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NUTRITION NEEDS OF ADOLESCENTS

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NUTRIENT REQUIREMENTS

The phenomenal growth that occurs in adolescence, second only to that in the first year of life, creates increased demands for energy and nutrients. Total nutrient needs are higher during adolescence than any other time in the lifecycle. Nutrition and physical growth are integrally related; optimal nutrition is a requisite for achieving full growth potential.¹ Failure to consume an adequate diet at this time can result in delayed sexual maturation and can arrest or slow linear growth.¹ Nutrition is also important during this time to help prevent adult diet-related chronic diseases, such as cardiovascular disease, cancer, and osteoporosis.

Prior to puberty, nutrient needs are similar for boys and girls. It is during puberty that body composition and biologic changes (e.g., menarche) emerge which affect gender-specific nutrient needs. Nutrient needs for both males and females increase sharply during adolescence.¹ Nutrient needs parallel the rate of growth, with the greatest nutrient demands occurring during the peak velocity of growth. At the peak of the adolescent growth spurt, the nutritional requirements may be twice as high as those of the remaining period of adolescence.²

DIETARY REFERENCE INTAKES

Dietary reference intakes (DRIs) developed by the Food and Nutrition Board of the Institute of Medicine provide quantitative estimates of nutrient intakes to be used for planning and assessing diets for healthy people.³⁻⁷ The DRIs replace and expand upon the Recommended Dietary Allowances (RDAs). The DRIs contain four categories of recommendations for nutrient reference values:

- **Recommended Dietary Allowance (RDA):** The average daily dietary intake level that is sufficient to meet the nutrient requirement of nearly all (97-98%) healthy individuals in an age- and gender-specific group.
- **Adequate Intake (AI):** A recommended intake value based on observed or experimentally determined approximations or estimates of nutrient intake by a group of healthy people that are assumed to be adequate— used when an RDA cannot be determined.
- **Tolerable Upper Intake Level (UL):** The highest level of daily nutrient intake that is likely to pose no risk of adverse health effects for almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects increases.
- **Estimated Average Requirement (EAR):** A daily nutrient intake value that is estimated to meet the requirement of half of the healthy individuals in an age and gender group. Used to determine dietary adequacy of populations but not for individuals.

Tables 1 and 2 provide the DRIs for adolescents. The DRIs provide the best estimate of nutrient requirements for adolescents; however these nutrient recommendations are based on chronological age categories, as opposed to individual levels of biological development. Thus, health care providers should use prudent professional judgment and consider growth and sexual maturation status (see Chapter 1), and not rely solely on chronological age, when determining the nutrient needs of an individual adolescent.

TABLE 1
DRIs and AIs: Recommended intakes for Adolescents; Vitamins and Minerals

	Females			Males		
	9-13 yrs	14-18 yrs	19-30 yrs	9-13 yrs	14-18 yrs	19-30 yrs
Energy (kcal/day)	2,071	2,368	2,403 ^a	2,279	3,152	3,067
Carbohydrate (g/day)	130	130	130	130	130	130
Total Fiber (g/day)	26	28	25	31	38	38
n-6 Polyunsaturated Fat (g/day)	10	11	12	12	16	17
n-3 Polyunsaturated Fat (g/day)	1.0	1.1	1.1	1.2	1.6	1.6
Protein (g/day)	34	46	46	34	52	56
Vitamins						
Vitamin A ($\mu\text{g}/\text{d}$)	600	700	700	600	900	900
Vitamin C (mg/d)	45	65	75	45	75	90
Vitamin D ($\mu\text{g}/\text{d}$)	5	5	5	5	5	5
Vitamin E (mg/d)	11	15	15	11	15	15
Vitamin K ($\mu\text{g}/\text{d}$)	60	75	90	60	75	120
Thiamin (mg/d)	0.9	1.0	1.1	0.9	1.2	1.2
Riboflavin (mg/d)	0.9	1.0	1.1	0.9	1.3	1.3
Niacin (mg/d) ^f	12	14	14	12	16	16
Vitamin B ₆ (mg/d)	1.0	1.2	1.3	1.0	1.3	1.3
Folate ($\mu\text{g}/\text{d}$) ^g	300	400	400	300	400	400
Vitamin B ₁₂ ($\mu\text{g}/\text{d}$)	1.8	2.4	2.4	1.8	2.4	2.4
Pantothenic acid (mg/d)	4	5	5	4	5	5
Biotin ($\mu\text{g}/\text{d}$)	20	25	30	20	25	30
Choline (mg/d)	375	400	425	375	550	550
Elements						
Calcium (mg/d)	1,300	1,300	1,000	1,300	1,300	1,000
Chromium ($\mu\text{g}/\text{d}$)	21	24	25	25	35	35
Copper ($\mu\text{g}/\text{d}$)	700	890	900	700	890	900
Fluoride (mg/d)	2	3	3	2	3	4
Iodine ($\mu\text{g}/\text{d}$)	120	150	150	120	150	150
Iron (mg/d)	8	15	18	8	11	8
Magnesium (mg/d)	240	360	310	240	410	400
Manganese (mg/d)	1.6	1.6	1.8	1.9	2.2	2.3
Molybdenum ($\mu\text{g}/\text{d}$)	34	43	45	34	43	45
Phosphorus (mg/d)	1,250	1,250	700	1,250	1,250	700
Selenium ($\mu\text{g}/\text{d}$)	40	55	55	40	55	55
Zinc (mg/d)	8	9	8	8	11	11

