# Medical Nutrition Therapy and Lifestyle Interventions

DIANE M. READER, BS, RD, LD, CDE

Nutrient intake plays a significant role in the health outcomes of all pregnant women. In a pregnancy complicated by gestational diabetes mellitus (GDM), excellent glucose control is as foundational as appropriate weight gain and adequate nutrient intake.

The controversies in GDM management include the following: how far to manipulate energy intake, dietary composition (carbohydrates and fats), and gestational weight gain. Signs that food restrictions have gone too far include weight loss or lack of weight gain, undereating to avoid insulin therapy, positive urinary ketones, and intentional restriction of healthy foods. If a balance between nutrient needs and glucose control cannot be achieved, then concurrent medication therapy is needed to assist in reducing insulin resistance and supplementing insulin production to provide normoglycemia and improved pregnancy outcomes.

Medical nutrition therapy is a self-management therapy. Education, support, and follow-up are required to assist the woman to make lifestyle changes essential to successful nutrition therapy. Women with GDM are at increased risk for type 2 diabetes; learning to manage GDM with lifestyle change provides an opportunity to affect personal risk factors and the health of the whole family.

*Diabetes Care* 30 (Suppl. 2):S188–S193, 2007

Nutrition intervention for women with gestational diabetes mellitus (GDM) has been recognized as the cornerstone of therapy at all of the international workshop-conferences on gestational diabetes (1–4). Dietary intake is foundational to optimal pregnancy outcomes because nutritional quality and quantity have an impact on the overall growth and development of the fetus. Specifically, the management of GDM entails calorie and nutrient restrictions and manipulations as a strategy to normalize blood glucose levels. Because medical nutrition therapy (MNT) is the primary therapy for 30–90% of women diagnosed with GDM (5,6), the challenge for MNT for GDM is to balance the needs of a healthy pregnancy with the need to control glucose level.

## FOURTH INTERNATIONAL WORKSHOP-CONFERENCE ON GDM

In the summary and recommendations of the Fourth International Workshop-Conference (4) on GDM, it was noted that relatively little information is available to guide evidence-based recommendations for nutrition interventions. Recommendations included the use of the Institute of Medicine (IOM) weight gain guidelines including the minimal gain of 15 lb (7 kg) for obese women (7). It was noted that calorie restriction lowered glycemia, but too severe a restriction produced ketonuria and ketonemia, which are undesirable. Carbohydrate intake should be limited to 35–45% of total calories. Self-monitoring of blood glucose, particularly postmeal monitoring, is recommended, since elevated values are associated with an increase in fetal risks. Exercise may be an adjunct to MNT to improve maternal glycemia; however, the optimal frequency and intensity has not been determined. Insulin is recommended when women are unable to achieve or maintain glycemic goals with MNT alone or show signs of excessive fetal growth. Nutrition therapy should fulfill the minimal nutrition requirement of pregnancy. The food plan should be individualized and culturally appropriate and provided by a qualified individual with experience in GDM management.

## OVERALL IMPACT OF NUTRITION THERAPY FOR GDM

In previous years, nutrition therapy research has focused on answering specific questions such as optimal carbohydrate amount or calorie level. Recently, two studies have shown the overall impact of nutrition intervention on GDM clinical care goals and perinatal outcomes.

The American Dietetic Association developed nutrition practice guidelines for GDM and then conducted a randomized prospective study to determine whether the implementation of these guidelines compared with usual care would improve specific clinical outcomes (8,9). Previously developed nutrition practice guidelines for type 1 and type 2 diabetes demonstrated a 1.0% lower A1C or 30–50 mg/dl lower blood glucose levels when implemented (10,11).

The nutrition practice guidelines for GDM were developed by dietitians experienced in GDM management. After reviewing the literature, they developed guidelines for all aspects of nutrition management. MNT was defined as a "carbohydrate-controlled meal plan that promotes adequate nutrition with appropriate weight gain, normoglycemia, and the absence of ketosis" (8). To define "carbohydrate-controlled," guidelines were developed for the following topics: total amount of carbohydrate, use of foods with sugar, carbohydrate distribution, breakfast-time carbohydrate, glycemic index, fiber, and artificial sweeteners. Guidelines were developed for other aspects of nutrition therapy: individualizing weight gain and caloric needs; monitoring ketone levels; and determining protein, fat, and micronutrient needs. Self-monitoring of blood glucose was recommended for all women with GDM and target pre- and postmeal glucose levels were identified. Criteria were defined for

From the International Diabetes Center, Minneapolis, Minnesota.

