Chapter 9: Nutrition for Ages

9.1 Nutrient Needs Across the Ages

Section Objectives

- Extend understanding of healthy adult nutrition to include that of younger and older populations
- Provide a description of changing nutrient needs in chronological order

Learning Outcomes

- Explain how infant nutrient needs are developed
- Describe toddler eating behaviors
- Describe puberty and the impact that the pubertal growth spurt has on daily nutrient needs
- Identify nutrients that are particularly problematic in adolescent children
- Recall the ages that daily nutrient intake guidelines are divided for boys and girls
- Identify what nutrients change and what nutrients stay the same for older adults

Nutritional needs change throughout the life stages to promote growth and development and, later, to neutralize the metabolic declines that come with aging. Accordingly, guidelines for daily nutrient intake are segmented into six age ranges: 0-6 months, 7-12 months, 1-3 years, 4-8 years, 9-13 years and 14-18 years. For older adults, the range is from 50-70 years and 70+ years.

Infancy

The period of human infancy spans from birth through 12 months of age and is divided into two six month periods. It is largely assumed that daily nutrient requirements slightly vary between zero and six months, and that the nutrients provided in human breast milk are completely adequate to meet infant needs over that period. Therefore, adequate intake levels for the first six-months of life are based on the average concentration in breast milk multiplied by .67 Liters, the average daily intake of young infants.

Table 9.1. Adequate daily nutrient Intake for infants 0-6 months old

A **young infant** needs two to four times the daily energy per unit of body weight, as compared to adults (40-50 calories/kg/day). The additional energy supports accelerated rates of tissue building and helps to maintain a 98.6° F core body temperature with a relatively high body surface area-to-weight ratio. Daily energy intake for the average size, healthy, four to six-month-old infant is anywhere from **500-600 calories per day**, which is consistent with the average amount secreted daily in human breast milk. Carbohydrates in breast milk are also adequate to sustain the daily glucose needs of the brain and central nervous system, which are estimated to use around **17 grams of carbohydrates per day**. Fat and cholesterol in breast milk are also adequate, support neural development, and produce tremendous gains in body fat mass over the first six-month period. **Protein requirements** of infants, per unit of body weight, are 75% higher than those of adults and are estimated to average **1.52 grams/kg/day**.

Breast milk may be inadequate for a few vitamins and minerals if the infant is born with a low storage endowment, or maternal intake or status is low. Take, for example, vitamin K, a critical component of serum clotting, among other things. Infants are born with low levels of vitamin K because immature gastrointestinal tracts do not produce sufficient levels and because vitamin K is poorly transferred across the placenta. To prevent infants from bleeding out in the case of an injury, a **0.5-1 mg intramuscular vitamin K** prophylaxis is given at birth to hold over the infant until the intestinal microflora that produce vitamin K mature and the clotting function is adequate. Another good example is Vitamin D — Vitamin D levels are naturally low in breast milk so pediatricians may advise a liquid **vitamin D supplement** for exclusively breast-fed infants who are not regularly exposed to small daily doses of UV light, especially if maternal vitamin D intake is low. Young infants with vegan mothers may similarly need special attention when it comes to vitamin B12, as they may be born with lower storage endowments and have a persistently low-level milk supply that mirrors the maternal diet. Other key micronutrients like selenium, pantothenic acid and iodine can also fluctuate with the maternal diet, emphasizing the importance of attention to nutrition for lactation (discussed next).

The daily requirements of **older infants**, in the range of
seven to twelve months old, are based on a slightly lower intake of .6 liters of breast milk per day added to amounts from 400 calories of complimentary weaning foods. For many nutrients, data related to content and volume of weaning food intake is not available. Accordingly, the daily requirements were extrapolated from the adequate intake of healthy 0 to 6-month-old infants, and healthy adults by adjusting for body weight and metabolic rate.

Around six months after birth, it is likely that iron stores endowed at birth have been fully utilized. Since iron in breast milk at this point is also relatively low, iron needs must be met “exogenously,” or by diet sources. Daily **iron requirements** for older infants are estimated using a factorial model that weighs the amount of iron deposited in the expansion of hemoglobin mass and blood volume, the amount deposited in storage and iron-containing tissues, and daily fecal, urinary and dermal losses. Like iron, newborn birth stores of zinc progressively decline across the first six months, coinciding with a reduction in the concentration in breast milk.

Dietary **zinc requirements** from six months of age onward are determined using a factorial approach similar to the method used for iron, where the sum of zinc tissue deposition and basal zinc losses are corrected by the bioavailability of zinc in the diet. **Daily protein requirements** for older infants are also estimated using factorial methods that add together the protein needed for protein turnover, or "maintenance," and the amount deposited in new tissue mass, corrected by a score for the efficiency of protein utilization. For infants closer to the one-year mark, protein deposition is reduced each day by nearly 50%; still, relative to the other stages of childhood (including puberty) these amounts are incredibly high.

Early Childhood

In early childhood, cognitive and emotional development impact the diet. Establishing healthy eating behaviors during **toddlerhood** supports improved habits throughout every stage of life. However, feeding a one to a three-year-old child a healthy and balanced diet can be difficult. Children at the older end of the period, especially, begin to exert stronger preferences for self-feeding and control in food choices. Toddlers express these feelings by exerting "food jags": refusals to foods that were recently liked as they express power in their own decision-making. The psychological challenges of feeding toddlers and pre-school age children can be overcome with creativity, flexibility and patience in meal planning and at meal time.

Early childhood is also a period of tremendous physical development that needs to be fostered by appropriate nutrition. For the typical one-year-old, motor learning and development has advanced to fine muscle groups of the fingers so that they can be used to grab ahold of and eat small and soft foods. Larger muscle groups are also developing as new locomotive skills are practiced.

Despite the increased physical activity expenditures, energy balance data for young toddlers in the one to two-year-old age range is consistent with the model that was generated for infants. Therefore, **energy requirements** in this group are extrapolated from young infants and adjusted for increased body weight and reduced energy deposition. Older toddlers, closer to the three-year mark, typically perform more vigorous physical activities for longer durations, and their daily energy requirements, therefore, include a factor for the level of physical activity, like at every other older stage.

After the first year, the reference intakes for several of the dietary nutrients for toddlers are determined using methods similar to those used for older children and adults. Using dietary fiber as an example, beginning at one, the requirements are directly based on calorie intake. At every stage of life after the age of one, 14 grams of **fiber** per 1000 calories is recommended. **Protein requirements** for young children, much like every older stage of life, are determined using the factorial model described above for older infants, with a slightly lower protein deposition factor since the rate of growth is lower relative to total body mass. **Iron** and **Zinc** needs for toddlers and all older people are also determined using the same factorial model but with adjustments for slowed hemoglobin mass expansion and reduced rates of tissue growth. Daily **vitamin D** requirements for toddlers aged one to three years are based on downward extrapolations from older children (ages four to eight) living in different continents where exposure to sunlight is variable. Serum vitamin D is the primary indicator of daily vitamin D requirement, as it correlates well with cumulative exposure to sunlight and dietary intake of vitamin D. If sun exposure is consistently adequate throughout the year, most children with typical dietary intake are not at risk of vitamin D deficiency. Since vitamin D is limited in the natural food supply, though, children of all ages that use UV protective sunscreens should consider adding 15-20 µg of vitamin D-fortified food products or supplements to their diets.