Note: This table presents RDAs in bold type and AIs in ordinary type. RDAs and AIs may both be used as goals for individual intake. RDAs are set to meet the needs of almost all (97-98%) individuals in a group. The AI is believed to cover needs of all adolescents in the group, but lack of data or uncertainty in the data prevent being able to specify with confidence the percentage of individuals covered by this intake.

Source: Data from reports from the Institute of Medicine, Food and Nutrition Board, Standing Committee on the Scientific Evaluation of Dietary Reference Intakes,³⁻⁷ © by the National Academy of Sciences, courtesy of the National Academies Press, Washington DC. (<http://www.nap.edu/>)

TABLE 2
DRI: Tolerable Upper Intake Levels* (UL), Vitamins and Elements

	Females					Males		
	9-13 yrs	14-18 yrs	19-30 yrs	Pregnancy ≤18 yrs	Lactation ≤18 yrs	9-13 yrs	14-18 yrs	19+yrs
Vitamins								
Vitamin A ($\mu\text{g}/\text{d}$)	1,700	2,800	3,000	2,800	2,800	1,700	2,800	3,000
Vitamin C (mg/d)	1,200	1,800	2,000	1,800	1,800	1,200	1,800	2,000
Vitamin D ($\mu\text{g}/\text{d}$)	50	50	50	50	50	50	50	50
Vitamin E (mg/d)	600	800	1,000	800	800	600	800	1,000
Vitamin K	ND ^f	ND	ND	ND	ND	ND	ND	ND
Thiamin	ND	ND	ND	ND	ND	ND	ND	ND
Riboflavin	ND	ND	ND	ND	ND	ND	ND	ND
Niacin (mg/d)	20	30	35	30	30	20	30	35
Vitamin B ₆ (mg/d)	60	80	100	80	80	60	80	100
Folate ($\mu\text{g}/\text{d}$)	600	800	1,000	800	800	600	800	1,000
Vitamin B ₁₂	ND	ND	ND	ND	ND	ND	ND	ND
Pantothenic Acid	ND	ND	ND	ND	ND	ND	ND	ND
Biotin	ND	ND	ND	ND	ND	ND	ND	ND
Choline (g/d)	2.0	3.0	3.5	3.0	3.0	2.0	3.0	3.5
Carotenoids	ND	ND	ND	ND	ND	ND	ND	ND
Elements								
Arsenic	ND	ND	ND	ND	ND	ND	ND	ND
Boron (mg/d)	11	17	20	17	17	11	17	20
Calcium (g/d)	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Chromium	ND	ND	ND	ND	ND	ND	ND	ND
Copper ($\mu\text{g}/\text{d}$)	5,000	8,000	10,000	8,000	8,000	5,000	8,000	10,000
Fluoride (mg/d)	10	10	10	10	10	10	10	10
Iodine ($\mu\text{g}/\text{d}$)	600	900	1,100	900	900	600	900	1,100
Iron (mg/d)	40	45	45	45	45	40	45	45
Magnesium (mg/d)	350	350	350	350	350	350	350	350
Manganese (mg/d)	6	9	11	9	9	6	9	11
Molybdenum ($\mu\text{g}/\text{d}$)	1,100	1,700	2,000	1,700	1,700	1,100	1,700	2,000
Nickel (mg/d)	0.6	1.0	1.0	1.0	1.0	0.6	1.0	1.0
Phosphorus (g/d)	4	4	4	3.5	4	4	4	4
Selenium ($\mu\text{g}/\text{d}$)	280	400	400	400	400	280	400	400
Silicon	ND	ND	ND	ND	ND	ND	ND	ND
Vanadium (mg/d)	ND	ND	1.8	ND	ND	ND	ND	1.8
Zinc (mg/d)	23	34	40	34	34	23	34	40

*UL = The maximum level of daily nutrient intake that is likely to pose no risk of adverse effects. Unless otherwise specified, the UL represents total intake from food, water, and supplements. Due to lack of suitable data, ULs could not be established for vitamin K, thiamin, riboflavin, vitamin B₁₂, pantothenic acid, biotin, or carotenoids, arsenic, chromium and silicon. In the absence of ULs, extra caution may be warranted in consuming levels above recommended intakes.

