Nutrition recommendations for a healthy pregnancy and lactation in women with overweight and obesity – strategies for weight loss before and after pregnancy

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A healthy eating pattern is recommended for all life stages and is central to achieving optimal pregnancy outcomes and successful lactation. The preconception period is a critical window of time during which good nutritional status benefits both the mother and the offspring. The ongoing overweight and obesity epidemic, especially in conjunction with poor nutritional status, presents maternal and infant health risks. Preconception and postpartum weight loss are routinely recommended in clinical practice. In this review, we discuss the nutritional recommendations for healthy weight loss during these periods. Unhealthy weight loss during preconception and for lactating women, can cause adverse maternal consequences that can impact the offspring. (Fertil Steril® 2022;118:434–46. ©2022 by American Society for Reproductive Medicine.)

Key Words: Healthy diet, pre and postpartum weight loss, overweight and obesity

The *2020–2025 Dietary Guidelines for Americans* recommend a healthy dietary pattern at every life stage (1). The guidance is particularly important for women before conception to prepare for the increased nutritional demands in early pregnancy; during pregnancy to achieve recommended nutrient and weight gain goals; and after delivery for successful lactation and return to prepregnancy weight (2). A healthy dietary pattern comprises nutrient-dense foods and beverages across all food groups in recommended amounts and within calorie limits. Healthy dietary patterns are high in vegetables, fruits, legumes, whole grains, low or nonfat dairy, lean meats, poultry, seafood, nuts, and liquid oils and is low in sodium, saturated fat, and added sugars (1). In Table 1 examples of recommended healthy dietary patterns are shown (1, 3–5).

Approximately one-half of women in the childbearing age group have a BMI classified as overweight or obese; in lower income groups the prevalence is significantly higher (1, 7). Prepregnancy obesity in the United States increased from 26.1% in 2016 to 29.0% in 2019 in all racial/ethnic groups (non-Hispanic white, non-Hispanic black, and Hispanic women). The prevalence of obesity in 2019 was much higher in non-Hispanic black women than the non-Hispanic white women (39.1% vs. 26.6%, respectively) (6) (Fig. 1). The prevalence of severe obesity (BMI $\geq$40 kg/m^2) in the United States among women between the ages of 20 and 39 years (2017–March 2020) was 12.4% (7). The *2020–2025 Dietary Guidelines for Americans* recommend that women should be encouraged to achieve and maintain a healthy weight before becoming pregnant (1). This recommendation aligns with one of the *Healthy People 2030 goals* for pregnancy and childbirth objectives, which is to increase the proportion of women who have a healthy weight before pregnancy. The most recent data (2020) indicate that only 40% of women are at a healthy weight (8).

Overweight and obesity during all stages of pregnancy and lactation are associated with adverse outcomes for both the mother and offspring. Thus, the objective of this review is to discuss

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healthy weight loss diets before conception and after pregnancy (1). During all stages of pregnancy and lactation, a nutritionally inadequate diet has health consequences for the developing placenta, fetus, infant, and mother. Although correcting some nutrient deficiencies later in pregnancy can mitigate negative outcomes for the offspring, there are adverse effects of inadequacy of some key nutrients in early gestation that cannot be reversed (2, 9). Consequently, good nutritional status 2–3 months before conception is critical for optimizing gamete function and early placental development (10).

Many individuals want to lose weight and frequently follow a nutritionally inadequate weight loss diet. Consequently, there is a need for guidance for healthy weight loss, especially for women planning to become pregnant and after pregnancy, because of the adverse consequences of nutritionally inadequate diets. Herein, we discuss the clinical management of healthy weight loss before and after pregnancy for women with overweight and obesity. Because of the ongoing obesity epidemic and the associated increased health risks for mothers-to-be and mothers as well as their offspring, it is imperative that clinicians be prepared to provide healthy weight loss guidance in practice. We will also discuss key nutrient recommendations that are relevant for a healthy pregnancy, especially as they relate to weight loss during preconception and lactation.

RECOMMENDATIONS FOR THE MANAGEMENT OF OVERWEIGHT AND OBESITY

The *2013 American Heart Association, American College of Cardiology, and Task Force on Practice Guidelines: Guideline for the Management of Overweight and Obesity in Adults* recommends prescribing a weight loss diet of 1,200 to 1,500 kcal/day for women (11). At these calorie levels it is possible to achieve nutrient adequacy. A 500 kcal/day or 750 kcal/day energy deficit is recommended to achieve a 0.5–1 kg loss per/week, respectively. The guideline notes that there are many dietary approaches that can produce weight loss in adults with overweight and obesity (11). A common feature of some is the restriction of certain food types (such as high-carbohydrate foods, low-fiber foods, or high-fat foods). However, significant food and food group restrictions may present challenges in meeting nutritional requirements.

The Academy of Nutrition and Dietetics (AND) has made similar weight loss recommendations for decreasing energy and underscores the importance of achieving nutrient adequacy during weight loss. Based on an evidence analysis review, several studies have reported reduced nutrient adequacy with caloric restriction. In fact, with an energy restriction of at least 500 calories/day or daily consumption below 1200 calories/day, nutrient adequacy can decrease (12). Consequently, achieving a healthy reduced-calorie diet for weight loss requires attention to meeting all nutrient recommendations.