Address correspondence and reprint requests to Diane M. Reader, Manager, Diabetes Professional Training, International Diabetes Center, 3800 Park Nicollet Blvd., Minneapolis, MN 55416. E-mail: diane.reader@parknicollet.com.

Received for publication 8 May 2006 and accepted in revised form 14 November 2006.

This article is based on a presentation at a symposium. The symposium and the publication of this article were made possible by an unrestricted educational grant from LifeScan, Inc., a Johnson & Johnson company.

**Abbreviations:** GDM, gestational diabetes mellitus; MNT, medical nutrition therapy.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

DOI: 10.2337/dc07-s214

when additional therapy (insulin) was needed.

A randomized prospective intervention trial was conducted at 25 sites across the U.S. that enrolled 215 women who had been diagnosed with GDM. The sites were randomized to provide either Nutrition Practice Guidelines or usual care; 12 sites received the nutrition practice guidelines, and the remaining 13 sites followed their usual care. The findings showed that sites following the nutrition practice guidelines had fewer patients treated with insulin (24.6 vs. 31.7%; $P = 0.05$), insulin was initiated later at 31.6 weeks compared with 30.4 weeks, A1C was lower at delivery (5.0 vs. 5.2%), and a smaller proportion had A1C above normal at delivery (8.1 vs. 13.6%, $P = 0.25$) (9).

Within each group were three clinical settings: diabetes clinics, ob-gyn clinics, and other clinics. Comparing the impact of the use of the guidelines in the three clinical settings found that outcomes were improved in ob-gyn and other clinics. In diabetes clinics, the use of guidelines did not change outcomes; these clinics were already implementing practices similar to the practice guidelines (9).

Another study (the Australian Carbohydrate Intolerance Study in Pregnant Women) determined whether treatment of women with GDM reduced the risk of perinatal complications (12). Women between 24 and 34 weeks' gestation who had GDM were randomly assigned to the intervention group or to routine care. The rate of serious perinatal complications was significantly lower among the infants of the 490 women in the intervention group than among the infants of the 510 women in the routine care group (1 vs. 4%, $P = 0.01$) (12). Women in the intervention group received an individualized diet plan from a qualified dietitian that took into consideration the woman's prepregnant weight, activity level, and weight gain and were instructed to monitor blood glucose four times per day: fasting and 2 h after each meal. Criteria were developed to determine when insulin was needed. The infants in the intervention group had lower birth weight, lower percentage large-for-gestational-age, and less macrosomia.

Both studies show that implementing nutrition therapy with self-monitoring of blood glucose and criteria for advancing treatment had a positive impact on maternal and infant outcomes. In both studies, the dietitian individualized the food plan. Modifiable components of a food plan include calorie level; amount, distribution, and type of carbohydrate; and amount and type of physical activity. Outcome measures that help guide adjustments to the food plan are: weight changes, blood glucose and ketone levels, and review of food records. This implies the need for follow-up visits to successfully implement nutrition intervention; the nutrition practice guidelines suggest three visits.

**MATERNAL WEIGHT GAIN AND CALORIE INTAKE FOR NORMAL AND OVERWEIGHT WOMEN** — The 1990 Institute of Medicine's Nutrition for Pregnancy publication provided the first weight-gain recommendations based on prepregnancy BMI (7). There is a strong correlation between infant birth weight and maternal pregravid BMI for women who begin pregnancy in the normal and underweight categories (7,13). Women with normal BMI (19.8–26.0 kg/m$^2$) were recommended to gain a total of 25–35 lb (11.4–15.9 kg).

For overweight women (BMI 26.1–29.0 kg/m$^2$), the weight-gain recommendation is 15–25 lb (6.8–11.4 kg). Obese women with a BMI $>$29 kg/m$^2$ need to gain 15 lb. As BMI increases, the correlation between infant size and maternal gain weakens to the point that there is no correlation between weight gain and infant size in obese women. Obese women, regardless of weight gain, produce larger infants: 3,593 $\pm$ 514 g (14).

Recently, the epidemic of obesity in America has been linked to pregnancy (15). Women often gain too much weight during pregnancy and retain excessive amounts of weight during the postpartum period. Moreover, women who are overweight or obese before pregnancy are more likely to gain more weight related to childbearing (16). Retention of gestational weight gain may contribute to obesity and increase future risk for chronic diseases, including type 2 diabetes in women. About 35% of pregnant women gain within the IOM weight gain recommendation. Also, 22% gain less and ~43% gain more than the recommended amount (17). Identifying strategies to avoid excessive weight gain is imperative. For women at high risk for excessive weight gain, interventions need to begin in the first trimester. Suggested ways to manage weight gain are recording food intake, plotting weight gain on a graph at each visit, setting behavioral goals, participating in a group, and receiving individually tailored mailings or periodic newsletters (18).