Source: Data from reports from the Institute of Medicine, Food and Nutrition Board, Standing Committee on the Scientific Evaluation of Dietary Reference Intakes,³⁻⁷ © by the National Academy of Sciences, courtesy of the National Academies Press, Washington DC. (<http://www.nap.edu/>)

NUTRIENT INTAKES: NATIONAL SURVEY FINDINGS

Nutrient intakes of US adolescents suggest that many youth consume inadequate amounts of vitamins and minerals.⁸⁻¹¹ This trend is more pronounced in females than males. This is not surprising, given the fact that most adolescents do not consume diets that comply with the Food Guide Pyramid or the Dietary Guidelines for Americans.¹² On average, adolescents consume diets that are inadequate in several vitamins and minerals, including folate, vitamins A and E, iron, zinc, magnesium and calcium.⁸⁻¹¹ Dietary fiber intake among adolescents is also low. Diets consumed by many teens exceed current recommendations for total fat and saturated fat, cholesterol, sodium and sugar. Table 3 lists nutrients of concern in the diets of adolescents.

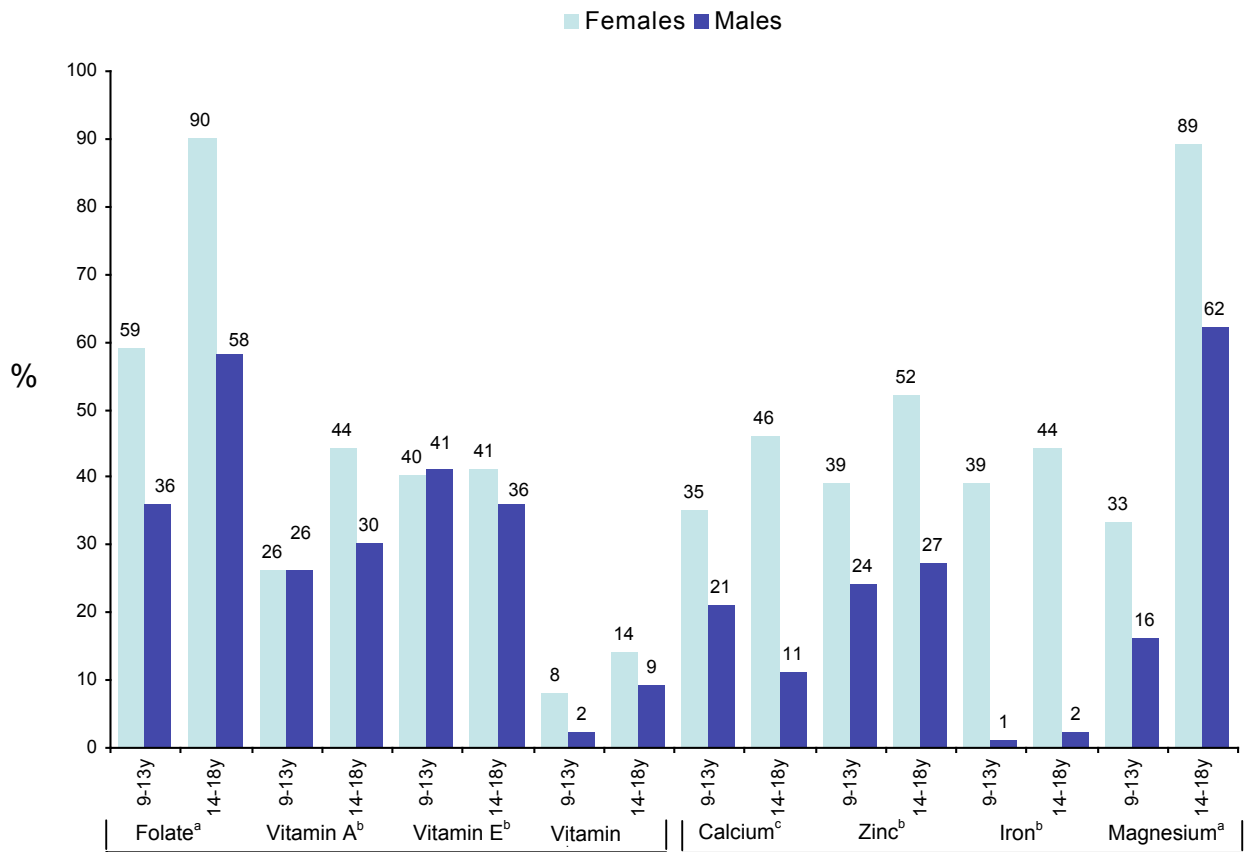
TABLE 3			
Nutrients of Concern in the Average Diet of US Adolescents			
Nutrient Intakes		Females	Males
Lower than Recommended Intakes	Vitamins		
	Folate	✓	✓
	Vitamin A	✓	
	Vitamin E	✓	✓
	Vitamin B ₆	✓	
	Minerals		
	Calcium	✓	✓
	Iron	✓	
	Zinc	✓	
	Magnesium	✓	✓
	Other		
Fiber	✓	✓	
Higher than Recommended Intakes	Total fat	✓	✓
	Saturated fat	✓	✓
	Sodium	✓	✓
	Cholesterol		✓
	Total sugars		✓