In 2020, the *International Federation of Gynecology and Obstetrics* (FIGO) and *Non - Communicable Diseases Committee* issued a guideline on the management of prepregnancy, pregnancy, and postpartum obesity (13). Weight loss before pregnancy is recommended and encouraged for women with obesity by both FIGO and the *American College of Obstetricians and Gynecologists* for improved pregnancy outcomes and better maternal metabolic health (13, 14). Weight loss is often required for women with obesity before in vitro fertilization treatments or by insurance guidelines to decrease the risk of gestational diabetes, gestational hypertension, and preeclampsia (13, 15). The FIGO guidelines provide no caloric recommendations but encourage reaching a BMI of <30 kg/m^2 (ideally 18.5–24.9 kg/m^2) before pregnancy through diet and healthy lifestyle modifications (e.g., moderate physical activity) (13). Although achieving a healthy weight is considered ideal, weight loss of 5%–10% of the body weight over approximately 6 months has been shown to be a realistic target and metabolically beneficial in individuals with obesity (13, 16). Weight loss also is recommended for women during the postpartum period, when indicated, to minimize cumulative weight gain and prevent pregnancy-related complications in subsequent pregnancies (17).

CALCULATING ENERGY NEEDS BEFORE, DURING, AND AFTER PREGNANCY

The Calculator for Healthcare Professionals (nal.usda.gov/fnic/dri-calculator) can be used to estimate calorie needs of women based on age, sex, height, weight, activity level, and pregnancy or lactation status. On the basis of calculated estimated energy requirements, a calorie prescription can be made for weight loss (that typically is 500 to 750 calories less per day) in the periods before or after pregnancy. Although weight loss during pregnancy typically is not recommended because of the increased calorie and nutrient needs to accommodate both maternal and fetal metabolism as well as fetal and placental growth, it is important to know the energy requirements to make energy-appropriate diet prescriptions. Nutritionally adequate, food-based dietary patterns at different calorie levels (from 1000 to 3200 calories) are available for healthy, calorie-controlled eating plans to accommodate weight gain during pregnancy, and also weight loss before and after pregnancy, the latter for both lactating and nonlactating women (Supplemental Table 1, available online) (1).

Lactation (because of increased energy needs) is an ideal time for weight loss, conditional on the mother avoiding energy and nutrient deficiencies, which could impact the quality and quantity of breast milk and compromise infant growth (18). A daily 500-calorie deficit for 6 weeks postpartum, approximately the calories expended from breast feeding (19), did not influence the growth of infants in mothers with overweight who were exclusively breastfeeding (20). During lactation, AND recommends approximately 0.5 kg of weight loss per week for 4 months and consumption of ≥ 1800 calories/day to return to prepregnancy weight.

TABLE 1

Healthy dietary patterns to meet nutrient recommendations.

	Daily amount of food from each group (2,000 kcal)				
	Healthy US style dietary pattern (1)	Healthy Mediterranean style dietary pattern (1)	Healthy vegetarian dietary pattern (1)	AHA eating pattern based on the healthy US style eating pattern (3)	Dietary approaches to stop hypertension dietary pattern (4, 5)
Vegetables (cup eq/d)	2 ½	2 ½	2 ½	2 ½	2–2 ½
Dark green vegetables (cup eq/wk)	1 ½	1 ½	1 ½	1 ½	—
Red and orange vegetables (cup eq/wk)	5 ½	5 ½	5 ½	5 ½	—
Beans, peas, lentils (cup eq/wk)	1 ½	1 ½	1 ½	1 ½	—
Starchy vegetables (cup eq/wk)	5	5	5	5	—
Other vegetables (cup eq/wk)	4	4	4	5	—
Fruit (cup eq/d)	2	2 ½	2	2	2–2 ½
Grains (oz. eq/d)	6	6	6 ½	6	6–8
Whole grains (oz. eq/d)	≥ 3	3	3 ½	3	—
Refined grains (oz. eq/d)	< 3	3	3	3	—
Dairy (cup eq/d)	3	2	3	3	2–3
Protein foods (oz. eq/d)	5 ½	6 ½	3 ½	5 ½	≤6
Meats, poultry, eggs (oz. eq/wk)	26	26	3 (eggs)	26	—
Seafood (oz. eq/wk)	8	15	6	8 (preferably oily)	—
Nuts, seeds, soy products (oz. eq/wk)	5	5	8 Soy products 7 Nuts and seeds	5	4–5
Beans, peas, lentils (cup eq/wk)	—	—	6	—	4–5
Oils (g/d)	27	27	27	45	27–41
Limit on calories for other uses (kcal/d)	240	240	250	—	—
Limit on calories for other uses (% kcal/d)	12	12	13	—	—
Saturated fat (% kcal/d)		<10		6 (solid fats)	6%
Added sugars (% kcal/d)		<10		5	—
Sodium (mg/d)		<2,300		1,787	—
Dietary cholesterol (mg/d)		No recommendation (diets have <300 mg/d)		—	150
Fiber (g/d)		28		31	30

Note: cup eq/d = cup equivalents per day; cup eq/wk = cup equivalents per week; oz eq/wk = ounce equivalents per week; kcal/d = kilocalories per day; g/d = grams per day; mg/d = milligrams per day.

