surgeon General's Report²</th>
<th>Healthy People 2000³</th>
<th>Diet and Health Report⁴</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL FAT, SATURATED FAT, AND CHOLESTEROL</td>
<td>Choose a diet low in fat that provides no more than 30% of total calories from fat. Reduce saturated fat to less than 10% of calories. Choose a diet low in cholesterol that provides 300 milligrams per day or lower. These guidelines do not apply to infants and toddlers below the age of 2 years. Children 2 years and over should gradually adopt a diet that, by about 5 years of age, contains no more than 30% of calories from fat.</td>
<td>For the general public, reduce consumption of fat (especially saturated fat) and cholesterol. Choose foods relatively low in these substances, such as vegetables, fruits, whole grain foods, fish, poultry, lean meats, and low-fat dairy products. Use food preparation methods that add little or no fat. Dietary recommendations for the general public are to decrease dietary fat intake from the present level of 37% of total caloric intake and decrease saturated fat from the present level of about 13% of total caloric intake. A reduction in cholesterol intake by the general public from present average levels of approximately 305 mg/day for women and 440 mg/day for men seems appropriate. Parents should guide their children in developing positive eating behaviors and on age-appropriate food patterns that meet nutritional requirements but avoid excessive intake of fat.</td>
<td>Objective 2.5: Reduce dietary fat intake to an average of 30% of calories or less and average saturated fat intake to less than 10% of calories among people aged 2 and older. This objective recommends that healthy children follow the recommended eating patterns that are lower in fat and saturated fat as they begin to eat with the family, usually at age 2 or older. It is considered prudent to move toward these recommended eating patterns because eating habits developed during childhood can influence lifetime eating practices. Infants and children younger than age 2 have dietary requirements different from those of older people. Diets that contain less than 30% of calories from dietary fat may not be appropriate for children younger than age 2 and no restriction of dietary fat is proposed. Care must be taken to ensure the calorie and nutrient needs of the growing child.</td>
<td>The Committee on Diet and Health concluded that recommendations concerning dietary fats and other lipids for children over 2 years of age should be generally similar to those for adults. Children over 2 years of age should eat a diet that includes a total fat intake of no more than 30% of calories, with less than 10% of calories from saturated fatty acids. PUFA should not exceed 10% of total calories and cholesterol intake should be 100 mg or less per 1000 calories, not to exceed 300 mg per day. Gradually phase in the recommended diet by slowly limiting the intake of fat and cholesterol, so that by age 5 the child is eating the recommended diet. In the committee's judgement, concerns that reduced fat intake may curtail intakes of meat and dairy products and thus limit intakes of adequate iron and calcium in women and children or that young children on reduced-fat diets might not obtain adequate calories to support optimal growth and development are not justified.</td>
</tr>
<tr>
<td>SUBJECT</td>
<td>Dietary Guidelines for Americans¹</td>
<td>Surgeon General's Report²</td>
<td>Healthy People 2000³</td>
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<tr>
<td>TOTAL FAT, SATURATED FAT, AND CHOLESTEROL (Continued)</td>
<td>Parents should help adolescents develop healthy eating habits and emphasize the importance of including sufficient quantities of low-fat nutritious foods in meals and snacks. Children of families whose blood cholesterol exceeds appropriate levels should be advised on dietary and other means to reduce CHD risk factors. Infants should consume 3.8 to 6.0 g of fat per 100 kcal (34-54% of total energy).</td>
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<td>Fat intake can be reduced to approximately 30% of calories without risk of nutrient deficiency, and this level of fat intake after infancy has not been associated with any detrimental effects. Adequate caloric intake can readily be maintained in children on diets containing 30% of calories from fat.</td>
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<tr>
<td>VARIETY OF FOODS</td>
<td>Dietary guidance for healthy American 2 years and over is to eat a variety of foods to obtain the nutrients and other substances needed for good health. No specific recommendations are made for infants, children, or adolescents.</td>
<td>There is not a specific recommendation to eat a variety of foods, but it is noted in the report that evidence supports the recommendation to consume a dietary pattern that contains a variety of foods, provided that these foods are generally low in calories, fat, saturated fat, cholesterol, and sodium. No specific recommendations are made for infants, children, or adolescents.</td>
<td>No specific recommendations are made for infants, children, or adolescents.</td>
