CHAPTER

1

Nutrition Requirements During Pregnancy

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With a Special Section: Unusual Complications of Pregnancy

CHAPTER OUTLINE

Reader Objectives

After studying this chapter and reflecting on the contents, you should be able to

1. Discuss the rationale for healthy nutrition during pregnancy.
2. Summarize the growth changes that occur during fetal development.
3. Discuss the common nutrition-related problems that can occur during pregnancy.
4. Explain the complications of pregnancy.
5. Summarize how life-style choices can affect fetal development.

What a woman eats when she is pregnant can have profound and lasting effects on her child's health. The expression "you are what you eat" applies, but in this case, it is this: "You are what your mother eats." During the prenatal period, the fetus has the enormous task of evolving in only 9 short months from a single-celled, fertilized egg to a human infant. In order to accomplish this, the fetus must have all of the necessary resources available in the proper quantities and at the exact times they are needed. Despite the daunting nature of the task, mothers have been producing healthy infants for thousands of years, demonstrating the amazing adaptability of both the mother and her child. The capacity of the mother's body to create the necessary conditions for fetal growth is one of the great miracles of life. There are limits, however, and the health of the child may suffer in obvious and not-so-obvious ways if certain thresholds for nutrients are not met.

Although a pregnant body has an amazing ability to compensate for nutrient deficiencies and excesses, a woman cannot provide essential nutrients for her child if she herself is deficient in them. Many factors influence a mother's nutritional status during her pregnancy. The mother's own health before conception, her health during pregnancy, her life-style choices, and environmental exposures can all change what and how much she eats and limit precious nutrients available for the growing fetus.

It is important that knowledgeable health care providers are available to support the mother-to-be with strategies to help her achieve the most balanced diet possible, thus ensuring the health of both mother and child. This chapter examines normal prenatal nutritional requirements and common factors that may compromise the mother's ability to provide ideal nutrition for her growing fetus.

Nutritional Status Prior to Pregnancy

The period when a woman is pregnant is often looked at in isolation and is not put in a larger context of the mother's overall health. Although this has been the traditional approach to pregnancy, there is a growing movement to look at human nutrition using the life-course approach, which is promoted by the World Health Organization (WHO). Using the life-course approach, a woman is followed from her own conception through death, and factors that have influenced her health since she herself was in utero are considered when assessing risk of developing chronic diseases for both the mother and her offspring (Darnton-Hill et al., 2004).

The Fetal Origins Hypothesis

The mother's health before and during pregnancy may be affected by genetics, as well as malnutrition, acute and chronic disease, exposure to environmental toxins, and a number of other factors. The fetal origins hypothesis proposes that certain genes in the fetus may or may not be "turned on" depending on the environment that the mother is exposed to while pregnant (Hampton, 2004). For example, if a mother is exposed to severe food restriction during pregnancy, as was the case in the Dutch famine during World War II, her developing fetus will adapt genetically to thrive in an environment of severe energy restriction. The child's genetic programming will be sensitized to store fat more efficiently compared with that of people not exposed to famine in utero. If the environmental conditions the child is born into

do not match the famine conditions, the child will accumulate fat more quickly than desired and be at higher risk for obesity, diabetes, and cardiovascular disease. Findings from the Dutch famine and other cohorts support the fetal origins hypothesis, and research is ongoing to confirm the process by which this may have occurred (Roseboom et al., 2006; Thompson, 2007).

In the World Health Organization's life-course approach to disease prevention, the passing on of excess risk for chronic disease from mother to child based on prenatal environmental exposures is known as the intergenerational effect. The intergenerational effect is thought to be one reason behind the clustering of chronic disease risk factors in families of lower socioeconomic status. Women in lower socioeconomic classes are more likely to be exposed to extreme environmental conditions and have substandard health care that exacerbates problems. Interventions should seek to maximize the mother's health before and during pregnancy to improve the short- and long-term health of her children.

Maternal Preconception Weight Status

Many aspects of the mother's health and life-style before pregnancy have been shown to affect her subsequent pregnancies with potential to impact the health of her children, but one area of particular concern is the mother's weight before pregnancy. The dramatic increase of overweight and obesity in women in the United States has forced many health care providers to focus their counseling on weight management before and during pregnancy. Preconception obesity has been associated with a substantial increase in risk for pregnancy complications, such as gestational diabetes and preeclampsia, as well as a significant increase in birth defects (Chu et al., 2007; Hauger et al., 2008; Stothard et al., 2009).

Both maternal obesity (body mass index [BMI] > 30) and maternal overweight status (BMI = 25 to 29.9) have been shown to increase the risk of birth defects. One study from the Centers for Disease Control and Prevention (CDC) found that babies born to mothers who were overweight at the time of conception had a higher risk of birth defects than those born to normal-weight women, and twice the risk of heart abnormalities. Mothers who were obese prior to conception were more than 3 times as likely to have babies with spina bifida or the abdominal malformation omphalocele (Watkins et al., 2003).

A mother who is underweight prior to becoming pregnant also puts her baby at higher risk for complications, mainly because of the association between underweight status and malnutrition (Ehrenberg et al., 2003). As discussed earlier, maternal malnutrition during pregnancy may influence fetal programming, priming the child to be more susceptible to heart disease, diabetes, and high blood pressure later in life. Malnutrition may be due to illness, food insecurity, or other factors, and both the malnutrition and the underlying cause need to be addressed to maximize positive outcomes for both mother and baby.

Regardless of nutritional status, a BMI of less than 18.5 has been associated with a higher risk of preterm delivery (Hauger et al., 2008). Underweight women should be carefully monitored to ensure that they are meeting their nutritional needs during pregnancy, and weight-gain goals should be emphasized. Supplements may need to be customized to ensure that the mother-to-be meets her nutritional requirements. Referrals to social service programs to help the mother obtain food, health insurance, and housing assistance may be necessary if malnutrition is caused by food insecurity.

In some cases, underweight status before pregnancy and/or failure to gain appropriate weight during pregnancy may be a sign of either a preexisting eating disorder or one that has developed during pregnancy. "Pregorexia" is a recently coined term used to describe the practice of overly restricting energy intake and/or overexercising during pregnancy to minimize weight gain. The pregorexic mother disregards prenatal health guidelines in an effort to control her weight, with potentially dangerous short- and long-term effects for her baby, placing her baby at risk for poor growth and vitamin deficiencies. One study found that women with eating disorders were significantly more likely than those without to be at risk for fetal growth restriction, preterm labor, anemia, genitourinary tract infections, and labor induction (Bansil et al., 2008).

Learning Point In 2009 the Institute of Medicine changed the guidelines for weight gain during pregnancy. See these guidelines in Table 1.1.

Preexisting Conditions

In some cases, the mother may have a preexisting medical condition that may jeopardize the fetus's health long before the child is born. Mothers with multiple sclerosis, type 1 diabetes, and other serious health conditions can have healthy, successful pregnancies, but they need to be carefully monitored by specialists as well as by a health care team that is typically led by the obstetrician/gynecologist.

Public Health Campaigns to Improve Preconception Nutritional Status

Ideally, most women will plan ahead and begin to adopt healthful behaviors compatible with a healthy pregnancy long before they are necessary. In reality, the majority of pregnancies are not planned, and thus health care providers need to take every opportunity to encourage women to adopt healthful practices that will support a healthy pregnancy.

A few social marketing campaigns have been mounted over the years, designed to educate women of childbearing age about behaviors related to positive pregnancy outcomes, thus maximizing the health of their children if pregnancy occurs. One example is the March of Dimes campaign to encourage supplementation with folic acid for all women of childbearing age. The campaign had limited success, and many experts concluded that these public health messages were ultimately far less effective than fortification of the food supply with folic acid (Bower et al., 2005). The March of Dimes discontinued this campaign and is currently focusing its education and prevention efforts more broadly on reducing behaviors in women associated with premature birth.

General Preconception Health and Nutrition Recommendations for Women

Preconception planning for all women should include advice to begin prenatal multivitamin/mineral supplements even before conception to build stores and ensure adequate intake of valuable nutrients. In addition to a standard prenatal supplement, most women could likely benefit from taking fish oil to build stores of essential fatty acids before becoming pregnant.

Life-style interventions should include advising women to stop smoking before they become pregnant. Alcohol and caffeine consumption should be moderated prior to conception, and drinking of alcohol should be discontinued altogether if a women suspects that she is pregnant.

Other good practices to prepare for a healthy pregnancy include evaluating the safety of all medications the mother takes, whether prescription or over the counter, to determine whether they are safe to take during pregnancy. Alternate medications that are determined to be safe during pregnancy should be identified, and women should work with their doctors to switch to these alternates if necessary in the case of prescription medications.

A woman who needs to lose weight prior to conception should be very careful not to over-restrict micronutrients to a point that she becomes deficient. She should be careful not to compromise the health of the fetus by following a strict diet plan before becoming pregnant. The focus of preconception weight loss should be on cutting empty-calorie foods and increasing low-calorie, nutrient-dense foods such as fruits and vegetables, whole grains, and low-fat meats and dairy. Increasing exercise may also help the woman lose weight prior to becoming pregnant and have benefits after she becomes pregnant in helping her cope with some of the unpleasant side effects associated with pregnancy.