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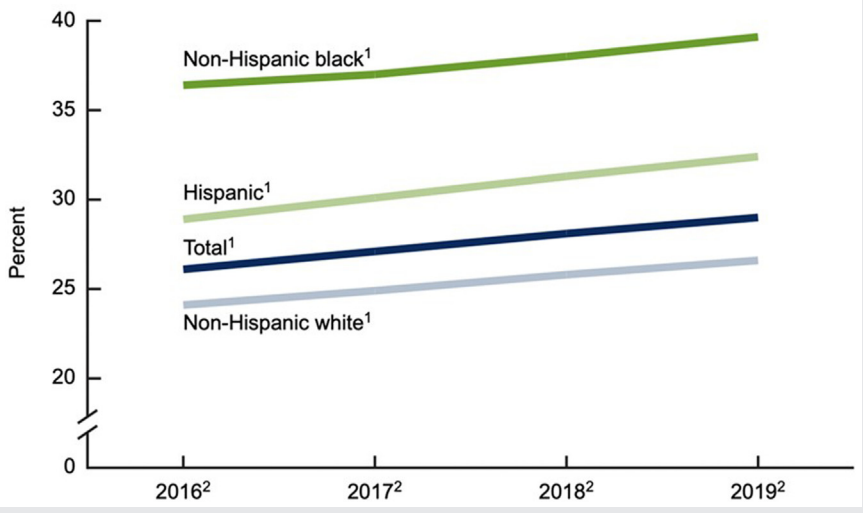
FIGURE 1



Prepregnancy obesity, by maternal race and Hispanic origin: United States, 2016–2019

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TABLE 2

Recommendations for key nutrients during preconception, pregnancy, and lactation.

Nutrient		Preconception	Pregnancy	Lactation	Sources
Folate RDA (μg/d) 14–18 y ≥19 y		400–800 (37) 400 (27)	600 600 (27)	500 500 (27)	Fortified grains (26), spinach, liver, asparagus, Brussels sprouts (27), supplements (2)
Iron RDA (mg/d) 14-18 y 19-50 y		15;30 mg supplement 18;30 mg supplement (28)	27 27 (28)	10 9 (28)	Fortified grains, lean meat and seafood, nuts, beans, vegetables, supplements (38)
Iodine RDA (μg/d) 14-18 y ≥19 y		150 150 (28)	220 220 (28)	290 290 (28)	Seaweed, seafood, dairy, iodized salt (40)
Choline AI (mg/d) 14–18 y ≥19 y		400 425 (41)	450 450 (41)	550 550 (41)	Meat, poultry, fish, dairy products, eggs, cruciferous vegetables and certain beans, nuts, seeds, whole grains (41)
Seafood Long-chain omega-3 fatty acids	Seafood (ounce equivalents/wk)	8-ounce equivalents/wk (1)	At least 8-ounces and up to 12-ounces of a variety of seafood low in mercury per wk (1)	At least 8-ounces and up to 12-ounces of a variety of seafood low in mercury per wk (1)	Consume salmon, trout, herring, sardines (29) AVOID high mercury fish (i.e., king mackerel, shark, swordfish, tilefish, bigeye tuna, marlin, orange roughy) (26, 30, 31)
	EPA and DHA (mg/d)	250 (89)	250 (89)	250 (89)	Fish, seafood, algae, fortified foods and supplements (29, 31)
Vitamin B6 RDA (mg/d) 14–18 y 19–50 y		1.2 1.3 (32)	1.9 1.9 (32)	2.0 2.0 (32)	Fish, beef liver other organ meats, potatoes and other starchy vegetables, as well as non-citrus fruit, fortified cereals, supplements (32)
Zinc RDA (mg/d) 14–18 y ≥19 y		9 8 (33)	12 11 (33)	13 12 (33)	Oysters, red meat, poultry, beans, nuts, certain types of seafood (e.g., crab and lobster), whole grains, fortified breakfast cereals, dairy products, supplements (33)

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DIET QUALITY

Diet quality, a measure of how well the dietary pattern consumed aligns with current dietary guidelines, is assessed using methods such as the Healthy Eating Index (HEI). A perfect score for the HEI is 100; however, the average HEI score for all population groups is 58. Interestingly, pregnant women have a slightly higher HEI than nonpregnant women (HEI = 62 vs. 54). Pregnant women fall short of meeting recommendations for vegetables, fruits, whole grains, dairy products, and seafood whereas they overconsume sodium, saturated fat, and added sugars (1). Saturated fat and added sugars are

TABLE 3

Potential nutritional concerns associated with following popular diets before pregnancy and during lactation.

