Preconception and Prenatal Nutrition

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Infant care does not begin on the day a baby is born; it is a journey that takes place before conception. The health of the mother prior to and during pregnancy is one of the major determinants to a successful outcome. If a woman enters pregnancy in less than optimal health, the risk of adverse effects to her and her baby are increased. Preconception care, which includes nutrition, physical activity, and behavioral interventions, is an important adjunct to the health care of all women in their reproductive years. However, only a small percentage of women receive preconception care to follow healthy lifestyle recommendations.[1–3] As preconception care becomes the norm and not the exception to routine medical care, women will seek to enter prenatal care early in their pregnancy. Any delay in accessing prenatal care may result in an increase in negative outcomes. Important components of preconception and prenatal care are nutrition counseling for normal pregnancy with medical nutrition therapy (when needed), and they should be incorporated into the health care of all women.

Preconception

Despite having the highest per capita healthcare costs in the world, the United States ranks 29th in infant mortality rate.[4] The primary reason for the higher infant mortality rate is the number of preterm births when compared to other nations. One in eight infants in the United States is born preterm, which is defined as less than 37 weeks gestation.[4] In 2005, 8.2% of all U.S. infants were born at low birth weight or less than 2500 grams.[4] Although this includes an increase in the number of multiple births, the rates continue to rise for singleton births.

One of the contributing factors to the poor pregnancy outcome in the United States is the date when a woman enters prenatal care. If prenatal care does not begin until late in the first trimester or in the second or third trimester, the delay may result in serious health consequences for the mother and her infant. To reduce the risks associated with delayed prenatal care, the focus must be on improving the woman's health prior to pregnancy. Because more than half of all pregnancies are unplanned or unintended, preconception care should be incorporated into the routine primary medical care of every woman of childbearing age.[1,5] Ideally, the medical care for adolescent girls would transition from the pediatrician to the family physician. This would ensure continuous medical care.

Preconception care is defined as a set of interventions that aim to identify and modify biomedical, behavioral, and social risks to a woman's health or pregnancy outcome through prevention and management.[1] These interventions, when applied before conception, may decrease the risk of adverse health effects in the woman, fetus, and neonate. The goal of preconception care is for every woman to receive services that will enable her to achieve optimal health before pregnancy. This includes health care for women between pregnancies.[6]

The Centers for Disease Control and Prevention (CDC) has identified 4 goals and 10 recommendations to improve health and pregnancy outcomes in the United States (**Tables 1-1** and **1-2**). The American Academy of Pediatrics (AAP) and the American College of Obstetricians and Gynecologists (ACOG) have emphasized nutrition as one of the eight areas for risk screening.[7,8] Two of the CDC-selected preconception risk factors for adverse pregnancy outcomes that are directly affected by a woman's nutritional health are diabetes and obesity.

Two other conditions, hypertension and polycystic ovary syndrome, are not listed in the CDC's preconception health care recommendations, but they may also affect perinatal outcome.

Diabetes

Women with pregestational diabetes are at increased risk for poor perinatal outcomes. Maternal complications include retinopathy, neuropathy, nephropathy, and cardiovascular disease.[9,10] Congenital anomalies and increased risk of stillbirth and miscarriage are among the complications associated

TABLE 1-1 Goals to Improve Health and Pregnancy Outcomes in the United States

- **Goal 1.** To improve the knowledge, attitudes, and behaviors of men and women related to preconception health.
- **Goal 2.** To ensure that all U.S. women of childbearing age receive preconception care services (screening, health promotion, and interventions) that will enable them to enter pregnancy in optimal health.
- **Goal 3.** To reduce risks indicated by a prior adverse pregnancy outcome through interventions in the interconception (interpregnancy) period that can prevent or minimize health problems for a mother and her future children.
- **Goal 4.** To reduce the disparities in adverse pregnancy outcomes.

Source: From Centers for Disease Control and Prevention. Recommendations to improve preconception health and health care—United States. *MMWR.* 2006;55(RR06):1–23.

with hyperglycemia during pregnancy. Conception should be delayed until optimal glycemic levels are achieved. The risk of perinatal complications decreases in women with pregestational diabetes to a level comparable to pregnant women without diabetes if their glycosylated hemoglobin levels are as close to normal as possible without significant hypoglycemia.[9,11] The American Diabetes Association has recommended preconception counseling to all women with diabetes to reduce the risk of malformations associated with unplanned pregnancies and poor metabolic control.[9,10] Effective contraception methods should be used at all times until good metabolic control is achieved.[10]

Medical nutrition therapy (MNT) provided by registered dietitians has been shown to be effective in managing type 1 and type 2 diabetes.[11–13] The overall goals of MNT for women with preexisting diabetes are to achieve and maintain blood glucose levels in the normal range through dietary and lifestyle modifications to decrease the risk of perinatal complications.[9] Evidence-based nutrition recommendations for type 1 and type 2 diabetes can be found online at the American Dietetic Association's Evidence Analysis Library and the American Diabetes Association's position statement on nutrition recommendations.[12,13]

Women with previous gestational diabetes mellitus (GDM) are at risk of developing type 2 diabetes mellitus later in life or GDM in subsequent pregnancies.[11] Six to eight weeks after delivery, a 75-gram oral glucose tolerance test (OGTT) should be performed on all women with GDM. The American Diabetes Association also recommends GDM women be screened every year if the fasting glucose or 2-hour postprandial on the postpartum OGTT was elevated.[11] Nutrition recommendations for GDM are discussed in the pregnancy section of this chapter.

TABLE 1-2 Recommendations to Improve Preconception Health

- **Recommendation 1. Individual Responsibility Across the Lifespan.** Each woman, man, and couple should be encouraged to have a reproductive life plan.
- **Recommendation 2. Consumer Awareness.** Increase public awareness of the importance of preconception health behaviors and preconception care services by using information and tools appropriate across various ages; literacy, including health literacy; and cultural/linguistic contexts.
- **Recommendation 3. Preventive Visits.** As a part of primary care visits, provide risk assessment and educational and health promotion counseling to all women of childbearing age to reduce reproductive risks and improve pregnancy outcomes.
- **Recommendation 4. Interventions for Identified Risks.** Increase the proportion of women who receive interventions as follow-up to preconception risk screening, focusing on high priority intervention (i.e., those with evidence of effectiveness and greatest potential impact).
- **Recommendation 5. Interconception Care.** Use the interconception period to provide additional intensive interventions to women who have had a previous pregnancy that ended in an adverse outcome (i.e., infant death, fetal loss, birth defects, low birthweight, or preterm birth).
- **Recommendation 6. Prepregnancy Checkup.** Offer, as a component of maternity care, one prepregnancy visit for couples and persons planning pregnancy.
- **Recommendation 7. Health Insurance Coverage for Women with Low Incomes.** Increase public and private health insurance coverage for women with low incomes to improve access to preventive women's health and preconception and interconception care.
- **Recommendation 8. Public Health Programs and Strategies.** Integrate components of preconception health into existing local public health and related programs, including emphasis on interconception interventions for women with previous adverse outcomes.
- **Recommendation 9. Research.** Increase the evidence base and promote the use of the evidence to improve preconception health.
- **Recommendation 10. Monitoring Improvements.** Maximize public health surveillance and related research merchanisms to monitor preconception health.

Source: From Centers for Disease Control and Prevention. Recommendations to improve preconception health and health care—United States. *MMWR.* 2006;55(RR06):1–23.

Obesity

According to the Expert Panel from the National Heart, Lung and Blood Institute's (NHLBI) Obesity Education Initiative, overweight is defined as a body mass index (BMI) of 25 to 29.9 kg/m^2, and obesity is defined as a BMI >30 kg/m^2.[14,15]

The prevalence of overweight and obesity in women over 20 years of age has not increased over the past 4 years; it remains at 62% and 33.2%, respectively.[16]

Overweight and obesity continue to be the leading public health concerns in the United States.[16] Obesity is a risk factor for cardiovascular disease and diabetes, and substantially increases the risk of morbidity from hypertension, coronary artery disease, and certain types of cancers.[14,15] Obesity also affects the outcome of pregnancy in the mother and her fetus. A higher prevalence of gestational diabetes, impaired glucose tolerance, hypertension, thromboembolism, preeclampsia, sleep apnea, cesarean section, preterm delivery, and postpartum weight retention are associated with maternal obesity.[17,18] Fetal complications include macrosomia, congenital anomalies, shoulder dystocia, and childhood obesity.[17–19] Ideally, women should delay conception until they have achieved a normal weight to improve their pregnancy outcome.[17,19,20] Treatment of the overweight or obese woman consists of assessment and management.[15]

Assessment includes determining the degree of obesity and health status by evaluating the BMI, waist circumference, and overall medical risk. Body mass index is a better indicator than body weight alone because it provides a more accurate measure of total body fat.[17,21,22] Waist circumference is a useful indicator of abdominal fat mass.[15,21,22] The American Dietetic Association's Evidence Analysis Library Weight Management Guidelines recommends using BMI and waist circumference to classify overweight and obesity, estimate risk for disease, and identify treatment options.[23] BMI and waist circumference are highly correlated to obesity or fat mass and risk of other diseases.[21,23] Women are at increased relative risk for disease if their waist circumference is greater than 35 inches (89 cm). The classifications for BMI and waist circumference are found in **Table 1-3**.