Nutrient Needs During Pregnancy

The needs for most nutrients are increased during pregnancy to meet the high demands of both the growing fetus and the mother, who herself goes through a period of growth to carry the child and prepare for lactation. In this section, we discuss the general need for increased macronutrients and micronutrients **(Figure 1.1)**.

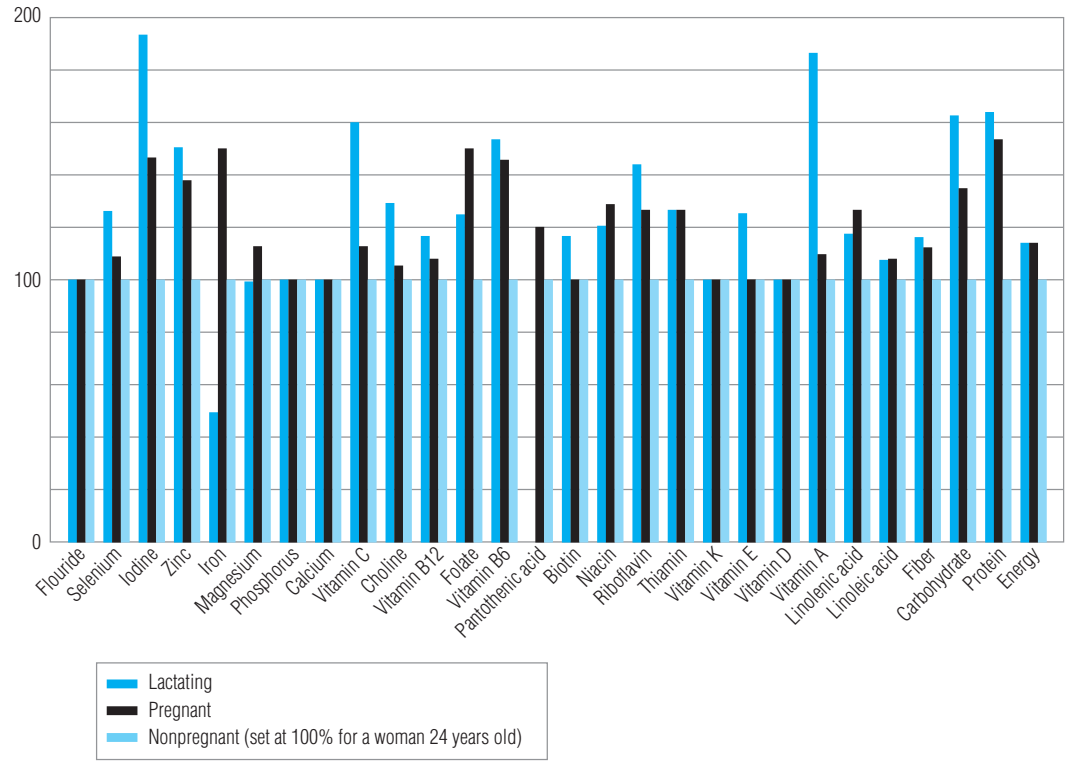


Figure 1.1 Compared Nutrient Needs

Total Energy

It is often said that a pregnant woman is "eating for two." Although this is technically correct, mothers-to-be often overestimate their need for additional calories, especially early in the pregnancy. For most women, the extra energy needs are easily met by adding a small snack or two during the day. Eating smaller amounts of food more frequently also has the benefit of helping with some of the uncomfortable side effects of pregnancy, including nausea and heartburn. The focus should be on increasing the consumption of nutrient-dense foods and minimizing empty-calorie foods that may provide the extra energy needed but do not provide micronutrients that are needed in much higher amounts compared with increased caloric needs.

Before 2002, the advice for pregnant women was to increase their energy intake by approximately 300 kcal/day in the second and third trimesters (Institute of Medicine, 1990). In 2002 the Institute of Medicine (IOM) revised the Dietary Reference Intake (DRI) recommendations for energy intake during pregnancy. The new recommendations are higher in total calories and more specific in how increased calorie needs should be distributed over the trimesters of pregnancy. The new recommendations advise no additional calories for the first trimester, add 340 kilocalories for the second trimester, and add 452 kilocalories for the third trimester (Panel on Macronutrients, Institute of Medicine, 2002).

In a comprehensive study released in 2004, Butte et al. reported that additional energy needs not only should differ by trimester but also should be tailored based on the mother's preconception BMI. Butte et al. (1994) outlined the additional energy needs during pregnancy by trimester: In the first trimester, the underweight woman should increase her usual energy intake by an additional 150 kcal/day. In the second trimester, the underweight woman should add 200 kcal/day to her usual intake, whereas the normal-weight woman should add 350 kcal/day extra, and the overweight/obese woman should add 450 kcal/day of extra energy. In the third trimester, the underweight woman should add 300 kcal/day to

TABLE 1.1 2009 Institute of Medicine Guidelines for Prenatal Weight Gain

Weight Category	Total Weight Gain (lbs)
Underweight: BMI under 18.5	28–40 lb
Normal weight: BMI 18.5–24.9	25–35 lb
Overweight: BMI 25–29.9	15–25 lb
Obese: BMI greater or equal to 30.0	11–20 lb

Source: Adapted from Institute of Medicine

TABLE 1.2 Average Weight Distribution of Weight Gained During Pregnancy

Weight	Distribution
7.5 pounds	Average baby's weight
7 pounds	Extra stored protein, fat, and other nutrients
4 pounds	Extra blood
4 pounds	Other additional body fluids
2 pounds	Breast enlargement
2 pounds	Uterine enlargement
2 pounds	Amniotic fluid
1.5 pounds	The placenta

Source: Adapted from Institute of Medicine

her usual energy intake, the normal-weight woman should add 500 kcal/day, and the overweight/obese woman should add 350 kcal/day.

Although the Butte et al. study and the DRI recommendations provide general guidelines for caloric intake during pregnancy, the most accurate way to monitor whether the mother is getting the appropriate energy intake is to monitor her weight gain. A variety of factors may alter the woman's need for additional calories, with level of physical activity being the most influential, just as it is for nonpregnant women. Physical activity during pregnancy is discussed later in this chapter **(see Tables 1.1 and 1.2)**.

Protein

Healthy fetal development is dependent on the availability of adequate protein, which provides the basic building blocks necessary for formation of enzymes, antibodies, muscle, and collagen. Collagen is used as the framework for skin, bones, blood vessels, and other body tissue. During pregnancy, the mother must consume adequate protein to meet the needs of her growing fetus in addition to meeting her own increased needs as she physically grows in size to carry her baby. To accommodate the high demand, the mother's body adapts during pregnancy to conserve protein. Hormones signal the body that she is in a state of anabolism, which causes her body to retain nitrogen for protein synthesis.

The DRI for protein for a nonpregnant woman is 0.8 g/kg/day, which comes to approximately 54 g/day for a 150-pound woman. The 2002 DRI for pregnant women recommends 1.1 g/kg/day of body weight or an additional 25 g/day to meet the needs of pregnancy. According to the National Health and Nutrition Examination Survey (NHANES), the average daily protein intake for a women aged 20 to 39 in the United States is 74 grams, and thus protein needs should easily be met by most American women, even during times of elevated need such as pregnancy (Centers for Disease Control and Prevention, 2004).

Despite the generally high level of protein intake within the United States, several special populations should be carefully monitored for adequate protein intake and quality during pregnancy: vegetarians, vegans, low-income women experiencing food insecurity, and women experiencing severe nausea and vomiting.

When evaluating the mother's protein status, several factors should be taken into account. The mother may be consuming an adequate number of calories but taking in insufficient protein, leading to a protein deficiency. Conversely, the mother may consume adequate protein but may still have a protein deficiency if her calorie intake is too low. To meet the increased energy needs of pregnancy, some amino acids may be used for energy, thus leading to a protein deficiency. Finally, the quality of the mother's protein intake should be accounted for. If the mother does not consume high-quality sources of protein, meaning sources that include all essential amino acids, such as meat, eggs, poultry, fish, and dairy, she should be encouraged to consume a variety of plant-based foods to ensure that all essential amino acids are available to the fetus.

A woman who chooses a vegan diet eats no dairy products, meat, fish, or poultry, placing her at high risk for protein deficiency both before and during pregnancy. She must consume all essential amino acids from plant sources to create the protein necessary for her fetus's growth. Although it is possible for a vegan mother to have a healthy pregnancy, careful planning and monitoring to ensure that she is meeting her increased protein needs is essential. Lacto-ovo vegetarians who do not eat red meat, poultry, or fish should also be screened for protein deficiency, although they are at a much lower level of risk because of consumption of high-quality protein in the form of milk, cheese, yogurt, and eggs.