Diet category	Diet subcategory	Common or popular diet names	Defining diet features	Potential nutritional concerns		Considerations for prepregnancy[a] and lactation
				Prepregnancy[a]	Lactation	
Carbohydrate restriction	Very low carbohydrate	Ketogenic; Keto; Atkins;	*CHO*: < 10% kcal *Fat*: >70% kcal (79)	*Insufficiency or deficiency:* folate, B vitamins (thiamine, riboflavin, niacin, vitamin B6, pantothenate, biotin) *Exceeds recommendations:* SFA	Insufficiency or deficiency: folate	Should be avoided (2)
	Low carbohydrate	South Beach	*CHO:* 10%–25% kcal *Fat:* 25%–45% kcal (79)	*Insufficiency or deficiency:* folate *Exceeds recommendations:* SFA	Insufficiency or deficiency: folate	Should be avoided (2)
	Paleolithic	Paleo	*Excludes:* grains, dairy, salt, refined fats, and sugar *Includes:* lean meat, fish or seafood, vegetables, eggs, nuts, and berries (80)	*Insufficiency or deficiency:* folate; calcium *Exceeds recommendations:* SFA	Insufficiency or deficiency: folate	Should be avoided (2)
Fat restriction	Very low fat	Ornish; Engine 2; Pritikin	*CHO:* 70%–77% kcal (30–60 g/d fiber) *Fat:* 10% kcal *PRO:* 13%–20% *Includes:* fiber-rich vegetables, beans, fruits, whole intact grains, nonfat dairy, fish, and egg whites (80)	*Insufficiency or deficiency:* essential fatty acids, vitamin B12, iron, choline	Insufficiency or deficiency: essential fatty acids, vitamin B12, choline	Should be avoided: severe fat restriction and lack of evidence (2)

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TABLE 3

Continued.

Diet category	Diet subcategory	Common or popular diet names	Defining diet features	Potential nutritional concerns: Prepregnancy[a]	Potential nutritional concerns: Lactation	Considerations for prepregnancy[a] and lactation
Vegetarian	Vegan	Whole food plant-based; plant-based	*Excludes:* all animal products *Includes:* plant foods (69)	*Insufficiency or deficiency:* Vitamin B12, choline, iron, calcium, iodine, EPA/DHA	Insufficiency or deficiency: vitamin B12, preformed vitamin A, zinc, iodine, choline, EPA/DHA	Intake of all micronutrients should be assessed, particularly folate, vitamin B12, iron, and zinc. Intake of EPA/DHA should be assessed (81).
	Lacto-ovo-vegetarian	Vegetarian; whole food plant-based; plant-based	*Excludes:* animal flesh foods *Includes:* plant foods + eggs + dairy (69)	*Insufficiency or deficiency:* iron, EPA/DHA	Insufficiency or deficiency: EPA/DHA	
	Lacto-vegetarian		*Excludes:* animal flesh foods + eggs *Includes:* plant foods + dairy (84)	*Insufficiency or deficiency:* choline, iron, EPA/DHA	Insufficiency or deficiency: choline, EPA/DHA	
	Ovo-vegetarian		*Excludes:* animal flesh foods + dairy *Includes:* plant foods + eggs (84)	*Insufficiency or deficiency:* iron, calcium, EPA/DHA	Insufficiency or deficiency: EPA/DHA	
	Pesco-vegetarian	Pescetarians	*Excludes:* meat + poultry *Includes:* plant foods + fish/seafood + eggs + dairy (82)	*Insufficiency or deficiency:* iron	-	Intake of all micronutrients should be assessed, particularly folate, vitamin B-12, iron, and zinc (87). Seafood (up to 12 oz/wk.) lower in methylmercury should be selected (1)
Short-term	-	Whole 30; Cleanses; Detox	Short-term diets (typically <2 months) with severe restriction or exclusion of ≥ 1 food group(s) with or without supplements or proprietary formulations	Depends on the nature of diet		Should be avoided: high likelihood of nutritional inadequacy; lack of evidence
Fasting	Intermittent fasting	5:2; Alternate day fasting	Periods of fasting where intake is limited (0–500 kcal/d) alternating with days of ad libitum intake (87)	Depends on food choices made during ad libitum intake periods		Should be avoided: Lack of evidence (87)
	Time-restricted eating	16/8	Intake only during a specific time-window each day (87)			

Note: SFA = saturated fat; CHO = carbohydrate; PRO = protein; EPA = eicosapentaenoic acid; DHA = docosahexaenoic acid.
[a] Prepregnancy is often defined as 2 to 3 months prior to conception (2).

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sources of "empty" (nutrient poor) calories and limiting or reducing them is a strategy to decrease calorie intake for weight loss and improve diet quality.