<td>The absence of supportive data precluded a specific recommendation for the general population about the need for variety in the diet or the number of meals per day. Nevertheless, the Committee on Diet and Health supports the concepts of eating a variety of foods to ensure nutrient adequacy.</td>
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<td>SUBJECT</td>
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<td>GRAIN PRODUCTS, VEGETABLES,</td>
<td>Healthy Americans 2 years and</td>
<td>For the general public,</td>
<td>Objective 2.6: Increase complex carbohydrates and fiber-containing foods in the diets of adults to 5 or more daily servings for vegetables (including legumes) and fruits, and to 6 or more daily servings for grain products.</td>
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<td>AND FRUITS</td>
<td>over should choose a diet with</td>
<td>increase consumption of</td>
<td>It is considered prudent for children aged 2 and older to progress toward this type of dietary pattern.</td>
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<td>plenty of grain products,</td>
<td>complex carbohydrates and</td>
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<td>vegetables, and fruits.</td>
<td>fiber -- whole grain</td>
<td>No specific recommendations are made for infants, children, or adolescents.</td>
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<td>According to Food Guide Pyramid</td>
<td>foods and cereal products,</td>
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<td>guidelines, recommended number of</td>
<td>vegetables (including</td>
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<td>servings per day are: grain</td>
<td>dried beans and peas),</td>
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<td>products (6-11 servings),</td>
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<td>vegetables (3-5 servings), and</td>
<td>No specific recommendations</td>
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<td>fruits (2-3 servings).</td>
<td>are made for infants,</td>
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<td>No specific recommendations are</td>
<td>children, or adolescents.</td>
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<td>FIBER</td>
<td>Dietary guidance for healthy</td>
<td>For the general public,</td>
<td>Objective 2.6: Increase complex carbohydrates and fiber-containing foods in the diets of adults to 5 or more daily servings for vegetables (including legumes) and fruits, and to 6 or more daily servings for grain products.</td>
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<td>Americans 2 years and over is</td>
<td>increase consumption of</td>
<td>A comment is made that the NCI recommends that the public increase dietary fiber levels to 20 to 30 g daily with an upper limit of 35 g, and that an expert committee of the LSRO/FASEB concluded that this range of intakes may not be appropriate for children (LSRO, 1987).</td>
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<td>to choose a diet with plenty of</td>
<td>complex carbohydrates and</td>
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<td>grain products, vegetables, and</td>
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<td>fruits.</td>
<td>foods and cereal products,</td>
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<td>According to Food Guide Pyramid</td>
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<td>guidelines, recommended number of</td>
<td>dried beans and peas),</td>
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<td>servings per day are: grain</td>
<td>and fruits.</td>
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<td>products (6-11 servings),</td>
<td>No specific recommendations</td>
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<td>vegetables (3-5 servings), and</td>
<td>are made for infants,</td>
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<td>fruits (2-3 servings).</td>
<td>children, or adolescents.</td>
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<td>Because there are different types</td>
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<td>of fiber in foods, choose a</td>
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<td>variety of foods daily.</td>
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<td>adolescents.</td>
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Healthy, North American adults and children eat 5 or more servings daily of a combination of vegetables and fruits, especially green and yellow vegetables and citrus fruits. Also recommended is an increase in intake of starches and other complex carbohydrates to 6 or more servings daily of a combination of breads, cereals, and legumes.

No specific recommendations are made for infants, children, or adolescents.

The Committee on Diet and Health believes that the strength of evidence does not justify recommendations for the general public or for specific segments of the population. However, the committee's recommendation to emphasize the consumption of vegetables, fruits, and other sources of complex carbohydrates would indirectly result in an increased consumption of dietary fiber.

Reference is made to a study by Zoppi et al. (1982) that infants given wheat bran to treat constipation developed clinical features indicative of vitamin D-dependent rickets.