For **four to eight**-year-olds, nutrient demands are not what they were during toddlerhood. There is a slower rate of nutrient deposition so that children in this group are at a lower risk of protein, iron and zinc deficiency compared to both younger and older children. However, it is not uncommon for children in this age range to refuse certain foods and resist the mixing or touching of meal components. To mitigate these psychological difficulties, it is recommended that children in this age group be allowed to participate in food shopping and meal preparation as it can also strengthen their sense of task completion, partnership, artistry, and self-confidence. Typically, by age five, children are influenced by external factors that can override their internal hunger and satiety signals; when coupled with a preference for sweet and salty tastes, excess calorie consumption can become problematic. The number of children who are overweight or obese in this age group has more than tripled in the last 20 years, due, at least in part, to the fact that around half of them now drink soda regularly and nearly all of them eat at least one meal away from home daily. It might come as little surprise, then, that most children ages 4-8 living in the US recognize the most popular fast food and junk food brands.

Older Children and Adolescents

The period of adolescence spans from 9 to 18 years old and is divided into two periods that span 9-13 and 14-18 years of age. The 9 to 13-year-old span is called "**puberty**," and those 14 years and old are known as "teens." Both periods are associated with great gains in body mass and stature as well as reproductive developments that are the beginning of the physical transformation from childhood to adulthood.

The daily nutrient needs of children in the 9-18 age range vary depending on their biological maturity, which is marked by the onset of puberty. **Puberty** is initiated by genetics and environmental influences that trigger the release of growth hormones to accelerate growth velocity. Once the genetically determined peak growth rate is achieved, growth steadily slows until a maximum height and sexual maturity is reached, which is around two years later for most teens. Nutrient needs during the **"growth spurt"** period are most significant during the time of peak growth velocity.

Generally, **girls** begin puberty at an earlier age than boys starting with an earlier growth spurt. The largest growth spurt for girls ends at the onset of menarche, 12.5 years old on average in the US. It ends approximately 2 years later when the complete fusion of the epiphyses occurs and the final height is reached. For **boys**, the major growth spurt begins at 12.5 years of age but peak growth in boys can last until 15-18 years. As a result, the time period to accumulate gains in height, lean muscle mass, and bone mass is much longer in boys than girls.

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 lean body mass amounts so that adolescent males have higher daily caloric requirements than girls. Adolescents who participate in competitive sports and are more physically active than their peers may require additional energy and protein needs.

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 each gender's peak height velocity. In the US, adolescents consume nearly two times more than adequate amounts of protein. Conversely, subgroups of adolescents who may be at risk for low protein intakes include those from food-insecure households, those who severely restrict calories, and vegans.

Early teens typically gain independence in managing where they spend their time, and with that comes freedom to choose what foods they eat. Often, teens congregate for social activities at food establishments, including fast food restaurants where soft drinks, and high fat, fried and salted foods predominate. As a result, the **adolescent eating pattern**, especially the one observed in teens, is problematic because nutrients that should be kept limited in the diet are often over-consumed. For instance, nearly 15% of the total carbohydrates consumed by adolescents comes from corn syrup and sucrose additives alone, which ranges from nearly 1/2 cup for females ages 9-18 to 3/4 cup for males ages 14-18 each day. Over 30% of 12 to19-year-olds also exceed the guideline for calories from fat and **saturated fat**, as well as **sodium** intake which in boys specifically, is almost double the adult salt intake target (4474 mg/day). In addition, cholesterol intake exceeds guidelines for nearly a quarter of teens, and a higher proportion do not meet the daily amounts of fiber associated with good health.

Teenagers are busy. As a result, as with adults, meals are skipped and sit-down meals are sometimes replaced with **grazing** and **snacking**. Snacking and grazing foods are typically more shelf-stable (i.e., more additives), less nutritious, and offer less nutrient variety than prepared meals. As a result, teenagers may consume inadequate amounts of nutrients needed for long-term good health. One of the key nutrients teenagers may miss is dietary **calcium**. Studies indicate that nearly a quarter of teenage girls fall short of the daily target for calcium intake, a shortfall compounded by the fact that both boys and girls in this age group begin to consume more than acceptable levels of salt and caffeine from soda, both of which contribute to calcium losses. Teens who substitute soda for milk and fortified fruit juice and consume lower than recommended amounts of fruits and vegetables can also fail to meet their daily intake needs of **vitamins C, E** and **A**. These latter two vitamins and dietary folate especially must be adequate during the growth spurt to accommodate DNA, RNA, and protein synthesis.

Iron requirements for teenagers are based on the factorial modeling approach described above for younger children. For both male and female teens, the need for iron increases with rapid growth and the expansion of blood volume and muscle mass, which is highest during the adolescent growth spurt in males and after menarche in females. Like iron, **zinc requirements** for teens are estimated using the factorial approach described above for other children, except that the amount of zinc required for new tissue accretion is higher; zinc losses, extrapolated from adult data, also include menstrual and semen losses and a slightly higher fractional zinc absorption coefficient. Like calcium, and several other mineral nutrients, zinc is not obtained in sufficient amounts in a quarter of teen girls, and for that reason, supplementing these minerals may be warranted.

Older & Elderly Adults

Adulthood is the longest stage of the life cycle. It begins after adolescence and continues through the end of life. From early adulthood until around the age of 30, the body systems are functioning at peak potential: peak stature, strength, endurance, stamina and systems running at peak efficiencies. After the peak, there is a 10 to 20-year period of maintenance where nutrient needs, for the most part, do not change.

Around the fifth decade, depending on the interaction of genetic and environmental factors, there is a gradual shift in tissue turnover so that tissue synthesis is outpaced by tissue breakdown. However, since most people in older adulthood, aged 51-70 years, are still actively working, the physiological indicators and daily intake levels for most nutrients in the DRI for this age range are the same as healthy adults, aged 19 to 50 years, as discussed in Chapters 2-7. The nutrient requirements for men and women **over 70 years** are also primarily extrapolated from healthy adults 19-50 years old, and modeled with data using subjects aged anywhere from 51+ and up, since *there is as much as a* 15 to 20-year age-related difference in level of reserve and functional capacity between elderly individuals in the 71+ age group.

For a handful of nutrients, there is a reduced daily requirement for individuals over 51 years of age. The reduced requirements for those nutrients are largely a function of the lower calorie intake reported by people in that age group. Since sodium balance and endothelial function is less effective with aging, lower intake targets for sodium in the older adult age group is appropriate, even if higher calorie levels are maintained. These drops in balance and function are so persistent with age, in fact, that daily intake of sodium must be further reduced after older adults, ages 50 to 71 years, reach the 71+ age range.