Source: Data from⁸⁻¹¹

The 1994-96 USDA Continuing Survey of Food Intake By Individuals (CSFII) 24-hour recall data using a 2-day average showed that among all age groups of children and adolescents, females ages 14-18 had the lowest mean intakes of vitamins and minerals.^{9,13} Based on CSFII dietary data, Figures 1 and 2 show the percent of females and males ages 9-18 whose diets are below recommended guidelines for several nutrients.

Several studies have found that mean nutrient levels among adolescents do not vary greatly by income level.^{8,9} On average, white children have somewhat higher intake levels of minerals and vitamins than black children.

FIGURE 1
Percentage of Females and Males Ages 9-13 and 14-18 Whose Usual Dietary Intake is Below Recommended Guidelines for Selected Vitamins and Minerals*



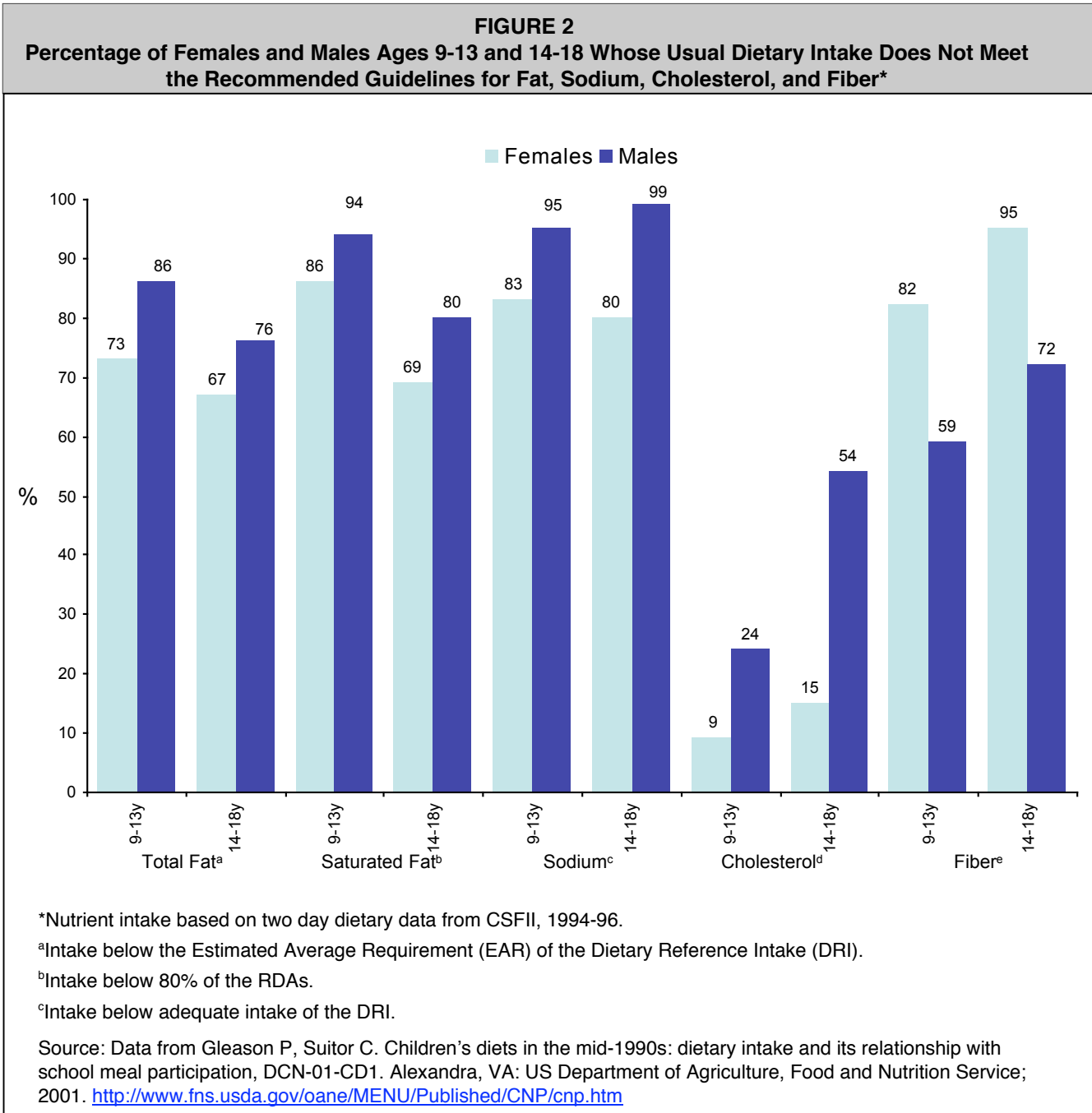
*Nutrient intake based on two-day dietary data from CSFII, 1994-96.