<table>
<thead>
<tr>
<th>SUBJECT</th>
<th>Dietary Guidelines for Americans$^1$</th>
<th>Surgeon General's Report$^2$</th>
<th>Healthy People 2000$^3$</th>
<th>Diet and Health Report$^4$</th>
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<td>CALCIUM</td>
<td>Adolescent girls need to eat more calcium-rich foods to get the calcium needed for healthy bones throughout life. Low-fat or fat-free milk products and other low-fat calcium sources are suggested to keep fat intake from being too high. No specific recommendations regarding intake levels are made.</td>
<td>Adolescent girls should increase consumption of foods high in calcium, including low-fat dairy products. Chronically low calcium intake, especially during adolescence and early adulthood, may compromise development of peak bone mass. The RDA for calcium, 1200 mg/day, for adolescents is higher than the RDA for adults and is designed to meet the needs of the adolescent who is growing at the fastest rate. The higher RDA for iron for adolescent males is also related to rapid growth, which is accompanied by increases in blood volume, muscle mass, and iron-containing enzymes. The RDA for calcium for infants is designed to meet the need of formula-fed infants, who retain 25-30% of the calcium in cow milk-based formula; breast-fed infants retain about 65% of the calcium consumed.</td>
<td>Objective 2.8: Increase calcium intake so at least 50% of people aged 12-24 and 50% of pregnant and lactating women consume 3 or more servings daily of foods rich in calcium, and at least 75% of children aged 2-10 consume an average of two or more servings daily. Children have special needs for calcium based on the extra demands of growth. Adolescent girls should increase food sources of calcium for development of peak bone mass, most of the accumulation of bone mineral occurs by 20 years of age.</td>
<td>Females, because of their low caloric intakes, and adolescents, because of their high nutrient requirements, need to make careful food choices to obtain adequate calcium. The committee recommends consumption of low- or nonfat dairy products and dark-green vegetables, which are rich sources of calcium and can assist in maintaining calcium intake at approximately RDA levels. The potential benefits of calcium intakes above the RDAs to prevent osteoporosis or hypertension are not well documented and do not justify the use of calcium supplements. In the committee's judgement, concerns that reduced fat intake may curtail intake of dairy products and thus limit intakes of adequate calcium in women and children are not justified. Intakes of 1200 mg/day between the ages of 10 and 25 may be required to achieve peak bone mass.</td>
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<td>IRON</td>
<td>Young children and teenage girls should eat enough iron-rich foods to keep iron stores at adequate levels. No specific recommendations regarding intake levels are made. Iron supplements are recommended for pregnant women.</td>
<td>Children, adolescents, and women of childbearing years should be sure to consume foods that are good sources of iron, such as lean meats, fish, certain beans, and iron-enriched cereals and whole grain products. This issue is of special concern for low-income families. Consuming foods that contain vitamin C increases the likelihood that iron will be absorbed efficiently. Because of the serious consequences of iron deficiency, continual monitoring of the iron status of individuals at high risk -- particularly children from low-income families, adolescents, and women of childbearing years -- is vital, as is treatment of those identified to be iron deficient. Pregnant women should receive iron supplements when iron stores are low. Proper infant feeding -- preferably breastfeeding, otherwise use of iron-fortified formula -- is the most important safeguard against iron deficiency in infants. Infants should begin consuming iron-fortified cereals at 4 to 6 months of age to prevent anemia.</td>
<td>Objective 2.10: Reduce iron deficiency to less than 3% among children aged 1-4 and among women of childbearing years. Comments are made that the prevalence of iron deficiency is higher in black children compared to white children and is substantially higher in children from families with incomes below the poverty level. A reduction in the prevalence of iron deficiency among young children can be achieved by increasing the proportion of mothers who breastfeed, increasing the use of iron-fortified formulas when formulas are used, and delaying introduction of whole cow milk until 9-12 months of age. A reduction in iron deficiency among women of childbearing years can be achieved by encouraging iron-rich foods and by adequate iron supplementation during pregnancy.</td>
<td>The Committee on Diet and Health does not specifically address the iron adequacy of the diet in its recommendations; however, in the committee's judgement, concerns that reduced fat intake may curtail intakes of meats and thus limit intakes of adequate iron in women and children are not justified.</td>
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<td>SUBJECT</td>