Maternal gestational weight gain and pregravid body size are two of the important factors that influence infant birth weight, whereas gestational age is the strongest predictor. Research on the pattern of maternal gestational weight gain shows that weight gained in the first trimester is more predictive of infant weight than weight gained in the third trimester (19). Daily cigarette smoking is negatively correlated with weight gain. Other factors include socioeconomic factors, ethnicity, and geographic location. Poor nutritional status of the mother is another factor. Maternal age and parity have been shown to have a positive correlation with birth weight.

Calorie intake is also a factor influencing weight gain. The Dietary Reference Intakes (DRI) published in 2001 recommend an increase in calories for pregnancy: no increase in calories in the first trimester, an additional 340 kcal/day during the second trimester, and 452 kcal/day during the third trimester (20). This has been a controversial recommendation. Determining actual calorie intake is always imprecise. As research has improved tools for improved data collection, there is a new awareness that actual calorie intakes are generally underestimated. A wide range of calorie intakes are compatible with successful pregnancy outcomes, ranging from 1,500 to 2,800 calories per day (7). Maternal adaptations to pregnancy that influence calorie needs to meet recommended weight gain include an increase in basal metabolism, decrease in physical activity level, body fatness, climate and living conditions, and prepregnant energy status (20).

**MATERNAL WEIGHT GAIN AND CALORIE INTAKE FOR THE WOMAN WITH GDM** —The remaining question is "Do the Institute of Medicine and other recommendations for weight gain and calorie intake apply to the woman with GDM?" There is no indication that normal-weight and underweight women with GDM should not follow the IOM weight-gain guidelines and calorie intake. These women need to gain the usual amount of weight and not restrict calories to ensure a normal infant birth weight. But for the overweight and obese woman, who produces larger infants independent of weight gain, there is no consensus regarding calorie and weight gain recommendations.

**Table 1—*Intervention studies of moderate to severe calorie restriction for obese women with GDM***

| Author | Number of study participants (type of trial) | Calorie comparison (kcal/day) | Range of carbohydrates (g/day) (percentage of total calories) | Outcomes |
|---|---|---|---|---|
| Knopp et al. (22) | 12 overweight GDM (randomized) | 1,200 (50% restriction) vs. 2,400 | 150 (50%) vs. 300 (50%) | 1,200 kcal restriction improved glycemia, with increased ketones |
| Knopp et al. (22) | 6 overweight with GDM (randomized) | 1,600–1,800 (30–33% restriction) vs. 2,500 plus prophylactic insulin | 200 (50%) vs. 300 (50%) | 1,600–1,800 kcal restriction improved glycemia and triglycerides with no marked ketonuria |
| Algert et al. (23) | 22 obese (nonrandomized) | 1,700–1,800 | 212–225 (50–60%) | Lower weight gain, higher mean birth weight; no ketonuria |
| Magee et al. (24) | 12 obese (randomized) | 1,200 (50% restriction) vs. 2,400 (usual intake) | 300 (50%) vs. 150 (50%) | 50% kcal restriction lowered mean glucose, no change in fasting plasma glucose, increased ketonemia |
| Rae et al. (25) | 66 intervention vs. 58 control with insulin (randomized) | 1,590–1,776 (30% restriction) vs. 2,010–2,220 | 210–244 (51%) vs. 240–274 (46%) | No difference in frequency of insulin use; 30% restriction therapy had later start, lower dose; no increase in ketones |

Modified with permission from Gunderson (6).

Restricting calories has been a strategy for controlling weight gain, glucose levels, and avoiding macrosomia in infants of women with GDM. Severe calorie restriction, <1,500 calories per day or 50% restriction, increases ketonuria and ketonemia. In one study, high levels of third-trimester β-hydroxybutyrate resulted in lowered mental developmental index scores and average Stanford-Binet scores (21). This study has been regularly cited to support guidelines that recommend avoiding ketonemia/ketosis due to severe calorie restriction.

Modest calorie restriction, 1,600–1,800 or a 33% reduction in intake, does not lead to ketosis but controls weight gain and glucose levels in obese women and has been more successful. Table 1 summarizes a few notable studies of obese women with GDM who underwent various levels of calorie restriction for glucose control. Many of these studies were small in sample size, were not conducted under strict metabolic conditions, and relied on reported dietary intakes.