For many of the dietary nutrients, **daily needs do not change** with aging, but the ease in consuming adequate amounts of those nutrients through diet does. Throughout most of the lifespan up to the elderly years, the cycle of hunger, eating, satiation and food procurement generally results in an acceptable range of health and nutritional status. In older and elderly people though, the relationship among food, nutrition, and health can change with illness or, in many elderly, a loss of personal or financial independence. These changes can make procuring affordable and fresh groceries challenging. Chronic health issues and use of medications can also interfere with the maintenance of good nutritional status by interfering with nutrient absorption, chewing, swallowing, or causing gastrointestinal discomfort that can lead to trouble eating and an overall reduced food intake. Psychological and neurological declines can also influence elderly nutrition, especially for those suffering from memory loss, a diminished sense of taste and smell, social isolation, grief or depression, who often skip meals completely and have an overwhelming lack of interest or fulfillment from preparing and consuming food.

Calorie and protein requirements for older and elderly adults are determined using the same formulas and models as healthy children and non-pregnant adults. The formula for the estimated energy requirement (EER) is adjusted for aging by including coefficients for age, weight and physical activity level, which accounts for some of the major variances in daily energy expenditures. The EER formula does not, however, account for changing body composition, which also significantly affects the metabolic rate. Anywhere between 40-50, usually younger for men, there are age-related reductions in all three components of EE, that collectively reduce the TDEE by approximately 1-2% per decade. This rate of decline is usually more dramatic after the age of 60, until basal metabolism or energy requirements are diminished by about 100 kcal/day per decade.

The AI for total water (drinking water, beverages, and foods) for the elderly is based on median total water intake of young adults, rather than the older age group, in order to ensure that total water intake is not limited in the face of waning ability to consume adequate amounts in response to thirst.

Micronutrient needs also deserve attention in elderly nutrition. For instance, **B12** requirements, while not different than younger adults, is followed with a guideline that B12-fortified foods (such as fortified ready-to-eat cereals) or B12-containing supplements made with crystalline B12 should meet a large portion of the total daily B12 requirement. Because these synthetic B12 forms are more absorbable than the protein-bound type in food, and because 10-30% of the people older than 50 years have atrophic gastritis coupled with low stomach acid secretion, which further inhibits protein and B12 dissociation and absorption, anyone over 50 should consider foods that have **added B12** totaling the 2.4 microgram requirement.

The relationship between functional losses and dietary inadequacies are more apparent for several nutrients in adults older than 51 years of age. As a result, their intake levels must be increased. The additional target for vitamin B6 offsets the natural blood homocysteine increases that occur even when folate and vitamin B12 status are adequate. For calcium, there is an additional 200 mg per day added to the 1000 mg adult AI for elderly adults over 71 years old. To minimize bone loss, older men (>70 years) and postmenopausal women should consume a dietary supplement that satisfies at least 25% of the calcium RDA. Since the DRI for calcium assumes that the requirement for **vitamin D** is being met, the use of a combined calcium and vitamin D supplement in the prevention of osteoporosis in older adults is common. The elderly are often at a higher risk for vitamin D deficiency as they typically have lower sun-to-skin exposure, reduced digestive efficiency, and less effective cutaneous vitamin D production in the skin. Therefore, additional fortified food products and daily multi-vitamins providing 10 to 20 µg (400 to 800 IU)/day are adequate to maintain healthy serum 25(OH)D concentration of 15 ng/ml.

9.1 Homework 1

Review

The adequate daily nutrient intake for young infants and newborns are based on their daily intake of what?

- **A** human breast milk
- **B** fortified infant formula
- **C** grass -fed cow milk formula
- **D** None of the above. Adequate intake levels are extrapolated from older infants.

Show Submitted Answer | Show Correct Answer | Check My Answer

9.1 Homework 2

Review

Match each nutrient to the appropriate statement regarding the change in daily intake level from younger to older adulthood

Show Submitted Answer | Show Correct Answer | Check My Answer

9.1 Homework 3

Review

The daily intake levels for VITAMINS separate for boys and girls at what age?

- A 1-3
- B 4-8
- C 9-13
- D 14-18

Show Submitted Answer

Show Correct Answer

Check My Answer

9.1 Homework 4
Review

Touch the two nutrients that need to be considered in the 6-12 month diet because the stores endowed at birth are depleted.

Targets placed: 0/2 Undo Delete selected Remove All

You can place up to 2 targets

Show Submitted Answer Show Correct Answer Check My Answer

9.2 Nutrient Sources across the Life Stages

Learning Outcomes

- Recall the major differences between human milk and commercial infant formulas
- Explain the rationale for some of the best first foods to introduce to infants
- Recognize food serving guidelines for each of the age groups
- Identify major dietary hazards in the toddler diet

For the first several months of life, Infants have a purely liquid diet of **breast milk** or **commercial milk formula**. Breast milk supplied from the human mother is the premier source of nutrition for newborns and young infants. Breast milk delivers irreproducible antibodies and lymphocytes, which give the newborn greater resistance to environmental pathogens that can lead to sickness and infection. Breast milk provides other bioactive substances, like endocannabinoids, which act as appetite stimulants and satiation signals to help regulate the new infant appetite.

Table 9.7 Nutrient Composition per .67 Liters of Human Milk, Cow Milk and Formula

For mothers who cannot breastfeed, human milk can be obtained from breast milk donation banks, or it can be supplied by "wet-nursing" services, where a child can nurse from the breast of a woman other than their mother. If human breast milk is not an option, preferred or otherwise, commercially formulated milk for newborns and young infants, or "formulas," can be used as nutritionally equivalent alternatives. Newborn and infant formulas are typically developed using processed cow's milk proteins or processed soy proteins. **Cow's milk formulas** feature whey proteins that are specially formulated to resemble the human milk protein, alpha-lactalbumin. These proteins are marketed as hydrosylated, or "pre-digested," meaning they are in smaller peptide chains that less resemble the larger, potentially allergenic, beta-lactoglobulin cow milk proteins from which the protein was derived. Cow formulas are also stripped of a portion of their mineral concentration, then enhanced with a dose of added essential linoleic and linolenic fatty acids from vegetable oil in an effort to closely resemble human breast milk.

Soy formulas have a significantly smaller market share compared to cow formulas. They typically feature considerably more total protein and have less than half the total fat of human milk but are lower in amino acids and devoid of dietary cholesterol—an important nutrient for infant brain development. Like cow formulas, soy formulas have added long chain polyunsaturated fatty acids from vegetable oils but, uniquely, they also feature added docosahexaenoic acid, or DHA, and arachidonic acid, or ARA.

While the lactose (i.e., carbohydrate) content of soy and cow formulas have long been matched to human milk, another bioactive carbohydrate compound has more recently been added to infant formulas in an effort to mimic human milk. Human milk oligosaccharides, or HMOs, are non-nutritive carbohydrate polysaccharides that range from 3 to 32 sugars in size. These structures are synthesized glycosyltransferases that act as enzymes on mucosal surfaces that can help the infant's developing GI tract.