Management involves weight loss, maintenance, and controlling other risk factors. The goals for weight loss and management include: (1) to reduce body weight, (2) to maintain lower body weight, and (3) to prevent further weight gain.

An initial weight loss of 10% of body weight within 6 months is considered achievable.[15,21] The weight loss should be at a rate of 1 to 2 pounds per week, based on a calorie reduction of 500–1000 kcal/day. Effective weight loss strategies include dietary therapy, physical activity, and behavioral therapy—or in certain cases, pharmacotherapy and surgery. Bariatric surgery is the most effective therapy for persons with BMI $\geq$ 40 or BMI $\geq$ 35 with comorbid conditions. This type of surgery could be considered warranted for adolescents under 18 years of age if they meet the following criteria: severely obese (BMI $\geq$ 40), attained skeletal maturity, and have comorbid conditions related to obesity.[24]

The BMI for girls under 20 years old is based on age. After the BMI is calculated, the number is plotted on the CDC BMI-for-age growth chart to obtain a percentile ranking. **Table 1-4** shows the weight status category and percentile range for adolescents.

Hypertension

Hypertensive disorders during pregnancy are a leading cause of maternal mortality and are associated with an increased risk of preterm birth and intrauterine growth retardation.[25] According to the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure, a woman's blood pressure should be evaluated prior to conception in order to define its status, assess its severity, determine the presence of organ damage, and plan treatment strategies.[26] Certain medications, such as angiotensin II receptor blockers (ARBs)

TABLE 1-3 Classification of Overweight and Obesity in Women by BMI, Waist Circumference, and Associated Disease Risk

	BMI (kg/m^2)	Obesity Class	Disease Risk (Relative to Normal Weight and Waist Circumference)	
			≤35 in (≤89 cm)	>35 in (89 cm)
Underweight	<18.5		—	—
Normal	18.5–24.9		—	—
Overweight	25.0–29.9		Increased	High
Obesity	30.0–34.9	I	High	Very High
	35.0–39.9	II	Very High	Very High
Extreme Obesity	≥40	III	Extremely High	Extremely High

Source: From National Heart, Lung and Blood Institute. *The Practical Guide. Identification, Evaluation, and Treatment of Overweight and Obesity in Adults*. Washington, DC: National Institutes of Health; 2000. NIH Publication No. 00–4084.

TABLE 1-4 BMI Categories for Adolescent Girls

Weight Status	Percentile
Underweight	Less than the 5th percentile
Healthy weight	5th percentile to less than the 85th percentile
Overweight	85th to less than the 95th percentile
Obese	Equal to or greater than the 95th percentile

Source: From Centers for Disease Control and Prevention. BMI children and teens. Available at: http://www.cdc.gov/healthyweight/assessing/bmi/childrens_bmi/about_childrens_bmi.html. Accessed September 3, 2010.

and angiotensin converting enzyme (ACE) inhibitors, are contraindicated in pregnancy and should be discontinued before the woman plans to conceive.[25] Methyldopa and beta blockers are safe to use during pregnancy.[25,26]

There is an increasing prevalence of hypertension in pregnant teenagers, which is related to higher rates of obesity among adolescents. Pregnant teenagers are more at risk of developing preeclampsia than women in the 20- to 30-year age group, and preeclampsia is most common among young primiparas.[27]

The American Dietetic Association's evidence-based nutrition practice guidelines for hypertension recommend a comprehensive program in the management of elevated blood pressure, which includes medical nutrition therapy, weight reduction, and physical activity.[28] Research indicates that a comprehensive program can prevent target organ damage and improve cardiovascular outcomes.[25,26,28,29] The DASH (Dietary Approaches to Stop Hypertension) dietary pattern has been shown to reduce systolic blood pressure by 8–14 mm Hg.[28–30] Lowering the daily sodium intake to less than 2300 mg also helps to lower blood pressure.[28–30]

Polycystic Ovary Syndrome

Polycystic ovary syndrome (PCOS) is an endocrine condition that affects about 1 in every 10 women.[31] It is associated with various metabolic dysfunctions, including menstrual irregularities, infertility, hyperandrogenism, hypertension, insulin resistance, and hyperinsulinemia.[31,32] Women with PCOS are at increased risk of developing cardiovascular disease, type 2 diabetes, and the metabolic syndrome.[31] Although most women with PCOS tend to be overweight, it is also seen in normal weight women with excessive abdominal fat distribution.[33]

Treatment for PCOS consists of dietary and lifestyle changes, including physical activity, weight management, behavior modification, and medication, if necessary. Insulin sensitivity has been shown to improve with weight loss.[34] Although there is no standardized food plan for PCOS, dietary patterns that emphasize unrefined carbohydrates with moderate protein and unsaturated fats have been recommended.[31–36] Dietary fats, especially saturated and trans fats, may play a role in insulin resistance by increasing inflammation. A prospective cohort study showed that a diet high in trans fats may increase the risk of ovulatory infertility.[37]

Metformin is commonly used in the treatment of PCOS to improve insulin resistance, reduce hyperandrogenism, and increase ovulation, and it may prevent the development of GDM.[31] Orlistat coupled with calorie restriction was shown to significantly decrease insulin resistance and weight in women with PCOS.[38]

Lifestyle Factors

Other modifiable risk factors have been identified that when addressed in the preconception period will help to improve pregnancy outcome. These risk factors include alcohol, folate deficiency, maternal phenylketonuria, and smoking.

Alcohol

Prenatal exposure to alcohol use during pregnancy is the leading cause of preventable birth defects and developmental disabilities.[39,40] Risks to the fetus include spontaneous abortions, intrauterine growth restriction, central nervous system and facial malformations, and mental retardation. Fetal alcohol spectrum disorders (FASD) is a term that describes a range of effects that can occur in persons exposed to alcohol in utero. Fetal alcohol syndrome (FAS) is the most commonly known of the disorders. In the United States, approximately 5000 babies are born each year with FAS. There is no safe level of alcohol consumption during pregnancy, so the U.S. Surgeon General's Advisory on Alcohol use in pregnancy urges women who are pregnant or who may become pregnant to abstain from alcohol use.[41]

Folate Deficiency

Each year in the United States, approximately 3000 pregnancies are affected by neural tube defects (NTDs), which include spina bifida and anencephaly.[42] Folate has been shown to protect against NTDs. All women of reproductive age are advised to take 400 mcg of folic acid daily, from fortified foods and/or supplements. Additional information on folate is found in the pregnancy section of this chapter.

Maternal Phenylketonuria

Phenylketonuria (PKU) is a metabolic disorder characterized by mental retardation, microcephaly, low birth weight, and congenital heart defects.[1,2,43,44] Women who were diagnosed with PKU as infants and enter pregnancy with elevated phenylalanine levels are at increased risk of delivering infants with congenital anomalies. Because the most critical period of pregnancy is in the first 10 weeks after conception, a phenylalanine-restricted diet is recommended for PKU women throughout their reproductive years.

Smoking

Cigarette smoking is the leading cause of preventable morbidity and mortality in the United States.[45,46] Women who smoke are at increased risk for heart disease, certain types of cancers, and lung disease.[45] Smoking during pregnancy has an adverse effect on both the woman and the fetus. Maternal effects include spontaneous abortion, premature rupture of the membranes, placenta previa, placenta abruption, and preterm delivery. Fetal effects associated with tobacco include intrauterine growth restriction, low birth weight, and sudden infant death syndrome. The CDC recommends cessation of smoking before pregnancy.[45] All women should be screened for tobacco use during their reproductive years and referred for counseling services.

Pregnancy

Pregnancy is a time of increased energy and nutrient needs for a woman to support fetal growth and development, as well as her own. As the length of gestation and the prepregnancy weight of the mother are two of the most influential factors affecting prenatal outcome, the mother's nutritional status is an important component to prenatal care.

Weight Issues in Pregnancy

Prepregnancy weight and weight gain are important aspects in pregnancy because both are associated with maternal outcomes, mode of delivery, preterm birth, birth weight, and postpartum weight retention.

BMI is the best available measure of prepregnancy weight; it serves as a baseline for weight gain recommendations. The World Health Organization (WHO) has established the following BMI categories to define weight status: underweight (<18.5), normal weight (18.5–24.9), overweight (25–29.9), and obese (>29.9).[47] The Institute of Medicine (IOM) provides guidelines for weight gain during pregnancy according to the prepregnancy BMI. These guidelines seek to improve maternal and infant outcomes.