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<td>Surgeon General's Report&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Healthy People 2000&lt;sup&gt;3&lt;/sup&gt;</td>
<td>Diet and Health Report&lt;sup&gt;4&lt;/sup&gt;</td>
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<td>DIET, PHYSICAL ACTIVITY, AND WEIGHT REGULATION</td>
<td>To promote growth and development and prevent overweight, teach children to eat proper foods (grain products, vegetables and fruits; low-fat milk products or other calcium-rich foods; beans, lean meat, poultry, fish or other protein-rich foods) and to participate in vigorous activity. Limit television time and encourage children to play actively in a safe environment. Although limiting fat intake may help to prevent excess weight gain in children, fat should not be restricted for children younger than 2 years of age. Helping overweight children to achieve a healthy weight along with normal growth requires more caution. Modest reductions in dietary fat are not hazardous. Major changes in diet should be accompanied by monitoring of growth by a health professional at regular intervals. General recommendations are made to participate in 30 minutes or more of moderate physical activity on most-preferably all-days of the week. Comments are made that being too thin can occur with anorexia nervosa and other</td>
<td>Of special concern for children and adolescents is the need to encourage and maintain appropriate levels of physical activity. For most overweight children and their families, qualified health professionals should provide counseling and assistance in developing diets that contain adequate, but not excessive, calories and suggesting social and physical activities in which the child enjoys participating. Lower-than-normal activity levels are related to childhood obesity. A correlation has been reported in young adolescents between degree of obesity and number of hours of television watched per week. Anorexia nervosa occurs most often in females and usually begins between the ages of 13 and 20. Bulimia also occurs primarily in females but onset occurs in slightly older persons. Energy requirements of children are determined by their individual basal metabolic rates, rates of growth, and activity patterns; therefore, appropriate intakes for children of the same age, sex, and size vary. The RDA's recommend a range that averages 105 kcal/kg/day for children 1 year of age to 80 kcal/kg/day for children 2-10 years of age.</td>
<td>Objective 1.2, 2.3, 15.10, 17.12: Reduce overweight to a prevalence of no more than 15% among adolescents aged 12 through 19. Overweight acquired during childhood or adolescence may persist into adulthood and increase the risk for some chronic diseases later in life. Obese children experience psychological stress. There is also concern that overemphasis on thinness during adolescence may contribute to eating disorders such as anorexia nervosa and bulimia. The target for this objective is set at no more than 15% to prevent an increase in overweight above the NHANES II 1976-80 baseline. The objective should be achieved through emphasis on physical activity accompanied by properly balanced dietary intake so that growth is not impaired. Objective 1.3, 15.11, 17.13: Increase to at least 30% the proportion of people aged 6 and older who engage regularly, preferably daily, in light to moderate physical activity for at least 30 minutes per day. Objective 1.4: Increase to at least 75% the proportion of children and adolescents aged 6-17 who engage in vigorous physical activity that promotes the development and maintenance of cardiorespiratory fitness 3 or more days per week for 20 or more minutes per occasion.</td>
<td>Healthy, North American adults and children balance food intake with physical activity to maintain appropriate weight. Comments are made that overeating and obesity in infancy are not good predictors of obesity in adulthood and that adiposity in later childhood is an increasingly better predictor of obesity in adolescence and adulthood. Addresses increases in energy requirements which peak during adolescence, a period characterized by rapid growth and changes in body composition. Daily energy requirements are noted for the following age groups: 0-0.5 yr: 117 kcal/kg body weight 0.5-1 yr: 108 kcal/kg body weight 1-3 yr: 1300 kcal 10-20 yr: Boys - 2,500 to 3,200 kcal Girls - 1,800 to 2,000 kcal Anorexia nervosa is found primarily among adolescent girls and young women. Bulimia occurs during late adolescence and young adulthood.</td>
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<td>DIET</td>
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<td>PHYSICAL ACTIVITY, AND WEIGHT REGULATION</td>
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<td>The role of early infant obesity as a risk factor for later obesity is inconsistent. Nearly all studies agree that the correlation between childhood obesity and later obesity increases as children grow older. Research data are presented that energy expenditure at 3 months was found to be more than 20% lower among infants who became overweight than in those weight remained normal (Roberts et al., 1988).</td>