Cow's milk formula is higher in iron than human milk because lactoferrin, the form of iron in human breast milk, is highly bioavailable. Soy formulas have the most iron per serving to account for the poor bioavailability of iron from plants but can, as a result, be associated with constipation in young infants. Most commercial formulas, especially those intended for babies older than 4 months, are fortified with iron and zinc.

An infant's readiness to eat **solid foods** is entirely dependent on size, strength and the ability to stiffen their neck enough to sit upright. Once the infant demonstrates signs of readiness and can sit upright, parents may begin soft liquid iron-fortified cereal mixtures to supplement breastfeeding. Pureed fruits and vegetables usually follow. The first foods in each of these categories must be easy to assimilate, nutrient-rich and non-allergenic.

The **first grains** should be moderate in fiber content and low in gluten or gluten-free, as wheat is a common culprit of gastrointestinal stress and eczema-like skin reactions. Accordingly, at least in the first few exposures to grain foods, wheat should be avoided. Rice, oat, and barley cereals are common first grains in the US because they are low in the allergenic protein, gluten. Several other grains, like quinoa and amaranth, are more commonly used in other countries; in the US, they are marketed as healthy alternatives to rice. Dried and instant grain cereals are popular in the first foods market. They are often fortified with iron and contain additional nutrients such as DHA and probiotics. Products that develop infant motor and feeding skills, like teething biscuits, often feature grain foods. Some later-stage grains are formulations of mixed grains featuring fruit and vegetable powders that blend into the puree.

First **fruits** and **vegetables** should have a relatively high pH and a good amount of soluble fiber. They should be peeled, cooked, pureed and strained for simple swallowing and digestion. Fruits and vegetables that are porous, or that will be left intact for the puree, should be purchased organic or in varieties grown locally to ensure that less chemical preservatives are used. If organic produce is unavailable or cost prohibitive, produce must be thoroughly washed, and skins, or peels, of those fruits and vegetables listed in the Environmental Worker's Group's "Dirty Dozen" should be avoided entirely. 100% fruit and vegetable juice varieties can be offered to infants older than 6 months; however, should be limited to no more than four to six ounces per day.

Once a food is well-tolerated for at least four days, another grain, fruit or vegetable can be introduced. As baby begins to tolerate various foods within each food group, an appropriate daily intake for balance should be adopted. At first, daily intake should be two to three tablespoons of grains and three tablespoons of fruit/vegetable servings combined. As the baby's system adapts to digest starches and break down the proteins in grains, animal protein sources may be introduced. **Yogurt** and **cheese** are safe animal foods to introduce first because the proteins that commonly trigger allergic reactions and gastrointestinal intolerances are partially broken down during the fermentation and maturing processes. Infants under one year of age must avoid honey and should avoid cow's milk. Cow's milk should not be substituted for infant formula or breast milk because it provides too little iron and too much protein.

As infant growth continues at an accelerated pace after the 8^{th} month and breastfeeding tapers off, the increasing dietary intake requirements for chromium, zinc, protein and B12 from foods justify the introduction of meat. **First meats** should be thoughtfully chosen and carefully handled because infants are more susceptible to foodborne illnesses from chemical toxicities and bacterial contamination. In addition, the textures of meats should be soft, easily manipulated by the tongue and cheeks, and sized appropriately so as not to present an undue choking risk. Higher-moisture lean meats, like meatballs, scrambled eggs and minced white fish are all good meats to introduce first.

Foods from all of the basic food groups are typically well-tolerated by an infant approaching one year old. By then, most infants have developed budding teeth and gums to manipulate chopped and mashed food textures, instead of purees. Chunks of food also help infants manage gum soreness and develop the "pincer grasp" — a skill comprised of using the thumb and index finger for feeding.

Figure 9.3. Milk type by age

By their first birthdays, infants are typically following a more regular meal pattern that divides around 1000 calories across the anywhere from five to six meal occasions. After the age of one, **whole cow's milk** may be added to the toddler diet. Since babies and young toddlers should get about half of their calories from fat, whole dairy milk, which is approximately 4% milk fat, is preferred over skim and reduced fat versions. By age two, fat consumption can be gradually decreased, and whole milk can be substituted for a 2%, lower-fat milk, which will provide the calcium needed for bone growth without interfering with the infant's appetite.

Daily food intake guides, such as MyPlate, begin at the age of two. Two to three-year-olds can meet their nutritional needs by eating around I cup of fruit, 1 cup of vegetables, 3 servings of grains and oils, and 2 servings each of dairy and meat. Foods within these groups should be high-quality and nutritious; toddlers too often fall short of daily food intake guidelines the number of servings and breadth of variety of choices. Within each of the main groups, foods preferred by toddlers are usually plain, lightly seasoned if at all, and served separated.

Snack timing is a major factor influencing food intake of toddlers. Toddlers have small stomachs that fill to a level to suppress hunger with very small amounts of foods and drinks. During the later hours of the day, or when activity levels have lowered, snacks should be limited in order to ensure toddlers consume the nutritious elements of their dinner meals. Despite its flaws, snack time is an excellent way to expand the selection of less common fruits and vegetables after around 18-24 months. When introducing new fruits, it is important to monitor for **allergic reactions**; like with berries for instance, which have birch-pollen that can cause itching and oral inflammation shortly after consumption.

Throughout the toddler period, foods that may cause **choking** should be avoided. Larger pieces of food should be quartered, cut lengthwise and then from there sliced into small pieces until they are small enough not to pose a choking risk in the event of inadequate chewing. Small foods that cannot be cut or mashed like whole nuts, candies, popcorn, or even chunks in crunchy nut butters should be avoided until after toddlerhood. Other toddler safety feeding related concerns include temperature control and post-feeding reactions to potential allergens in the foods listed in Figure 9

For all children above the age of four, food guides account for the energy needed to sustain 30-60 minutes of higher intensity physical activity each day. Food intake recommendations in each group are the same for boys and girls in the four to eight-year-old group, but by the 9-13 age range, boys' needs for fruits, vegetables and grains outpace those of girls. Less than 20% of the diets of kids ages four to eight include adequate intake levels of fruits and vegetables, and girls in this age range typically do not meet the guidelines for meat and dairy, as well.

Number of daily servings from each major food group for primary school aged children. Contribution from National School Lunch Program for primary-level schools

Primary and middle school-aged children in the 5-13 age range who eat lunch at school are served at least one serving from each of the food groups daily. The **National School Lunch Program**, funded by the USDA, ensures that school lunches, and in some districts breakfasts too, satisfy at least one-third of the RDA for selected nutrients and are restricted in calories from sugar and fat.