A systematic review of 34 studies reported inverse relationships of varying strengths between healthy diets and obesity in most studies (21). For instance, a 1-point increase in the HEI was associated with a decrease of 0.8% for the risk for abdominal obesity in a cross-sectional study of 8,188 nonpregnant women (21, 22). Of 1,255 women over 8 years, women with the highest score on a 5-point scale based on alignment with the key US dietary recommendations (5 of 5) gained an average of 1.5 kg whereas those with the lowest (1 of 5) gained an average of 3.2 kg (21, 23). Furthermore, preconception obesity was associated with a 76% increased likelihood of being in the lowest tertile (i.e., 42 ± SD [7.2]) of diet quality measured with the Diet Quality Index (DQI) for pregnancy with a perfect score of 100 vs. an average of 56 ± SD (3.0) for the middle, and 68 ± SD (4.2) at the highest DQI in a study of 2,394 women with varying weight status (24). An additional concern beyond lower diet quality and preconception obesity, is that many people report following a variety of weight loss diets, some of which could further compromise nutritional status (25). Consequently, interventions are needed to improve diet quality during the prepregnancy period, especially in women with obesity who typically have a low diet quality. Achieving a high diet quality will assure that all nutritional demands are met.

KEY NUTRIENTS OF IMPORTANCE BEFORE, DURING, AND AFTER PREGNANCY

For all life stages, nutrients of public health concern because of low intakes include calcium, vitamin D, potassium, and dietary fiber. Moreover for women who are pregnant, iron is also a nutrient that falls short of meeting intake recommendations. For preconception through lactation, there are special nutrient and dietary considerations for folate, iodine, choline, and seafood (specifically, long-chain omega-3 fatty acids) that are described in Table 2 (26–33).

Nutrients that have a time period of sensitivity for normal neurodevelopment processes include protein, long-chain polyunsaturated fatty acids, zinc, copper, iodine, iron, folate, and choline. Growth and development that occur during the first 1,000 days (starting with conception) require these essential nutrients (34, 35). In addition, there is evidence of health benefits of optimizing nutritional status before conception (2).

Folate

Adequate folate is needed for normal neural tube formation and closure in early pregnancy (days 21–28 after conception). An inadequate maternal folate status is also associated with low birth weight, preterm delivery, and fetal growth retardation. Pregnant women are at risk of folate deficiency because of the expansion of the maternal blood supply, growth of fetal and maternal tissues, and inadequate intake (36). A folic acid supplement (400–800 mcg/day) is recommended for women who are planning to become pregnant or are pregnant. Approximately, 31% of pregnant women consume less than the *estimated average requirement* (37).

Iron

Iron needs increase during pregnancy because of the increase in plasma volume and red blood cell mass, which results in an increase in red blood cell production. Approximately 10% of pregnant women are iron deficient, which increases to approximately 25% in the last trimester. The consequences of iron deficiency during pregnancy are increased risk of maternal and infant mortality, premature birth, and low birth weight. An iron supplement (30 mg/d) is recommended for both women who are planning to become pregnant or who are pregnant (38). Common causes of iron deficiency anemia among women in the childbearing age group include: low iron intake including vegetarians (because of low intake of bioavailable iron) and women who have excessive blood loss. It frequently takes 3–6 months to restore iron levels after anemia (39).

Iodine

Adequate iodine intake during pregnancy is important for fetal neurocognitive development. Many women consume insufficient amounts of iodine (40). Those at greatest risk include women who do not consume dairy products and limit their sodium intake. Vegans as the result of limiting the best dietary sources of iodine (i.e., seafood, eggs, and dairy products) might not obtain sufficient amounts of iodine. As noted in the *2020–2025 Dietary Guidelines for Americans*, women who are pregnant or lactating should not be encouraged to use table salt; however, any table salt used in cooking or added to food at the table should be iodized (1). The *American Academy of Pediatrics* recommends that women who are pregnant, planning to become pregnant, or lactating take a daily supplement that provides at least 150 μg/day of iodine and also use iodized salt (40). Many prenatal supplements do not contain iodine. Breast milk is the source of iodine for exclusively breastfed infants; consequently, the mother's diet must be adequate to provide sufficient iodine for the infant (41).

Choline

Choline needs increase during pregnancy and lactation to replenish maternal stores and support normal brain and neuronal growth and development. As noted in the *2020–2025 Dietary Guidelines for Americans*, most women do not meet the recommended intakes of choline during pregnancy and lactation (1). In fact, 90%–95% of pregnant women consume less choline than is recommended. There is inconsistent evidence that inadequate choline intake during pregnancy is associated with an increased risk of neural tube defects (42).

Meeting choline requirements through foods and beverages is preferred. There is some concern about overconsumption of choline and exceeding the tolerable upper intake level, which can cause hypotension and liver toxicity (42). In addition, there is evidence that choline consumption increases

production of trimethylamine-N-oxide, a compound that has been linked to a higher risk of cardiovascular disease (42). Nonetheless, it is important that pregnant women meet dietary choline recommendations and not avoid it because of concerns about the link between high intakes, trimethylamine-N-oxide production, and risk of cardiovascular disease.

Seafood and Long-Chain Omega-3 Fatty Acids

Two systematic reviews of 44 publications on 106,237 mother-offspring pairs and 25,960 children concluded that there is moderate and consistent evidence that seafood vs. no seafood consumption during pregnancy was associated with improved neurocognitive development of offspring (as assessed by a wide spectrum of neurocognitive outcomes) (43). The investigators noted that neurocognitive development benefits began at the lowest amounts of seafood consumed (approximately 4 oz/wk) and continued through the highest amounts, >12 oz/wk. The *2020 Dietary Guidelines Advisory Committee report* also concluded that limited evidence suggests that seafood consumption during pregnancy may be associated favorably with language and communication development in children (37).