^aIntake below the Estimated Average Requirement (EAR) of the Dietary Reference Intake (DRI).

^bIntake below 80% of the RDAs.

^cIntake below adequate intake of the DRI.

Source: Data from Gleason P, Suitor C. Children's diets in the mid-1990s: dietary intake and its relationship with school meal participation, DCN-01-CD1. Alexandria, VA: US Department of Agriculture, Food and Nutrition Service; 2001. <http://www.fns.usda.gov/oane/MENU/Published/CNP/cnp.htm>



ENERGY AND NUTRIENT NEEDS

Energy

Energy needs of adolescents are influenced by activity level, basal metabolic rate, and increased requirements to support pubertal growth and development. Basal metabolic rate is closely associated with the amount of lean body mass. Adolescent males have higher caloric requirements since they experience greater increases in height, weight, and lean body mass than females.¹ Due to the wide variability in the timing of growth and maturation among adolescents, the calculation of energy needs based on height will provide a better estimate than total daily caloric recommendation.¹⁴ The

RDAs for total calories and calories per centimeter of height by age group are listed in Table 4 and the DRIs for total energy intakes by age group are listed in Table 1.

TABLE 4
Recommended Caloric (Kcal) and Protein Intakes for Adolescents

Age (years)	Calorie (Kcal)		Protein (grams)	
	Kcal/day	Kcal/cm*	Grams/day	Grams/cm
Females				
11-14	2,200	14.0	46	0.29
15-18	2,200	13.5	44	0.27
19-24	2,200	13.4	46	0.28
Males				
11-14	2,500	15.9	45	0.29
15-18	3,000	17.0	59	0.34
19-24	2,900	16.4	58	0.33

*2.54 cm = 1 in

Source: Data taken from Gong EJ, Heard FP. Diet, Nutrition and adolescence. In: Shils ME, Olson JA, Shike M, eds. Modern nutrition in health and disease. 8th Edition. Philadelphia, PA: Lea & Febiger, 1994; and 1989 Recommended Daily Allowances, 10th Edition of the RDAs, Food and Nutrition Board, Commission on Life Sciences. Washington, DC: National Academy Press; 1989.

The DRI for energy is based upon the assumption of a light to moderate activity level. Adolescents who participate in competitive sports and those who are more physically active than average may require additional energy to meet their daily caloric needs. Adolescents who are not physically active and those who have chronic or handicapping conditions that limit mobility will require less energy to meet their needs.

One day dietary recall data from the third National Health and Nutrition Examination Survey (NHANES III), 1988-94 showed a mean energy intake of 1793 calories/day for females ages 12-19 and 2843 calories/day for males ages 12-19.¹⁵ Using CSFII data, Subar and colleagues¹⁶ showed the top 10 sources of energy among teens were milk, breads, cakes/cookies/donuts, beef, cereal, soft drinks, cheese, chips, sugar, and chicken. In NHANES III, beverages provided 21% of energy intake, with soft drinks alone providing 8% caloric intake among adolescents.

The adolescent growth spurt is sensitive to energy and nutrient deprivation. Chronically low energy intakes can lead to delayed puberty or growth retardation.^{17,18} Insufficient energy intake may occur because of restrictive dieting, inadequate monetary resources to purchase food, or secondary to other factors such as substance abuse or chronic illness.

Protein

Protein needs of adolescents are influenced by the amount of protein required for maintenance of existing lean body mass and accrual of additional lean body mass during the adolescent growth spurt. Protein requirements per unit of height are highest for females in the 11 to 14 year age range and for males in the 15 to 18 year age range, corresponding to the usual timing of peak height velocity. When protein intakes are consistently inadequate, reductions in linear growth, delays in sexual maturation, and reduced accumulation of lean body mass may be seen.

US adolescents consume more than adequate amounts of protein. National data suggest that on average, teens consume about twice the recommended level of protein and 31% of adolescent boys 14-18 years of age consume more than twice the RDA for protein.⁹ Subgroups of adolescents who may be at risk for marginal or low protein intakes include those from food-insecure households, those who severely restrict calories, and vegans (see Chapter 17). Recommended protein intakes based upon age, gender and height are shown in Table 4. DRI values for total protein intake by age are listed in Table 1.

