



ADOLESCENT HEALTH & NUTRITION
Topic Overview



Adolescent Health & Nutrition: Cause for Concern

Adolescence is a transitional stage from childhood into adulthood distinguished by physical and psychological changes occurring between the ages of 9-19 years – sometimes divided into the tween (9-12 years) and teen years (13-19 years). The adolescent life stage is a time for a child to grow into an adult physically, psychologically and socially – developing the independence, confidence and agency to establish a unique identity and purpose.

Due to the tremendous rate of growth and development occurring throughout this life stage, nutrition plays a critical role

from both a short- and long-term health perspective – yet, diet quality and nutrient adequacy for tweens and teens in the U.S. are poor. Based on these measures, it is clear more research is needed to better understand the impact of nutrition on adolescent health. Additionally, developing comprehensive dietary guidance recognizing the challenges and preferences unique to this life stage could facilitate effective education and intervention for this population.

Key Considerations

- Adolescence is a unique and complex life stage characterized by an increased rate of physical and cognitive growth and development. Social, emotional and mental challenges affecting eating behaviors, food choices and diet quality occur simultaneously and are often impacted by factors like social media and peer pressure, desire for greater autonomy, food and nutrition literacy issues and broader societal uncertainty.
- Adolescence is an important time for establishing an individual's lifelong health habits including food and dietary choices and physical activity in conjunction with the development of self-confidence, healthy body image and overall self-esteem. Establishing good habits during adolescence contributes to both short- and long-term health.
- Public health guidance like the 2020-2025 *Dietary Guidelines for Americans* (DGA) recognizes adolescence as a critical period for growth and development, while also acknowledging it as a life stage where nutrient adequacy and diet quality decline.
- This most recent DGA notes under-consumed nutrients of public health relevance affecting adolescent health include iron, protein, folate, vitamin B₆, vitamin B₁₂ and phosphorus for female adolescents and phosphorus for male adolescents; these are in addition to potassium, dietary fiber, calcium, vitamin D, choline, magnesium, and vitamins A, C, E and K noted as under-consumed nutrients of public health relevance for all Americans.
- The paucity of available data in the adolescent population highlights an urgent need for research in this age group to better understand the distinct and complex landscape of psychosocial, environmental and behavioral factors that impact dietary intake and nutrient adequacy in tweens and teens.

Setting the Stage: A Complex, Unique Life Stage

Adolescence is a period of rapid change in physical growth and development in both the brain and body that is often impacted by emotional, social and mental challenges. Environmental factors like social media and peer pressures, desire for autonomy, food and nutrition literacy issues and broader societal uncertainty can affect dietary choices, eating behaviors and diet quality.⁶⁻¹¹ Adolescence is also an important time to establish an individual's lifelong health habits including a healthy relationship with food and physical activity and to develop self-esteem and a healthy body image.

The World Health Organization and the American Academy of Pediatrics refer to adolescence as the period between the ages of 10 and 19 years, though early adolescence can start sooner, and late adolescence can last into the early 20s.¹⁴ Without distinct observable starting and ending points, there is no consensus on a defined age range for adolescence.¹⁵

Second only to the first year of life, adolescence is the life stage with the most significant growth and development – including longitudinal growth (height) increasing by 20%, body weight doubling, nearly half of peak bone mass accruing, muscle mass rapidly increasing, blood volume expanding, internal organs like the heart, brain, lungs, liver and kidneys all increasing in size and pubertal and sexual maturation starting, including the onset of menstruation in adolescent girls.¹⁶ At the same time, the “second window of opportunity” which refers to the profound development and growth in the adolescent brain is also occurring.¹⁷

DID YOU KNOW?

On average, adolescents gain 15-20% of their final adult height, and 40-50% of their adult weight during this time period. Bone mass also increases by 40-60%. Inadequate nutrient intake can lead to delayed development and slowed linear growth.^{16,18}

Overall Growth and Development

The normal onset of puberty ranges from 8 -13 years in girls, and 9-14 years in boys.¹⁹ In girls, linear growth (i.e., height) is accompanied by a greater increase in body fat than in boys, and growth in boys is accompanied by a greater increase in lean body mass and blood volume than in girls. In contrast to other life stages, nutritional requirements during adolescence depend more on sexual maturity rating (i.e., Tanner staging) than on chronologic age.^{16,19} Importantly, nutritional needs during this time period are dramatically increased to properly support these significant growth trajectories.