Low-income women are also at high risk for protein deficiency during pregnancy because of potential issues with food insecurity. A woman who is food insecure may lack adequate resources to obtain protein-rich, nutrient-dense foods, which often cost more compared with less nutritious foods. It is important to help food-insecure women identify low-cost protein sources, such as canned tuna, beans, eggs, and limited amounts of meat. Woman experiencing food insecurity should also be referred to nutrition assistance programs such as the Supplemental Nutrition Assistance Program (SNAP) for Women, Infants, and Children (WIC), formerly known as the Food Stamps program, and local food pantries.

Lipids and Fats

The mother-to-be must include enough fat in her diet to meet the needs of her growing baby. Lipids, including sterols, phospholipids, and triglycerides, which are primarily made up of fatty acids, are another basic building material of body tissue and integral to body functioning. Lipids are essential for the formation of cell membranes and hormones and are necessary for proper eye and brain development, especially during the prenatal period and into the first few years of the child's life (Innis & Friesen, 2008).

Fat is also a source of concentrated calories and may be beneficial to women at risk of energy malnutrition while pregnant. Women who are not at risk should avoid excess fat because it can easily lead to undesired weight gain; moderation is essential. There is no separate RDA/DRI for fat intake during pregnancy, and the recommendation remains 20% to 35% of total calories, the same as for the general population. Fat intake during pregnancy should emphasize sources that provide the essential fatty acids and choline, a component of phospholipids necessary for healthy brain function.

Essential Fatty Acids

The essential fatty acids linoleic acid (omega-6) and linolenic acid (omega-3) are necessary for optimal formation of the brain and eyes and also play a key role in the body as precursors of hormone-like substances called eicosanoids. Eicosanoids are used to signal a number of local reactions within the human body necessary for basic functioning. Reactions such as muscle relaxation and blood vessel constriction are signaled by eicosanoids. Immune functions such as the inflammatory response to injury and infection that signals initiation of fever, aggregation of antibodies, and pain are also controlled by eicosanoids (Connor, 2000).

Although omega-6 fatty acids are used to create proinflammatory eicosanoids, omega-3 fatty acids are used to create anti-inflammatory versions. When the body has sufficient access to both essential fatty acids, it is able to create balanced amounts of each type, allowing for optimal immune function. This balance is possible only when the two essential fatty acids are consumed through diet or supplements in adequate amounts. Although omega-6 fatty acids are plentiful in the American diet through meat and vegetable oils, omega-3 fatty acids are relatively insufficient. This imbalance would theoretically lead to the ability to mount a pro-inflammatory response without an equal ability to slow and stop it. Omega-3 fatty acid deficiency has also been linked with lower intelligence quotient (IQ) scores in infants and with lower scores of visual acuity, as well as an increased risk of depression in adults; it is suspected to be one potential reason for an increased risk of chronic diseases with an inflammatory component such as cardiovascular disease (Horrocks and Yeo, 1999; Bourre, 2007; Connor, 2000).

The amount of these essential fatty acids available to the fetus is based on how much of each the mother eats. If a mother-to-be consumes a typical American diet, the fetal tissue will have a high concentration of omega-6. Omega-3 fatty acids are generally deficient in the standard American diet and

consumed in a 1:10 ratio with omega-6 fatty acids (Briefel & Johnson, 2004). This deficiency may be even more pronounced in pregnant women, who may avoid seafood, one of the richest sources of omega-3, because of fears of mercury contamination.

Supplementation with omega-3 fatty acids increases the availability to the fetus and should be recommended to every woman who is currently pregnant or is planning to become pregnant. The mother should be advised to continue to supplement with omega-3 fatty acids during lactation.

The revised 2002 RDA/DRI recommendation for essential fatty acids is an adequate intake (AI) of 13 g/day of omega-6 and 1.4 g/day of omega-3. It further states that the ratio of the two fatty acids should be no more than 5:1. Because of a lack of data, the AI for essential fatty acids likely does not represent ideal levels for each nutrient and will almost certainly change as more information becomes available.

Choline

When selecting appropriate dietary fat sources, mothers-to-be should be advised to include good sources of choline. Choline is a component of phospholipids and is needed for synthesis of lecithin, a structural component of cell membranes and an essential constituent of the human brain and nervous system. Choline is also necessary to make the neurotransmitter acetylcholine. During fetal development, choline supports the structure and function of the brain and spinal cord. In animal models, choline deficiency during pregnancy in the mother has been associated with impaired memory in her children (Zeisel, 2006).

The AI for pregnant and lactating women is 450 mg/day, increased from 425 mg/day in nonpregnant women of childbearing age. Good sources of choline are whole, reduced-fat, and low-fat milk; liver; eggs; and peanuts. Choline intake in the United States has declined over the past few decades because Americans avoid eating egg yolk and reduce the amount of milk and dairy products they consume to lower cholesterol intake.

Fiber

Fiber is a very important component of the prenatal diet. The development of the fetus is not dependent on an adequate supply of fiber, but a high-fiber diet significantly increases the comfort of the pregnant mother by helping to reduce constipation, a common side effect of pregnancy. Although the AI for pregnant women is 28 g/day, according to NHANES 1988–91, the average intake for a nonpregnant American woman of childbearing age is only approximately 13 g/day (Alaimo et al., 1994).

Although the American diet is generally low in fiber, leading to adverse effects on health, including constipation, hemorrhoids, and diverticulitis, it is even more important that pregnant women get enough fiber because they are at higher risk for these problems. Higher fluid needs, reduced exercise, and hormonal changes within the woman's body designed to allow the baby more room for growth may all contribute to problems with constipation and hemorrhoids during pregnancy. Pregnant women should be given the standard advice to reduce these problems, including increasing noncaffeinated fluids, moderate exercise, and high fiber intake. Fruits, vegetables, beans, whole grains, seeds, and nuts are all good dietary sources of fiber.

Learning Point See what MyPyramid recommends for pregnant and breast-feeding women at: http://www.mypyramid.gov/mypyramidmoms/

Carbohydrate

Dietary carbohydrate is broken down to form glucose, also known as blood sugar. The rapid growth of the fetus requires that ample amounts of energy in the form of glucose be available to the fetus at all times. The recommended daily allowance (RDA) for carbohydrate during pregnancy is 175 g/day, increased from 130 g/day for nonpregnant women. Most Americans eat enough carbohydrate to meet normal and pregnancy requirements with a mean intake of approximately 260 g/day for women of childbearing age (Centers for Disease Control and Prevention, 2004).

Pregnant women should be advised that a low-carbohydrate diet is dangerous during pregnancy and could place the baby at risk for poor growth. A mild restriction of dietary carbohydrate may be recommended if the mother is diabetic. If a mother enters pregnancy with preexisting diabetes or develops it

while she is pregnant, she will need to work closely with her health care team to make sure that she provides enough, but not too much, glucose to ensure optimal growth of her baby. Gestational diabetes is discussed in more detail later in this chapter.

Vitamin A

Vitamin A, a fat-soluble vitamin, and beta carotene, which can be used in the body as either an antioxidant or a precursor to vitamin A, are critical during fetal development because of their involvement in growth, vision, protein synthesis, and cell differentiation. Beta carotene is found in fruits and vegetables, and preformed vitamin A can be found in animal products, including fish, meat, and milk. Despite the important role vitamin A plays in the body, the RDA for pregnant women of 770 μg/day is only slightly higher than the RDA for nonpregnant women. This is due to the high risk of birth defects associated with excessive doses of preformed vitamin A early in pregnancy (Miller et al., 1998).

Although it is unlikely that the mother-to-be will overconsume vitamin A from food sources alone, close attention should be paid to choosing a prenatal vitamin supplement that contains no more than the usual RDA for vitamin A. To minimize risks associated with excess intake, a significant percentage of the vitamin A content in the supplement should come from beta carotene instead of providing it all as preformed vitamin A (Strobel et al., 2007). Beta carotene is not converted to vitamin A unless the body determines the need, and thus it is a safer form to consume.

Vitamin D

Vitamin D may be obtained through diet and supplements or can also be made by the body when skin is exposed to ultraviolet rays. Vitamin D is necessary to help build and maintain strong bones and teeth and is very important during fetal development for this reason. Recent research shows that babies born during the late summer and early fall are taller and have wider bones (Sayers & Tobias, 2008). There is also mounting evidence that vitamin D plays a key role in preventing common cancers, autoimmune diseases, type 1 diabetes, heart disease, and osteoporosis. Furthermore, studies have shown that vitamin D deficiency is common in the United States, suggesting that most Americans would benefit from supplements (Holick, 2008).

Fatty fish (mackerel, sardines, salmon), liver, egg yolks, and fortified milk are all good dietary sources of vitamin D. Vegans, women with lactose intolerance or milk allergies, women who dislike dairy products, and women who avoid the sun may be at particular risk for vitamin D deficiency. The RDA for vitamin D in pregnant and nursing women is currently 200 IU (5 μg/day), although this is considered much too low by experts in the field. Michael Holick, MD, PhD, one of the leading researchers on vitamin D, recommends 1,000 IU daily for everyone over the age of 1 year. Alternatively, if the latitude provides adequate year-round ultraviolet light, vitamin D needs can be met by exposure of the arms and legs to sunlight for 5 to 10 minutes three times a week. Women in the United States living north of Atlanta, Georgia; women with darker skin tones; and women who use a lot of sunblock or who limit their sun exposure should be strongly advised to supplement with additional vitamin D beyond that provided by the prenatal supplement.

