

RESEARCH BRIEF:

The Role of Beef in Closing Nutrient Gaps: Addressing the Adolescent Nutrition Public Health Concern



Key Takeaways from Research Brief:

- Adolescence is a unique life stage compounded by increasing emotional and mental health challenges, impacted by factors like social media and peer pressures, desire for autonomy, food and nutrition literacy/knowledge, and broader societal uncertainty that can affect dietary choices, eating behaviors, and diet quality.
- In terms of nutrition, adolescence is an important time in establishing an individual's lifelong relationship with food, physical activity, and body image. Establishing healthy dietary habits during adolescence contributes to long-term health.
- Including beef in a healthy dietary pattern can increase nutrient adequacy in the adolescent population. Among all age groups, adolescents have the largest discrepancy between recommended and currently consumed nutrients so for adolescents, and particularly female adolescents, including beef in their dietary pattern could help narrow these gaps and promote healthy growth during this vulnerable life stage.

Adolescence is a Unique Life Stage

Adolescence is a period of rapid changes in physical growth and development in both the brain and body, compounded by increasing emotional and mental health challenges, impacted by factors like social media and peer pressures, desire for autonomy, food and nutrition literacy/knowledge, and broader societal uncertainty that can affect dietary choices, eating behaviors, and diet quality.¹⁻⁶ In terms of nutrition, adolescence is an important time in establishing an individual's lifelong relationship with food, physical activity, and body image.⁷

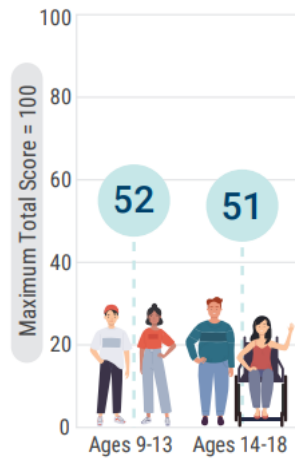
Adolescence (defined by the World Health Organization being between ages of 10 and 19 years old) is a period of nutritional vulnerability as well as a window of opportunity for influencing optimal growth and development and (potentially) reducing the risk of chronic diseases later in life. After the first year of life, the adolescence life stage is the period with the greatest growth and development – including longitudinal growth (height) increasing by 20%, body weight doubling, nearly half of peak bone mass accruing, muscle mass increasing, blood volume expanding, the heart, brain, lungs, liver, and kidneys all increasing in size, pubertal and sexual maturation, and onset of menstruation (in adolescent girls).⁸ Additionally, the development of the adolescent brain has been referred to as a “second window of opportunity”.⁹ Population data indicate adolescents are a vulnerable age group for malnutrition as most are not meeting dietary recommendations contributing to a growing public health concern.

It is important to understand the growth, developmental, and nutritional aspects of adolescence and how best to address the public health concern of inadequate adolescent nutrition.¹⁰ Dietary intake data (e.g., understanding what foods adolescents consume) and micronutrient biomarker data have been recognized as two key data gaps. While dietary recommendations often call for reducing intake of red meat, particularly beef, there are potential unintended consequences if adolescents limit red meat or beef consumption during this crucial developmental stage – especially considering how this population is already underconsuming nutrients of public health concern and challenge. The research brief provides an outline of the evidence concerning beef intake as a source of nutrients for adolescents and the role of beef in adolescent growth, development, health, and wellness.

The Current State of U.S. Adolescent Diets

In general, U.S. adolescent diets are of poor quality and exceed recommendations for fat, saturated fat, and sodium, due to the inclusion of high caloric foods (including fast food and sugar-sweetened beverages).⁸ The Healthy Eating Index (HEI) score is a measure for diet quality developed as a collaboration between U.S. Department of Agriculture, Food and Nutrition Services, Center for Nutrition Policy and Promotion, U.S. Department of Health and Human Services, and the National Cancer Institute. The HEI score assesses how someone's diet aligns or adheres to the recommendations of nutritional variety and food group consumption as outlined in the Dietary Guidelines for Americans (DGA). An HEI score of 100 reflecting an 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 show 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 those for young children.¹¹