Growth of Muscle Mass

During this time, muscle mass also increases, leading to amplified nutrient requirements including protein, amino acids and iron necessary for building skeletal muscle. Very few studies have evaluated the role of dietary behaviors and physical activity on skeletal muscle mass in adolescents,²⁰ yet the overall understanding of human physiology suggests these play a key role in healthy development.

Although research in this area is limited, what exists has identified the extreme health outcomes. For example, a relatively newer health concern for children and adolescents is sarcopenia, which is more often associated with the older adult population. The etiology of pediatric sarcopenia is likely multifaceted, including nutrient inadequacy or malnutrition, physical inactivity and altered metabolic environments influencing skeletal muscle mass

accumulation and function.²¹ More research is necessary to better understand the underlying physiological and lifestyle factors contributing to the development of pediatric sarcopenia, which is characterized by clinical outcomes such as decreased muscle strength, decreased mobility and function, increased fatigue and increased risk of falls and skeletal fractures.

Bone Health

Adolescence is a critical period for bone growth and metabolism with approximately 40-60% of peak bone mass accrued during this lifestage.¹⁶ Attention has focused on optimizing nutrition, primarily calcium and vitamin D, but also phosphorus and magnesium, to minimize bone loss later in life. Additionally, sufficient intake of protein and energy (calories) is critical to proper bone development. A positive correlation between protein intake and bone mass accrual has been demonstrated in children.²² Although genetics contribute up to 80% of the variance of bone mineral density, healthful eating and overall good nutrition help support achieving the full genetic potential for peak bone mass. On the other hand, poor diet and lack of balanced nutrition can result in lower peak bone mass, contributing to weaker bones and related health issues in adulthood.²²

ACTIVE ADOLESCENTS

As opposed to their less-active peers, adolescent athletes have increased energy and nutrient requirements to support athletic performance. According to the Center for Disease Control (CDC), in 2020, more than half of adolescents age 12-17 years participated in sports in the previous 12 months.⁵ Given the strong evidence for the inverse association between muscular fitness and cardiometabolic risk factors in children and adolescents,¹² advocating for increased participation in physical activity and muscular fitness in this population is important for short- and long-term health goals.





Immune Function

Adequate nutrition is essential in the regulation of optimal immune response by providing sufficient fuel and nutrients to immune cells. Deficiencies in overall energy intake as well as in both macronutrients (such as dietary protein) and micronutrients (such as minerals like zinc and B vitamins) can lead to impaired production and activity of immune cells and antibodies.¹⁸

Cognitive Development and Performance

Although brain growth occurs rapidly in adolescence, the grey and white matter subcomponents continue to develop and mature into the mid- to late-20s. During adolescence, the cortical folding continues to allow the brain to become more complex and attain a larger surface area relative to brain volume.¹⁸ The biggest changes in the folds of the brain during adolescence occur in the parts of the cortex that process cognitive and emotional information.²³ For example, there is a marked transition in style of thinking (such as concrete to abstract thinking) and cognitive control centers (such as increased self-regulation and less risk-taking) during adolescence.²⁴

Poor diet quality and nutrient inadequacy may impair rapidly developing brain and cognitive functions, and low nutrient-quality diets may also contribute to lower academic achievement of children and adolescents.²⁵

Psychosocial and Emotional Health

Pubertal sex hormones (such as estrogen, progesterone, and testosterone) and growth hormones are generally activated together to increase and prompt enhanced skeletal growth and sexual maturation, as well as mood regulation.²⁶ Mood swings occur when the hormone levels are fluctuating, affecting regulation of serotonin, a neurotransmitter that contributes significantly to feelings of well-being and happiness.²⁷

The average age of onset for anxiety and mood disorders is 6 years and 13 years, respectively.²⁸ Early intervention using strategies targeted at improving dietary intake on a population level may be of substantial public health benefit as a healthful diet providing essential nutrients may help regulate hormones and support mood stability.²⁹

Behavioral, Social and Environmental Pressures

The adolescent life stage is often distinguished by characteristic behaviors including a strong desire and drive for increased independence and autonomy, the urge to challenge existing values by engaging in risk-taking behaviors, a burgeoning relationship with body image, a search for self-identification, the desire for peer acceptance and a need to conform with peers.¹⁶

With this increased desire for independence and autonomy and the increased influence of peers comes a decreased influence of parents and caregivers on various choices including those related to diet and food. During adolescence, more food is consumed outside of the home with preference increasing for convenience foods, snack foods and sugar-sweetened beverages – all of which tend to be less nutrient-dense and more energy-dense.