Weight Gain Recommendations

Recommendations for weight gain during pregnancy should be individualized according to the prepregnancy BMI to improve pregnancy outcome, avoid excessive maternal postpartum weight retention, and reduce the risk of adult chronic disease in the child.[48]

After nearly two decades, the IOM reexamined the guidelines for weight gain during pregnancy, which took into consideration the recent increase in the prevalence of obese women of childbearing age. The new guidelines differ from the previous recommendations in two aspects: (1) they are based on the WHO BMI categories rather than the previous categories from the Metropolitan Life Insurance tables, and (2) they include a narrow range of weight gain for obese women. Recommendations of total and weekly weight gain for the second and third trimesters for each BMI are displayed in **Table 1-5**. The recommended total weight gain for the first trimester is 0.5–2 kg or 1.1–4.4 pounds, depending on the prepregnancy BMI.[49,50]

Overweight and Obesity

Obesity occurs in approximately 50% of non-Hispanic black women, followed by black Mexican American (38%), and non-Hispanic white (31%) women of childbearing age.[51] Numerous studies have reported an increased risk of gestational diabetes mellitus (GDM) among women who are overweight and obese. A meta-analysis of 20 studies determined the risk of developing gestational diabetes with maternal obesity. The unadjusted odds ratio (OR) of developing GDM were 2.14 (95% confidence of interval 1.82–2.53), 3.56 (3.05–4.21), and 8.56 (5.07–16.04) among overweight, obese, and severely obese women, respectively, compared with normal-weight

TABLE 1-5 Total and Mean Weight Gain Recommendations During Pregnancy

	Underweight (< 18.5)	Normal (18.5–24.9)	Overweight (25–29.9)	Obese (> 29.9)
Total				
Kg	12.5–18	11.5–16	7–11.5	5–9
Lb	28–40	25–35	15–25	11–20
Weekly Gain for Second and Third Trimesters				
Mean, Kg	0.51	0.4	0.28	0.22
Range, Kg	(0.44–0.58)	(0.35–0.50)	(0.23–0.33)	(0.17–0.27)
Mean, Lb	1	1	0.6	0.5
Range, Lb	(1–1.3)	(0.8–1)	(0.5–0.7)	(0.4–0.6)

Source: Adapted from Institute of Medicine, *Weight Gain During Pregnancy: Reexamining the Guidelines*. Report brief. Washington, DC: The National Academies Press; 2009.

pregnant women. The authors concluded that high maternal weight is associated with a higher risk of GDM.[52] Other complications associated with maternal overweight and obesity are hypertension, preeclampsia, cesarean section, preterm delivery, labor induction, postpartum hemorrhage, macrosomia, and neonatal hypoglycemia.[53–59] Due to the multiple maternal and infant detrimental effects associated with maternal overweight and obesity, the American Dietetic Association and the American Society for Nutrition released the position statement that "all overweight and obese women of reproductive age should receive counseling on the roles of diet and physical activity in reproductive health prior to pregnancy, during pregnancy, and in the interconceptional period in order to ameliorate these adverse outcomes."[60]

Multiple Gestation

Multiple births have risen dramatically over the past 20 years in the United States, primarily due to the increasing use of assisted reproductive technologies (ART). Newborns conceived through ART are at higher risk for prematurity, low birth weight, and perinatal mortality. Women who conceive through ART are more likely to develop preeclampsia and gestational diabetes, and experience preterm birth or vacuum or forceps delivery. The most common antenatal complications include preterm premature rupture of membranes, hemorrhage, and anemia.[61–64] In a recent population study that included 316,696 twin, 12,193 triplet, and 778 quadruplet pregnancies from the 1995–2000 Matched Multiple Birth Data Set, triplet and quadruplet pregnancies had significantly higher risks than twin pregnancies for most maternal and neonatal complications. The study also showed that maternal anthropometric, nutritional, and previous reproductive factors may be particularly important in the reduction of these excess risks and improvement of outcomes in multiple births.[65] Most infants of multiple gestation are preterm births (37 weeks gestation) and are among the low birth weight (2500 g) and very low birth weight (1500 g) infant populations. Early preterm births (32 weeks gestation) occur in 35% of triplet and higher order births and 11% of twin births, compared with less than 2% of singleton births.[66] Weight gain recommendations for twin pregnancies from the IOM suggest a range of maternal weight gain of 37–54 pounds for the normal BMI category, 31–50 pounds for overweight women, and 25–42 pounds for obese women, with a suggested rate gain of 1.5 pounds per week during the second and third trimesters.[49] In a study by Luke and colleagues, optimal rates of fetal growth and birth weights in twins were achieved at rates of maternal weight gain that varied by period of gestation and maternal pregravid BMI status. For example, in normal weight women, the specific recommended rate of weight gain up to 20 weeks of gestation is 1–1.5 lb/wk (0.45–0.68 kg/wk), 1.25–1.75 lb/wk (0.57–0.79 kg/wk) between 20 and 28 weeks, and 1.0 lb/wk (0.45 kg/wk) from 28 weeks to delivery.[67]

Gastrointestinal Discomforts

Nausea and Vomiting

Symptoms of nausea and vomiting in pregnancy (NVP) constitute a frequent and often highly unpleasant syndrome during early gestation. Nausea and vomiting affect 70% of pregnant women during the first trimester and vomiting alone affects between 30% and 50% of pregnant women.[68] Commonly referred to as "morning sickness," nausea and vomiting may occur at any time during the day or night. Nausea, a frequent discomfort of early pregnancy, can last well into the second trimester and varies greatly in its severity. A prospective cohort study that included 2407 newly pregnant women in three U.S. cities found that 89% of women experienced NVP; in 99%, the symptoms started in the first trimester. NVP symptoms in multigravidas were more likely to last beyond the first trimester with each additional pregnancy.[69]

Management of nausea and vomiting depends on the severity of the symptoms. Dietary modifications may resolve mild cases. First trimester nausea may improve by consuming small amounts of liquid or food at frequent intervals, and avoiding fried, spicy, and high fat foods. Some pregnant women may tolerate foods high in carbohydrates such as crackers rather than high-protein or high-fat foods.[48] Some women respond by avoiding cooking odors, getting out of bed slowly in the morning, and drinking small amounts of liquid between meals.[70–72] Current dietary recommendations shown to have beneficial nausea-reducing effects and considered safe and effective include taking a multivitamin early in the pregnancy-planning process, supplementation with vitamin B_6, and eating ginger as a nonpharmacologic option.[73]

Hyperemesis gravidarum (HG), or severe nausea and vomiting, is a high-risk condition usually requiring hospital admission, antiemetic medications, rehydration, correction of electrolytes, and nutritional support. In a study of 819 women with HG, 214 (26.1%) experienced extreme weight loss, defined as a loss of greater than 15% of prepregnancy weight. Extreme weight loss ($p < 0.001$) was associated with indicators of the severity of HG, such as hospitalization, use of parenteral nutrition, gallbladder and liver dysfunction, renal failure, and retinal hemorrhage.[71] The interventions mentioned in the previous paragraph may help prevent excessive pregnancy weight loss and infants born with low birth weight.[72,73]

Heartburn

Heartburn is a common symptom in pregnancy, affecting up to 80% of women in the third trimester. The reasons

for the increased symptoms during the latter stage of pregnancy are not well understood, but the effects of pregnancy hormones on the lower esophageal sphincter and gastric clearance are thought to play a part. A range of interventions has been used to relieve symptoms including advice on diet and lifestyle, antacids, antihistamines, and proton pump inhibitors.[74] In a systematic review of placebo controlled trials, three studies examined various medications to relieve heartburn (intramuscular prostigmine, an antacid preparation, and an antacid plus ranitidine). All three produced positive findings in favor of the intervention groups; however, the authors concluded that there was a paucity of information to draw conclusions on the overall effectiveness of interventions to relieve heartburn in pregnancy.[75]

Practical approaches that may ease heartburn in pregnancy include avoiding lying down immediately after eating; sleeping with the woman's head slightly elevated to avoid acid reflux; consuming small, frequent meals; and avoiding known irritants such as caffeine, chocolate, or highly seasoned foods.[48]

Ptyalism

Ptyalism is of unknown origin and is usually defined as an excessive secretion of saliva. It is common in women with nausea and vomiting who might have difficulty swallowing their saliva.[76] Dietary alterations to overcome ptyalism include the use of chewing gum or lozenges and restricting fluids.[77] In two case studies complicated by ptyalism during pregnancy, one case reported that ptyalism recovered spontaneously at 35–36 weeks gestation; in the other it did not resolve until after delivery.[75] Further research is needed to determine the physiologic origin of ptyalism and to identify treatment.[78]

Constipation

Constipation is common during pregnancy and occurs most frequently during the third trimester as the weight of the uterus puts pressure on the rectum, which may also result in hemorrhoids. Increased consumption of liquids in combination with high fiber foods and regular physical activity are recommended to alleviate constipation. It is recommended to drink from six to eight glasses of fluids daily. The dietary reference intake (DRI) for fiber during pregnancy is 28 g/day.[79] High fiber foods include whole grains, legumes, fruits, and vegetables.