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 patterns¹¹

(image from Dietary Guidelines for Americans, 2020-2025)

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.¹²

While the focus of this research brief is on U.S. adolescents, the poor quality of diet in adolescents is a global health concern, and there is a need to better understand the role of foods and their nutrients to help meet requirements for populations with high burdens of micronutrient malnutrition.¹³ For example, undernutrition, micronutrient deficiencies and anemia widen the inequality between genders by lowering learning potential, wages and life opportunities for adolescent girls, weakening their immunity to infections and increasing their risk of life-threatening complications during pregnancy and childbirth.

Adolescent Eating Behavior and Food Environment

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 and home, school, and commercial/retail settings, respectively. Foods and beverages consumed at snack occasions account for a large proportion of adolescents' overall diets.¹⁴ In fact, nearly 25% of adolescent energy intake is estimated to be consumed during snacking occasions.¹⁵ 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.¹⁶ Approximately 1 out of 5 adolescents regularly skips breakfast.^{14, 17} And those who ate fewer meals tended to snack more during the day.¹⁴ Interestingly, total snack frequency was positively associated with diet quality, while total snack size was inversely

associated.¹⁶ It is estimated that adolescents consume 35% to 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.¹⁸ While adolescent participants in school lunch programs demonstrate more nutritious lunch meals than those not consuming school lunches, overall diet quality is not different between these groups.¹⁹ Meals consumed at home represent an important opportunity to improve adolescent diet quality with parental participation likely to improve dietary quality.^{17, 20} Dietary quality improves following the establishment of regular family meals and are sustained 5 years later, when the adolescents become young adults.²⁰

Adolescent Nutrient Inadequacy

The gap between current intakes and nutrient recommendations widens during adolescence, and is largest for those age 14-18 years, putting older adolescents at increased risk of nutrient inadequacy.²¹ The 2020-2025 DGA note that “[t]he potential for nutrient deficiencies 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”.¹¹ Low intakes of nutrient-dense foods and beverages lead to low intakes of phosphorus, magnesium, and choline in all adolescents. Specifically, adolescent girls consume less meat, poultry, and eggs than do adolescent boys, contributing to the underconsumption of total protein. Additionally, adolescent girls have low dietary intakes of iron, folate, vitamin B6, and vitamin B12. There is a higher prevalence of nutrient inadequacy relative to younger and older age groups in adolescents, who also are less likely to take dietary supplements, which reiterates the need for increased consumption of nutrient-dense foods (such as beef) to meet nutrient requirements.²² Adolescents are challenged with significant nutrient gaps during this period of rapid growth and development. A considerable portion of the adolescent subpopulation do not meet recommendations for many essential nutrients, with more than half falling below the estimated average requirement (EAR) for calcium, magnesium, and vitamins A, C, D, and E and over 70% below the adequate intake (AI) for potassium and total choline.²¹

Beef Provides Essential Nutrients for Adolescents

Beef is an example of “red” meat but, importantly, not all red meat is beef. Terms such as red meat and red and processed meat represent broad categories that include combinations of beef, pork, lamb, and game meat, both fresh and processed.²³ Characterizing intake of total beef (i.e., any beef type) and individual beef types (fresh lean, ground, and processed) across life stages is important for understanding the nutrients contributions beef can make to vulnerable population sub-groups such as adolescents.

As noted above, adolescents are at higher risk for nutrient inadequacies, due to low intakes of foods and beverages containing adequate protein, iron, folate, vitamin B6, and vitamin B12 in girls, and low intakes of phosphorus, magnesium, and choline in both girls and boys.²² Beef is a unique package of high-quality protein and essential vitamins and minerals in a bioavailable matrix that is well suited to meet nutrient requirements.²⁴