Disordered eating and eating disorders are a more extreme and troubling example of the confluence of behavioral, social and environmental factors impacting adolescent eating behaviors. Disordered eating sits on a spectrum between normal eating and an eating disorder and includes behaviors such as dieting, restrictive eating and compulsive eating. Dieting is one of the most common forms of disordered eating.³⁰ Adolescents – particularly adolescent girls who may be even more preoccupied with body shape, size and weight, in an attempt to exert control during this stage of such overwhelming growth and change – may choose restrictive eating patterns and behaviors, which may further exacerbate nutrition and nutrient adequacy concerns during this life stage. Disordered eating and eating disorders can result in medical and psychosocial consequences impacting short- and long-term health.

Research suggests the most common period for the onset of eating disorders is during the adolescent years.^{31,32} In a recent global analysis of disordered eating among 63,181 children and adolescents, 22% reported disordered eating, with girls significantly more likely than boys (30% vs. 17%, respectively).³³ Within the U.S., more than 50% of adolescent girls and nearly 40% of adolescent boys reported dieting and/or disordered eating behaviors to try and lose weight.³⁴ Additionally, it is estimated that 5.7% of adolescent girls and 1.2% of adolescent



HABITS ESTABLISHED IN ADOLESCENCE

Establishing healthful dietary habits and patterns early in life has important implications for both short- and long-term health in addition to chronic disease prevention. The 2020 *Dietary Guidelines for Americans* notes that “suboptimal current intake patterns among children and adolescents and inadequate physical activity contribute to overweight and obesity in this life stage and risk of chronic disease (e.g., type 2 diabetes, cardiovascular disease) later in life. Changing this trajectory is crucial because dietary patterns established during this life stage tend to continue into adult years.”³

boys have an eating disorder (as defined in DSM-IV: Diagnostic and Statistical Manual of Mental Disorders).¹⁶

Studies show that the development of eating disorders can be attributed to a complex combination of social and emotional influences including low self-esteem and intense societal/ family pressures.³² Common risk factors include gender (female), age (adolescence through early 20s), underlying mental health issues (anxiety, depression, obsessive compulsiveness), family history (including exposure to dieting or history of addiction), stress and participation in activities or interests like elite sports, dance or modeling which place high value on maintaining a certain body type.³⁵

Evidence proposes that social media use can influence diet, food choices and eating behaviors which can, in turn, foster the development of disordered eating habits.³⁶ Moreover, social media use can contribute to body-image concerns, idealization of certain body types, social comparisons using thin/fit ‘ideals’ and self-objectification. Adolescence is a time when thoughts and feelings surrounding physical appearance become much more relevant. The adoption of healthful dietary and physical activity patterns may reinforce the development of a more positive body image, provide outlets for dealing with increased pressures and contribute to improvements in self-confidence and self-esteem.

The State of Adolescent Diets

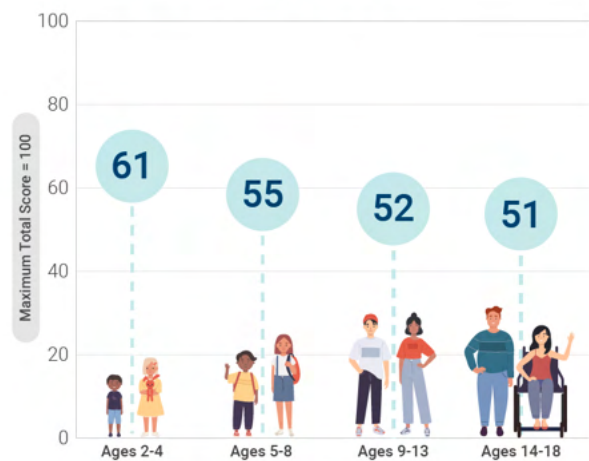
In general, U.S. adolescent diets are low quality and exceed recommendations for fat, saturated fat, and sodium due to the inclusion of energy-dense, high-caloric foods with little nutrient value.¹⁶ The Healthy Eating Index (HEI) score is a measure for diet quality that assesses the degree to which an individual’s dietary intake aligns or adheres to the dietary guidance and recommendations outlined in the *Dietary Guidelines for Americans* (DGA). An HEI score of 100 reflects the ideal dietary pattern and an HEI score of 80 represents a diet meeting the minimum federal guideline for “good” health. Current dietary intake data of adolescents indicates that their overall diet quality is poor (i.e., HEI score of 52 and 51 in adolescents ages 9-13 years and 14-18 years, respectively). HEI scores decline throughout childhood and adolescence, with adolescents approximately 10 points lower than scores for young children.³