Carbohydrates

Carbohydrate is the body's primary source of dietary energy. Carbohydrate-rich foods, such as fruit, vegetables, whole grains, and legumes are also the main source of dietary fiber. Dietary recommendations suggest that 50% or more of total daily calories should come from carbohydrate, with no more than 10-25% of calories derived from sweeteners, such as sucrose and high fructose corn syrup. DRI values for total carbohydrate intake are listed in Table 1. Adolescents consume approximately 53% of their calories as carbohydrate.¹⁹ Foods that contribute the most carbohydrate to the diets of adolescents include (in descending order) yeast bread, soft drinks, milk, ready-to-eat cereal, and foods such as cakes, cookies, quick breads, donuts, sugars, syrups, and jams.¹⁶

Sweeteners and added sugars provide approximately 20% of total calories to the diets of adolescents. Mean intake of added sugars ranges from 23 teaspoons/day (nearly 1/2 cup) for females ages 9-18 to 36 teaspoons/day (3/4 cup) for males ages 14 to 18.⁹

Soft drinks are a major source of added sweeteners in the diets of adolescents, accounting for over 12% of all carbohydrate consumed.²⁰ Soft drink consumption has steadily increased over the years among adolescents; among teenage boys it nearly tripled between 1977 and 1994.²¹

Fat

The human body requires dietary fat and essential fatty acids for normal growth and development. The Dietary Guidelines for Americans recommend that adolescents consume no more than 30% of calories from fat, with no more than 10% of calories derived from saturated fat.²² The DRIs do not list specific requirements for total fat intake, but do make recommendations for the intake of linoleic (n-6) and α -linolenic (n-3) polyunsaturated fatty acids (Table 1). Studies consistently show that adolescents' intakes of total fat and saturated fat exceed recommendations.^{9,11,21}

Dietary 24-hour recall data from NHANES III (1988-94) showed the mean percentage of energy for adolescents ages 12-19 was about 34% from total fat and 12% from saturated fat.¹⁵ There were no differences by gender. Only about one-third of females and one-fourth of males ages 14 to 18 met the recommendations for total fat and saturated fats (Figure 2). National data suggest black adolescents consumed more total fat and saturated fat than did white youth.^{9,15} Major sources of total and saturated fat intakes among adolescents include milk, beef, cheese, margarine, and foods such as cakes, cookies, donuts, and ice cream.¹⁶

Minerals

Calcium

Calcium needs during adolescence are greater than they are in either childhood or adulthood because of the dramatic increase in skeletal growth. Because about 45% of peak bone mass is attained during adolescence, adequate calcium intake is important for the development of dense bone mass and the reduction of the lifetime risk of fractures and osteoporosis.²³ By age 17, adolescents have attained

approximately 90% of their adult bone mass. Thus, adolescence represents a “window of opportunity” for optimal bone development and future health.

The DRI for calcium for 9 to 18 year olds is 1300 mg/day. Only 19% or about 2 out of 10 adolescent girls meet their calcium recommendations. In NHANES III, the mean calcium intake of adolescent girls ages 12-15 was 796 mg/day and 822 mg/day for ages 16-19.²⁴ Males consume greater amounts of calcium at all ages than females (Figure 1).

Milk provides the greatest amount of calcium in the diets of adolescents, followed by cheese, ice cream and frozen yogurt.¹⁶ Calcium-fortified foods are widely available (e.g., orange juice, breakfast bars, bread, cereals) and can be excellent sources of calcium; many of these foods are fortified to the same level as milk (300 mg/serving).

Soft drink consumption by adolescents may displace the consumption of more nutrient-dense beverages, such as milk and juices. In one study, adolescents in the highest soft drink consumption category were found to consume less calcium and vitamin C than non-soft drink consumers (Table 5).²⁵

TABLE 5
Mean Nutrient Level of Soft Drink Consumption for Adolescents

	Nonconsumers (n = 70)	0.1 – 12.9 oz/day (n = 136)	13.0-25.9 oz /day (n = 120)	≥ 26 oz/day (n = 97)
Energy (kcal)	1984	2149	2312	2604
Folate (μg)	239	238	191	178
Vitamin C (mg)	98.3	100.6	62.2	52.5
Calcium (mg)	820	804	652	636

Source: Data from: Harnack L, Stang J, Story M. Soft drink consumption among US children and adolescents. *J Am Diet Assoc* 1999;99(4): 436-441.

Supplemental calcium may be warranted when adolescents are unable or unwilling to get sufficient calcium from food sources. Most chemical forms of calcium— carbonate, citrate, lactate, or phosphate— have 25-35% absorption rates. Of the calcium supplements available, calcium carbonate contains the highest proportion (40%) of elemental calcium by weight and is the least expensive.²⁶ The efficiency of absorption of calcium from supplements is greatest when calcium is taken with food in doses of not more than 500 mg.