Calcium

Although calcium is also necessary for proper bone formation in conjunction with vitamin D, the RDA/DRI for pregnant women is the same as it is for nonpregnant women: 1,000 mg/day for women over 18 years old. Dietary sources include milk, yogurt, and cheese, as well as sardines with bones and some leafy green vegetables. Vegan women and women who consume fewer than 3 servings of dairy per day should be advised to take a separate calcium supplement during pregnancy to make sure they are getting enough. Alternatives to cow's milk such as soy, rice, and almond milk should be checked to make sure that they are fortified with calcium. These products must be shaken well because the calcium has a tendency to settle on the bottom on the containers. Consuming adequate calcium while pregnant and breast-feeding may not affect the baby's bone density, but it will protect the mother's bones from losing too much of the calcium that she will give to her baby if dietary calcium is not enough.

B Vitamins

The RDA/DRI for most B vitamins is higher during pregnancy compared with that of nonpregnant women in the same age category. B vitamins are primarily used as cofactors in energy metabolism, and the need for these vitamins is increased proportional to the increase in energy needs during pregnancy. Deficiency of most B vitamins is rare because of their availability in a wide variety of food sources and their presence in prenatal supplements. Two B vitamins, folate and B12, should be given special attention, however, because of their unique roles during fetal development and potential for deficiency in a pregnant woman.

Vitamin B12

Vitamin B12 is essential for the production of red blood cells, the manufacturing of genetic material, and healthy functioning of the nervous system. The RDA is 2.4 μg/day in nonpregnant women, compared with 2.6 μg/day in pregnant women. Deficiencies in pregnant and breast-feeding women may cause neurologic damage in their children. Deficiency of B12 at the start of pregnancy may increase risk of birth defects such as neural tube defects and may contribute to preterm delivery (Molloy et al., 2008). The only natural dietary sources are animal products, including meats, dairy products, eggs, and fish (clams and oily fish are very high in B12), but like other B vitamins, B12 is added to commercial dried cereals and included in adequate amounts in prenatal supplements.

Folate

Folate, available also in its synthetic form folic acid, is a B vitamin that is used in the manufacturing of neurotransmitters and is particularly important during early pregnancy because of its essential role in synthesizing DNA in the cells. The RDA for folic acid in nonpregnant women of childbearing age is 400 μg/day and increases to 600 μg/day during pregnancy. Good food sources include avocado, bananas, orange juice, dry cereal, asparagus, fruits, green leafy vegetables, and dried beans and peas.

In preconception and early pregnancy, 400 μg of folic acid in supplement form appears to be adequate for the prevention of neural tube defects, the most common of which are spina bifida and anencephaly. Spina bifida occurs when there is an incomplete closure of the spinal cord and spinal column, and anencephaly is severe underdevelopment of the brain. Neural tube defects occur during the first 28 days of pregnancy, usually before a woman even knows that she is pregnant, making the timing of folate supplementation of particular importance. Additional folate introduced after this critical period will not reverse prior damage done by a lack of the nutrient (Molloy et al., 2008).

As with other nutrients, the fetus has priority for folate over the mother's needs, potentially leaving the mother deficient after delivery unless her intake is sufficient to meet both of their needs. The extra folate in most prenatal vitamins is to prevent the mother from becoming deficient as the pregnancy progresses, both for her own health and to prevent birth defects if a pregnancy occurs within a few months of delivery.

The U.S. Public Health Service recommended in 1992 that all women of childbearing age consume 400 μg of folic acid daily (Centers for Disease Control and Prevention, 1992); however, surveys suggested that the overwhelming majority of U.S. women were not doing so. To deal with the public health crisis of neural tube defects, the Food and Drug Administration mandated folic acid supplementation in enriched grain products. Supplementation, which began in 1998, was estimated to increase the daily folate intake of the average American by approximately 100 μg (Honein et al., 2001).

Monitoring has shown that fortification has been effective in reducing the incidence of neural tube defects; they have decreased by 70% in the United States since the program began. Although prevention of neural tube defects was the primary justification, folic acid fortification has been effective in reducing cardiovascular events as well. During the same period, stroke and stroke deaths declined by 15% (Yang et al., 2002). Despite concern about potential adverse effects, such as a masking of B12 deficiency, no problems have been identified as a result of the fortification, and controversy remains over whether the level should be increased in the United States to match the model used in Canada and Europe.

Iron

Iron is a trace mineral that is vital for fetal growth and development because it plays a key role as a cofactor for enzymes involved in oxidation-reduction reactions, which occur in all cells during metabolism. Iron is also necessary as the component of hemoglobin that allows red blood cells to carry oxygen needed throughout the body. Perhaps most important, iron is essential for normal neurodevelopment during fetal and early childhood development. Iron deficiency in infancy and early childhood is associated with impaired memory function and changes in temperament that may mimic attention deficient disorder. Memory deficits persist even after normal iron levels are achieved (Georgieff, 2008). Worldwide, inadequate dietary iron intake is the most common nutrient deficiency, and women are at particularly high risk because of a regular loss of iron during monthly menses.

Pregnancy places an even higher demand for iron on the woman's body, both as her own blood volume expands to carry the pregnancy and as her child demands iron for normal development. The DRI for iron during pregnancy is 27 mg/day, and is particularly vital to meet this recommendation during the second and third trimesters. During the last 3 months, the baby is accumulating iron for use during early life. Studies show that if adequate iron is not available during the prenatal period and first 6 months of life, there can be lifelong neurologic effects that cannot be reversed even if iron is supplemented at adequate levels in early childhood (Beard, 2008).

Fetal iron stores are meant to last the child until approximately 6 months of life. After the age of 6 months, the American Academy of Pediatrics recommends a good dietary source of iron be introduced into the infant's diet to help support the accelerated growth of the child during the first year of life. The best method for combating iron deficiency in pregnancy is to promote high intakes before pregnancy so that there will be at least 300 mg of iron stored as a woman enters pregnancy.

Mothers should be encouraged to take a prenatal vitamin with adequate iron to meet their needs, although high amounts of supplemented iron are associated with constipation and upset stomach for many pregnant women. If a woman enters pregnancy iron replete, prenatal supplements do not have to contain as high a level of iron as for a woman who enters pregnancy iron deficient. Lower levels of iron in the multivitamin/mineral will minimize unpleasant side effects.

For women who require high amounts of iron during pregnancy, several measures can be suggested to decrease associated discomfort. It is important to give these women strategies to improve their tolerance of the high iron levels in prenatal supplements, as iron intolerance is a primary reason that mothers stop taking their vitamins. Many women find taking their prenatal vitamin just before bed and/or with food helps them tolerate the high level of iron better. Taking the iron with a source of vitamin C will improve absorption and may help the mother to reduce the amount of extra iron she needs to take. Finally, eating sources of iron that are highly bioavailable, such as red meat, or snacking on iron-fortified cereal will also help to increase iron intake. Women who snack on dry cereal should be advised to have with it juice or another vitamin C source, instead of dairy products, which inhibit the absorption of iron.

Magnesium

Magnesium is a cofactor in over 300 enzymes in the body. Dietary magnesium inadequacy has been demonstrated to be common among American women and is associated with an increased risk of miscarriage, fetal growth retardation, maternal hospitalizations, and preterm delivery (Durlach, 2004). Inadequacy of magnesium has also been identified as a risk factor for the development of both gestational diabetes and type 2 diabetes (Barbagallo et al., 2007). After birth, it has been associated with an increased risk of Sudden Infant Death Syndrome (SIDS) and increased referrals to the neonatal intensive care unit (NICU). Most prenatal vitamins contain only 10% to 25% of the RDA for magnesium, and thus emphasis should be put on consuming good dietary sources. The best dietary sources include peanuts, bran, wheat germ, nuts, and legumes. Acute therapeutic intravenous magnesium is sometimes used to treat preeclampsia and premature labor (Thapa & Jha, 2008). Other studies have shown a potential benefit of supplementing magnesium at the RDA level in the reduction of leg cramps in pregnancy, although the association is not conclusive (Young & Jewell, 2002).

Zinc

The RDA for zinc during pregnancy is 11 mg/day, increased from 8 for nonpregnant women. Adequate zinc is extremely important during the first trimester, when organs are formed and may play a role in assisting in immune system development (Shah & Sachdev, 2006). Zinc deficiency is common worldwide, and supplementation within the RDA is advised during pregnancy. Because red meat is the best source of zinc, it may be more difficult for vegans and vegetarians to get enough. Furthermore, phytates found in a plant-based diet can interfere with zinc absorption. For vegetarian and vegan women, a supplement that includes 15 mg of zinc is advised throughout the pregnancy.