Adolescent 14 to 18-year-olds need a higher number of servings from each of the major food groups compared to kids who are in the 9-13 age range. Adolescent boys need roughly 20% more servings of each of the food groups than girls, except for dairy. Adolescent girls, 9-13 years old, have additional daily fruit, vegetable, meat, dairy and oil requirements compared to their 4 to 11-year-old counterparts, but the same intake recommendations for grains. Older teen girls, ages 14-18, have the same intake guidelines for fruit, meat, oil and dairy as girls in the 11-13 age group, but slightly higher needs from the vegetable and grain groups. Teens who are vegan must include a greater number of servings of protein-rich legumes and nuts to satisfy protein needs compared to non-vegan teens who consume animal meat equivalents.

Number of servings from each food group for teens and vegan teens

Adolescent girls and boys, by and large, do not get enough fruits and vegetables. The most common vegetables in this age range are **carrots**, **white potatoes**, **corn**, and **tomatoes**. These foods provide the majority of vegetable-provided fiber and vitamins A and C in the adolescent diet which, even when combined, are inadequate to meet the intake guidelines. Adolescents, especially teens, also get too many calories from poorer choices within the groups, including soft drinks, beef, cheese, and ice cream.

Healthy snacks for teens

Another major concern for adolescents and teens is their **snacking pattern**. Approximately 25-35% of the daily adolescent calorie intake comes from snacking, with a reported average intake of one to seven snacks per day. The most problematic foods like chips, cookies, crackers and other **processed snacks** are often consumed at snack time, as is soda, which alone provides an estimated 8% of total adolescent caloric intake, on average.

Older adults, as compared to those under the age of 51, need fewer servings per day of every food group except dairy and oil. For adults over 51 years, daily fruit, vegetable and meat intake guidelines are reduced by one-half cup, and grain servings are reduced by one full cup.

Reduced number of daily servings for older adults (51 years +)

The ideal **meal pattern** for older adults is small and frequent. Seniors should eat five to six small meals a day to mitigate insulin highs and lows and, for some, gastrointestinal discomfort or breathing troubles caused by eating large meals. The largest meal of the day should not be dinner, because older adults tend to sleep earlier and have more digestive problems when they lie down that can interfere with their rest.

Older adults have changes in **taste acuity** that make foods taste blander. They are also often placed on restricted diets low in fat and salt so that the taste and smell of foods are less appealing. Many seniors have eyesight and motor skill feeding issues that make eating with a fork, knife and spoon difficult. Motor problems with swallowing can require that foods be prepared in small pieces to prevent choking.

Adequate protein intake is critical for older and elderly populations. Protein can be supplemented in snacks and drinks and should be the focal point of most meal periods. Adequate vitamin K for bone health can be achieved by about one cup of **dark green vegetables** daily.

9.2 Homework 1
Review

Match each source of infant nutrition to the feature that accurately describes it

Show Submitted Answer | Show Correct Answer | Check My Answer

9.2 Homework 2
Review

Match each age to the appropriate type of cow's milk

Show Submitted Answer | Show Correct Answer | Check My Answer

9.3 Nutrient Processing Across the Ages

Section Objectives

- Reinforce understanding of nutrient processing systems
- Highlight the major physiological changes that occur with aging that impact nutrition status

Learning Outcomes

- Recall similarities between older adults and infants in terms of their digestive and absorptive capabilities
- Describe the major highlights of the bone growth and development timeline
- Identify the hormones that initiate bone growth and those that accelerate bone loss
- Explain muscle protein synthesis and the major ways that it is affected by the aging process

There are changes in the nutrient processing systems throughout the life stages. During infancy and puberty, the nutrient processing systems are functioning at peak efficiency. Following young adulthood, the structural and functional changes associated with healthy aging eventually give way to reductions in the body's ability to efficiently process nutrients from food.

After birth, nutrient **digestive processes** begin in the mouth at every stage of life. At first, infants form a secure latching of the mouth to the nipple of a lactating breast to stimulate "milk letdown," and to expel milk by a repetitive tongue thrust. Around four to six months of age, the natural tongue thrust that pushes solid foods out of the mouth when first offered, also known as the "extrusion reflex," begins to fade and the infant can begin feeding on semi-solid foods. First foods are not significantly digested in the mouth of infants as the teeth have not erupted and salivary enzyme production is low. Softer, liquid or high moisture foods, however, are manipulated by the tongue and cheeks in preparation for swallow. After the teeth erupt, and the pH of saliva lessens, the mouth takes on a larger role in digestion.

Digestion takes place at a considerably **higher pH** in the stomach of young infants, as compared to children and adults. Despite a higher pH, proteins from human breast milk can still form a soft curd in the stomach of an infant, and the primary milk carbohydrate, alpha-lactalbumin, will unfold. The protein in cow's milk, casein, is not as easily formed into a curd and is, therefore, tougher for a newborn to digest. The minerals in dairy milk, like zinc and iron, are only 10% bioavailable compared to 50% in human milk because they are protein-bound, and protein is not as easily digested by the higher pH in the infant stomach.

Compromised digestive functions that are common in young and old age

Elderly people with **atrophic gastritis** or who take medications, like antacids, can have a reduced gastric acidity similar to that of young infants. Atrophic gastritis causes a reduction in the amount of **hydrochloric acid** produced by the stomach, which can impair the intestinal absorption of certain protein bound nutrients such as iron, zinc and magnesium.

Both infants and a higher proportion of elderly people compared to adults suffer incompetence of lower esophageal sphincter, permitting a condition called **"acid reflux."** Older babies get acid reflux from eating while lying down, and aging people develop the condition from the wearing of the muscle over time. Many older adults are also commonly prescribed medications such as nitrates and calcium channel blockers that can relax the sphincter acutely over time.

The absorptive surface area in the intestine is greatest at the infant stage of life. In the first days and weeks after birth, breast milk hormones, like epidermal growth factor (EGF), increase DNA synthesis and cell division and enhance the absorption of water and glucose. Growth factors also help the infant intestine mature by eliciting a tightening at the junctions of the intestinal epithelial cells, which protects against foreign proteins and enhances paracellular absorption.

During early childhood and the adolescent growth spurt, calcium is absorbed passively in the intestines by diffusion, or actively through intestinal cells by binding to a vitamin D dependent transport protein called calbindin. Both mechanisms are in peak use during growth periods of young childhood and adolescence.

The GI tracts of infants, children and older adults are susceptible to foodborne illness from food pathogens as well as other common intolerances, including diarrhea and constipation. Constipation, in babies, it is caused by the introduction of solid foods, iron-fortified foods, milks and cheeses. In older adults, lack of gut motility and reduced fiber consumption cause constipation.

Bone formation begins in utero when the bones consist primarily of soft and flexible hyaline cartilage. By birth, the bone has more features and details, like a medullary cavity with blood vessels and bone tissue more prominently pushing out from the center of the epiphyses region of hyaline cartilage. Bone ossification centers develop during the first phase of bone growth while the size of the bone increases. Bone growth, particularly the longitudinal type, is driven by the action of human growth hormone, secreted from the anterior pituitary. Bone lengthening takes place in the epiphyses region, or proliferative zone, of the long bones. Bone cells in the epiphyses region undergo mitotic division, causing such an increase in cell number that the bone is lengthened.