Based on the studies in Table 1, American Diabetes Association Clinical Practice Recommendations have suggested a 30–33% calorie restriction for obese women with GDM, noting a minimum 1,800 calorie level since the year 2000 (26,27).

In the outpatient setting, a calorie restriction is often recommended without specific calorie calculation. Using a food record or food recall, the practitioner and patient can identify obvious food selections or portions to change or restrict. To ensure that overrestriction of calories and nutrition is not occurring, the practitioner can monitor urine ketones, food intake, and weights until there is confidence that the nutrient changes are appropriate. Recordkeeping has been shown in numerous studies to be an effective tool to increase adherence to calorie control (28). It also provides the caregiver with more specific information for assessment and counseling.

Calorie formulas have been suggested in articles and guidelines for GDM. Frequently cited are 35–40 kcal/kg desirable body weight for underweight, 30–35 kcal/kg for normal weight, and 25–30 kcal/kg for overweight subjects. However, there is a lack of research to support these formulas. Snyder et al. (29) determined energy intake at ~2,047 calories (8.56 MJ/day) in all BMI categories in women with GDM. At that level of intake, weight gain was reduced, euglycemia obtained, ketonuria minimal, and birth weight averaged 3,542 g. Their study results support recommendations of 23–25 kcal/kg (pregravid weight) for obese and 30–34 kcal/kg (pregravid weight) for normal-weight women. They also noted that calorie intake was not a significant independent predictor of birth weight (29).

## CARBOHYDRATES AND POSTPRANDIAL GLUCOSE CONTROL

In the nonpregnant state, there is ample strong evidence that controlling total amount of carbohydrate is a strategy for controlling glucose levels (30). Since 1994, the American Diabetes Association has not specified a specific macronutrient percentage for carbohydrate; instead they have suggested that carbohydrate intake be based on individual tolerances and treatment goals. The IOM Food and Nutrition Board recommends 45–65% of total calories from carbohydrate for a healthy diet (20). Carbohydrates are an important dietary source of energy, vitamins, minerals, and fiber content.

The 2002 Dietary Reference Intake Report set a minimum level of 130 g/day for nonpregnant women and 175 g carbohydrate per day for pregnancy; this is an additional 33 g carbohydrate for fetal brain development and functioning. This new minimum recommendation provides an important basis for the level of carbohydrate restriction for women with GDM.

Elevated glucose values, and in particular postprandial glucose elevations, are associated with adverse outcomes in GDM (31). Carbohydrate is the main nutrient that affects postprandial glucose levels. Carbohydrate intake can be manipulated by controlling the total amount of carbohydrate, the distribution of carbohydrate over several meals and snacks,

**Table 2—*Nutrition prescriptions and prevalence of insulin use in observational and nonrandomized studies in GDM***

| Author | Study design (*n*) | % Carbohydrate of total calories | % Women treated with insulin |
|---|---|---|---|
| Kitzmiller et al. (32) | Prospective, clinical (150) | 38–45 | 30 |
| Catalono et al. (33) | Retrospective cohort (78) | 50 | 17 |
| Langer et al. (34) | Population-based, prospective (2461) | 50–55 | 36–66 |
| Snyder et al. (29) | Retrospective, chart review (353) | 34 | 46 |
| Jovanovic-Peterson and Peterson (35) | GDM clinics; nonrandomized, low carbohydrate (30) | 30–40 | 26 |
| Jovanovic-Peterson and Peterson (35) | GDM clinics; nonrandomized, high carbohydrate (30) | 50–60 | 50 |
| Major et al. (36) | GDM clinic; nonrandomized, low carbohydrate (21) | 42 | 5 |
| Major et al. (36) | GDM clinic; nonrandomized (21) | 45–50 | 33 |
| Romon et al. (37) | Prospective, observational (80) | 43 | 39 |

Modified with permission from Gunderson (6).

and the type of carbohydrate. These modifications need not affect the total caloric intake level/prescription.

A few nonrandomized trials have examined the effect of varying levels of carbohydrate amount, type, and distribution on blood glucose control and the need for exogenous insulin. In Table 2, the carbohydrate prescription and prevalence of insulin use in observational and nonrandomized studies of GDM are highlighted.