Currently, average diets of adolescent males (ages 12-19 years) are composed of 2299 kcal, 49% of calories from carbohydrates, 15% from protein, and 37% from total fat, while average diets of adolescent girls (ages 12-19 years) are composed of 1812 kcal, 50% of calories from carbohydrates, 14% from protein, and 37% from total fat.³⁷

It is important to understand the growth and development occurring during adolescence and the resulting nutrient needs to best address the public health concern of inadequate adolescent nutrition.³⁸ Dietary intake data, better understanding what foods adolescents consume and micronutrient biomarker data have been recognized as key data gaps.

Adolescence provides an important window of opportunity for influencing optimal growth and development and potentially reducing the risk of chronic diseases later in life. This life stage is also a period defined by nutrition vulnerability as population data indicate adolescents are susceptible to malnutrition. Most are not meeting dietary recommendations, contributing to the growing public health concern for this population.

Healthy Eating Index Scores Across Childhood and Adolescence



Data Source: Analysis of What We Eat in America, NHANES 2015-2016, ages 2 through 18, day 1 dietary intake, weighted.



Dietary Guidelines for Americans, 2020-2025

The Healthy Eating Index (HEI) is a measure of diet quality used to assess how well a set of foods aligns with key recommendations and dietary patterns.³



Adolescent Nutrient Inadequacy

The gap between current intakes and nutrient recommendations widens during adolescence, growing largest for those age 14-18 years, putting older adolescents at increased risk of nutrient inadequacy.⁴

Based on evidence presented by the 2020 Dietary Guidelines Advisory Committee and subsequent DGA, under-consumed nutrients of public health relevance were recognized and categorized for all Americans, as well as by age/gender subpopulations. Nutrients of public health concern (nutrients under-consumed by 5% or more of the population with supporting evidence directly related to an adverse health outcome) and nutrients of public health challenge (nutrients under-consumed by 5% or more of the population but lack of adverse clinical and health outcomes measured) were reported for all Americans more than 2 years of age. Nutrients of public health concern for all Americans include calcium, dietary fiber, potassium and vitamin D; nutrients of public health challenge include choline, magnesium and vitamins A, C, E and K. Phosphorous is also a nutrient of public health challenge for adolescent males, while adolescent females are at even greater nutritional risk with iron added as a nutrient of public health concern, and folate, phosphorus, protein and vitamins B₆ and B₁₂ as nutrients of public health challenge.

Female adolescents under-consume several nutrients, including iron (nutrient of public health concern) and protein, folate, vitamin B₆, vitamin B₁₂ and phosphorus (nutrients of public health challenge).⁴

The DGA encourage consumption of nutrient-dense foods and beverages as a part of an overall healthful dietary pattern for all Americans, across all age groups. Nutrient-dense foods and beverages provide energy, macronutrients, vitamins, minerals and other health-promoting components with little added sugar, saturated fat and sodium. Examples of nutrient-dense foods include vegetables, fruits, whole grains, lean proteins, low-fat and non-fat dairy. Importantly, during adolescence, the low intake of nutrient-dense foods and beverages across all food groups leads to declining diet quality scores, which is further exacerbated by an increased intake of refined grains, sugar-sweetened beverages and added sugars. Furthermore, adolescent girls tend to consume less protein-rich, nutrient-dense foods like meat, poultry and eggs than do adolescent boys, contributing to adolescent girls' underconsumption of total protein in addition to low dietary intakes of iron, folate, vitamin B₆ and vitamin B₁₂.

The 2020-2025 DGA notes: "The potential for nutrient deficiencies in adolescence existing alongside underconsumption of nutrients of public health concern for all Americans creates a concerning constellation of nutritional risks at a time of rapid growth and development along with the onset of puberty, menarche, and hormonal changes."³ In particular, for adolescent girls, inadequate intakes of calcium, potassium, dietary fiber, vitamin D, protein, iron, folate, vitamin B₆, vitamin B₁₂, phosphorus, magnesium and choline are noted.