Diarrhea

Diarrhea is characterized by several changes in the stool, including an increased frequency, looser consistency, and more volume. It is caused by an increase in water content in the stool. Diarrhea during pregnancy may be the result of foodborne infections, irritable bowel syndrome, or other causes. Acute diarrhea may lead to severe dehydration that can result in the loss of important electrolytes from the body. Symptoms of dehydration include excessive thirst, dry mouth, scant or no urine or dark yellow urine, decreased tears, severe weakness or lethargy, and dizziness. Fluids are the most effective treatment for preventing dehydration in pregnant women. Consumption of liquids, such as oral rehydration fluids, juice, or water, can help pregnant women reduce the risk of becoming dehydrated. Medical attention should be required when diarrhea is not resolved within 24 hours. Also diarrhea with bloody stools, fever, or severe abdominal pain requires immediate medical attention.

Eating Disorders

The eating disorders (EDs) anorexia nervosa, bulimia nervosa, and eating disorders not otherwise specified (EDNOS) have profound effects on the overall well-being of women and their children. Clinically, these disorders can present as menstrual dysfunction, low bone density, sexual dysfunction, miscarriage, preterm delivery, or low birth weight.[80] A recent study evaluated ED symptoms in pregnancy and reported that women with recent episodes of ED restricted their intake, used laxatives, self-induced vomiting, and exercised more than other groups during pregnancy. Their weight and body shape concern scores remained high during pregnancy. Women with past histories of ED were also more likely than controls to have some ED behaviors and/or concerns about weight gain during pregnancy.[81] Complications associated with eating disorders during pregnancy include miscarriage, premature labor, low birth weight, stillbirth or fetal death, and delayed fetal growth.

Physical Activity

The benefits of physical activity during pregnancy have been extensively documented. Physical activity is recommended by ACOG for most pregnant women without medical or obstetric risk. The recommendation for normal risk pregnant women in the absence of either medical or obstetric complications is 30 minutes or more of moderate-intensity physical activity on most, if not all, days of the week. According to the ACOG committee, in general, participation in a wide range of recreational activities appears to be safe during pregnancy. However, each sport should be reviewed individually for its potential risk, and activities with a high risk of abdominal trauma should be avoided. Physical activity is contraindicated if the following conditions are present: restrictive lung disease, incompetent cervix, multiple gestation, premature labor, rupture of membranes, preeclampsia/pregnancy-induced hypertension, persistent second and third trimester bleeding, and placenta previa.[82] A study of 44 healthy women in late pregnancy that compared active vs. inactive women reported that active women (those who engaged in more than 30 minutes of moderate-intensity

physical activity per day) had significantly better cardiovascular fitness and lower sleeping heart rates without any negative effects on fetal condition or outcome of labor and delivery compared to the inactive women. The duration of the second stage of labor was 88 and 146 minutes, respectively, for the active vs. inactive women ($p = 0.05$).[83]

It is important to evaluate the overall health of pregnant women, including obstetric and medical risks, before prescribing an exercise program. Additional factors to take into consideration are prepregnancy BMI, weight gain goals, dietary intake, and history of physical activity.

Nutrient Recommendations

The quality of the diet during pregnancy has a profound impact on fetal and maternal outcomes. A well-balanced diet providing recommended calories and optimal nutrients throughout pregnancy should favor fetal normal growth and development and desired maternal outcomes. Conversely, maternal malnutrition, especially during the first trimester, a crucial period of fetal development, may predispose the infant to chronic diseases in adult years. Recent research suggests chronic diseases such as coronary heart disease, hypertension, and type 2 diabetes may originate in impaired intrauterine growth and development.[84,85]

The dietary reference intakes (DRIs) is a set of daily nutrient intake guidelines for different age groups and genders that encompasses several reference values such as the recommended dietary allowances (RDAs), adequate intake (AI), tolerable upper intake level (UL), and estimated average requirement (EAR). These values serve as a guide to prevent nutritional deficiencies and to promote optimal health benefits. Recommended levels of energy and nutrient intakes vary for adults, children, and women who are pregnant or breastfeeding.[79,86]

Energy

The energy allowance for pregnancy can be estimated by dividing the gross energy cost (80,000 kcal) by the approximate duration (250 days following the first month), yielding an average value of 300 kcal per day in addition to the allowance for nonpregnant females.[79,86] Caloric requirements for pregnant adolescents (14–18 years) and adult women (19–50 years) can be calculated by using the estimated energy requirements (EER) formula.[79] **Table 1-6** displays EER formulas to determine energy requirements for normal prepregnancy BMI for each trimester. The DRIs for total energy indicate that for healthful birth outcomes, pregnant women should consume an extra 340 kcal/day in the second trimester and 452 kcal/day in the third trimester.

The formulas displayed in Table 1-6 are not applicable to overweight and obese women. An estimate of the caloric requirement for overweight and obese women can be obtained by using an adjusted body weight in the Harris Benedict formula and adding 150–300 kcal for the second and third trimesters.[79,87] (See **Table 1-7**.)

A simple method to determine caloric needs during pregnancy for normal weight women is to estimate a daily need of 30 kcal per kilogram prepregnancy weight per day during the first trimester, and adding 300 kcal during the second and third trimesters. In underweight women, these caloric prescriptions would need to be increased.

Regardless of the method used to estimate caloric level, weight gain pattern, goals, and appetite are used by registered dietitians or other healthcare professionals to make the necessary caloric adjustments. Frequent monitoring ensures that pregnant women will consume adequate calories from nutrient-dense foods to sustain weight gain and provide appropriate nutrients.

Macronutrients

The main function of macronutrients in the diet is to provide energy. Besides providing the RDA or AI for carbohydrates, proteins, and fat, the DRIs for macronutrients also provide a range of daily macronutrient distribution. The Acceptable Macronutrient Distribution Range (AMDR) is the range of intake for a particular energy source that is associated with reduced risk of chronic disease while providing intakes of essential nutrients. If an individual consumes in excess of the AMDR, there is an increased risk of chronic

TABLE 1-6 Estimated Energy Requirements for Normal Prepregnancy BMI

First Trimester [EER + 0]	$EER = 354 - (6.91 \times A) + PA \times (9.36 \times Wt + 726 \times Ht)$
Second Trimester [EER + 340]	$EER = 354 - (6.91 \times A) + PA \times (9.36 \times Wt + 726 \times Ht) + 340$
Third Trimester [EER + 452]	$EER = 354 - (6.91 \times A) + PA \times (9.36 \times Wt + 726 \times Ht) + 452$

Abbreviations: A = age; PA = physical activity coefficient: sedentary (1.0), low activity (1.12), active (1.27), very active (1.45); Wt = weight in kilograms; Ht = height in meters

Source: Data from Institute of Medicine. *Dietary Reference Intakes for Energy, Carbohydrates, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids (Macronutrients)*. Washington, DC: National Academies Press; 2002.

TABLE 1-7 Energy Requirements for Overweight and Obese Prepregnancy BMI

Energy = [655 + (9.6 × AdBWt kg) + (1.8 × Ht cm) − (4.7 × A)] × PA + (150 − 300) kcal

Abbreviations: AdBWt = Adjusted Body Weight: [(Actual Body Wt − Desirable Body Wt) × 0.25] + Desirable Body Wt

diseases and/or insufficient intakes of essential nutrients. The AMDR for pregnancy is the same as for all healthy adults: 45–65% of kcal from carbohydrates, 10–35% of kcal from protein, and 20–35% of kcal from fat.[79]

Carbohydrates and Nutritive Sweeteners

The primary role of carbohydrates is to provide energy to cells. The major types of carbohydrates in the diet are starch, a complex carbohydrate, and simple sugars such as glucose, fructose, sucrose, and lactose. Sources of starch include grains and vegetables such as cereals and starchy vegetables. Natural sugars are found in foods such as fruits, vegetables, milk, and milk products. Added sugars include brown sugar, corn sweetener, corn syrup, dextrose, fructose, fruit juice concentrate, high-fructose corn syrup, and honey, and can be found in desserts, fruit drinks, soft drinks, and candy.[88]

The median intake of carbohydrates for women is approximately 180 to 230 g/day. To assure provision of glucose to the fetal brain (approximately 33 g/day), as well as to supply the glucose fuel requirement for the mother's brain independent of utilization of ketoacids, the RDA for pregnancy for ages 14 to 50 years is 175 g/day. There is no evidence to indicate that a certain portion of the carbohydrate must be consumed as starch or sugars.[86]

Carbohydrate-containing foods have been ranked according to their effect on blood glucose level response compared with a reference food (either glucose or white bread). This concept is known as the glycemic index (GI), and it classifies foods as low (< 55), medium (56–69), or high (> 70) GI foods. Foods with a low GI score contain slowly digested carbohydrates, which produce only small fluctuations in blood glucose and insulin levels. Examples of low GI foods include whole-wheat bread, old-fashioned oatmeal, bran cereal, legumes, vegetables, and fruits. Foods with high GI scores contain rapidly digested carbohydrates, which produce a rapid rise and fall in the blood glucose level. Examples of high GI foods are highly processed breakfast cereals, instant potatoes, instant noodles, sugar, honey, molasses, corn syrup, candy, and sweetened beverages.[89]