<td>Objective 1.5: Reduce to no more than 15% the proportion of people aged 6 and older who engage in no leisure-time physical activity. Objective 1.6: Increase to at least 40% the proportion of people aged 6 and older who regularly perform physical activities that enhance and maintain muscular strength, muscular endurance, and flexibility. Objective 1.7, 2.7: Increase to at least 50% the proportion of overweight people ≥ 12 years who have adopted sound dietary practices combined with regular physical activity. Objective 1.8: Increase to at least 50% the proportion of children and adolescents in 1st through 12th grade who participate in daily school physical education. Objective 1.9: Increase to at least 50% the proportion of school physical education class time that students spend being physically active, preferably engaged in lifetime physical activities.</td>
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<td>SUGAR</td>
<td>Dietary guidance for healthy Americans 2 years and over is to use sugars in moderation and cautions about eating sugars in large amounts and about frequent snacks of foods and beverages containing sugars that supply unnecessary calories and few nutrients and may contribute to tooth decay. No specific recommendations are made for infants, children, or adolescents.</td>
<td>Those who are particularly vulnerable to dental caries, especially children, should limit their consumption and frequency of use of foods high in sugars. Of special concern is the need to encourage children to choose nutritious snacks that do not promote tooth decay. Parents should guide their children on age-appropriate food patterns that meet nutritional requirements but avoid excessive intake of sugar. Sugar should be added sparingly, or not at all, to foods prepared for normal infants.</td>
<td>Objective 2.12, 13.11: Increase to at least 75% the proportion of parents and caregivers who use feeding practices that prevent baby bottle tooth decay. Baby bottle tooth decay is caused by frequent or prolonged use of nursing bottles that contain milk, sugared water, fruit juice, or other sugary beverages during the day or night. Continual use of a sweetened pacifier and/or breastfeeding at will throughout the night can also cause baby bottle tooth decay.</td>
<td>The Committee on Diet and Health does not recommend that healthy, North American adults and children increase the intake of added sugars, because their consumption is strongly associated with dental caries and although they are a source of calories for those who may need additional calories, they provide no nutrients. Furthermore, foods high in added sugars are generally also high in fat.</td>
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<td>SALT AND SODIUM</td>
<td>For the healthy population 2 years and over, choose a diet moderate in salt and sodium. No specific recommendations are made for infants, children, or adolescents.</td>
<td>For the general public, reduce intake of sodium by choosing foods relatively low in sodium and limiting the amount of salt added in food preparation and at the table. Parents should guide their children on age-appropriate food patterns that meet nutritional requirements but avoid excessive intake of sodium. No specific recommendations for dietary intake levels of sodium or salt are made for infants, children, or adolescents. Salt need not be added to foods prepared for normal infants.</td>
<td>Objective 2.9: Decrease salt and sodium intake so at least 80% of people avoid using salt at the table. No specific recommendations are made for infants, children, or adolescents.</td>
<td>The Committee on Diet and Health recommends that healthy, North American adults and children limit total daily intake of salt (sodium ride) to 6 g or less. Limit use of salt in cooking and avoid adding it to food at the table. Salty, highly processed salty, salt-preserved, and salt-pickled foods should be consumed sparingly. Populations that maintain low sodium intake from birth do not experience a rise in blood pressure with age, nor do they develop clinical hypertension. In general, populations consuming 1,200 mg sodium or less per day (≤ 3 g of salt) have very low rates of hypertension, whereas salt intakes above 3 g/day from a young age appear to show a direct, linear relationship with risk of hypertension in adults. Only comment made for infants related to findings of a randomized trial (Hofman et al., 1983) during the first 6 months of life in which infants who consumed a low-salt formula approximating the salt content of human milk (365 mg NaCl per liter) had a systolic blood pressure slightly lower than those on normal formula (1,100 mg NaCl per liter).</td>
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<td>ALCOHOL</td>
<td>Specific recommendations are made that children, adolescents, and pregnant women should not drink alcoholic beverages at all.</td>
<td>For the general public, take alcohol only in moderation (no more than two drinks a day), if at all, to reduce the risk for chronic disease. Avoid drinking alcohol while pregnant. No specific recommendations are made for infants, children, or adolescents.</td>