Beef consumption in adolescents has slowly declined between 2001 – 2018.²³ Approximately half of the children and adolescent subpopulation (2-18 years of age) were reported to consume beef on any given day, and amongst beef consumers in this age range, the usual intake of total beef was 2.2 oz per day, which is within the DGA recommendation for Meat, Poultry, and Eggs subgroup.²³ As the DGA encourages individuals to have the flexibility to choose a healthy dietary pattern within calorie limits that fits their personal preferences, someone could choose to consume more beef and still meet the Meat, Poultry, and Eggs subgroup recommendation.²³ Approximately 70-75% of U.S. adolescents reporting beef consumption are of non-Hispanic White and Hispanic ethnicity.²¹ Of the beef types analyzed, processed beef was the least often chosen by beef consumers.²³ A quarter of the children and adolescent beef consumers (2-18 years) reported consuming ground beef on any given day. Beef sandwiches (e.g., burger and non-burger) have been reported to account for 5.8% of total energy.²⁵ While fast food is often considered a major contributor to food intake, 31% of adolescents and children (2-18 years) were reported to consume ground beef from fast food.²³ Further, a recent analysis of beef sandwich intake found hamburgers provided the lowest intake of energy, sodium, and saturated fat compared to non-burger beef sandwiches in the overall population.²⁵

Overall, fewer adolescent beef consumers were nutrient inadequate (i.e., below the EAR) for numerous nutrients compared to those in the same age group who did not consume beef, particularly for nutrients inherently found in beef, including iron, niacin, phosphorus, riboflavin, thiamin, vitamin B12, vitamin B6, and zinc.²¹ Female adolescents (14-18 years) who consumed beef had an average total beef intake of 1.7 ounces per day. When compared to adolescent female non-beef consumers, 19 out of the 20 vitamins and minerals reported in the study were numerically higher intakes. Of these, statistically higher intakes were reported for 13 of the reported nutrients (i.e., calcium, folate, iron, niacin, phosphorus, potassium, riboflavin, selenium, sodium, thiamin, total choline, vitamin B12, and zinc). Meanwhile, male adolescent (14-18 years) beef consumers had a 24% greater beef intake when compared to females, with 2.0 ounces per day.²¹ Compared to adolescent male non-beef consumers, all 20 vitamins and minerals reported in the study were numerically higher, with 11 statistically higher (i.e., calcium, iron, niacin, phosphorus, potassium, selenium, sodium, thiamin, total choline, vitamin B12, and zinc).²¹



Beef’s nutrient package²⁶ uniquely contributes to healthy adolescent growth and development.

Protein

Beef is an excellent source of protein; with a 3 ounce serving of beef providing about 51% of the daily value for protein.^{26, 27} Beef is in the top 3 foods sources for protein in children and adolescents.²⁸ Research has demonstrated that animal-based protein is more bioavailable than protein from plant food sources.²⁹

Dietary protein is a key nutrient for growth and development as it supplies amino acids necessary for the processes such as tissue growth, energy production, immune function and nutrient absorption³⁰. In the U.S., dietary protein intake generally meets the Recommended Dietary Allowance (RDA) except for adolescent females age 14-18 years.¹¹ It is reported that 7% of adolescent females age 9-13 years were below the RDA, while 23% of adolescent females age 14-18 years were below the RDA. For their male counterpart, 2% of adolescent males age 9-13y were below the RDA and 11% of adolescent females age 14-18 years were below the RDA.³¹

While the dietary recommendations were established based on preventing deficiency, there are no guidelines for an “optimal” protein intake in the pediatric population for promoting healthy growth and development.³² The Acceptable Macronutrient Distribution Range (AMDR) for protein is 10 to 30 percent of total calories for adolescents 9 to 18 years of age.³³ Approximately 2% and 1% of adolescent females age 9-13 years and 14-18 years, respectively, are below the AMDR, while 1% of adolescent males age 9-18 years are below the AMDR.³¹ No adolescent age groups were reported to be above the AMDR.³¹ Additionally, evidence-based reviews designed to establish dietary reference values for healthy children, adolescents and teens, have considered the potential for adverse outcomes and consistently found insufficient evidence to establish an upper limit for protein intake.^{33, 34}