Based on a Cochrane Analysis (of 70 RCTs with 19,927 women), omega-3 fatty acid addition during pregnancy, long-chain omega-3 fatty acids from supplements or seafood compared with no omega-3 fatty acids decreased preterm birth <37 weeks (11.9% vs. 13.4%) and early preterm birth <34 weeks (2.7% vs. 4.6%). In addition, the investigators concluded that prolonged gestation >42 weeks increased from 1.6% to 2.6% in women who received omega-3 long-chain polyunsaturated fatty acids compared with no omega-3 fatty acids (44). Mean gestational length was greater among women who received long-chain omega-3 fatty acids (mean difference of 1.67 days) and preeclampsia may have been reduced, as well. There is emerging evidence that long-chain omega-3 fatty acid supplements increase fecundity in women with fertility problems. A secondary analysis of 900 women found that those taking a prenatal omega-3 supplement (dose not defined) had 1.51 (95% confidence interval [CI] [1.12, 2.04]) times the probability of conceiving compared with women not taking long-chain omega-3 fatty acids (45). Interestingly, the concentration of long-chain omega-3 fatty acids in red blood cells increases after supplementation and stabilizes in approximately 1 month (46).

Seafood consumption is important during lactation to provide the infant with long-chain omega-3 fatty acids and specifically docosahexaenoic acid (DHA). Early infant development, including specific cognition functions, visual acuity, and immune responses (47) may benefit from DHA intake, although the evidence is limited (48). The maternal diet affects the fatty acid composition of breast milk (49). A recent study has shown that a DHA supplement (200 mg/day) increased the percent DHA milk content from 0.19% to 0.34% after 10 weeks (50). To put this DHA dose in context, 3 oz of Atlantic salmon contains about 1.2 g DHA. Based on the *National Health and Nutrition Examination Survey* (NHANES) 2013–2016, only 18.3% of women among the age group of 20–39 years consumed seafood at least 2 times/week (51). Pregnant women consume even less fish (50.4 g/week) (52) and 10%–20% report no fish consumption (53).

Vitamin B6

During periconception, vitamin B6 plays a critical role in fetal nervous system development and functioning throughout pregnancy as well as alleviates nausea during early pregnancy (54–57). An estimated 12% of women fall short of meeting vitamin B6 requirements in the United States (58). Healthy women (n = 364), who had adequate vitamin B6 intake (determined by plasma levels) in the first trimester, had a higher adjusted hazard ratio for conception (adjusted hazard ratio = 1.4; 95% CI [1.1–1.9]) and lower adjusted odds of early pregnancy loss (adjusted odds ratio = 0.7; 95% CI [0.4–1.1]) than women with vitamin B6 deficiency (59). However, because of methodology shortfalls (inadequate follow up among other limitations), further research is needed to evaluate the clinical outcomes through pregnancy (e.g., preterm birth, preeclampsia, and adverse events) related to vitamin B6 status (54). Adequate B6 status is important throughout lactation to meet infant B6 requirements (56).

Zinc

Preconception, zinc status can influence fertilization, preimplantation, and fetal development; impaired zinc status can be restored within 1–2 weeks with a 20–40 mg/day supplementation (60, 61). An estimated 11% of pregnant women in the United States are deficient in zinc, but mild zinc deficiency may be more prevalent (58, 62). Importantly, zinc improves folate absorption and decreases the risk of folate deficiency (56).

PRECONCEPTION

A healthy lifestyle before pregnancy lowers the risk of birth defects, suboptimal fetal development, and chronic health problems in both the mother and child (63). A recent *expert review* on the importance of nutrition in pregnancy and lactation concluded that improvements in the nutritional as well as health status of women before conception contributes to beneficial placental, fetal, and obstetrical outcomes; improved perinatal survival; and better long-term health in both the mother and offspring (2). Cohort studies have demonstrated that higher diet quality before pregnancy decreases the risk of hypertension during pregnancy, gestational diabetes, and preterm birth (1, 10). Therefore, the diet consumed before pregnancy should be nutrient-dense to ensure nutritional adequacy at conception.

An analysis by the NHANES (2003–2012) of 795 pregnant women in the United States during prepregnancy reported a relationship between weight status and diet quality, including consumption of "empty" calories (64). During the prepregnant

period, women with obesity consumed approximately 10% more "empty" calories compared with normal weight women, which was reflected in lower diet quality scores. In another study, approximately 20% of women (aged 18–80 years) did not meet the *estimated average requirement* recommendation for iron, and approximately 7% were being treated for anemia (65). Moreover, based on the NHANES 2011–2016 analysis of girls and women (12–49 years), the prevalence of folate insufficiency (based on red blood cell folate levels) was 23.8%. This is of major concern to pregnant women who have overweight and obesity because they are at increased risk for delivering a child with neural tube defects and require high levels of folic acid preconception (approximately 800 μg/day vs. 400 μg/day) (66). Collectively, the evidence indicates that many women are nutritionally compromised before pregnancy.