<td>Objective 4.6: Reduce to at least 12.6% the proportion of young people aged 12-17 years who have used alcohol in the past month. Objective 4.7: Reduce to no more than 28% the proportion of high school seniors engaging in recent occasions of heavy drinking of alcoholic beverages (5 or more drinks on 1 occasion in the previous 2-week period as monitored by self-reports). Objective 4.8: Reduce alcohol consumption by people aged 14 and older to an annual average of no more than 2 gallons of ethanol per person. Objective 4.9: Increase to at least 70% the proportion of high school seniors who perceive social disapproval associated with the heavy use of alcohol (5 or more drinks once or twice each weekend). Objective 4.9: Increase to at least 70% the proportion of high school seniors who associate risk of physical or psychological harm with the heavy use of alcohol (5 or more drinks once or twice each weekend).</td>
<td>The Committee on Diet and Health does not recommend alcohol consumption for healthy, North American adults and children. Pregnant women should avoid alcoholic beverages. A comment is made that no significant association was found between alcohol consumption and blood pressure among 203 school children in Italy – 50% of the boys and 39% of the girls reported a mean regular alcohol consumption of 57 g/week and 42 g/week, respectively, i.e., less than one 4-oz drink of table wine per day.</td>
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<td>FLUORIDE</td>
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<td>VEGETARIAN DIETS</td>
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<td>No specific recommendations are made for infants, children, or adolescents.</td>
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<td>BREASTFEEDING AND</td>
<td>No recommendations.</td>
<td>Proper infant feeding –</td>
<td>Objective 2.11:</td>
<td>No recommendations.</td>
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<td>INFANT FEEDING PRACTICES</td>
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<td>preferably breastfeeding, otherwise use of iron-fortified formula – is the most important safeguard against iron deficiency in infants.</td>
<td>increasing to at least 75% the proportion of mothers who breastfeed their babies in the early postpartum period and to at least 50% the proportion who continue breastfeeding until their babies are 5 to 6 months old.</td>
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<td>Objective 2.12:</td>
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<td>Increasing to at least 75% the proportion of parents and caregivers who use feeding practices that prevent baby bottle tooth decay.</td>
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<td>SUBJECT</td>
<td>Dietary Guidelines for Americans¹</td>
<td>Surgeon General's Report²</td>
<td>Healthy People 2000³</td>
<td>Diet and Health Report⁴</td>
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<td>SUPPLEMENTS</td>
<td>Daily vitamin and mineral supplements at or below the RDAs are considered safe, but are usually not needed by people who eat the variety of foods depicted in the Food Guide Pyramid. Sometimes supplements are needed to meet specific requirements. For example, people with little exposure to sunlight may need a vitamin D supplement. Women of childbearing age may reduce risk of certain birth defects by consuming folate-rich foods or folic acid supplements. Iron supplements are recommended for pregnant women. No specific recommendations are made for infants, children, or adolescents.</td>
<td>Although vitamin and mineral supplements increase the quantity of nutrients in the diet, they have not been shown to improve biochemical indices of nutrient status in children who are already well nourished. For this reason, recommendations on vitamin and mineral supplements for children target those at high risk, those from socioeconomically deprived families, and those who have poor appetites or eating habits.</td>
<td>There is no specific objective for supplements; however, comments under objective 2.10 note that a reduction of iron deficiency can be achieved by adequate supplementation of iron during pregnancy.</td>
<td>The Committee on Diet and Health recommends that healthy, North American adults and children avoid taking dietary supplements in excess of the RDA in any one day. Healthy children and adults should obtain adequate nutrient intakes from dietary sources by choosing a variety of foods rather than by supplementation, but supplement usage may be indicated in some circumstances: women with excessive menstrual bleeding may need iron supplements, pregnant and breastfeeding women need more of certain nutrients, especially iron, folic acid, and calcium; people with very low caloric intakes; some vegetarians may not be receiving adequate calcium, iron, zinc, and vitamin B12; newborns are commonly given a single dose of vitamin K to prevent abnormal bleeding.</td>
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</table>

¹U.S. Department of Agriculture (USDA) and U.S. Department of Health and Human Services (HHS), 1995  
²U.S. Department of Health and Human Services (HHS), 1988  
³U.S. Department of Health and Human Services (HHS), Public Health Service, 1990  
⁴National Research Council, 1989