Iron

Beef is a good source of iron; a 3 ounce serving of beef provides about 14% of the daily value for iron.^{26, 27} Beef is in the top 5 foods sources for iron in children and adolescents.²⁸ Additionally, beef is a source for heme iron, which is more easily absorbed in the body when compared to non-heme iron found in plant foods and is critical to reversing iron deficiency.^{11, 35, 36}

Iron plays a significant role in many functions because it helps the blood carry oxygen to the lungs, muscles and all parts of our bodies. Because of this role, it also is involved in brain function and helps keep our immune system strong. During adolescence, there are increased needs for iron in both males and females to sustain the rapidly enlarging muscle mass, expansion of blood volume, and increase in hemoglobin concentration.⁸ Recommended intake of iron during 9 to 13 years, both boys and girls need about 8 milligrams of iron daily, while the recommendation jumps to 15 milligrams of iron daily for girls ages 14 to 18 years, and 11 milligrams daily for boys ages 14 to 18 years. The higher levels of iron in adolescent girls are necessary to offset menstrual blood loss.⁸

Iron deficiency can impact physical growth, endurance and cognitive performance, and can also lead to depressed immune function in adolescents.^{8, 37} Although overall, very few (i.e., 6% are below the EAR) Americans are at risk of

inadequate dietary intake of iron, iron deficiency is especially problematic among adolescent girls and women of reproductive age, given that approximately 20 percent of this population subgroup is at risk of inadequate dietary iron based on biomarker data.²² In a recent analysis of U.S. females ages 12-21 years old, iron deficiency affected almost 40% and iron deficiency anemia affected 6%.³⁸

Physically active adolescents are at increased risk of iron deficiency due to iron losses through sweat, urine, foot-strike hemolysis, and inflammatory responses. In an assessment of youth athletes (8-16 years) in Nebraska, poor iron status was prevalent, particularly in adolescent females, with anemia reported in 46% of the males and 53% of the females.³⁹

To improve iron status, public health leaders recommend that women and adolescent girls consume foods containing heme iron, such as lean meats (including beef), poultry, and seafood, which is more readily absorbed by the body.²² It is estimated that 420,000 fewer adolescent females would fall below EAR for iron if they incorporated an average of 1.7 ounces of beef into their dietary pattern.²¹ Similarly, 160,000 fewer adolescent males would fall below the EAR for iron if they consumed 2.0 ounces of beef per day.

Zinc

Beef is an excellent source of zinc; a 3 ounce serving of beef provides about 53% of the daily value for zinc.^{26, 27} Beef is the top food source for zinc in children and adolescents.²⁸ Zinc is essential for growth and sexual maturation.⁸ Zinc deficiency can delay growth and development as well as impair brain function by affecting attention, learning, memory, and motor development and may contribute to possible development of neuropsychological diseases.^{8, 40, 41} It is estimated that 1.4 million fewer adolescent females and 890,000 fewer adolescent males would fall below EAR for zinc by incorporating 1.7 or 2 ounces of beef per day into their dietary patterns, respectively.²¹

B vitamins

B vitamins help various important functions for body growth and maintenance, including supporting brain function and energy metabolism. Beef is an excellent source of vitamins B6, B12, and niacin (B3); a 3 ounce serving of beef provides about 28%, 101%, and 31%, respectively, of the daily value.^{26, 27} Additionally, beef is a good source of riboflavin (B2); a 3 ounce serving of beef provides about 19% of the daily value for riboflavin.^{26, 27} Beef is in the top 5 foods sources for niacin, B6 and B12 in children and adolescents²⁸ Animal-derived foods, such as beef, are the only good dietary sources of vitamin B12. By incorporating an average of 1.7-2 ounces of beef in their daily dietary pattern, it is estimated that 600,000 fewer adolescent females and 200,000 adolescent males would fall below EAR for vitamin B12, respectively.²¹