Despite current recommendations for weight loss before pregnancy, concerns about preconception weight loss have been raised because of trends of higher rates of miscarriage in the first trimester after weight loss before conception (i.e., 33.3% with approximately 7% weight loss vs. 23.7% without weight loss) (15, 67). A systematic review and meta-analysis of 6 studies reported an increased rate of miscarriage in women after a weight loss lifestyle intervention before pregnancy (i.e., physical exercise and/or any low calorie diet) (Relative Risk: 1.50, CI: 95% 1.04 to 2.16; Percentage of Heterogeneity =0; $N = 543$) (68). Many of these studies did not assess nutritional adequacy, which is critical during this time and could have contributed to the loss of pregnancy. This is supported by a systematic review of 18 studies evaluating nutritional adequacy of diets during preconception and pregnancy that found women during preconception do not meet recommendations for vegetable, cereal grains, and folate intake (69). There are currently no recommendations on a waiting period between weight loss and pregnancy (with the exception of bariatric surgery) despite suggestive evidence that weight loss immediately followed by pregnancy may result in increased risk of miscarriage (70). Therefore, caution in pursuing fertility treatment immediately after preconception weight loss is advised (71). A dietitian should be consulted in this time period to maximize diet quality throughout the caloric restriction period (66).

EARLY CONCEPTION

A healthy diet and good nutritional status during early pregnancy (throughout the first trimester) is important for a normal pregnancy outcome (13). Weight loss is not advised during pregnancy and weight gain should be limited to 5–9 kg to avoid increased risk of preeclampsia, cesarean delivery, and respiratory distress in neonates (13). Similar to the prepregnancy period, diet quality in early conception in the US population is poor, especially in lower income groups, socially disadvantaged and less educated women (72). In an analysis of women ($n = 7,511$) in the *Nulliparous Pregnancy Outcomes Study: Monitoring Mothers-to-Be* cohort during the 3 months around conception, diet quality was lowest (about 25% lower) in women with a high school education or less compared with women with a graduate degree. Interestingly, the investigators estimated that approximately 39% of calories came from empty calorie foods (i.e., foods with added sugars, solid fats, and alcohol). More than half of the women reported consuming less that the recommended servings of fruits, vegetables, legumes, and protein foods. Only 10% of the participants reported meeting the recommendations for whole grains, healthy fats, sodium, and empty calories (72). As noted by Bodnar et al. (72), poor diet quality during the periconception period increases risk of preterm birth, fetal growth restriction, preeclampsia, maternal obesity, and postpartum weight retention. Clinicians can use the *FIGO's Pregnancy and Non - Communicable Diseases Committee's* short dietary assessment tool for pregnancy (i.e., the FIGO Nutrition Checklist) to evaluate nutritional adequacy in all pregnant women, including those with overweight or obesity (13), and recommend a healthy dietary pattern (Table 1).

POSTPARTUM

The 2020–2025 *Dietary Guidelines for Americans* (1) and the *American Academy of Pediatrics* (73) recommend exclusive breastfeeding for approximately 6 months, and then continuing breastfeeding while introducing complementary foods until the child is $\geq$12 months old. Therefore, the diet of lactating mothers must meet the nutrient and energy needs of the infant. An additional 330 calories/day is recommended during the first 6 months of lactation and an additional 400 calories is recommended for the next 6 months (1). As noted by Kominjarek and Rajan (18), it is not uncommon for lactating women to lose 0.5–1.0 kg per month after the first postpartum month.

Weight loss during lactation is generally safe, conditional on the mother avoiding nutrient deficiencies, which impacts the quality and quantity of breast milk (18). To ensure adequate nutrition and provide the necessary protein, vitamins, and minerals, keeping calories $\geq$1800 is recommended because going below this level can impact the quality and quantity of breast milk (74, 75). Because the calorie cost of lactation is approximately 500 calories per day, the recommendation for consuming an extra 330 calories per day during the first 6 months of breast feeding and 400 during the second 6 months will promote a gradual weight loss (1). With increased nutrient needs, restricting calories during lactation may result in nutrient inadequacies in the maternal diet for magnesium, vitamin B6, folate, calcium, and zinc, which in turn compromises the nutrient quality of the breast milk. Vitamins A, D, E, and K as well as C, B1, B6, and B12 in breast milk are determined by the maternal diet and can be inadequate for the infant if a healthy dietary pattern is not followed (18).

For women who still need to lose weight after lactation, or for those who have not breastfed and have overweight or obesity, the recommended caloric restriction for healthy weight loss is 500–750 calories per day (11). Baseline energy needs can be determined using the *Calculator for Healthcare Professionals* (nal.usda.gov/fnic/dri-calculator) followed by implementing a weight loss diet with a 500 to 750 calorie deficit. The food-based dietary recommendations for different calorie levels appear in Supplemental Table 1.