Several studies have evaluated the effects of glycemic index foods on pregnancy outcomes. For example, birth defects have been associated with poor glycemic control. One study reported that a diet high in sucrose and other high-glycemic foods increased the risk of neural tube defects by twofold in women among all weight groups, but the risk was fourfold among obese women (BMI > 29).[90] Another study reported that pregnant women who consumed diets with low-GI carbohydrates had reduced infant birth weight and an approximately twofold increased risk of a small-for-gestational-age baby.[91] Epidemiologic data from the Nurses' Health Study also showed that a low-glycemic, high-cereal-fiber diet reduced the risk for GDM by approximately one half.[92] A high-fiber and high-complex-carbohydrate diet may reduce the need for insulin after a meal, and theoretically decrease beta cell failure; however, efficacy data are limited.[60]

The concept of glycemic index foods is controversial and has not reached consensus among the scientific community. Additional studies are needed to determine if the glycemic index depends on food composition, cooking methods, or individual response. The IOM does not recommend the GI because of the lack of sufficient evidence in its use in the prevention of chronic diseases in generally healthy individuals.[79]

Fiber

Fiber is composed of complex carbohydrates and can be classified as insoluble or soluble fiber. Insoluble fiber such as cellulose, hemicellulose, and lignin increase water-holding capacity, thus increasing fecal volume and decreasing gastric transit time. Soluble fiber, such as gums and pectins, form gels, resulting in slowed gastrointestinal transit time and slowed or decreased nutrient absorption. Soluble fibers also bind other nutrients such as cholesterol and minerals to decrease their absorption. Foods high in insoluble fiber include wheat bran, whole grains, cereals, seeds, and the skin of fruits and vegetables. Foods containing high levels of soluble fiber are oats, legumes, barley, apples, strawberries, carrots, and citrus fruits. The DRI for fiber during pregnancy is 28 g/day.[86] Careful selection of fiber sources can help achieve the recommended level. Foods containing an average of 10–15 g of fiber per cup include baked beans, lentils, and chickpeas. Foods containing 5–10 g of fiber per cup include winter squash, spinach, mixed vegetables, peas, and cereals.[93]

Nonnutritive Sweeteners

The Food and Drug Administration (FDA) has approved five nonnutritive sweeteners: saccharin, aspartame, acesulfame potassium (or acesulfame K), sucralose, and most

recently, neotame. The safety of these nonnutritive sweeteners has been determined with animal studies. The use of aspartame within FDA guidelines appears to be safe during pregnancy. Aspartame (Equal or Nutrasweet) is the methyl ester dipeptide of the natural amino acids L-aspartic acid and L-phenylalanine. Women with phenylketonuria (PKU) must restrict their phenylalanine intake. Because the amino acid phenylalanine is one of the metabolites of aspartame, women with PKU should avoid this sweetener. Maternal plasma levels of phenylalanine after ingestion of normal amounts of aspartame-containing foods are not higher than after the ingestion of protein-containing meals.[94]

Acesulfame potassium (Sweet One or Sunette) is considered safe for use during pregnancy. Sucralose (Splenda) is derived from sucrose and is safe for human consumption. The FDA concluded that sucralose does not pose carcinogenic, reproductive, or neurologic risk to human beings. Saccharin (Sweet'n Low) crosses the placenta and may remain in fetal tissue because of the slow fetal clearance. The American Medical Association and the American Dietetic Association suggest careful use of saccharin in pregnancy. Many practitioners suggest avoidance of saccharin during pregnancy. According to the American Dietetic Association position statement on the use of nonnutritive sweeteners during pregnancy, it is acceptable during pregnancy. Neotame® is a sweetener and flavor enhancer for beverages and foods. It is a derivative of the dipeptide composed of the amino acids aspartic acid and phenylalanine that is readily eliminated from the body. The FDA approved neotame as a general-purpose sweetener in 2002 after reviewing evidence of more than 100 scientific studies. It is considered safe for the general population, including pregnant and lactating women, children, and people with diabetes. Although no specific recommendations have been made regarding their use during pregnancy, moderation of ingestion of nonnutritive sweeteners may be appropriate.[95]

Dietary Fat

Dietary fat provides energy and is essential for the absorption and transport of fat-soluble vitamins. The main types of dietary fat are saturated, polyunsaturated, monounsaturated, and trans fats. Besides having an impact on weight gain, dietary fat also plays an important role in the modulation of lipid profile. Saturated fatty acids have been positively correlated with low-density lipoprotein (LDL) cholesterol levels, whereas monounsaturated and polyunsaturated fatty acids tend to decrease LDL cholesterol. Dietary trans-fatty acids are associated with increased LDL cholesterol levels. The main sources of trans-fatty acids in the diet are partially hydrogenated vegetable fats, baked goods, and commercial fried foods.

Essential fatty acids (EFA) are required in the human diet. Two closely related families of EFA are omega-3 and omega-6 fatty acids. The major fatty acids of the omega-6 series are linoleic (18:2n-6), γ-linolenic (18:3n-6), and arachidonic (20:4n-6) acids. The long-chain omega-3 fatty acids eicosapentaenoic acid (EPA) (20:5n-3) and docosahexaenoic acid (DHA) (22:66n-3) can be synthesized from α-linolenic acid.[96] Sources of omega-3 fatty acids include vegetable oils such as soybean, canola, and flaxseed oil; fish oils; and fatty fish, with smaller amounts found in meats and eggs. Sources of omega-6 fatty acids include nuts, seeds, and vegetable oils such as soybean, safflower, and corn oil. The AMDR of fat for pregnant women is 20–35% of total energy, the same as for nonpregnant women. Besides total fat recommendations, DRIs have been formulated for omega-3 and omega-6 fatty acids. The AI of omega-6 linoleic acid is 13 g/d and for omega-3, ∝-linolenic acid is 1.4 g/d.[86]

Protein

Pregnant women have additional protein requirements to support the expansion of maternal tissue and fetal growth. Protein intake has a significant effect on birth weight. In a study that increased the dietary protein intake by 1 g per day during preconception and in the 10th, 26th, and 38th weeks of gestation resulted in a significant increase of 7.8–11.4 g in birth weight.[97] A higher than average protein intake during pregnancy resulted in a significant depression of birth weight; in fact, a protein intake of more than 84 g/day on average was more detrimental than inadequate protein. It appears that moderate protein intake is optimal during pregnancy.[98]

Sources of protein providing all essential amino acids required for protein synthesis include meats, poultry, fish, milk, and eggs. Complementation of vegetable protein from a variety of cereals and legumes can also facilitate protein synthesis. The current RDA of 71 g of protein for pregnant women is 25 g more than the requirement for nonpregnant women. The additional 25 g is based on 1.1 g/kg/day using prepregnant weight.

Table 1-8 summarizes the DRIs for macronutrients for pregnant women ages <18–50 years of age.

Micronutrients

Certain vitamins and minerals are of particular significance during pregnancy. A deficiency of micronutrients during pregnancy has been associated with complications such as anemia and hypertension, as well as impaired fetal function, development, and growth. The main cause of multiple deficiencies is the quality of the diet. Women who avoid meat and/or milk in wealthier regions of the world are also at higher risk of micronutrient depletion during pregnancy and lactation. In certain dietary patterns high in unrefined grains and legumes, the amount of nutrients consumed may be adequate, but dietary constituents, such as phytates and polyphenols will limit micronutrient absorption.

TABLE 1-8 Dietary Reference Intakes (DRIs) of Macronutrients for Pregnant Women (grams/day)

	AMDR[a]	RDA[b]/AI[c] <18–50 years
Carbohydrates	45–65	175
Total fiber		28
Protein	10–35	71
Fat	20–35	ND[d]
Omega-6, linoleic acid	5–10	13
Omega-3, linolenic acid	0.6–1.2	1.4

Source: Adapted Institute of Medicine. Dietary reference intakes. National Academy of Sciences. www.nap.edu.

[a]Acceptable macronutrient distribution range (AMDR)

[b]Recommended dietary allowance (RDA)

[c]Adequate intake (AI)

[d]Not determinable (ND) due to lack of data of adverse effects in this age group and concern with regard to lack of ability to handle excess amounts. Source of intake should be from food only to prevent high levels of intake.

Several micronutrient deficiencies are well established as contributors to abnormal prenatal development and/or pregnancy outcome. These include magnesium, iron, folate, and vitamin D deficiencies. Less well recognized for their importance are deficiencies of B vitamins (and subsequently elevated plasma homocysteine concentrations).[99] See **Table 1-9** for the RDAs and adequate intakes for micronutrients for pregnant and nonpregnant adolescents and women.