In addition to the total amount of carbohydrate, the type of carbohydrate may also be a factor. In recent years, the glycemic index has received attention as a nutrition intervention to improve glucose control among nonpregnant people. Foods with a low glycemic index (<55) produce a lower postmeal glucose elevation and area under the curve. Foods with a high glycemic index (>70) show higher postprandial values. A meta-analysis of studies using low–glycemic index diets, in nonpregnant people with diabetes, found an additional 0.4% lowering of A1C (38). The ADA Standards of Medical Care state that the glycemic index can provide additional benefit to total carbohydrate control, at least for nonpregnant individuals.

Research using the glycemic index in pregnancy has found that pregnancy does not change the glycemic index values of specific foods (39). Using a low–glycemic index diet or foods will reduce the glucose level after eating. Three studies using a low–glycemic index diet have shown reduced birth weight and increased small-for-gestational-age birth weights in pregnant (nondiabetic) women (40–42). To date, no intervention studies using the glycemic index have been done with women with GDM. Practitioners reviewing postprandial glucose levels for women with GDM often observe that some foods cause higher glucose values, even when total carbohydrate level is controlled. The glycemic index can help explain these glucose spikes and guide nutrition recommendations. Because there is wide interindividual variability in the glycemic index, each woman needs to determine which foods to avoid or use in smaller portions at all meals or during specific times of the day, for the duration of her pregnancy. Practice guidelines have avoided labeling foods as “good” or “bad” based on the glycemic index (8).

High-fiber diets have also been studied for the management of glucose control in the nonpregnant state; however, no specific glucose benefit has been identified (43). One study compared low-fiber (20 g), moderate-fiber (40–60 g), and high-fiber (70–80 g) diets in non–insulin-requiring women with GDM. This pilot study demonstrated that high-fiber diets were not associated with a lowering of blood glucose levels (44).

## NUTRIENT NEEDS, VITAMINS, MINERALS, AND SWEETENERS

— Table 3 lists the 2001 Dietary Reference Intakes for pregnancy (20). There is no indication that women with GDM should not follow the same guidelines for nutrient intakes that are indicated for all pregnant women. Because calorie and carbohydrate restriction is often used to manage women with GDM, these values provide a minimum level of intake for maternal and fetal health. If a woman with GDM consumes less than an adequate intake to achieve glucose targets, then combining MNT with pharmacological therapy is indicated.

## PHYSICAL ACTIVITY AS AN INTERVENTION FOR GLUCOSE MANAGEMENT IN GDM

— Physical activity has been shown, in nonpregnant individuals with diabetes, to improve blood glucose control, reduce insulin resistance, reduce cardiovascular risk factors, contribute to weight control, and improve well-being (45). Diabetes prevention trials using exercise and weight reduction have shown a 56% decrease in the incidence of diabetes in a population of people with impaired glucose tolerance (46,47). Therefore, it is reasonable to consider that regular exercise may prevent GDM. In one study, women who participated in any physical activity before and during pregnancy experienced a 69% reduced risk of GDM (48).

Exercise is an obvious adjunct therapy to MNT for women with GDM. One study of the acute effect of exercise on glucose levels showed a 23 mg/dl (1.3 mmol/l) drop in glucose values at 30 min (49). However, the safety of prescribed exercise for glucose management has been a concern. Women should monitor fetal activity and blood glucose levels before and after exercise and limit physical activity to 15–30 min. Women who have been physically active before becoming pregnant are encouraged to continue an active lifestyle.

## NEED FOR ADDITIONAL CONCURRENT THERAPY

—MNT is the primary therapy for 30–90% of woman with GDM (5,6). Criteria for adding pharmacological therapy vary in research studies. In many studies, the criteria are one or more blood glucose values outside the target range within a designated time frame. Also, elevated fasting glucose values alone are criteria for insu-

**Table 3—*Dietary reference intakes for pregnancy***

| Nutrient | RDA or AI* for pregnancy |
|---|---|
| Energy | +340 kcal/day second trimester<br>+452 kcal/day third trimester |
| Carbohydrate | 175 g/day |
| Total fiber | 28 g/day* |
| Linoleic acid | 13 g/day* |
| α-Linolenic acid | 1.4 g/day* |
| Protein ($g \cdot kg^{-1} \cdot day^{-1}$) | 1.1 (additional 25 g/day) |
| Total water | 3.0 l/day (~12 cups) |
| Sodium | 1.5 g/day* |
| Potassium | 4.7 g/day* |
| Calcium | 1,000 mg/day |
| Phosphorus | 0.7 g/day |
| Magnesium | 350 mg/day |
| Copper | 1,000 μg/day |
| Iodine | 200 μg/day |
| Iron | 27 mg/day |
| Zinc | 11 mg/day |
| Vitamin A | 770 μg/day retinol activity equivalents |
| Vitamin C | 85 mg/day |
| Vitamin D | 5 μg/day* |
| Vitamin E | 15 mg/day |
| Vitamin K | 90 μg/day* |
| Thiamin | 1.4 mg/day |
| Riboflavin | 1.4 mg/day |
| Niacin | 18 mg/day |
| Vitamin B6 | 1.9 mg/day |
| Folate | 600 μg/day |
| Vitamin B12 | 2.6 μg/day |