Alternatives exist for youth with lactose intolerance. Many adolescents with lactose intolerance can tolerate small amounts of milk, especially when consumed with meals. Lactose-free and low-lactose milks and chewable enzyme tablets are also available. Yogurt and aged cheese are better tolerated than milk.²³

Iron

Iron is vital for transporting oxygen in the bloodstream and for preventing anemia. For both male and female adolescents, the need for iron increases with rapid growth and the expansion of blood volume and muscle mass. The onset of menstruation imposes additional iron needs for girls. Iron needs are highest during the adolescent growth spurt in males and after menarche in females. The RDA for iron is 8 mg/day for 9-13 year olds, 11 mg/day for males ages 14-18 and 15 mg/day for females ages 14-18.

Estimates of iron deficiency among adolescents are 3-4% for males and females ages 11-14, 6-7% for females ages 15-19, and 0.6% for males ages 15-19.²⁷ Rates of iron deficiency tend to be higher in adolescents from low-income families.

National data suggest that most adolescent males (98%) met recommended dietary intake guidelines for iron, but only about half (56%) of females ages 14-18 had adequate intakes (Figure 1). The most common dietary sources of iron in diets of adolescents included ready-to-eat cereal, bread, and beef.

The availability of dietary iron for absorption and utilization by the body varies by its form. Heme iron, which is found in meat, fish, and poultry, is highly bioavailable while nonheme iron, found predominantly in grains, is much less so. More than 80% of the iron consumed is in the form of nonheme iron. Bioavailability of nonheme iron can be enhanced by consuming it with heme sources of iron or vitamin C. Because the absorption of iron from plant foods is low, vegetarians need to consume twice as much iron to meet their daily requirement.²⁸ (See [Appendix A: Food Sources of Vitamins and Minerals](#)).

Zinc

Zinc is associated with more than 100 specific enzymes and is vital for protein formation and gene expression. Zinc is important in adolescence because of its role in growth and sexual maturation. Males who are zinc deficient experience growth failure and delayed sexual development. It is known that serum zinc levels decline in response to the rapid growth and hormonal changes that occur during adolescence. Serum zinc levels indicative of mild zinc deficiency (<10.71 $\mu\text{mol/L}$) have been found in 18% to 33% of female adolescents.²⁷

The RDA for zinc for males and females ages 9-13 is 8 mg/day. For males and females ages 14-18, the RDA is 11 mg/day and 9 mg/day, respectively. Data from the CSFII showed that about one-third of adolescents had inadequate intakes of zinc (Figure 1).

Zinc is naturally abundant in red meats, shellfish, and whole grains. Many breakfast cereals are fortified with zinc. Indigestible fibers found in many plant-based sources of zinc can inhibit its absorption. Zinc and iron compete for absorption, so elevated intakes of one can reduce the absorption of the other. Adolescents who take iron supplements may be at increased risk of developing mild zinc deficiency if iron intake is over twice as high as that of zinc. Vegetarians, particularly vegans, and teens who do not consume many animal-derived products are at highest risk for low intakes of zinc.

Vitamins

Vitamin A

Besides being important for normal vision, vitamin A plays a vital role in reproduction, growth, and immune function.²⁸ To ensure adequate body stores of vitamin A, boys and girls ages 9-13 should consume 600 $\mu\text{g/day}$, females ages 14-18, 700 $\mu\text{g/day}$ and males ages 14-18, 900 $\mu\text{g/day}$. In the CSFII survey about 30% of adolescents had inadequate intakes of vitamin A (Figure 1).

The most obvious symptom of inadequate vitamin A consumption is vision impairment, especially night blindness, which occurs after vitamin A stores have been depleted.²⁸ Vision impairment caused by inadequate vitamin A is rarely seen in the US. However, up to 500,000 children in developing countries go blind each year because of vitamin A deficiency.²⁸

The top five dietary sources of vitamin A in the diets of adolescents are ready-to-eat cereal, milk, carrots, margarine, and cheese. Beta-carotene, a precursor of vitamin A, is most commonly consumed by teens in carrots, tomatoes, spinach and other greens, sweet potatoes, and milk.¹⁶ The low intake of fruits, vegetables and milk and dairy products by adolescents contributes to their less than optimal intake of vitamin A.

Vitamin E

Vitamin E is well known for its antioxidant properties, which become increasingly important as body mass expands during adolescence. The RDA for vitamin E for 9-13 year olds is 11 mg/day and 15 mg/day for 14-18 year olds. There are few data available on the vitamin E status of adolescents. National nutrition surveys suggest that dietary intakes of vitamin E are below recommended levels.⁹ About 40% of adolescents had lower than recommended intakes in the CSFII survey (Figure 1). Among adolescents the five most commonly consumed sources of vitamin E are margarine, cakes/cookies/quick breads/donuts, salad dressings/mayonnaise, nuts/seeds, and tomatoes.¹⁶ Increasing adolescent intakes of vitamin E through dietary sources is a challenge, given that many of the sources of vitamin E are high fat foods. Fortified breakfast cereals and nuts are good sources of vitamin E to recommend for youth.