Choline

Beef is a good source of choline; a 3 ounce serving of beef provides about 13% of the daily value for choline.^{26, 27} Choline is an essential nutrient in brain development, cell signaling, nerve impulse transmission, and lipid transport and metabolism. The adequate intake (AI) for choline is 375mg/d for adolescents age 9-13y, 400mg/d for females 14-18y and 550mg/d for males 14-18 years.⁴² In general, choline intake is suboptimal across the

population with no exception for adolescents, with 14% and <3% of males and females aged 9–13 years, respectively, meeting the AI. Similarly, 5% and <3% of males and females age 14-18 years, respectively, meet the AI for choline.⁴² Animal-derived products (such as beef) typically contain higher levels of choline than most plant foods. Certain plant foods like cruciferous vegetables and some beans are good sources of choline, provide approximately 10% of the daily value for choline.⁴²

Phosphorus

Phosphorus helps build bones and teeth and is needed for the body to make protein for the growth, maintenance, and repair of cells and tissues. Beef is a good source of phosphorus; a 3 ounce serving of beef provides about 16% of the daily value and is in the top 5 food sources for phosphorus in children and adolescents.²⁶⁻²⁸ It is estimated that 730,000 fewer adolescent females would fall below EAR for phosphorus if they incorporated an average of 1.7 ounces of beef into their dietary pattern.²¹ Similarly, it is estimated that 440,000 fewer male adolescents would fall below the EAR for phosphorus by incorporating an average of 2 ounces of beef into their dietary pattern. In addition, beef sandwiches were recently found to be a source of phosphorus in the diets of children and adolescents (2-18 years).²⁵

Potassium

Potassium is a mineral involved in muscle contractions, heart function and water balance. Although not a good or excellent source, a 3 ounce serving of beef provides about 6% of the daily value for potassium and is in the top 10 foods sources of potassium in children and adolescents.²⁶⁻²⁸

Role of Beef and Beef's Nutrients in Adolescent Health

DID YOU KNOW?

On average, adolescents (age 10-19 years) gain 15-20% of their final adult height, and 40-50% of their adult weight during this time. Bone mass also increases by 40%. Inadequate intake can lead to delayed development and slower linear growth.³⁷

Overall, there is minimal research exploring the role of beef on health outcomes in adolescents. In fact, it has been reported that less than 1.5% of all randomized clinical trials include children and adolescents.⁴³ Though limited quantitatively, research on beef's nutrients suggests the inclusion of beef in healthy eating patterns can provide key components that are critical to addressing increased requirements in adolescents.

Growth and Development

The normal onset of puberty ranges from 8 to 13 years old in girls, and 9 to 14 years of age in boys.⁴⁴ 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 the proportion of 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.^{8, 44} Along with this rapid growth and development are dramatically increased nutritional needs to properly support the growth trajectories. Establishing healthy habits and patterns early in life may have important implications for long-term health and chronic disease prevention. The 2020 DGA note 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.”¹¹

Heart Health

Although heart disease is not a major cause of death among adolescents, atherosclerosis can begin in early childhood, progress through adolescence and continue into adulthood. Therefore, it is important to track risk factors of heart disease for prevention of its development later in life. The American Heart Association dietary recommendations stresses a diet that includes fruits, vegetables, whole grains, legumes, low-fat dairy products, fish, poultry, and lean meats and low intakes of saturated and *trans* fat, cholesterol, added sugar, and salt.⁴⁵ Minimal research has been conducted on adolescent beef intake and heart health, but it is suggested that diet quality likely plays a factor. One study looking at adolescent girls over a 10-year timeframe, concluded that those consuming ≥ 6 oz lean red meat per week combined with ≥ 2 servings of fruit/non-starchy vegetables/day had lower levels of LDL cholesterol levels compared to those who consumed less lean red meat, fruits, and vegetables. The authors concluded that healthy adolescent diets may include lean red meat without negative impact on lipoprotein values.⁴⁶ Additionally certain nutrients inherently found in beef, such as B vitamins, may be favorably associated with heart health in adolescents.⁴⁷