From the Food and Nutrition Board, Institute of Medicine (20). *AI, adequate intake; RDA, recommended dietary allowance.

lin or glyburide, as nutrition therapy primarily targets postprandial glucose levels. Additional criteria to consider are weight loss, positive ketone levels, and inadequate nutrient intake; blood glucose values alone are not enough to judge the need for additional therapy.

**CONCLUSIONS**— Nutrition recommendations for women with GDM, including gestational weight gain, calorie intake, and macronutrient composition and distribution, are based on limited scientific evidence. Further research is needed in all areas (6). In particular, randomized, controlled trials comparing intensive dietary strategies would help to guide specific nutrition recommendations regarding the type, amount, and distribution of carbohydrate. Because many women with GDM are overweight or obese before becoming pregnant, questions regarding the level of energy restriction and safety of ketone levels remain unclear. Research is also needed on how to implement strategies to manage weight gain during pregnancy for these women. New awareness of the risks of postpartum weight retention and the fact that women with GDM are at risk for developing type 2 diabetes are additional reasons to figure out ways to safely control nutrient intake and increase physical activity in GDM pregnancies.

Regardless, MNT remains the cornerstone of treatment for GDM. The food plan should be designed to fulfill minimum nutrient requirements for pregnancy set by the Institute of Medicine and to achieve glycemic goals without inducing weight loss and ketonemia. MNT is best prescribed by a registered dietitian or a qualified individual with experience in the management of GDM. Food plans should be culturally appropriate and individualized to take into account the patient's body habitus, weight gain, and physical activity and be modified as needed throughout pregnancy to achieve treatment goals. Women with GDM are at risk for developing type 2 diabetes postpartum. Nutrition interventions for GDM should emphasize overall healthy food choices, portion control, and cooking practices that can be continued postpartum and may help prevent later diabetes, obesity, cardiovascular disease, and cancer.

**References**

1. American Diabetes Association: Summary and recommendations of the First International Conference-Workshop on Gestational Diabetes Mellitus. *Diabetes Care* 3:499–501, 1980
2. Frenkel N: Summary and recommendations of the Second International Workshop-Conference on Gestational Diabetes. *Diabetes* 34 (Suppl. 2):S123–S126, 1985
3. Metzer BD: Summary and recommendations of the Third International Workshop-Conference on Gestational Diabetes Mellitus. *Diabetes* 40 (Suppl. 2):S197–S201, 1991
4. Metzger BE, Coustan DR: Proceedings of the Fourth International Workshop-Conference on Gestational Diabetes Mellitus. *Diabetes Care* 21 (Suppl. 2):B1–B167, 1998
5. Langer O: Maternal glycemic criteria for insulin therapy in gestational diabetes mellitus. *Diabetes Care* 21 (Suppl. 2):B91–B98, 1998
6. Gunderson EP: Gestational diabetes and nutritional recommendations. *Curr Diab Rep* 4:377–386, 2004
7. Food and Nutrition Board: *Nutrition During Pregnancy. Part 1: Weight Gain. Part 2: Nutrient Supplements.* Washington, DC, Institute of Medicine, National Academy of Sciences, 1990
8. *Medical Nutrition Therapy, Evidence-Based Guides for Practice: Nutrition Practice Guidelines for Gestational Diabetes Mellitus* (CD-ROM). Chicago, IL, American Dietetic Association, 2001
9. Reader D, Splett P, Gunderson E: Impact of gestational diabetes mellitus nutrition practice guidelines implemented by registered dietitians on pregnancy outcomes. *J Am Diet Assoc* 106:1426–1433, 2006
10. Franz MJ, Monk A, Barry B, McClain K, Weaver T, Cooper N, Upham P, Bergenstal R, Mazze RS: Effectiveness of medical nutrition therapy provided by dietitians in the management of non-insulin-dependent diabetes mellitus: a randomized, controlled clinical trial. *J Am Diet Assoc* 95:1009–1017, 1995
11. Kulkarni K, Castle G, Gregory R, Holmes A, Leontos C, Powers M, Snetselaar L, Splett P, Wylie-Rosett J, for the Diabetes Care and Education Dietetic Practice Group: Nutrition practice guidelines for type 1 diabetes mellitus positively affect dietitian practices and patient outcomes. *J Am Diet Assoc* 98:62–70, 1998
12. Crowther CA, Hiller JE, Moss JR, McPhee AJ, Jeffries WS, Robinson JS, for the Aus-