Magnesium

Magnesium is an essential mineral for optimal metabolic functions, which include energy production, synthesis of essential molecules such as nucleic acids and proteins, bone structural integrity, ion transport across membranes, and cell signaling.[99] Research has shown that the mineral content of magnesium in food sources is declining, and magnesium depletion has been detected in persons with some chronic diseases. Magnesium may be effective in the management of eclampsia and preeclampsia, arrhythmia, severe asthma, and migraine.[100] Food sources of magnesium include green leafy vegetables, nuts, legumes, and whole grains. The RDA of 360 to 400 mg of magnesium in pregnancy is an increase of 40 mg over nonpregnant requirements.[86]

Iron

Iron is an essential component of multiple proteins and enzymes, and participates in oxygen transport and storage, electron transport and energy metabolism, and DNA synthesis. The requirement for iron is significantly increased during pregnancy due to increased iron utilization by the developing fetus and placenta, as well as blood volume expansion. Heme iron is readily absorbed and is present in meat, poultry, and fish. Non-heme iron sources, such as legumes, require the addition of vitamin C, organic acids, or meat, fish, or poultry to enhance its absorption. Inhibitors of non-heme iron absorption are phytates, polyphenols, and soy protein. Good sources of iron include beef, lentils, beans, bran cereal, and raisins.[99] Iron deficiency during pregnancy leads to maternal anemia, defined as a hematocrit less than 32% or a hemoglobin less than 11 g/dL. According to the Institute of Medicine, an appropriate time to begin iron supplementation at a dose of 30 mg/day is after 12 weeks of gestation, when iron requirements begin to increase.[101] The DRI for iron during pregnancy is 27 mg/day.[86]

Folate

Folate and folic acid participate in nucleic acid and amino acid metabolism and interact with vitamins B_6 and B_{12}. A deficiency of folate during the first days after conception may result in low birth weight, premature birth, and/or neural tube defects (NTDs) and elevated homocysteine levels, which may be a predictor of poor pregnancy outcomes.[99,102] Folate is naturally found in food; folic acid, the synthetic form of folate, is found in supplements and fortified foods. Folic acid is 100% absorbed when consumed whereas folate is only partially absorbed. Folic acid is added to breakfast cereals and many other foods with the purpose of preventing NTDs. Important sources of folate include asparagus, spinach, lentils, broccoli, and orange juice. The DRI for folate during pregnancy is 600 μg/day.[86]

Vitamin D

Vitamin D is essential for skeletal health, and a prolonged deficiency will result in infant rickets and adult osteomalacia. Besides being essential for the efficient utilization of calcium by the body, vitamin D also plays a role in cell differentiation, provides immunity, and participates in insulin secretion and blood pressure regulation. Serum 25(OH)D (25-hydroxyvitamin D) concentration is a useful indicator of vitamin D nutritional status.[100] A study of 180 pregnant women of various ethnic backgrounds evaluated the effects of daily and single-dose vitamin D supplementation at 27 weeks gestation. Study participants were randomly assigned to three treatment groups: a single oral dose of 200,000 IU vitamin D, a daily supplement of 800 IU vitamin D from 27 weeks until delivery, and a no treatment group. The women who received either the single or daily dose had significant improvement in their 25-hydroxyvitamin D levels.[103]

Common foods that are fortified with vitamin D include dairy products, cereals, and orange juice. The AI for

TABLE 1-9 Recommended Dietary Allowances and Adequate Intakes for Micronutrients

	Nonpregnant		Pregnant	
Micronutrient	**Females 13–18 yr**	**Females 19–50 yr**	**Females 13–18 yr**	**Females 19–50 yr**
Thiamin (mg/day)[a]	1.0	1.1	1.4	1.4
Riboflavin (mg/day)[a,c]	1.0	1.1	1.4	1.4
Niacin (mg/day)[a]	14	14	18	18
Biotin (μg/day)[b]	25	30	30	30
Pantothenic acid (mg/day)[b]	5	5	6	6
Vitamin B_6 (mg/day)[a]	1.2	1.3	1.9	1.9
Folate (μg/day)[a,d]	400	400	600	600
Vitamin B_{12} (μg/day)[a]	2.4	2.4	2.6	2.6
Choline (mg/day)[b]	400	425	450	450
Vitamin C (mg/day)[a]	65	75	80	85
Vitamin A (μg/day)[a,e]	700	700	750	770
Vitamin D (μg/day)[b,f]	5	5	5	5
Vitamin E (mg/day)[a,g]	15	15	15	15
Vitamin K (μg/day)[b]	75	90	75	90
Sodium (mg/day)[b]	1500	1500	1500	1500
Chloride (mg/day)[b]	2300	2300	2300	2300
Potassium (mg/day)[b]	4700	4700	4700	4700
Calcium (mg/day)[b]	1300	1000	1300	1000
Phosphorus (mg/day)[a]	1250	700	1250	700
Magnesium (mg/day)[a]	360	310	400	350
Iron (mg/day)[a]	15	18	27	27
Zinc (mg/day)[a]	9	8	12	11
Iodine (μg/day)[a]	150	150	220	220
Selenium (μg/day)[a]	55	55	60	60
Copper (μg/day)[a]	890	900	1000	1000
Manganese (mg/day)[b]	1.6	1.8	2.0	2.0
Fluoride (mg/day)[b]	3	3	3	3
Chromium (μg/day)[b]	24	25	29	30
Molybdenum (μg/day)[a]	43	45	50	50

[a]Recommended dietary allowance (RDA)

[b]Adequate intake (AI)

[c]Niacin recommendations are expressed as niacin equivalents (NE).

[d]Folate recommendations are expressed as dietary folate equivalents (DEF).

[e]Vitamin A recommendations are expressed as retinol activity equivalents (RAE).

[f]Vitamin D recommendations are expressed as cholecalciferol and assume absence of adequate exposure to sunlight.

[g]Vitamin E recommendations are expressed as α-tocoferol.

vitamin D recommended by the Institute of Medicine is 5 μg/day or 200 IU/day.

B Vitamins

B vitamins such as thiamin, riboflavin, niacin, biotin, pantothenic acid, vitamin B_6, folate, and vitamin B_{12} participate in many metabolic pathways, including those involved in energy metabolism. Poor maternal vitamin B status may be a major cause of homocysteinemia and poor pregnancy outcomes. It has not yet been established how homocysteinemia affects pregnancy outcome adversely, but proposed mechanisms include: (1) homocysteine increases free radical oxygen concentrations, which reduces nitrous oxide concentrations, leading to endothelial dysfunction; (2) homocysteine may cause oxidative stress and subsequent placental ischemia; (3) homocysteine may cause an inflammatory response that is cytotoxic to endothelial cells; (4) B-vitamin deficiencies lead to hypomethylation of DNA and altered gene expression; (5) homocysteine induces apoptosis of the endothelial cells; (6) birth defects may be caused by homocysteine interference with the N-methyl-D-aspartate receptor system; or (7) homocysteine is thrombogenic.[99]

Comorbidities During Pregnancy

There are certain conditions during pregnancy that require special dietary interventions. Pregnant women experiencing diabetes, hypertension, and pre-eclampsia require individualized dietary modification that will help to reduce the risks associated with these conditions.

Diabetes

The risk of developing gestational diabetes has increased in the last 10 years. Numerous studies have reported an increased risk of gestational diabetes mellitus (GDM) among women who are overweight or obese.[52] GDM is defined as glucose intolerance occurring during pregnancy.[104,105] Women at risk for GDM typically have a previous history of GDM, may exhibit obesity, have a strong family history of diabetes, or belong to an ethnic group with a high prevalence of diabetes. GDM is associated with fetal macrosomia, large-for-gestational-age infants, and an increased risk of a difficult labor and delivery.[106,107] Intensive treatment of hyperglycemia in women with GDM lessens the risk of adverse outcomes by reducing the risk of fetal macrosomia and providing the best outcome for normal or large-for-gestational-age infants.[108,109]

GDM nutrition management includes individualized nutrition counseling and medical nutrition therapy (MNT) by a registered dietitian. Nutrition management consists of specifying the appropriate amount of carbohydrates that will help the patient gain the recommended amount of weight, while achieving normoglycemia and preventing ketonuria. Carbohydrate intake affects postprandial blood glucose levels of women with GDM. The recommendation of a minimum of 175 g of carbohydrates per day is the same as for pregnant women without GDM.[110] Carbohydrates are less tolerated at breakfast than at other meals and should be adjusted based on monitoring weight, blood glucose, and ketones.[111] Food plans that contain 40% carbohydrates have been shown to reduce postprandial glucose levels.[112] For optimal glucose control, carbohydrates are usually distributed throughout the day in three meals and three snacks.