Body Weight and Composition

The combination of poor diet quality and a decrease in physical activity during adolescence can lead to greater accumulation of body fat and body mass. Approximately 1 in 5 adolescents is obese and it is estimated that 80% of adolescents with obesity are at risk of remaining obese in adulthood.⁴⁸ Obesity in childhood and adolescence may contribute to the development of many chronic diseases in adulthood, including cardiovascular disease, hypertension and metabolic syndrome. Additionally, research suggests that childhood obesity can improve one’s social and emotional well-being, self-esteem, quality of life, as well as academic performance.⁴⁹ Although previous research in adults has demonstrated that higher-protein diets (1.2-1.6 g protein /kg/day) can improve appetite and satiety and body weight management (weight loss, fat mass loss, preservation of lean mass),⁵⁰ compared to lower protein diets, research is lacking in adolescents to show the same impact.

In a randomized crossover clinical trial, researchers compared whether overweight/obese breakfast-skipping adolescent girls 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 reduced evening snacking. These data suggest that eating a high protein breakfast may be a useful strategy to improve satiety, reduce food motivation and reward, and improve diet quality in overweight or obese teenage girls.⁵¹

Muscle mass

Muscle mass increases during adolescence, leading to increased nutrient requirements including protein, amino acids, and iron necessary for growth of skeletal muscle. Very few studies have evaluated the role of diet behaviors and physical activity on skeletal muscle mass in adolescents.⁵² Adolescent athletes have different nutrition needs than their less-active peers, needing more calories and other nutrients to support their athletic performance. The CDC reports that in 2020, a little over half of adolescents (age 12-17 years) participated in sports in the past 12 months.⁵³ There is strong evidence for an inverse association between muscular fitness and total and central adiposity, and cardiovascular disease and metabolic risk factors in children and adolescents.⁵⁴

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.⁵⁵ More research is necessary to better understand the underlying physiological and lifestyle factors contributing to the development of pediatric sarcopenia.

Bone Health

Adolescence is a critical period for bone health with approximately 40-60% of peak bone mass accrued during this lifestage.⁸ Attention has focused on optimizing nutrition, primarily on calcium and vitamin D, but also phosphorus and magnesium, to minimize bone loss later in life. Additionally, insufficient intake of calories and protein can severely impair bone development. A positive correlation between protein intake and bone mass gain has been demonstrated in children.⁵⁶ Although genetics contributes up to 80% of the variance of bone mineral density, healthy eating and good nutrition helps support achieving the full genetic potential for peak bone mass. On the other hand, a poor diet can result in lower peak bone mass, contributing to weaker bones in adulthood.⁵⁶

Immune Function

Adequate nutrition is essential in the regulation of optimal immunological response by providing sufficient nutrients to immune cells. Dietary deficiencies in both macronutrients (such as insufficient dietary protein) and micronutrients (such as inadequate intake of B vitamins) can lead to impaired production and activity of immune cells and antibodies.³⁷ Nutrients in beef (e.g., protein and zinc) can help support a strong immune system.^{57, 58}

Cognitive development and performance

Although the brain may be done growing in size, the grey and white matter subcomponents do not finish developing and maturing until 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.³⁷ The biggest changes in the folds of the brain during this time occur in the parts of the cortex that process cognitive and emotional information.⁵⁹ For example, there is a marked transition in style of thinking (such as concrete to abstract thinking) or cognitive control centers (such as increased self-regulation and less risk taking).⁶⁰

Poor nutrition may impair rapidly developing brain and cognitive functions, and low-quality diets may also deteriorate the academic achievement of children and adolescents.⁶¹ To our knowledge, there has not been research assessing the direct impact of beef intake on academic performance, but some research suggests that micronutrients available in beef such as iron, zinc and B vitamins may lead to improvement in cognitive achievement, intelligence (e.g., IQ points) and school performance (e.g., math scores) in adolescents.⁶²⁻⁶⁴