Iodine

Although overt deficiency of iodine is uncommon in the United States because of fortification of table salt, iodine deficiency affects more than 2 billion people worldwide and is the leading cause of mental retardation. Women in the United States are at risk, however, of consuming inadequate amounts of iodine caused by variable levels in commonly eaten foods. Given the nutrient's important role in fetal development, supplementation is recommended for pregnant and lactating women (Pearce, 2007).

The RDA for pregnant women is 220 μg of iodine per day. Mothers who do not get enough can put their baby at greater risk for mental retardation, as well as growth, hearing, and speech problems. Women consuming a low-salt diet during pregnancy, especially those trying to manage edema and/or pregnancy-induced hypertension, are at particular risk for iodine insufficiency.

In a recent study done by scientists at the Boston University Iodine Research Laboratory, researchers determined that a large percentage of prenatal vitamins do not include any iodine (Leung et al., 2009). They found that of 223 prenatal multivitamins in the United States, both prescription and over the counter, only half of them contained iodine. Of the vitamins that listed iodine, many fell short of the amount stated on the label. Prenatal multivitamins that contain potassium iodide instead of kelp were more likely to contain adequate amounts. Pregnant women are advised to take a prenatal supplement containing iodine, preferably one that uses potassium iodide as the source.

Fetal Development

A healthy pregnancy lasts an average of 40 weeks, with a normal range of 38 to 42 weeks. There are 3 distinct stages of fetal development during which the baby must complete specific developmental tasks. The zygote period is the first stage, beginning at conception and lasting approximately 2 weeks. The embryonic period goes from 2 to 8 weeks, and the fetal period lasts from 8 weeks until birth.

Weeks of pregnancy are counted from the first day of the woman's last period, and thus a woman is considered pregnant approximately 2 weeks before she actually conceives the baby. After conception, the fertilized egg, also known as the zygote, makes its way to the uterus, where it implants and begins its rapid growth.

The Embryonic Phase

The embryonic stage begins shortly after implantation of the zygote in the wall of the uterus and lasts until the 8th week. This period often begins before a woman even knows she is pregnant, but it is a critical stage of fetal development. During this time, the embryo's cells are dividing rapidly to form the basic body systems. By 8 weeks after conception, the embryo is only approximately 1.25 inches long, but it already has a complete central nervous system, a beating heart, a digestive system, fingers, toes, and the beginning of facial features.

The Fetal Phase

Fetal development begins after the 8th week. Early in this period the fetus continues to develop all of the necessary body systems and begins to take on a more human appearance. Distinguishable genitals, hair, nails, and vocal cords form. The kidneys begin to process bodily fluids, and the liver begins to function. Bones also begin to harden early in the fetal period.

Although far from ready for birth, by the 28th week of gestation, most babies born can survive outside the womb with intervention to aid breathing until the lungs are more mature.

During the final 12 weeks of gestation, brain and eye development proceed at a fast rate. The fetus also builds bone mass and gains fat stores to help him or her survive outside of the protective environment of the womb. The immune system begins to mature during this time, and lungs develop to a point where the baby can breathe without external intervention after approximately 37 weeks' gestation. Finally, the fetus spends the last several weeks of gestation laying stores of nutrients to help support functioning during early life until he or she is able to transition to a more varied diet at 6 months of age.

Critical Periods of Nutrient Intake During Embryonic and Fetal Development

Given the fast rate of growth and the enormous complexity of the task, it is easy to see how deficiency of any nutrient needed during a specific phase of development could impact this delicate process. Although deficiency of almost any micronutrient or macronutrient will certainly impact the course of development, several in particular have been identified with specific birth defects if the nutrient is not present during a very narrow window of time. Several others are suspected to cause less-overt problems if the nutrient is deficient during a critical period.

Folic acid deficiency during the first 4 weeks of development, when the central nervous system is forming, is perhaps the most devastating nutrient deficiency because it may result in neural tube defects. Deficiency of iodine during brain development can also have dramatic and obvious permanent effects, such as mental retardation. The effects of other nutrient deficiencies may be less dramatic but may nonetheless have a significant impact in the child's health over the course of the lifetime. For example, a deficiency of vitamin D during the fetal period can result in undermineralized bones, and a deficiency of iron during brain development may lead to permanent alteration of memory function (see the sections on each specific nutrient for more information).

Even when adequate nutrients are available for the child's physical development, during the last several weeks in the womb, the fetus builds stores of nutrients, including fat, vitamin D, vitamin B12, and iron to help the baby through its early development outside of its mother. If nutrient supplies are not adequate in the mother during pregnancy, the infant will need to consume these nutrients in ample amounts after birth, which may tax the immature digestive system.

Common Problems Associated with Pregnancy

How a woman experiences pregnancy is very different from woman to woman. Even for the same woman, the experience may be very different from pregnancy to pregnancy. A number of factors contribute to the mother's experience with pregnancy, including how the mother feels about being pregnant; her physical reaction to pregnancy; any health conditions that she has or develops; her physical environment, including availability of food, housing, and health care; and finally, other demands that cause stress for the mother (e.g., her job or other kids). This section discusses some of the common physical side effects of pregnancy, as well as some of the more serious health problems that may develop as a result of the pregnancy.

Nausea and Vomiting of Pregnancy and Food Aversions and Cravings

During pregnancy, the mother's body goes through many changes to accommodate the new life growing inside her. Many women experience side effects of these changes that influence her ability to eat as healthfully as she might like. Hormonal shifts caused by the pregnancy are thought to be responsible for the majority of these side effects, but controversy remains regarding whether some common conditions related to pregnancy are physiologic or psychological phenomena (Markl et al., 2008). Regardless of their origin, it is important to help pregnant women struggling with problems like nausea, vomiting, food aversions, and cravings to minimize the impact of these factors and maximize nutrition for the health of both mother and baby (Keller et al., 2008).

Nausea and Vomiting of Pregnancy

One of the most common side effects of pregnancy is known as "nausea and vomiting of pregnancy" (NVP), more commonly known as "morning sickness." Ironically, morning sickness is usually not limited to the morning, although that may be when a woman experiences it most acutely. Up to 80% of pregnant women experience NVP at some point, usually beginning between the 4th and 7th weeks after their last period and ending for most women by the 20th week. For 10% of those that have it, however, it remains an ongoing battle throughout the pregnancy (Quinla & Hill, 2003).

Nutrition Requirements During Pregnancy

The underlying causes of nausea and vomiting of pregnancy remain unclear, but hormonal shifts are hypothesized to be one potential cause. Estrogen, progesterone, and human chorionic gonadotropin (hCG) have all been investigated for possible mechanisms of action (Davis, 2004). Progesterone, for example, which is released during pregnancy, has been suggested to cause delayed gastric motility, which can cause nausea. One study found that when progesterone was given to nonpregnant women they developed nausea and vomiting similar to the symptoms of NVP (Walsh et al., 1996).

The most severe version of NVP is known as hyperemesis gravidarum, which is estimated to affect approximately 1 in every 200 pregnant women. Although there is no standard definition, the condition is characterized by persistent vomiting, dehydration, ketosis, electrolyte disturbances, and weight loss of more than 5% of body weight (Ismail & Kenny, 2007).

Although normal NVP is actually associated with positive outcomes for the baby, hyperemesis can be dangerous to both the mother and the child. NVP has been associated in several studies with improved pregnancy outcomes, including fewer miscarriages, preterm deliveries, and stillbirths, as well as fewer instances of fetal low birth weight, growth retardation, and mortality. One potential explanation for this is that NVP is a mechanism designed to increase the mother's intake of simple carbohydrates, which alleviates her symptoms and supplies increased amounts of glucose to the growing fetus (Furneaux et al., 2001). In contrast, hyperemesis gravidarum has been associated with increased adverse effects for both the mother and fetus. The mother is more likely to experience splenic avulsion, esophageal rupture, Mallory-Weiss tears, pneumothorax, peripheral neuropathy, and preeclampsia. The fetus is at increased risk for fetal growth restriction and mortality (Ismail & Kenny, 2007).

Dietary modifications are the first line of treatment for women with mild nausea and vomiting. Several measures are often used in combination to help manage symptoms until they pass on their own. Most women find that it helps to eat small, frequent meals. Avoidance of smells and food textures that cause nausea also helps, keeping in mind that what triggers the nausea may be different for each woman. Usually, bland-tasting, cold foods that are high in carbohydrates and low in fat are best tolerated. Eating high-carbohydrate foods first thing in the morning often helps and may be most useful even before the woman gets out of bed. Sour and tart liquids such as lemonade often are tolerated better than water. It may also help if the woman avoids the smell of food until mealtime, as smells often trigger nausea.

Other treatments include acupressure bands, ginger, and special supplements made specifically for NVP, such as "Pregipops" and "Pregidrops." Supplementation with vitamin B6 has also been associated with relief of symptoms, and several trials have tested both the effectiveness and safety of this treatment (Sahakian et al., 1991; Tiran, 2002).