Factors initiating bone growth

During **bone modeling**, bones undergo lengthening and vascularization. The extra vasculature delivers osteoclast and osteoblast cells to the matrix of spongy and trabecular bone tissues. Osteoblasts are activated by estrogen, parathyroid hormone and serum vitamin D. If local bone matrix minerals, phosphate, fluoride and magnesium concentrations are adequate, osteoblasts are stimulated to form new bone. Bone collagen production by **osteoclasts** is dependent on circulating vitamin C. Vitamin C is a co-factor in the hydroxylation of lysine and proline in the synthesis of osteoid, which is the collagen component of bone. **Osteoblasts** secrete osteoid, which is subsequently mineralized by osteocalcin. Once they have finished secreting bone matrix, many of the osteoblasts transform into osteocytes--long-lived bone cells that make up nearly 95% of all adult compact bone. Bone modeling during childhood and early adulthood exceeds the rate of bone breakdown so that there are net gains in the quantity of bone tissue in the matrix and mineral compartments. Soon after all of the cartilage in bone tissue is replaced with a strip of compact bone, and the medullary capillary is filled with yellow fat (i.e., bone marrow), the bone will no longer grow in length, but will continue to gain density and mass upon physical stressors and forces as long as adequate nutrients are available.

After peak bone density is reached in early adulthood, bone metabolism switches to the **remodeling phase**. The remodeling phase consists of a constant process of bone mineral and organic bone matrix resorption, or breakdown, and formation that predominates continues throughout life. During remodeling, bone breakdown and formation activity are in sync. Osteoclasts first dissolve a section of bone by secreting certain enzymes and acids, then osteoblasts invade the newly created space and secrete bone matrix. The full bone remodeling cycle from osteoclast resorption to final osteoblast mineralization lasts approximately 40 weeks.

Hormonal Factors Contributing to Age-Associated Bone Loss

Bone resorption and formation are equally paced until the mid-30s. At that point, the rate of bone resorption begins to exceed bone formation, which leads to age-related bone mass loss. This effect is multiplied during the fourth decade of life when **growth Hormone (GH)** production begins to decline and, by the fifth decade, when growth factor secretion drops by more than 50%. The decline in the GH–IGF–I axis results in decreased bone tissue synthesis and, therefore, reduced bone mass. The loss of **reproductive hormones** from the ovaries and testicles accelerates bone loss.

Protein turnover and nitrogen balance are relatively constant across most life stages. Nitrogen accretion in newborns is higher, but by late infancy, it lowers and maintains for the rest of the life stages. Protein synthesis and deposition are also greatest during infancy, occurring at a rate of 17+ grams of protein per kg each day. After the first year, children with adequate protein status synthesize around 3 grams of protein per kg body weight per day, a rate that maintains throughout adulthood.

Factors initiating muscle growth during adolescence

General **somatic growth** is most rapid during the first 4 years, and then again from 12 to 16 years of age. During the first stage, a child typically becomes ambulatory and somatic muscle growth is slightly stimulated. The second stage follows adrenarche and the increasing stimulation from gonadotrophin releasing Hormone (GnRH) that kicks off puberty. Growth hormone activation triggers the hypothalamic-pituitary-gonadal axis to activate and enhance ovarian and testicular sex hormone secretion and secrete growth hormone.

Growth factors and adequate amounts of amino acid leucine stimulate muscle protein synthesis by a mechanism known as “mTOR.” mTOR is a gene inside the nucleus of cells that initiates transcription to yield cell metabolism products like enzymes and hormones and also to initiate **cell growth and differentiation**. During puberty, the mTOR pathways that result in cell growth and differentiation are highly sensitive to insulin receptor binding and circulating amino acid levels such that total muscle synthesis and body protein deposition exceeds tissue and protein losses which, in turn, results in muscle growth. After puberty, there is a long steady state where protein turnover is balanced, and protein synthesis and breakdown in skeletal muscle are equal unless stimulated by stress, such as resistance training.

Factors contributing to reduced muscle protein synthesis and enhanced muscle protein catabolism with aging

For older adults (51+ years), continual protein turnover gradually transitions from a steady state to net losses. The decline of anabolic hormones (e.g., testosterone, growth hormone, and insulin-like growth factor-I) has a catabolic effect on the musculoskeletal system known today as the **“somatopause”** of aging adults. By the time an adult reaches the very elderly years (75+), daily protein synthesis is reduced by more than 50% to 1 gram per kilogram of body weight per day. Impairments in muscle protein synthesis, strength, and muscle mass result from age-related changes in skeletal muscle amino acid delivery and dysfunctional mTORC1 activity.

9.3 Homework 1

Review

Which hormone does NOT play a direct role in triggering the adolescent musculoskeletal growth spurt ?

- **A** Growth Hormone
- **B** Estrogen
- **C** Testosterone
- **D** Insulin

Show Submitted Answer Show Correct Answer Check My Answer

9.3 Homework 2

Review

Which hormone activity increases with aging to accelerate bone loss?

- A Thyroid hormone
- B Growth Hormone
- C Estrogen
- D Testosterone

Show Submitted Answer | Show Correct Answer | Check My Answer

9.4 Nutrient Functions Across the Life Stages

Section Objectives

- Explain the role of nutrients in promoting and mitigating the physiologic changes with aging

Learning Outcomes

- Identify nutrients that support the accelerated growth during infancy and during the period of peak growth velocity
- Recognize nutrients that support immune function and neural development during childhood
- Explain how nutrition can impact the rate of aging by preserving muscle and bone tissue

A good diet optimizes the structural and functional capacities of the human body at every life stage. In earlier stages, adequate nutrition promotes the natural physiological processing of aging; later in life, it helps to mitigate them. The outcomes of adequate nutrient intake can, and will below, be studied at the cellular and tissue levels. More broadly, however, they are assessed at the whole human system level in the categories of immunity, neurological development, and gains in body mass.

Promotion of Growth and Development

DailyInfant Weight Gain

Nutrition promotes growth throughout childhood by providing many of the building materials and enzyme-cofactors that are needed to sustain **tissue growth**.

Dietary amino acids cultivate muscle protein mass. Dietary fat is integrated into new cell membranes and stored in the liver and adipocytes. Dietary minerals are deposited into the elongating skeletal bones. Adequate supply of these nutrients in the childhood diet helps to ensure optimal daily weight gain.

Starting in infancy, when peak growth velocity is most impressive, appropriate nutrient intake ensures that growth is fostered, and that the division of body nutrient stores between fat and lean tissue compartments is ideal. By the end of the first year of infancy, body weight and body surface area have likely tripled since birth. These tremendous gains are supported by intake of dietary lipids, proteins and bioactive compounds from drinking breast milk. Adiponectin, a multi-functional hormone found in large concentrations in human milk, acts together with the neurochemical signals, leptin and ghrelin, to promote energy conservation, anabolism and appetite stimulation so that daily breast milk intake is maximized.