The amount of protein, fat, and vitamins and minerals should be based on DRI for pregnant women. Vitamin and mineral supplementation should be encouraged when DRIs are not met through dietary intake. Most women with GDM return to normal glucose levels in the postpartum period. Postpartum counseling should highlight the importance of attaining a normal BMI and regular physical activity in an effort to reduce the lifetime risk of GDM in subsequent pregnancies or type 2 diabetes.[113]

Hypertension and Preeclampsia

Gestational hypertension and preeclampsia are more common in overweight and obese pregnant women. Gestational hypertension, defined as a systolic blood pressure of at least 140 mm Hg or a diastolic blood pressure of at least 90 mm Hg, affects approximately 6% to 17% of nulliparous women and 2% to 4% of multiparous women.[60] Approximately 50% of women with gestational hypertension diagnosed before 30 weeks gestation develop preeclampsia. Risk factors include preeclampsia in a previous pregnancy, maternal age younger than 20 years or older than 40 years, obesity, insulin resistance, diabetes, and genetic factors.[48,114]

The cause of preeclampsia is unknown, but may be related to an inadequate placental blood supply, possibly due to maternal hypertension, which causes placental oxidative stress and the release of placental factors into maternal circulation that triggers an inflammatory response. Subclinical inflammation is more common in obese individuals, hence obese women may enter pregnancy with preexisting inflammation that enhances their risk for preeclampsia.[60,115]

The incidence of preeclampsia is greater in twins than in single births.[116] Preeclampsia is associated with preterm delivery, low birth weight infants, neonatal death, maternal morbidity and mortality, and an increased risk of developing cardiovascular disease later in life.[117–119] Theories abound concerning the management and prevention of preeclampsia. The role of diet and nutrient supplementation has not been adequately studied. Sodium restriction and calcium, zinc, and magnesium supplementation have not been proven effective.[120] A recent study of nulliparous pregnant Norwegian women at risk for preeclampsia suggests that a dietary pattern characterized by high intake of vegetables, plant foods, and vegetable oils decreases the

risk of preeclampsia, whereas a dietary pattern characterized by high consumption of processed meat, sweet drinks, and salty snacks increases the risk.[115]

Food Safety

Seafood

Fish and shellfish are important additions to the diet, providing lean protein and essential nutrients such as omega-3 fatty acids. However, nearly all fish and shellfish contain traces of mercury. Mercury occurs naturally in the environment, but can also be released into the air through industrial pollution that may accumulate in oceans, thus exposing fish to this contaminant.[121] Microorganisms convert mercury into methylmercury, which the fish absorb as they feed in contaminated waters. Larger fish consuming smaller fish may contain additional methylmercury, although the contamination from methylmercury varies with fish age, size, diet, species, and water location.[122,123] Mercury contained in seafood products readily crosses the placental barrier and has the potential to damage the developing fetal nervous system.[121,122] To educate the public about the hazards of methylmercury, the FDA and the Environmental Protection Agency (EPA) issued a joint consumer advisory regarding mercury in fish and shellfish and recommended that pregnant women, women of childbearing age, and young children avoid eating shark, swordfish, mackerel, and tilefish.[124] The recommendation is to consume up to 12 ounces (two average meals) a week of a variety of fish and shellfish that are lower in mercury. Five of the most commonly eaten fish that are low in mercury are shrimp, canned light tuna, salmon, pollock, and catfish. Another recommendation is to check local advisories concerning the safety of fish caught by family and friends in local lakes, rivers, and coastal areas.

Listeriosis

Listeriosis is a serious infection caused by consuming food contaminated with the pathogen *Listeria monocytogenes*, a gram-positive anaerobe that grows at temperatures as low as 3°C (37°F) and can multiply in refrigerated foods.[125] Pregnant women, the elderly, and adults with weakened immune systems are susceptible to listeriosis.[126] Symptoms of listeriosis include influenza-like symptoms, persistent fever, and gastrointestinal symptoms such as nausea, vomiting, and diarrhea. The onset time to gastrointestinal symptoms is unknown but is probably greater than 12 hours; the onset time to the serious forms of listeriosis is unknown but may range from a few days to 3 weeks.

The manifestations of listeriosis include septicemia, meningitis (or meningoencephalitis), encephalitis, and intrauterine or cervical infections in pregnant women, which may result in spontaneous abortion or stillbirth.[127] Listeriosis is diagnosed by culturing the organism from blood, cerebrospinal fluid, or stool. The FDA recommends that all pregnant women avoid the following foods to prevent listeriosis:[125]

- Hot dogs or luncheon meats (including deli meats such as ham, turkey, salami, or bologna) unless reheated until steaming hot.
- Soft cheeses, such as feta, brie, Camembert, Roquefort, blue-veined, queso blanco, queso fresco, or Panela, unless the label clearly states the cheese is made with pasteurized milk. Hard cheeses, processed cheeses, cream cheese, and cottage cheese are safe.
- Refrigerated pâtés or meat spreads. Canned and shelf-stable versions are safe.
- Refrigerated smoked seafood unless cooked (as in a casserole). Canned and shelf-stable versions can be eaten safely.
- Unpasteurized milk, eggs, or juice, or foods made from these foods.

Post-Delivery Issues

Proper nutrition plays an important role not only before and during pregnancy but also after delivery. Obtaining the recommended types and amounts of nutrients after delivery can help women alleviate symptoms associated with postpartum depression.

Depression

Perinatal depression refers to major and minor episodes during pregnancy (antenatal) or within the first 12 months after delivery (postpartum or postnatal). The term *maternal depression* has been used interchangeably with perinatal depression. Signs and symptoms for perinatal depression are similar to those for the disease in the general population: depressed mood, loss of interest or pleasure, feelings of guilt or low self-worth, disturbed sleep or appetite, low energy, and poor concentration. Many factors have been associated with depression, including genetic predisposition and environmental factors, as well as a number of social, psychological, and biological factors. One biological factor given increasing consideration is inadequate nutrition. Women are particularly vulnerable to the adverse effects of poor nutrition on mood because pregnancy and lactation increase nutrient requirements. It has been suggested that depletion of nutrient reserves throughout pregnancy and a lack of recovery postpartum may increase a woman's risk for maternal depression.[128] Several studies have reported association between deficiency of some micronutrients such as folate, vitamin B_6, vitamin B_{12}, vitamin D, calcium, iron, zinc, and omega-3 fatty acids and postpartum depression.[128,129] Previous studies have shown that zinc levels are lower among patients with depression, and one study found

that 25 mg zinc supplementation may improve depressive symptoms.[130]

Breastfeeding

The DRIs for lactation are similar to the dietary recommendations for pregnancy for macronutrients and most micronutrients. Nutrients required in greater amounts during lactation in women ages 19–50 years compared to pregnant women are: vitamin A (1300 μg/day), vitamin C (120 mg/day), riboflavin (1.6 mg/day), vitamin B_6 (2.0 mg/day), vitamin B_{12} (2.6 μg/day), choline (550 mg/day), copper (1300 mg/day), iodine (290 μg/day), selenium (70 μg/day), zinc (12 mg/day), and potassium (5100 mg/day).

The position of the American Dietetic Association on promoting and supporting breastfeeding states, "exclusive breastfeeding provides optimal nutrition and health protection for the first 6 months of life and breastfeeding with complementary foods from 6 months until at least 12 months of age is the ideal feeding pattern for infants. Breastfeeding is an important public health strategy for improving infant and child morbidity and mortality, and improving maternal morbidity and helping to control health care costs."[131] Breastfeeding provides multiple benefits to the infant and mother. Benefits for the infant include optimal nutrition, enhanced immune system, protection against allergies and intolerances, promotion of correct development of the jaw and teeth, and reduced risk for chronic disease. Advantages of breastfeeding for the mother include increased energy expenditure, which may lead to faster return to prepregnancy weight, and decreased risk for chronic diseases such as type 2 diabetes, breast and ovarian cancers, and postpartum depression.[131] Additional benefits of breastfeeding were reported from a 20-year prospective study that found the longer the duration of lactation, the lower the incidence of the metabolic syndrome among women with and without histories of GDM. Lactation may have persistent favorable effects on women's cardiometabolic health as well.[132] Currently there is no available evidence that any dietary factors significantly enhance breast milk production in healthy adult lactating women.[133] (See also Chapter 5, "Normal Nutrition During Infancy.")

Lifestyle Interventions

Lifestyle interventions aimed at the prevention of overweight and chronic disease in the perinatal and postpartum periods are important to prolong a state of optimal health. Nutrition education plays an important role in the modification of eating habits. A study of obese pregnant women evaluated two different nutrition education approaches. One group of women received nutritional advice from a brochure (passive group), the second group received the brochure and lifestyle education by a registered dietitian, and the third was a control group. Results indicated that energy intake did not change during pregnancy and was comparable in all groups. Fat intake, specifically saturated fat intake, decreased and protein intake increased from the first to the third trimester in the passive and active groups, as compared to an opposite change in the control group. Calcium intake and vegetable consumption increased during pregnancy in all groups. Physical activity decreased in all groups, especially in the third trimester. It was concluded that both lifestyle interventions improved the nutritional habits of obese women during pregnancy, although physical activity was not affected.[134] For women with GDM, dietary modifications including lowering fat and carbohydrate intake in combination with physical activity can reduce the risk of developing GDM in subsequent pregnancies.[135] In another study, a diagnosis of diabetes was prevented when diet and intense exercise were implemented for a 2-month period. This intervention was sufficient to reduce fasting glucose, normalize blood lipid profile, and achieve weight loss.[136] In addition to the implementation of dietary modifications and increased physical activity, the use of oral hypoglycemic agents was demonstrated to prevent or delay a diagnosis of type 2 diabetes.[137]

Case Study

Nutrition Assessment

Patient history: A 17-year-old female with history of irregular periods who has gained 20 pounds in the last 6 months. She also has noticed having heavy acne, and sprouting hair on her chest and face. She reports fatigue, depression, and alopecia. The pediatrician has diagnosed her as having PCOS. She is a senior in high school, and does not participate in gym classes. She usually does homework after school or is on the Internet or watches TV during the evening.