Cravings and Aversions

Although food cravings and their flip-side food aversions are thought of as a common condition of pregnancy, not all women experience these sensations. One study found that food cravings occurred in only 61% of pregnant women, whereas aversions occurred even less frequently, appearing in 54% of pregnant women (Bayley et al., 2002). There is little understanding of what causes craving and aversions, and not all experts agree that they are a real phenomenon and not simply a psychological manifestation.

One plausible explanation for cravings and aversions during pregnancy is changes in smell and taste. One study found that abnormal smell and/or taste perception was reported by 76% of pregnant women surveyed. Increased smell sensitivity was found to be very common in early pregnancy, occurring in 67% of respondents. Abnormal taste sensitivity was reported by 26% of women in the study, who often described increased bitter sensitivity and decreased salt sensitivity. The results of this study suggest that abnormal smell and/or taste perception is experienced by a large majority of pregnant women and may underlie food aversions and cravings during pregnancy (Nordin et al., 2004).

Another theory behind the development of craving is that some women who deprive themselves when they are not pregnant think of pregnancy as a time to treat themselves to foods they typically avoid and indulge themselves—because, after all, they are "eating for two."

There are also several less plausible theories behind the prevalence of food cravings and aversions during pregnancy. One states that food cravings are nature's way of helping the mother meet her nutritional needs. For example, the woman may need sodium to help manage her increased fluid volume during pregnancy, and thus she may crave salty foods. Although this is an interesting idea, there is no evidence that potential nutrient shortfalls are translated into food cravings in the body.

Common Problems Associated with Pregnancy

A similar theory regarding food aversions is that they are a protective mechanism during pregnancy designed to steer the mother away from dangerous foods. For example, a woman may have an aversion to drinking coffee when pregnant, which is beneficial because limiting caffeine intake during pregnancy may aid in fetal mental and physical development and decreases risk of infant death. Many women also develop aversions to the taste and smell of cigarettes while pregnant, which increases compliance with smoking cessation during the prenatal period (Pletsch & Kratz, 2004). Although there is no evidence that aversions are developed as a protective mechanism, this remains a persistent myth.

Pregnant women can indulge their cravings so long as they are meeting their needs nutritionally. The craved-for food also should be screened to ensure that it is not contraindicated by special dietary restrictions, such as a high-carbohydrate food for a woman with gestational diabetes. Finally, the concept of moderation must be emphasized to keep the mother's weight gain within the IOM guidelines based on her pre-pregnancy BMI. Mothers-to-be should be advised to keep portions small and to try to eat only healthier versions. For example, a woman who craves ice cream may want to indulge in a reasonable half cup of low-calorie ice cream or frozen yogurt instead of a pint of premium high-calorie ice cream.

Reflux

Reflux, also known as heartburn, occurs when acid from the stomach makes its way through the lower esophageal sphincter, causing a burning sensation in the lower esophagus. It is a very common problem during pregnancy and is often one of the first symptoms of pregnancy, appearing within the first month after conception for many women. Occurring early in pregnancy, reflux is likely caused by hormonal changes, perhaps even before most women have gained any pregnancy weight. Later in pregnancy, the pressure of the baby pushing upward against the mother's stomach may exacerbate the problem (Ali & Egan, 2007).

Most health authorities agree that calcium carbonate supplements like Tums are safe to use during pregnancy and helpful for alleviating symptoms (Richter, 2005). Other measures encompass standard advice for anyone with reflux, including keeping upright for 1 to 2 hours after eating, eating smaller meals, drinking between meals instead of with the meal to avoid overfilling the stomach, elevating the head of the bed a few inches, and avoiding trigger foods. Although trigger foods differ from person to person, the most common are coffee, acidic foods such as tomato sauce, minty foods, and chocolate. Other novel approaches to managing reflux include drinking water to wash down the acid and chewing sugarless (non-mint-flavored) gum to generate saliva to help wash down the acid.

Reflux is not serious for most women and will go away within a few months post pregnancy. In very rare cases, the mother may need to be prescribed a stronger medication to manage her reflux. This decision should be made based on the mother's level of discomfort.

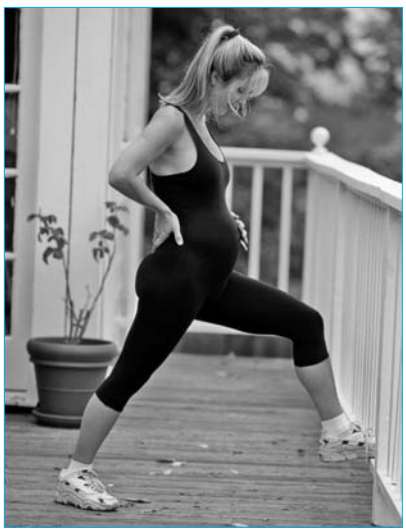
The Interaction of Life-style and Pregnancy

Life-style behaviors such as physical activity, smoking, and alcohol consumption have a strong impact on pregnancy. When a pregnancy is planned, it is easier to modify harmful behaviors ahead of time, but women are often unexpectedly pregnant. Furthermore, many life-style choices are coping mechanisms used to handle stress. Pregnancy may place extra stress on the mother, making it even more difficult to give up harmful practices. It is important to help the mother develop a strong support system to help her cope with the stress of pregnancy as well as stress she may face after delivery to help her give up harmful behaviors and adopt positive ones that will benefit both her child's health and her own. This section discusses some of the common life-style choices that may impact pregnancy.

Physical Activity, Safety, and Energy Needs

There are many good reasons for women to exercise during pregnancy. Exercise during pregnancy helps to reduce some of the common complaints of pregnancy, including backaches, constipation, and bloating and swelling. It improves mood and may help mothers sleep better. It also promotes the strength, muscle tone, and endurance that may be helpful during labor and recovery. The American College of Obstetricians and Gynecologists (ACOG) recommends that pregnant women without medical or obstetric complications engage in 30 minutes or more of moderate exercise a day on most, if not all, days of the week (ACOG Committee on Obstetric Practice, 2002).

Expert organizations, including the ACOG and the National Academy of Sports Medicine, have agreed that most women can safely engage in a level of physical activity similar to their activity level prior to pregnancy, as long as weight gain and infant development are not compromised (ACOG, 1994). Women who maintain a moderate to high level of physical activity during pregnancy will have relative caloric needs higher than less-active women who are in the same stage of pregnancy. Moderate to high levels of physical activity have been associated with lower infant birth weights compared with infants of more sedentary women, but this is likely because the higher caloric needs of the active women were not met during pregnancy (Penney, 2008). If the mother is gaining appropriate weight, indicating that she is meeting her caloric needs, the birth weight of the baby should not be affected, regardless of the amount of physical activity.



Some caution should be observed when helping mothers decide on an exercise program during pregnancy. Women with medical or obstetric complications should be encouraged to avoid vigorous physical activity. Contraindications to exercise during pregnancy put forth by ACOG include pregnancy-induced hypertension, preterm rupture of membranes, preterm labor during the prior or current pregnancy, incompetent cervix or cerclage placement, persistent second- or third-trimester bleeding, placenta previa, and intrauterine growth retardation. Relative contraindications include chronic hypertension, thyroid function abnormality, cardiac disease, vascular disease, and pulmonary disease.

Pregnant women should be advised to avoid contact sports such as soccer and high-impact sports and those that require advanced balance, which may be affected later in pregnancy. Examples include horseback riding, skiing, and gymnastics.

Pregnant women should also be warned to be careful when engaging in flexibility exercises. During pregnancy, a hormone called relaxin is produced that is designed to help loosen joints so that the baby has room to grow and to make labor easier. The relaxing of ligaments caused by the release of relaxin increases risk of injury, especially during flexibility exercises, and thus women should be advised not to overdo stretching.

Food Safety

Food safety should be a concern for every American at all times, but pregnant women, young children, individuals with compromised immune systems, and older individuals need to take extra precautions to avoid exposure to food-borne pathogens.

Infection from a food-borne illness may cause harm to both the mother and her fetus and should be avoided if possible. Women become more susceptible to infection with the hepatitis E virus, *Coxiella burnetii, Listeria monocytogenes,* and *Toxoplasma gondii,* which are intracellular pathogens that take advantage of hormonal shifts during pregnancy that down-regulate cell-mediated immune functions (Smith, 1999).

All pregnant women in the United States are currently advised to avoid foods that are considered health risks for pregnant women and developing babies. These include any meat, seafood, or egg item that is raw or undercooked and any unpasteurized food, including milk, cheeses made from unpasteurized milk like brie and feta, and unpasteurized juice. Women are advised to wash all fruits and vegetables thoroughly before eating them and to avoid any that cannot be properly washed or are known to carry food-borne illness, such as alfalfa sprouts.

Special precautions have been set forth by the American Food and Drug Administration Center for Food Safety and Applied Nutrition to reduce risk of contamination with *Listeria monocytogenes (http://www.fda.gov/Food/ResourcesForYou/HealthEducators/ucm083320.htm). L. monocytogenes* is of particular concern because it can grow at refrigerator temperatures, whereas most other food-borne bacteria do not. Measures to reduce exposure include avoiding unpasteurized foods and heating ready-to-eat foods until they are steaming to kill the bacteria. For example, it is recommended that hot dogs and luncheon meats should be eaten only if they are reheated until steaming hot.