tralian Carbohydrate Intolerance Study in Pregnant Women (ACHOIS) Trial Group: Effect of treatment of gestational diabetes mellitus on pregnancy outcomes. *N Engl J Med* 352:2477–2486, 2005
13. Eastman NJ: Weight relationship in pregnancy. *Obstet Gynecol Surv* 23:1003–1025, 1968
14. Abrams BF, Laros RK Jr: Prepregnancy weight, weight gain, and birth weight. *Am J Obstet Gynecol* 154:503–509, 1986
15. Gunderson EP, Abrams B: Epidemiology of gestational weight gain and the body weight changes after pregnancy. *Epidemiol Rev* 22:261–274, 2000
16. Gunderson EP, Murtaugh MA, Lewis CE, Quesenberry CP, West DS, Sidney S: Excess gains in weight and waist circumference associated with childbearing: The Coronary Artery Risk Development in Young Adult Study (CARDIA). *Int J Obes Relat Metab Disord* 28:525–535, 2004
17. Schieve LA, Cogswell ME, Scanlon KS: Trends in pregnancy weight gain within and outside ranges recommended by the Institute of Medicine in a WIC population. *Matern Child Health J* 2:111–116, 1998
18. Olson CM, Strawderman MS, Reed RG: Efficacy of an intervention to prevent excessive gestational weight gain. *Am J Obstet Gyn* 191:530–536, 2004
19. Brown JE, Murtaugh MA, Jacobs DR Jr, Margellos HC: Variation in newborn size according to pregnancy weight change by trimester. *Am J Clin Nutr* 76:205–209, 2002
20. Food and Nutrition Board, Institute of Medicine: *U.S. Dietary Reference Intakes: Energy, Carbohydrates, Fiber, Fat, Fatty Acids, Cholesterol, Protein, and Amino Acids.* Washington, DC, National Academies Press, 2002
21. Rizzo T, Metzger BE, Burns WJ, Burns K: Correlations between antepartum maternal metabolism and child intelligence. *N Engl J Med* 325:911–916, 1991
22. Knopp RH, Magee MS, Raisys V, Benetti T: Metabolic effects of hypocaloric diets in management of gestational diabetes. *Diabetes* 40 (Suppl. 2):165–171, 1991
23. Algert S, Shragg P, Hollingsworth DR: Moderate caloric restriction in obese women with gestational diabetes. *Obstet Gynecol* 65:487–491, 1985
24. Magee MS, Knopp RH, Benedetti TJ: Metabolic effects of 1200 kcal diet in obese pregnant women with gestational diabetes. *Diabetes* 39:234–240, 1990
25. Rae A, Bond D, Evans S, North F, Roberman B, Walters B: A randomized controlled trial of dietary energy restriction in the management of obese women with gestational diabetes. *Aust N Z J Obstet Gyn* 40:416–422, 2000
26. American Diabetes Association: Gestational diabetes (Position Statement). *Diabetes Care* 23 (Suppl. 1):S77–S79, 2000
27. American Diabetes Association: Gestational diabetes (Position Statement). *Diabetes Care* 27 (Suppl. 1):S88–S90, 2004
28. Foyett JP: Management of obesity. *Primary Care Reports* 6:19, 2000
29. Snyder J, Gray-Donald K, Koski KG: Predictors of infant birth weight in gestational diabetes. *Am J Clin Nutr* 59:1409–1414, 1994
30. Sheard NF, Clark NG, Brand-Miller JC, Franz MJ, Pi-Sunyer FX, Mayer-Davis E, Kulkarni K, Geil P: Dietary carbohydrate (amount and type) in the prevention and management of diabetes (ADA statement). *Diabetes Care* 27:2266–2271, 2004
31. de Veciana M, Major CA, Morgan MA, Asrat T, Toohey JS, Lien JM, Evans AT: Postprandial versus preprandial blood glucose monitoring in women with gestational diabetes mellitus requiring insulin therapy. *N Engl J Med* 333:1237–1241, 1995
32. Kitzmiller JL, Hoedt LA, Gunderson EP, Theiss TS, Caresa CL, Kitzmiller AM: Macrosomia and birth trauma in infants of diet treated gestational diabetic women. In *Gestational Diabetes.* Weiss P, Coustan DR, Eds. New York, Springer-Verlag, 1988, p. 160–166