Family history: Mother has type 2 diabetes.

Food/nutrition-related history: Skips breakfast and occasionally eats lunch at the school cafeteria, but mostly eats a hamburger, French fries, and a soda at the fast food restaurant located two blocks from the school. Dinner is usually a large meal consisting of a meat, starch, and salad. Her average fiber intake is 16 g/day and sodium intake is 4000 mg/day.

Anthropometric Measurements

Weight: 190 pounds (86.2 kg)

Height: 64 in (1.63 m)

BMI: 32.5 kg/m^2

Estimated energy needs: Mifflin-St. Jeor's method BMR = 10 x weight (kg) + 6.25 x height (cm) – 5 x age (years) – 161

Estimated protein needs: 15–30% of total calories

Laboratory data: (normal values in parentheses)

Fasting insulin: 29 mIU/mL (1.8–24.6 mU/L)
Total testosterone: 58 ng/dL (20 ng/dL)
Luteinizing hormone (LH)/follicle stimulating hormone (FSH) ratio: 3.5:1 ↑ (1:1)
Prolactin, thyroid stimulating hormone (TSH), and liver function test: normal
Total cholesterol: 230 mg/dL (< 170 mg/dL)
LDL cholesterol: 150 mg/dL (< 110 mg/dL)
HDL cholesterol: 33 mg/dL (≥ 35 mg/dL)
Fasting glucose: 120 mg/dL (59–96 mg/dL)

Nutrition Diagnoses

1. Inappropriate eating choices related to (RT) lack of variety of foods and consumption of large meals
2. Excessive caloric intake from fat RT frequent consumption of high fat foods
3. Excessive caloric intake from high glycemic index carbohydrates RT frequent consumption of carbonated and sweetened beverages
4. Consumption of lower fiber and high sodium intake as evidenced by consumption of lower than recommended fiber intake and consumption of higher than recommended sodium intake
5. Inadequate meal pattern RT skipping breakfast
6. Continuous risk of weight gain RT lack of physical activity

Nutrition Interventions

Planning

1. Teach the basis of healthy eating including the following topics: importance of eating a variety of foods, meal planning, portion size, low-fat cooking methods, and food record keeping.
2. Plan consumption of three meals and three snacks a day to reduce body weight and improve hormone, lipid, and glucose profile.
3. Plan the following daily macronutrient distribution:
   - *Protein:* 15–30% of total calories (e.g., lean meats, egg substitute, low-fat dairy products, legumes, nuts, and soy products such as tofu, soymilk, and soynuts).
   - *Carbohydrates:* 35–40% calories from low GI carbohydrates (e.g., whole grains cereals, legumes).
   - *Fat:* 35–45% of total daily calories. Include sources of:

     Polyunsaturated fats (PUFAs): Corn, soybean, safflower, and cottonseed oils

     Monounsaturated fats (MUFAs): Olive oil, canola oil, peanuts, avocados, and olives

     Omega-3 fatty acids: Fatty types of fish, flaxseed, canola and olive oils, nuts

     Saturated fat: No more than 5% total calories from saturated fat

     Trans fats: Avoid consumption (fast foods, partially hydrogenated vegetable oil, commercial baked goods, chips, crackers, vegetable shortening)
   - *Fiber:* 25 g of insoluble fiber (wheat bran, whole grains, cabbage, carrots) and soluble fiber (oat bran, oatmeal, beans, peas, citrus fruits, vegetables). Increase fiber intake gradually and add 8 cups of water per day.
4. Plan to address the following micronutrients:
   - *Sodium:* Reduce sodium intake to 2300 mg/day (avoid canned soups, baked goods, soy sauce, seasoned salts, processed foods, and monosodium glutamate [MSG]).
   - *Magnesium:* Include dietary sources of magnesium (whole grains, legumes, vegetables, seeds and nuts, dairy products, and meats).
   - *Vitamin D:* Include dietary sources of vitamin D (salmon, tuna fish, orange juice, and dairy products fortified with vitamin D).
5. Recommend moderate to vigorous physical activity for 60–90 minutes daily. Initiate with 10 minutes, adding gradual increments of 5–10 minutes per day.

Implementation

1. Comprehensive nutrition education:
   - Instruct on healthy eating practices including variety and low-fat cooking methods.
   - Review cooking methods conducive to healthy meals.
   - Review portion size.
   - Review how to read food labels.
   - Instruct on meal planning to include three meals and three snacks, emphasizing the importance of eating breakfast.
   - Include low glycemic and high calcium foods.
   - Instruct on avoidance of high GI carbohydrates, sweetened beverages, unhealthy fats, and salty products.
   - Instruct on reducing fat, salt, and sodium when eating out.
   - Provide patient education related to lifestyle modification.
   - Provide patient education related to diabetes prevention.
2. Nutritional supplements:
   - Offer a chromium picolinate and biotin supplement as adjunctive therapy to improve glucose control and lipid profile.

Monitoring and Evaluation

- Evaluate meal patterns of three meals and three snacks a day and its effect on weight loss goals (nutrition-related behavioral and environmental outcomes and nutrition-related patient/client-centered outcome).

- Assess intake of low GI carbohydrates, fiber, protein, fat, sodium, and magnesium at follow-up clinic visits (food and nutrient intake outcomes).

Questions for the Reader

1. What is the patient's estimated energy needs based on her initial assessment?
2. What is the patient's estimated carbohydrate intake based on her initial assessment?
3. What is the purpose of including low glycemic index carbohydrates?
4. Why is it important to distribute total calories in three meals and three snacks throughout the day?
5. Write three possible Problem, Etiology, Signs/Symptoms (PES) statements.
6. What will you do during the follow-up visit 2 months later?
   a. If the patient has not lost any weight?
   b. If the patient has not changed her eating habits?
   c. If the patient has not engaged in physical activity?
   d. If the fasting glucose level continues to be elevated?
   e. If the total-cholesterol and LDL-cholesterol levels continue to be elevated?

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Resources for Preconception and Prenatal Nutrition

Nutrition During Pregnancy Resource List, July 2008
http://www.nal.usda.gov/fnic/pubs/bibs/topics/pregnancy/pregcon.pdf

This publication is a collection of resources on the topic of nutrition during pregnancy. Resources include books, pamphlets, and audiovisuals, and are limited to those published in 2004 or later. Many of the pamphlets are available in single copies and some may also be purchased in bulk from the organization listed. (Web addresses are provided for materials available online.)

USDA. Lifecycle Nutrition: Pregnancy
http://fnic.nal.usda.gov/nal_display/index.php?info_center=4&tax_level=2&tax_subject=257&topic_id=1356

This site provides information on maintaining a healthy pregnancy, the nutritional needs of pregnancy, and breastfeeding. It also provides link to government agencies such as the National Center for Education in Maternal and Child Health and WIC, the Special Supplemental Program for Women, Infants, and Children. This site also provides a link to folic acid information and resources.

Interactive DRIs for Health Professionals
http://fnic.nal.usda.gov/interactiveDRI

Use this tool to calculate daily nutrient recommendations for dietary planning based on the dietary reference intakes (DRIs). Developed by the National Academy of Science's Institute of Medicine, these represent the most current scientific knowledge on nutrient needs. Individual requirements may be higher or lower than the DRIs.

USDA. MyPyramid for Mom
http://www.mypyramid.gov/mypyramidmoms/index.html

The MyPyramid Website is designed specifically for pregnant and breastfeeding mothers to provide interactive guidance. The site provides advice on healthy eating and on the importance of meeting nutrient recommendations. The site includes an interactive menu planner.

Dietary Supplement Fact Sheet: Folate
http://dietary-supplements.info.nih.gov/factsheets/folate.asp

A fact sheet of the Office of Dietary Supplements of the National Institutes of Health.

EPA. Fish Advisories. What You Need to Know about Mercury in Fish and Shellfish
http://www.epa.gov/fishadvisories/advice/

FDA toll-free food hotline: 1.800.SAFEFOOD

A fact sheet from the Environmental Protection Agency providing three essential recommendations for selecting and eating fish or shellfish to reduce exposure to the harmful effects of mercury.

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