The Center for Food Safety and Applied Nutrition (CFSAN) recommends that pregnant women avoid the following foods:

Sushi or sashimi. Raw fish (including oysters, clams, mussels, and scallops) or foods made with raw fish are more likely to contain parasites or bacteria than foods made from cooked fish.

Swordfish, tilefish, king mackerel, and shark. These fish can contain high levels of methylmercury, a metal that can be harmful to the unborn baby. Other cooked fish/seafood is considered safe, but women should try to vary their seafood. Up to 12 ounces (2 average meals) a week of a variety of fish and shellfish that are lower in mercury appear to be safe during pregnancy. Five of the most commonly eaten fish that are low in mercury are shrimp, canned light tuna, salmon, pollock, and catfish. Albacore ("white") tuna has more mercury than canned light tuna.

Raw sprouts (including alfalfa, clover, radish, and mung bean). Bacteria can get into sprout seeds through cracks in the shell before the sprouts are grown. After this occurs, these bacteria are nearly impossible to wash out. Sprouts grown in the home are also risky if eaten raw. Many outbreaks have been linked to contaminated seed. If pathogenic bacteria are present in or on the seed, they can grow to high levels during sprouting—even under clean conditions.

Unpasteurized or untreated juice. These juices are normally in the refrigerated sections of grocery stores, health food stores, cider mills, or farm markets.

Mothers should also be advised to wash their hands regularly.

Alcohol

No level of alcohol consumption is considered safe during pregnancy. Alcohol can pass freely through the placenta, and thus if the mother drinks, so does her unborn child. Consumption of alcohol during pregnancy is associated with higher risk of birth defects and miscarriage. At high levels, alcohol may cause fetal alcohol syndrome (FAS), which is the leading cause of preventable mental retardation (Chiriboga, 2003).

FAS is characterized by mental retardation, malformations of the skeletal system, malformation of the heart and brain, growth problems, central nervous system problems, poor motor skills, increased

mortality, and problems with learning, memory, social interaction, attention span, problem solving, speech, and/or hearing. Children with FAS can often be identified by characteristic facial features, including small eyes, a short or upturned nose, flat cheeks, and thin lips. These features fade as the child gets older, but other effects do not (National Organization on Fetal Alcohol Syndrome, n.d.).

It is important for mothers to understand that although FAS is usually caused by binge drinking or regular alcohol consumption during pregnancy, any alcohol intake during pregnancy may contribute to fetal damage and place the child at risk of fetal alcohol spectrum disorder (FASD). The term "FASD" is used to encompass the full spectrum of birth defects that are caused by prenatal alcohol exposure. FASD is usually split into two levels of damage: fetal alcohol syndrome, which represents the most severe damage, and fetal alcohol effects, used to describe lesser damage caused by more moderate drinking.

According to the Fetal Alcohol Spectrum Disorders Center for Excellence, fetal alcohol effects are manifestations of moderate drinking during pregnancy. Physical and neurological deficiencies may be a result of fetal alcohol effects. The effect that fetal alcohol exposure has on the developing brain explains common mental and behavioral impairments characteristic of fetal alcohol exposure, such as learning disabilities, poor school performance, poor impulse control, and problems with memory, attention, and judgment.

Illegal Drug Use

Just as with alcohol, there is no safe level of illegal drug consumption during pregnancy. Illegal drug use during pregnancy may result in miscarriage, low birth weight, premature labor, placental abruption, and fetal death. Mothers suspected of using illegal drugs during pregnancy should be referred to their doctor, who should prescribe appropriate treatment (Floyd et al., 2008).

Learning Point More research is needed on the life-style of the father and fetal health, especially in the areas of paternal alcohol and drug use.

Cigarette Smoking

According to the American Lung Association, smoking during pregnancy is estimated to account for 20% to 30% of low-birth-weight babies, up to 14% of preterm deliveries, and about 10% of all infant deaths. Furthermore, even exposure to secondhand smoke can increase risk. Smoking during pregnancy has also been associated with an increased risk for colds, lung problems, learning disabilities, and physical growth problems for exposed children after birth.

It is strongly advised that pregnant women quit smoking for the duration of the pregnancy. Studies show that approximately half of all women who smoke are able to do this, but half are not. One study looked at the profile of women who did not quit smoking and found that they were more likely to have been heavy smokers prior to pregnancy and had more psychosocial problems compared with women who quit (Pickett et al., 2009). If a woman is not able to quit smoking, she should be encouraged to cut her usual amount to the lowest possible level.

Helping the mother-to-be deal with the stressors in her life may help her quit smoking. In addition to putting her in contact with food, housing, and counseling resources, there are public health resources available to help women stop smoking in addition to help she may get from her doctor. The American Lung Association has the following suggestions for pregnant women who wish to quit smoking: Ask for help from health care providers, family, and friends. Make a list of reasons for wanting to quit, for yourself as well as for the baby. Set a quit date—the sooner the better. If you are not ready to set a date, you can begin to cut down on smoking, and then you can make a plan to stop all smoking in the near future. Try the four Ds: delay, deep breathe, drink water, and do something else. If you slip and go back to smoking, you should first find out what caused the slip, and then you can keep trying to quit again until you succeed. The only failure is if you stop trying.

Caffeine

Caffeine is one of the most widely consumed pharmacologically active substances in the world. It is found in various drinks, chocolate, and some medications. Caffeine is an important concern during pregnancy because it crosses the placenta to the baby, whose metabolism is still maturing and cannot fully process it. Some studies have shown that there may be an increased risk of miscarriage among women who consume more than 300 mg/day, the equivalent of a medium cup of coffee at most fast-food restaurants. Other potential adverse outcomes include preterm labor and low-birth-weight babies (Kuczkowski, 2009).

Although most doctors advise women that they can drink caffeine in moderation while pregnant, keeping under 300 mg/day, it is safer to avoid caffeine altogether if possible. If a woman must have caffeine, she should be advised to limit herself to 1 cup per day of coffee, tea, or soda. To reduce the common side effects of headache, ideally women would gradually reduce their intake prior to pregnancy. A stepwise reduction during pregnancy will also help to manage headaches that will likely result from sudden stoppage of caffeine consumption.

SPECIAL SECTION: UNUSUAL COMPLICATIONS OF PREGNANCY

Pica

A pregnant woman may occasionally crave nonfood items such as ice, dirt, clay, paper, and even paint chips, a condition known as pica. It has been theorized, although never proved, that pica may signal iron deficiency (Mills, 2007). Expectant mothers may also get the urge to eat flour or cornstarch, which despite being food items are a problem in large amounts. Too much can lead to blocked bowels and crowd out the nutrients the baby needs by causing the mother to feel full. A woman with pica or an unhealthy craving such as cornstarch should resist eating these items and should speak to her doctor right away.

Preeclampsia

Preeclampsia is a syndrome that is characterized by dangerously high blood pressure and protein in the urine. It is often accompanied by edema, sudden weight gain, headaches, and changes in vision. It occurs only during pregnancy and up to 6 weeks postpartum, usually appearing in the late second or the third trimester. According to the National Heart, Lung, and Blood Institute (NHLBI), the condition appears in 5% to 8% of pregnancies in the United States.

Preeclampsia, pregnancy-induced hypertension, and eclampsia (formerly known as toxemia) are closely related conditions. Pregnancy-induced hypertension is generally considered the mildest manifestation, whereas eclampsia is one of the most serious complications of severe preeclampsia. Left untreated, eclamptic seizures can result in coma, brain damage, or maternal or infant death. HELLP syndrome, which stands for hemolysis, elevated liver enzymes, and lowered platelets, is another of the most severe forms of preeclampsia, usually affecting the liver and causing stomach and right shoulder pain.

HELLP syndrome occurs in 4% to 12% of the women who have preeclampsia. It is particularly dangerous because it may occur even before the mother develops the classic symptoms of preeclampsia. It is often mistaken for the flu or gallbladder problems (Haram et al., 2009).

Complications of preeclampsia in the fetus include prematurity, growth restriction, and death. Fetal growth restriction results from reduced blood flow to the placenta, which compromises the supply of nutrients to the baby and can result in a shortage of food and subsequent starvation. As a result, the baby may be small for its gestational age. This shortage of nutrients available through the placenta places the baby at serious risk, and premature birth may result naturally or be induced for the protec-

tion of both mother and child (Sibai et al., 2005). According to the March of Dimes, preeclampsia is a leading cause of premature birth in the United States. Worldwide, preeclampsia and other hypertensive disorders of pregnancy are leading causes of maternal and infant death.