Vitamin C

Vitamin C is involved in the synthesis of collagen and other connective tissues. For this reason, vitamin C is an important nutrient during adolescent growth and development. The RDA for vitamin C is 45 mg/day for 9-13 year olds, 75 mg/day for males ages 14-18 and 65 mg/day for females ages 14-18. According to CSFII data, 86-98% of adolescents had adequate dietary intakes of vitamin C (Figure 1). Almost 90% of vitamin C in the typical diet comes from fruits and vegetables, with citrus fruits, tomatoes and potatoes being major contributors. The five most common sources of vitamin C among adolescents are orange and grapefruit juice, fruit drinks, ready-to-eat cereals, tomatoes, and white potatoes.¹⁶

Evidence suggests that smokers have poorer vitamin C status than nonsmokers, even with comparable vitamin C intakes. Because smoking increases oxidative stress and metabolic turnover of vitamin C, the requirement for smokers is increased by 35 mg/day.⁴ Nationwide, 33% of students in grades 9-12 report current cigarette use.²⁹ Male students (37%) are more likely to smoke compared to female students.²⁹ On average, adolescents who use tobacco and other substances have poorer quality diets and consume fewer fruits and vegetables, which are primary sources of vitamin C.

Folate

Folate plays an integral role in DNA, RNA and protein synthesis. Thus, adolescents have increased requirements for folate during puberty. The RDA for folate is 300 µg/day for 9-13 year olds and 400 µg/day for 14-18 year olds. National data suggests that many adolescents do not consume adequate amounts of folate (Figure 1). The top five sources of dietary folate consumed by adolescents include ready-to-eat cereal, orange juice, bread, milk, and dried beans or lentils.¹⁶ Teens who skip breakfast or do not commonly consume orange juice and ready-to-eat cereals are at an increased risk for having a low consumption of folate.

Severe folate deficiency results in the development of megaloblastic anemia, which is rare among adolescents. There is evidence, however, that a number of adolescents have inadequate folate status. In one study, 12% of adolescent females were mildly folate-deficient, based on low serum folate levels, while 8-48% of female teens had been shown to have low red cell folate levels indicative of subclinical folate deficiency.^{30,31}

Adequate intakes of folate prior to pregnancy can reduce the incidence of spina bifida and select other congenital anomalies, and may reduce the risk of Down syndrome among offspring.³² The protective effects of folate occur early in pregnancy, often before a teen may know she is pregnant. Thus, it is important that female adolescents who are sexually active consume adequate folic acid. In view of the evidence linking folate intake with neural tube defects in the fetus, it is recommended that all women capable of becoming pregnant consume 400 µg/day from supplements or highly fortified breakfast cereals in addition to food folate from a varied diet that includes fruits, vegetables, and whole grains.

Other Food Components

Fiber

Dietary fiber is important for normal bowel function, and may play a role in the prevention of chronic diseases, such as certain cancers, coronary artery disease, and type 2 diabetes mellitus. Adequate fiber intake is also thought to reduce serum cholesterol levels, moderate blood sugar levels, and reduce the risk of obesity. Recommendations by the American Health Foundation suggest that daily fiber goals for youth be based on an “age plus five” rule, where the individual’s age is added to the number five.³³ A factor of 10 is added to age to determine the recommended upper limit of fiber intake.

Adolescents’ mean fiber intake is well below the age-adjusted target goal (Figure 2). National data show that mean daily fiber intake among girls ages 9-18 is only 12 g, and among males 9-18 years of age it is 15 g.¹⁶

Significant sources of fiber in the diet of adolescents include whole grain breads, ready-to-eat cereal, potatoes, popcorn and related snack foods, tomatoes, and corn.¹⁶ The low intake of fruit, vegetables, and whole grains among adolescents is the greatest contributing factor affecting fiber intake among adolescents. Adolescents who skip breakfast or do not routinely consume whole grain breads or ready-to-eat cereals are at high risk for having an inadequate consumption of fiber.

Cholesterol and sodium

Mean cholesterol and sodium intakes increase with age for both males and females. Males ages 14-18 have a mean cholesterol intake of 320 mg/day, which exceeds the goal of 300 mg/day.²² The suggested sodium intake is 2400 mg/day.²² Average intake for both adolescent males and females exceeds this target (Figure 2). Adolescent males 14-18 have especially high mean intakes— 4474 mg/day, almost twice the target goal.⁹

FACTORS INFLUENCING NUTRIENT NEEDS

There are many factors and conditions which affect nutrient needs during adolescence including pregnancy, lactation, level of physical activity, and chronic illnesses. These are discussed in the individual chapters on specific topics.

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