Life Stage Dynamics Impact Food Choices

Adolescence represents an important time for increasing autonomy and agency around food acquisition and consumption. Adolescent eating occasions span a variety of food environments and behaviors to include meals and snacks at home, school and commercial/retail settings. Foods and beverages consumed at snack occasions account for a large proportion of adolescents' overall diets.³⁹ In fact, nearly 25% of adolescent energy intake is estimated to be consumed during snacking occasions.⁴⁰ School-age children and adolescents tend to snack more often in the evening and at night and from foods obtained and eaten outside the home.⁴⁰

Approximately 1 out of 5 adolescents regularly skips breakfast.^{39,42} And those who eat fewer meals tend to snack more during the day.³⁹ Interestingly, total snack frequency is positively associated with diet quality, while total snack size is inversely associated.⁴¹

It is estimated that adolescents consume 35-40% of their daily energy in schools from a combination of formal meal programs and a wide variety of foods brought into the school by students, parents, teachers and other staff.⁴³ While adolescent participants in school lunch programs tend toward more nutritious lunch meals than those not consuming school lunches, overall diet quality is not different between these groups.⁴⁴ Meals consumed at home with parental participation represent an important opportunity to improve adolescent diet quality with parental participation likely to improve dietary quality.^{42,45} Research shows that dietary quality improves following the establishment of regular family meals and the improvement is sustained during the next five years, when the adolescents become young adults.⁴⁵



Nutrition Research is Limited

It is important to note the lack of research on the adolescent population. Reports suggest that less than 1.5% of all randomized clinical trials include children and adolescents.⁴⁶ Limited nutrition research in the adolescent population exists on the following topics:

Body Weight and Composition

The combination of poor diet quality and a decrease in physical activity during adolescence can lead to a greater accumulation of body fat and body mass. Approximately 1 in 5 adolescents have obesity, and it is estimated that 80% of adolescents with obesity are at risk of remaining obese in adulthood.⁴⁷ Obesity in childhood and adolescence may contribute to the development of many chronic diseases later in life, including cardiovascular disease, hypertension and metabolic syndrome. Additionally, research suggests that childhood obesity can impact one's social and emotional well-being, self-esteem, quality of life, as well as academic performance.⁴⁸ Although previous research in adults has demonstrated that higher-protein diets (1.2-1.6 g protein/kg/day) can improve appetite, satiety and body weight management (weight loss, fat mass loss, preservation of lean mass),⁴⁹ compared to lower-protein diets, research is lacking in adolescents to show the same impact and/or consequences of this diet approach for this age group.

In the "Eat Smart Study", changes in body weight and body composition were assessed in obese adolescents who followed either a low-carbohydrate or low-fat calorie-restricted diet, or a control diet for 12-weeks. Both the low-carbohydrate and low-fat groups had significantly lower BMI compared to the control group, with no difference between the two intervention diet groups. Both diets were high in protein content, 20% and 30% of total calories in the low-fat and the low-carbohydrate diets, respectively.⁵⁰ In a randomized crossover clinical trial, researchers compared whether breakfast-skipping adolescent girls with overweight/obesity eating a high-protein (egg- and beef-rich (350 kcal, 35 g protein), a normal-protein (cereal-



based (350 kcal, 13 g protein)) breakfast or continued breakfast skipping daily for 6 days affected their appetite, satiety, food motivation and reward, and evening snacking.⁵¹ Eating breakfast improved the appetitive, hormonal and neural signals that control food intake regulation, with the egg and beef breakfast having further beneficial changes in the signals, as well as reduced evening snacking.⁵¹ These data suggest a strategy such as eating high-protein meals may be useful to improve body composition, satiety, reduce food motivation and reward and improve diet quality in teenage girls with overweight or obesity.^{50,51} However, more research studies in this age group is greatly needed to better understand optimal strategy for healthy weight management in adolescents.

Mental Health

Little evidence exists that evaluates the relationship between dietary patterns or diet quality and mental health in adolescents. However, the available evidence appears to show consistent associations between unhealthy dietary patterns/habits and poorer mental health in adolescents, though research does not demonstrate the inverse of healthy dietary patterns and improved mental health.^{52,53} Like many other areas of adolescent nutrition already mentioned, this area also needs more research.

Call To Action

There Is a Distinct Need to Support Research and Develop Evidence-Based Strategies Focused on Promoting Adolescent Health through Improved Nutrition.

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