Mental Health

There is a little evidence evaluating the relationship between dietary patterns or diet quality and mental health in adolescents, but there appears to be consistent cross-sectional associations between unhealthy dietary patterns and worse mental health in childhood and adolescence, though research lacks demonstrating the inverse of healthy dietary patterns and improved mental health.⁶⁵ A meta-analysis including adults and adolescents comparing mental health of meat consumers and meat abstainers concluded that meat consumption was associated with lower depression and lower anxiety.⁶⁶

During adolescence, there is a strong desire to be independent, to challenge existing values by engaging in risk-taking behaviors, dissatisfaction with body image, search for self-identification, desire for peer acceptance, and need to conform with peers.⁸ As such, adolescents, particularly adolescent girls who are preoccupied with body shape and weight, may choose to follow a vegetarian diet (excludes meat, seafood and products containing both, but may include eggs and dairy) or a vegan diet (excluding all animal products), stemming from personal initiative, ethical reasons or social factors.^{67, 68} Although a well-executed vegetarian or vegan diet could provide adequate nutrition (including dietary supplements), it is more likely that restrictive eating such as vegetarian/vegan diets are a means of controlling eating in unhealthy ways, leading to disordered eating to achieve their perceived “thin ideal” weight.^{67, 68}

The onset of eating disorders is usually during adolescence with an estimated prevalence of 5.7% of adolescent girls and 1.2% of adolescent boys being impacted, which is associated with significant medical and psychosocial consequences and poor long-term health.⁸

Emotional Health

Pubertal sex hormones (such as estrogen, progesterone, and testosterone) and growth hormones generally increase together and are responsible for the enhanced skeletal growth and sexual maturation as well as mood regulation.⁶⁹ 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.⁷⁰ A healthy diet providing essential nutrients may help regulate hormones and support mood stability. In a study on older adults, investigators saw an overall positive effect of amino acids and protein on wellbeing,⁷¹ but research assessing the role of beef itself is lacking.

Unintended Consequences of Reducing/Excluding Beef from The Diet

There is strong evidence supporting the inclusion of animal-source foods, such as beef, in healthy dietary patterns to provide essential nutrients such as high-quality protein, iron, choline, vitamins B6 and B12, and zinc, some of which are not always easily obtained with vegetarian and vegan diets. Additionally, plant protein foods often contain less bioavailable forms of these needed nutrients or require significantly more calories to get the same amount of nutrients.^{72, 73} Over a third of protein consumed from the average adolescent diet is derived from lower quality protein sources such as grains, legumes, nuts and seeds.⁷⁴ A systematic review of children and adolescents following vegetarian and vegan or omnivore (meat containing) diets concluded that the vegetarian and vegan children and adolescents were at risk for inadequate vitamin B12, iron, and zinc intakes.⁷⁵

A Call to Action

Poor nutrient intake during adolescence can lead to significant challenges in growth and learning, such as delayed physical development, poor academic performance, and depressed immune function. Dietary habits and behaviors are established in adolescence which can lead to long-term health consequences, so it's important to make sure adolescents eat a balanced diet that provides the nutrients needed to fuel play, empower learning, and optimize growth. Including beef in a healthy dietary pattern can increase nutrient adequacy in the adolescent population. Among all age groups, adolescents have the largest discrepancy between recommended and currently consumed nutrients so for adolescents, and particularly adolescent girls, including beef in their dietary pattern could help narrow these gaps and promote healthy growth during this vulnerable life stage but more evidence is needed.

Relevant Resources:

- NUTRITION2023 Session: Teens and Nutrient Deficiencies: A Growing Public Health Crisis. <https://discover.nutrition.org/content/teens-and-nutrient-deficiencies-growing-public-health-crisis#group-tabs-node-course-default1>
- American Academy of Pediatrics Committee on Nutrition. Pediatric Nutrition, 8th Ed. Itasca, IL: American Academy of Pediatrics, 2019. <https://www.aap.org/Pediatric-Nutrition-8th-Edition-eBook>
- UNICEF Report: Undernourished and Overlooked. A global nutrition crisis in adolescent girls and women. <https://www.unicef.org/reports/undernourished-overlooked-nutrition-crisis>
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