POPULAR DIETS AND POTENTIAL NUTRITIONAL CONCERNS

In 2022, over half of adults in the United States reported following a diet or eating pattern. Dieting was commonly reported in women (53%) and individuals aged 18-34 years (74%) and 35-49 years (62%). In those following a diet, a key motivation was weight loss (76). Although weight loss may improve fertility in individuals with overweight or obesity, severe dieting, often classified as extreme energy restriction (e.g. <800 kcal/d) (77) at or around conception (within approximately 3 months) is not recommended because of the potential for nutrient deficiencies associated with adverse pregnancy outcomes (78). In this section, potential nutritional concerns with following popular diets in the prepregnancy and postpartum period will be described.

Diets commonly followed by US adults for weight loss or other health-related reasons often diverge from recommended healthy dietary patterns increasing the risk of poor nutritional status, especially when followed by women during the prepregnancy, pregnancy, or postpartum period. A recent expert review concluded that diets that consistently and substantially restrict any macronutrient should be avoided during pregnancy. It was further noted that widely followed diets, promoted by the popular press, may be especially harmful during pregnancy because of resulting micronutrient deficiencies or ketosis (2). In Table 3, diets that the US adults commonly report following are summarized with specific consideration for the nutritional implications of following the diets in the prepregnancy and lactation phases (76, 79–82).

Very low and low carbohydrate diets are not recommended before conception because restriction of carbohydrate-containing foods limits intake of folic acid and increases risk of neural tube defects (2). An analysis of the National Birth Defects Prevention Study showed intake of a carbohydrate restricted diet ($\leq$5% percentile of controls; <95 g/d) in the 3 months before conception increased the odds of neural tube defects by 30% after adjusting for preconception folic acid supplementation. Intake of folic acid was substantially lower in women consuming a carbohydrate restricted diet (folic acid 67.4 μg/d; total dietary folate 217.9 daily folate equivalents) compared with those not restricting carbohydrate intake (183 μg/d; 540.1 daily folate equivalents) (83). In addition, very low and low carbohydrate diets are typically high in saturated fat, which promotes dyslipidemia and may increase the risk of fetal overgrowth (2).

Vegetarian diets can be appropriate for pregnant and lactating women (84). However, individuals following a vegetarian diet are at greater risk for some nutrient deficiencies and may require supplementation to meet the increased nutritional demands of pregnancy (85). The *Academy of Nutrition and Dietetics* recommends that a registered dietitian assesses intake of all micronutrients, particularly folate, vitamin B12, iron, and zinc in pregnant women following a vegetarian diet to ensure that dietary reference intakes are met (86). Evidence suggests that intake of a healthy vegetarian diet during pregnancy is associated with low risk of excessive gestational weight gain and gestational diabetes, while having limited impact on infant birth weight or birth duration (84).

There has been limited investigation of very low-fat diets in pregnant or lactating women. However, severe restriction of any macronutrient including fat is not recommended during pregnancy or lactation (2). Similarly, fasting diets (i.e., intermittent fasting and time-restricted eating) are not recommended during pregnancy or lactation because of the lack of safety data for these life stages (87). Following a fasting diet in the preconception or lactation period may result in nutrient deficiencies or insufficiencies if foods consumed during the ad libitum periods are not nutrient-dense and/or the quantity of food consumed does not meet the needs of these life stages. Short-term diets focused on elimination of foods/food groups, commonly referred to as "cleanses" or "detoxes," are not appropriate for the preconception or lactation period because of the very restrictive nature and high likelihood of nutritional inadequacy. Given the lack of evidence, fasting and short-term diets should not be consumed before conception or during lactation.

In summary, many diets promoted by popular cultural beliefs are not nutritionally adequate and if followed in the preconception period may lead to nutrient deficiencies or insufficiencies associated with adverse pregnancy outcomes. Similarly, lactating women have increased nutritional needs that may not be met with many popular diets. Instead, a healthy food-based dietary pattern (Table 1) that meets all nutrient needs, and can be followed for healthy weight loss for those who choose to do so (Supplemental Table 1), should be recommended for all women who plan to become pregnant and lactate, as well.

SUMMARY

Good nutritional status is essential for healthy pregnancy and lactation. Achieving optimal nutritional status for essential nutrients takes time and should be accomplished before conception. As noted by Marshall et al. (2), from a nutrition perspective the prenatal period is an underrecognized period of importance for healthy pregnancy outcomes. Waiting until pregnancy is diagnosed to improve nutritional status will miss a critical window in the periconception period during which time gametogenesis, organogenesis and placental development occur (88). Thus, during the approximately 3 months before conception a healthy nutrient-dense dietary pattern should be followed, with appropriate vitamin and mineral supplementation, to ensure optimal nutritional status at the time of conception.

The ongoing overweight and obesity epidemic coupled with very poor diet practices further compounds the challenges of a healthy pregnancy. Women following restrictive or nutritionally inadequate diets in the preconception, pregnancy or lactation period should be provided with nutrition education to optimize their nutritional status to prevent adverse pregnancy outcomes. Although there is an important need to implement healthy weight loss programs, there are still questions that remain about how to best implement this, especially during the preconception period. Thus, it is essential that research be conducted to address the gaps in

our knowledge about healthy and safe weight loss during this time.

DIALOG: You can discuss this article with its authors and other readers at https://www.fertstertdialog.com/posts/35728

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