33. Catalono PM, Roman NM, Tyzbir ED, Merritt AO, Driscoll P, Amini SB: Weight gain in women with gestational diabetes. *Obstet Gynecol* 81:523–528, 1993
34. Langer O, Rodriguez DA, Xenakis EM, McFarland MB, Berkus MD, Arrendondo F: Intensified versus conventional management of gestational diabetes. *Am J Obstet Gynecol* 170:1036–1046, 1994
35. Jovanovic-Peterson L, Peterson CM: Percentages of carbohydrate and glycemic response to breakfast, lunch and dinner in women with gestational diabetes. *Diabetes* 40:172–194, 1991
36. Major CA, Henry MJ, de Veciana M, Morgan MA: The effects of carbohydrate restriction in patients with diet-controlled gestational diabetes. *Obstet Gynecol* 7: 465–470, 1998
37. Romon M, Nuttens MC, Vambergue A, Verier-Mine O, Biausque S, Lemaire C, Fontaine P, Salomez JL, Beuscart R: Higher carbohydrate intake is associated with decreased incidence of newborn macrosomia in women with gestational diabetes. *J Am Diet Assoc* 101:897–902, 2001
38. Brand-Miller J, Hayne S, Petocz P, Colagiuri S: Low-glycemic index diets in the management of diabetes: a meta-analysis of randomized controlled trials. *Diabetes Care* 26:2261–2267, 2003
39. Lock DR, Bar-Eyal A, Voet H, Madar Z: Glycemic indices of various foods given to pregnant diabetic subjects. *Obstet Gynecol* 71:1800–1183, 1988
40. Clapp JE: Diet, exercise, and feto-placental growth. *Arch Gynecol Obstet* 261:101–107, 1997
41. Clapp JF: Effect of dietary carbohydrate on the glucose and insulin response to mixed caloric intake and exercise in both nonpregnant and pregnant women. *Diabetes Care* 21 (Suppl. 2):B107–B112, 1998
42. Scholl TO, Chen X, Khoo CS, Lenders C: The dietary glycemic index during pregnancy: influence on infant birth weight, fetal growth, and biomarkers of carbohydrate metabolism. *Am J Epidemiol* 159: 467–474, 2004
43. Franz MJ, Bantle JP, Beebe CA, Brunzell JD, Chiasson J-L, Garg A, Holzmeister LA, Hoogwerf BJ, Mayer-Davis E, Mooradian AD, Purnell JQ, Wheeler M: Evidence-based nutrition principles and recommendations for the treatment and prevention of diabetes and related complications (Technical Review). *Diabetes Care* 25:148–198, 2004
44. Reece EA, Hagay Z, Caseria D, Gay LJ, DeGennaro N: Do fiber-enriched diabetic diets have glucose lowering effects in pregnancy? *Am J Pernit* 10:272–274, 1993
45. American Diabetes Association: Standards of medical care in diabetes. *Diabetes Care* 28 (Suppl. 1):S4–S36, 2005
46. Dempsey JC, Sorensen TK, Williams MA, Lee IM, Miller RS, Dashow EE, Luthy DA: Prospective study of gestational diabetes mellitus risk in relation to maternal recreational physical activity before and during pregnancy. *Am J Epidemiol* 159:663–670, 2004
47. Knowler WC, Barrett-Connor E, Fowler SE, Hamman RF, Lachin JM, Walker EA, Nathan DM, Diabetes Prevention Program Research Group: Reduction in the incidence of type 2 diabetes with lifestyle intervention or metformin. *N Engl J Med* 346:393–403, 2002
48. Tuomilehto J, Lindstrom J, Eriksson JG, Valle TT, Hamalainen H, Ilanne-Parikka P, Keinanen-Kiukaanniemi S, Laakso M, Louheranta A, Rastas M, Salminen V, Uusitupa M, Finnish Diabetes Prevention Study Group: Prevention of type 2 diabetes mellitus by changes in lifestyle among subjects with impaired glucose tolerance. *N Engl J Med* 344:1343–1350, 2001
49. Avery MD, Walker AJ: Acute effect of exercise on blood glucose and insulin levels in women with gestational diabetes. *J Matern Fetal Med* 10:52–58, 2001