Between ages one and eight, a child's height increases by about 40%, but the velocity of change in height, as compared to infancy and puberty, is relatively low. The pre-adolescent growth spurt accounts for 20% of the full adult height, averaging a rate of two to 2.4 inches per year for boys and girls in the 9 to Puberty initiates **peak growth velocity** which spans a two-year period. Girls will gain around 17 cm of height and 15 pounds during the 12th and 13th years; a velocity near double the period from ages 9-12, and more than four times the rate of her remaining teen years. Peak growth velocity for adolescence boys yields a 20-pound weight gain and a 17cm upsurge in height together with a much higher ratio of gained lean mass than girls.

Skeletal muscle mass represents 25% of body mass for pre-pubescent boys and girls. In average boys, fat free mass increases from 28 to 61 kg between years 10 to 18, and coincides with peak gains in height. Over the same age range, girls deposit on average 6 kg of fat, which yields a 10% gain in body fat. For boys and girls, by the end of the adolescent growth spurt, almost all of the genetically determined muscle mass has been deposited, and **peak muscle mass** is attained.

Annual body mass gains in adolescents

Adequate nutrient intake during adolescence is especially critical for **bone elongation** and attainment of **peak bone mass**. About 45% of the peak bone mass is attained during adolescence, and by age 17, adolescents have attained approximately 90% of their lifetime bone mass. With adequate intake of dietary calcium, magnesium, fluoride, phosphorus, and protein and exposure to UV light from the sun, hydroxyapatite (HA) crystal formation and structure is maximized, which has a long-term positive effect on bone mineral density.

Immune function gradually increases from birth through childhood. It peaks in adulthood where it remains steady until a gradual decline back to birth levels in the mid-to-late forties. Susceptibility to illness, cancers and disease is high in young children, and then lowest throughout childhood and young adulthood. Nutrition promotes maximum immune function at each stage of life by providing proteins and energy for immune cell production and for preventing catabolism and inflammation.

Breast feeding promotes acquired and innate factors of immunity by protecting against infection and inflammation. Early milk is enriched in immune factors that help to ensure infant survival, including a variety of cells, of which, about 80% are macrophages. The other portion includes T cells, stem cells and lymphocytes. Macrophages in breast milk provide powerful protection against pathogens while stimulating development of the infant's own immune system. Human milk cytokines cross the intestinal barrier and communicate with intestinal cells to stimulate immune activity. Human milk-borne cytokines are grouped broadly into those that enhance inflammation and those that reduce it. Pro-inflammatory cytokines are known to be engaged in the recruitment of neutrophils which further stimulate the infant immune system. Human milk sIgA-antigen complexes also provide the infant with antibodies that were formed in the mother's body against the bacteria in her gut, and against infections that she has encountered. These antibodies are taken up and processed by intestinal cells which provide significant protection against infection. Among the breastmilk antibodies is lactoferrin, an iron-binding glycoprotein which helps prevent rotoviral infection in the newborn and, following infection or damage, stimulates a signaling cascade that stunts inflammation.

Breast milk contains as many as 600 different species of bacteria. Colostrum provides **Lactobacillus bifidus factor**, which encourages the growth of Lactobacillus bifidus in the GI tract. The **human milk oligosaccharides** (HMOS) are "prebiotic" agents that selectively encourage the growth of beneficial probiotic organisms. HMOS and their protein conjugates are also recognized as pathogen-binding inhibitors that function as soluble "decoy" receptors for pathogens that have an affinity for binding to oligosaccharide receptors expressed on the infant's intestinal surface.

Brain Growth in Early Childhood

The central nervous system grows most rapidly in the first three years of life. Long chain polyunsaturated fatty acids, such as omega 3 or its metabolic intermediate, DHA, found in breast milk and infant formula are important for the **neurological development** of an infant. The myelin sheath tissue that insulates and surrounds the nerve fibers is made of lipids, cholesterol and proteins. This sheath acts as a conduit in an electrical system, allowing rapid and efficient transmission of nerve impulses. Although myelination primarily occurs during fetal development and early infancy, it continues through childhood and adolescence. Because vitamins folate, B_{12} and B6 enable trans-methylation and isomerization reactions inside oligodendrocytes (i.e., nerve cells), it is essential these nutrients are adequate for the metabolism of necessary components of the myelin sheath.

Mitigation of Natural Losses

Longevity and quality of life are the big picture outcomes of adequate nutrition and healthy diet in the older ages. Life expectancy in the US is about 75 years for men and 80 years for women. The oldest living people and populations have common lifestyle patterns that center on a healthy diet, which some genetic experts believe maximizes one's pre-programmed genetic potential. Often, the outcomes of most interest for older adults in relation to good nutrition are those related to **quality of life**, which is most often assessed by an individual's ability to maintain neurological function, memory, musculoskeletal strength, flexibility and rigidity, and to preserve one's status as pain-, disease- and infection-free.

Preserving skeletal muscle mass helps maintain metabolic rate and keeps body fat relatively low. Adequate dietary protein and calorie intake for daily protein turnover, and carbohydrate intake to stimulate insulin release, are vital to promoting optimal protein synthesis. A diet balanced in carbohydrate and protein also helps older adults keep a healthier body composition favorable for mitigating chronic metabolic diseases. Maintenance of lean tissue is also particularly important for the preservation of total body water, which, for older people who are less effective at regulating body temperature and sensing thirst, can help minimize dehydration risk. Conserving muscle mass will also help minimize the average 15% loss per decade in strength and power. Muscle atrophy is a function of reduced muscle fiber number and size and a smaller number of motor units, with a more pronounced effect in the motoneurons of the glycolytic, or type II, muscle fibers. Type I, slow twitch, oxidative muscle fibers are less influenced by aging, such that the effects of good nutrition are less pronounced. However, one's susceptibility to function failures or losses in anaerobic capacity over time can be minimized with adequate amino acid and carbohydrate intake in the diet. These dietary components, when combined with resistance exercise, can minimize the 1-2% loss of leg mass and 1.5–5% strength loss that takes place with aging for older adults (51+) each year.

Bone loss following peak mass and menopause

Good nutrition later in life, especially if supplemented with high impact resistance exercise, can also help **prevent bone loss and bone fracture.** Calcium supplementation in older adults has a modest positive effect on bone resorption and bone density. The risk of hip and other non-vertebral fractures may be significantly lower in women treated with calcium and 10 to 25 µg of daily vitamin D3 supplements, but like with isolated calcium trials the magnitude of the effect of vitamin D supplementation is more apparent in women with low calcium intake and inadequate vitamin D status. Adequate intake of magnesium and phosphorus also have direct roles in hydroxyapatite (HA) crystal formation and structure such that they can influence bone density retention. Fluoride has been used as an experimental drug for the treatment of osteoporosis to stimulate bone formation, and regular intake of fluoridated water (1 mg/L) is associated with reduced fracture incidence in elderly individuals.