There are several known risk factors for preeclampsia, two of which should be of particular concern given changing trends in the profile of pregnant women in the United States over the past few decades: a BMI of 30 or higher and a maternal age of over 40 or under 18 years. Other risk factors include a previous history of preeclampsia, a history of chronic high blood pressure, diabetes or kidney disorder, a family history of the disorder, carrying multiple fetuses, polycystic ovarian syndrome, and lupus or other autoimmune disorders, such as rheumatoid arthritis, sarcoidosis, or multiple sclerosis.

Several nutritional interventions have been associated with reduced risk of developing preeclampsia. Increased intake of fiber and calcium has been positively associated with reduced risk in several studies (Hofmeyr et al., 2007; Wallis and Saftlas, 2008). Women who are at risk should be encouraged to consume adequate dairy products and fruits and vegetables before and during pregnancy.

The role of nutrient deficiencies has also been examined. One study showed that women with low levels of the mineral selenium were 4 times more likely to have preeclampsia than women with higher levels (Rayman et al., 2003). The researchers also found that low selenium was associated with an increased risk of premature delivery. Selenium is found in whole grains, fortified cereal, and Brazil nuts.

Gestational Diabetes

"Gestational diabetes" is the term used for diabetes diagnosed during pregnancy whether or not it is thought to be directly caused by the pregnancy. It is present in about 5% of all pregnancies and is usually detected between 24 and 28 weeks by an oral glucose tolerance test (Lucas, 2001). In some cases, type 2 diabetes is originally diagnosed during pregnancy. In this case, the diabetes is referred to as gestational diabetes until the mother is no longer pregnant. If the blood sugar fails to return to normal levels after the baby is delivered, the mother will then be diagnosed with type 2 diabetes.

Women of certain ethnic backgrounds appear to have a higher genetic predisposition, increasing rates to as high as 7% to 9% within certain populations. Women who identify themselves as Hispanic, African-American, Native American, Asian, Pacific Islander, or Indigenous Australian are at an elevated risk. Women who were obese prior to pregnancy, who have been diagnosed with polycystic ovarian syndrome, and who have thyroid disorders are also at higher risk (Cheng and Caughey, 2008).

Under normal conditions, the mother's body adapts during pregnancy to ensure that a constant supply of glucose is available to her baby by becoming slightly insulin resistant. If the mother's body is not able to control this natural phenomenon adequately, she may develop gestational diabetes, creating an overabundance of glucose in her bloodstream. To compensate for the extra supply of glucose, the fetus begins to overproduce insulin in order to manage its own blood sugar level. Insulin is a growth hormone, and a high level of fetal production leads to excessive infant growth and high birth weight.

Untreated gestational diabetes is associated with a higher risk of stillbirth and macrosomia, usually defined as a birth weight of over 10 pounds. When the infant is abnormally large, the mother is at a high risk for a caesarian section, which carries with it all of the complications of any major surgery (Schmidt et al., 2001). In addition, children born via caesarean section are more likely to develop asthma and allergies, potentially because of a lack of exposure to the normal vaginal flora that helps immunize them (Bager et al., 2008).

A macrosomic (large) baby is also at high risk for birth complications such as shoulder dystocia, which occurs when the baby's shoulders are too large to move through the birth canal. Shoulder dystocia can lead to permanent nerve damage for the infant and may be a potentially life-threatening situation. In addition to the physiological complications associated with delivery of a large infant, there are other potential adverse outcomes. If the baby is overproducing insulin at the time of delivery, there is a serious risk of subsequent low blood sugar for the infant after the umbilical cord is cut and the constant supply of glucose is no longer present. There is a significantly higher rate of neonatal intensive care unit admissions for infants of diabetic mothers who have poor blood sugar control. Prevention is very effective in reducing most risks associated with gestational diabetes.

Women who are diagnosed with gestational diabetes can usually keep their blood sugar within a reasonable range with a mild restriction of carbohydrate in their diet. If the mother has tried dietary modifications but blood sugars remain above optimal levels, medication may be indicated. Insulin therapy is the accepted treatment for gestational diabetes if a mother fails diet and life-style therapy.

Even if the mother's blood sugar returns to normal after the birth, it is important to continue to follow up. Women with gestational diabetes are at high risk for developing the disease during subsequent pregnancies. Furthermore, studies show that as many as 70% of all women with gestational diabetes will eventually be diagnosed with type 2 diabetes (Kim et al., 2002). Prevention efforts after the birth include stressing the importance of maintaining or achieving a healthy weight, regular exercise, and a diet that emphasizes complex carbohydrates.

Summary

Pregnancy is a critical time of human development, and anything that compromises the fetal environment may have important and lasting effects on the child's future health. It is important as a society to prioritize helping women understand the impact that their life-style choices have on their children. Maximizing the health of the pregnant mother will ensure her child the best start at life possible.

Nutrition is a vital component of fetal development, as the baby cannot build with materials he or she does not have. Limiting exposure to damaging substances such as nicotine, caffeine, food-borne bacteria, and alcohol will also aid in the child's development. Helping women deal with unpleasant side effects of pregnancy as well as more serious ones should be a focus of prenatal support. Finally, encouraging healthful life-style practices during pregnancy such as moderate exercise and healthy eating will impact not only the child's long-term health, but potentially the mother's as well.

Issues to Debate

1. Does the public have a responsibility to assist pregnant women in receiving good nutrition?
2. What are the long-term consequences of a lack of assistance programs for pregnant women?
3. Most of the discussion in this chapter has revolved around the nutritional health of the fetus, but what is the effect of poor nutrition during pregnancy on the mother?

Case Studies

(Answers to all case studies are in the Instructor's Manual available at jbpub.com.)

Case Study 1

Nadine is a 37-year-old African-American woman. She is at 28 weeks' gestation and has 3 children already. Her routine glucose screen at 24 weeks was high; she has not yet had a follow-up glucose tolerance test to determine if she has gestational diabetes.

Her weight is 244 lb; height is 5′6″. Her mother has type 2 diabetes. Her first baby weighed 9 lb, her second baby weighed 9 lb, 4 oz. She has a hectic job as a day-care provider. She often skips meals.

1. How likely is it that Nadine will be diagnosed with gestational diabetes? What are her risk factors?
2. Assuming Nadine is diagnosed with gestational diabetes, what recommendations would you make in terms of her nutrition management?
3. Below is a 24-hour recall for Nadine. Help Nadine modify her diet to better control her blood sugar.

Continues

Sample 24-hour recall:

8:30 am	1.5 cups orange juice, 2 slices toast (white bread)
11:00 am	candy bar
12:30 pm	2 slices pepperoni pizza (14″)
5:30 pm	20 banana chips
8:45 pm	2 cups red beans and rice

Case Study 2

Maria is a 27-year-old woman with a 2-year-old child who is now 14 weeks pregnant with her second child. She weighs 160 lb and her height is 4′11″.

Maria gained 80 pounds with her first pregnancy and has never lost most of the weight. She is at home all day with her child, while her husband works 2 jobs. Maria drinks 4 cups of coffee and 3 cans of diet cola a day because she is so tired all the time. She also drinks fruit punch with her son when they have meals. She has not been taking her prenatal vitamin because she feels that it upsets her stomach and constipates her. She and her son often eat at fast-food restaurants or have packaged food like boxed macaroni and cheese or frozen chicken nuggets because those are foods her son likes to eat. She eats very few fruits and vegetables, and she drinks no milk, although she eats some American cheese.

Maria would like to eat better, but doesn't know what she should do. She has also heard that exercise during pregnancy is a good idea because it will help keep her back and legs from aching, and she would like to try it.

1. What recommendations would you make in terms of life-style management for Maria?
2. How would you modify her diet? Based on the Institute of Medicine guidelines, how much weight should Maria gain during this pregnancy?
3. How should the weight gain break down by trimester? What recommendations can we give her to slow her weight gain?
4. Assuming that Maria and her family are at the federal poverty line, what nutrition programs are they eligible for?

Case Study 3

Arunima is a 25-year-old woman born in India. She is 8 weeks pregnant with her first child. For the past month she has been very nauseous, though not vomiting, and has not been eating much. She weighs 110 lb and her height is 5′4″; she has lost 2 lb since she became pregnant. She does not work outside the home, and her husband works as a store manager. She is a strict vegetarian (vegan).

1. Discuss interventions that may help manage Arunima's nausea.
2. At 12 weeks the nausea passes and Arunima is hungry! What recommendations would you make in terms of nutrition management for Arunima? As a vegan, what elements of her diet do we need to be concerned about? How can you modify her diet to make sure she gets the nutrients she needs?

Websites

American Lung Association http://www.lungusa.org/
Exercise During Pregnancy http://www.acog.org/publications/patient_education/bp119.cfm
Fetal Alcohol Spectrum Disorders Center for Excellence www.fascenter.samhsa.gov/
National WIC Association www.nwica.org/
Supplemental Nutrition Assistance Program www.fns.usda.gov/fsp/
World Health Organization http://www.who.int/nutrition/publications/fetomaternal/en/
March of Dimes http://www.marchofdimes.com/21209_11560.asp
The National Partnership for Smoke-Free Families http://www.smokefreefamilies.tobacco-cessation.org/

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