Too often, the discussion of skeletal health focuses exclusively on the mineral aspect of bone, but the organic matrix is also an integral part of bone quality and health associated with aging. Collagen makes up 90% of the organic matrix of bone. Type I collagen fibers twist around each other in a triple helix and become the scaffold upon which minerals are deposited. Vitamin C intake promotes the hydroxylation of collagenous proline and lysine residues as well as osteoblastic adhesion to the bone matrix. Diets that are adequate in the methylation vitamins folate, B12 and B6 will help minimize the homocysteine metabolite, lysyl oxidase — an enzyme that stimulates osteoclastic (i.e., bone breakdown) activity

Age-related deterioration of immune function is an outcome of increasing scientific interest today. Appropriate nutrient intake can **enhance immune function** and reduce risk of infection in older adults. Reductions in cell-mediated immune response with advancing age may be partially mitigated by appropriate levels of dietary vitamin E. Daily intake of 100 mg of *RRR*-α-tocopherol enhances the T lymphocyte-mediated immunity and significantly improves other cell-mediated responses, such as natural killer (NK) cytotoxic activity, phagocytic response, and enhanced mitogen-induced lymphocyte proliferation and interleukin-2 production. Collectively, the effect of improvements in immune response have clinical outcomes that include reduced risk of upper respiratory tract infections like the common cold.

The prevalence of several neurodegenerative diseases increases with advanced age. Inflammation, oxidative stress and transition metal accumulation appear to play a role in the pathology of several neurodegenerative disorders, including Parkinson's and Alzheimer's diseases. Several nutrients and other dietary compounds are suspected to **prevent cognitive impairment.** For instance, α-Lipoic acid by itself or in combination with other antioxidants and/or L-carnitine may **improve memory.** Flavonoids have also been found to prevent cognitive impairment associated with aging and inflammation, but a consistent inverse association between flavonoid intake and the risk of dementia or neurodegenerative disease has not yet been identified.

9.4 Homework 1

Review

Which child sustains the greatest daily gains in body weight?

- A 1 year old girl
- B 5 year old boy
- C 11 year old girl
- D 14 year old boy

Show Submitted Answer | Show Correct Answer | Check My Answer

9.4 Homework 2

Review

Match the age range to the natural PEAK in physiologic action

Show Submitted Answer

Show Correct Answer

Check My Answer

9.4 Homework 3

Review

The natural aging process has a more apparent affect on ______________ muscle fibers, which results in ______________ power.

A type I, less aerobic

B type II, less anaerobic

C oxidative, less anaerobic

Show Submitted Answer

Show Correct Answer

Check My Answer

9.5 Nutrient Status Measures Across the Ages

Section Objectives

- Reinforce understanding of anthropometric measures that are indicative of growing and wasting.

Learning Outcomes

- Explain how the infant growth charts are used to assess childhood growth

Too often, the discussion of skeletal health focuses exclusively on the mineral aspect of bone, but the organic matrix is also an integral part of bone quality and health associated with aging. Collagen makes up 90% of the organic matrix of bone. Type I collagen fibers twist around each other in a triple helix and become the scaffold upon which minerals are deposited. Vitamin C intake promotes the hydroxylation of collagenous proline and lysine residues as well as osteoblastic adhesion to the bone matrix. Diets that are adequate in the methylation vitamins folate, B12 and B6 will help minimize the homocysteine metabolite, lysyl oxidase — an enzyme that stimulates osteoclastic (i.e., bone breakdown) activity

In older infants and young children, linear monitoring of the changes in height and weight are important anthropometric indices of growth. Children in the lowest percentiles of weight for age are clinically termed as "wasting," and those with heights in the lowest percentiles are termed "stunting." Since growth is dynamic, repeated measures over time are necessary to make these diagnoses.

Excess energy intake and excess body weight cause similar risks for metabolic perturbations that lead to disease and early morbidity as undernutrition. A commonly used measure of excess body weight in children is **Body Mass Index**. BMI is calculated for children the same way as it is for adults, but the results are interpreted differently depending on age and gender. BMI for age is the indicator for relative position of the child's BMI value among children of the same age and gender. In children, the BMI percentiles include: underweight (<5th percentile), healthy weight (5th to 85th percentile), overweight (85th to 95th percentile), and obesity (≥95th percentile).

Chronically low protein and energy intakes can lead to reductions in linear growth in adolescents, delays in sexual maturation, and reduced accumulation of lean body mass. Micronutrient deficiencies can also negatively affect growing bones. **Ascorbic acid** deficiency, for instance, may impair the quality and quantity of the bone matrix by limiting the hydroxylation of collagenous proline and lysine residues, and interfering with osteoblastic adhesion to the bone matrix. Vitamin A deficiency can also cause bone abnormalities due to impaired osteoclastic and osteoblastic activities associated with **poor bone growth and mineralization.** Excessive intake of micronutrients can also have deleterious effects on children. For instance, too much vitamin D in the diet can lead to high levels of deposited calcium salts in the soft tissues, including the kidneys, heart and lungs. It can also result in hypercalcemia, or high levels of calcium in the blood.

Nutrition is also an important determinant of health in **elderly adults**. It is estimated that 10-20% of elderly people are **nutritionally deficient** in protein and calories, and when mineral and vitamin deficiencies are considered, malnutrition in persons over the age of 65 may be as high as 35%. Although there is no uniformly accepted definition of malnutrition in the elderly, common indicators include involuntary weight loss, abnormal BMI and decreased dietary intake. Screening tools for older adults typically include height and weight measurements, BMI calculations, and examinations of eating habits, living environment, and functional status.

Bone formation and breakdown can also be measured biochemically and anthropometrically. Alkaline phosphatase travels to the bloodstream and is, therefore, used as a clinical marker of bone formation rate. End products of bone matrix breakdown (e.g., hydroxyproline and amino-terminal collagen peptides) are excreted in the urine and can be used as convenient biochemical measures of bone resorption rate.

Technically, the matrix component of bone mass cannot be measured directly so, instead, bone mineral density is measured using dual X-ray absorptiometry (DEXA). In this technique, the absorption of photons from an X-ray is a function of the density of minerals present in a given section of bone and is used as a proxy for bone mass.

Osteomalacia, also known as "adult rickets," is a failure to mineralize bone. Stereotypically, osteomalacia results from **vitamin D deficiency** and the associated inability to absorb dietary calcium and phosphorus across the small intestine. This results in incomplete mineralization of the newly secreted bone matrix such that the bone can be deformed under the strain of body weight. **Osteopenia** and osteoporosis are conditions related to varying degrees of low bone mass. Whereas osteomalacia is characterized by low-mineral and high-matrix content, osteopenia and osteoporosis result from low levels of both. **Osteoporosis** is a condition of increased bone fragility and susceptibility to fracture due to loss of bone mass. Skeletal sites that are rich in trabecular bone are often sites of osteoporotic fracture, such as the hip, femoral neck and vertebrae of spinal column.

9.5 Homework 1

Review

Match the clinical conditions to the nutrients deficiencies that they are associated with

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