Exercise has long been accepted as an adjunctive nonmedical intervention in the management of diabetes in nonpregnant subjects. It is universally accepted that pregnancy is a diabetogenic event which could develop into gestational diabetes mellitus (GDM) in up to 12% of pregnant women. GDM, a carbohydrate intolerance of variable severity with onset or first recognition during pregnancy, involves a relative resistance to insulin. Exercise becomes thus a logical intervention, only recently offered as an adjunctive therapy to pregnant diabetics. This article reviews our current understanding of the role of exercise in the management of GDM.

Pregnant diabetic women have been denied, in the past, the option of exercise as a therapeutic intervention, primarily because of the fear that maternal benefits could be offset by fetal risks. Recently gathered information and better understanding of the maternal and fetal responses to exercise have led to new clinical interventions that have included exercise. This approach has recently gained recognition by professional organizations.

Including exercise in the management schemes of GDM is based on a physiological rationale. Pregnancy is characterized by an increase in diabetogenic hormones (estrogen, prolactin, human chorionic somatomammotropin [hPL], cortisol, and progesterone) and by increased insulin requirements and insulin resistance. During pregnancy, catabolic stress hormones trigger an increase in fuel delivery to the mother’s circulation. This state of chronic metabolic stress causes large fluctuations in fuel metabolism between the fed and fasted state. This hormonal activity results in decreased fasting blood glucose levels and increased postprandial glucose levels. It is these changes that are responsible for insulin resistance and development of GDM in 1.4% to 12.3% of all pregnant women. The impaired insulin sensitivity in patients with GDM results in decreased glucose uptake by the muscles and splanchnic organs, whereas hepatic glucose production is suppressed.

Extensive research has been conducted in recent years in nonpregnant subjects on the mechanism of the glucose transport system into skeletal muscle, the predominant tissue responsible for insulin-stimulated glucose disposal and a dominant site of insulin resistance in Type II diabetics. Thus, incorporating exercise in the general management scheme for the treatment of diabetes has a physiological rationale. From our current understanding of the muscle physiology, it seems that muscles participate in the contraction-stimulated glucose transport. Numerous other factors can alter the glucose transport, including catecholamines, growth factors, corticosteroids, thyroid, and growth hormones. A contracting skeletal muscle can increase its glucose uptake 40-fold, thus leading to a three to four times increase in total body glucose uptake. After an exercise bout, glucose tolerance is increased for variable periods depending on both insulin and contractile activity.

The process of glucose transport into insulin-sensitive cells has not been studied in pregnancy; however, one could assume that GDM may represent heretofore an undiagnosed or early Type II diabetes and, thus, the mechanism could be similar to the one in nonpregnant individuals.

It is well recognized that exercise modifies the interaction of diet, obesity, hyperlipidemia, central and peripheral insulin resistance, defective insulin release, and postreceptor cellular defects. In this process defined as the “permissive effect of uptake,” insulin modulates the glucose uptake. Figure 1 illustrates the different endocrine interactions during exercise. Clearly the benefits of physical activities result in both cardiopulmonary and metabolic benefits. These metabolic changes should benefit patients with...
Figure 1. Hormonal interactions during exercise in the muscles. Interaction between glucagon, epinephrine, and insulin determines the full contribution of liver and muscle glycogen to exercising muscle. Brain glucopenia shifts the balance toward muscle glycogenolysis. (Reprinted with permission.)

GDM, similarly to the nonpregnant, by a decrease in basal and glucose-stimulated serum insulin levels, regulation of insulin receptors, improved insulin sensitivity, and improved carbohydrate utilization. As previously shown, different variables influence metabolic responses to physical activity in normal and diabetic subjects. Apart from the basic endocrine state and anthropometric characteristics, the level of fitness and emotional state need to be considered as well as the extent and duration of the activity.

Very few studies and reports are available on the effect of physical activity on pregnant diabetics. In an observational study, Hollingsworth and Moore reported on the effects of "exercise prescription" on two cohorts of sedentary gravidas: normal controls and subjects with IDDM assigned to a 20-minute "leisurely" walk program (1 mile) after each meal. Walking exercise was selected because it required no expense or special equipment. Glycemic control was modestly but not significantly superior in the exercise group compared with a non-exercise diabetic group; however, these patients had poor metabolic control while entering the study. There was no difference in neonatal outcomes in the two studied groups. These investigators concluded that exercise appeared to be beneficial in normalizing glucose metabolism only in patients who still have an adequate ability to secrete insulin and in whom insulin resistance was the major cause of abnormal glucose tolerance, suggesting that other factors, rather than exercise, had the predominant effect; a fact well recognized in IDDM patients who engage in exercise.

Patients with IDDM are particularly at risk for hypoglycemia primarily because of the variable effect of the previously injected insulin. In these patients, the expected decline in exogenous plasma concentrations and increase in hepatic glucose production do not occur. The counter-regulatory adaptations in these patients may be altered by inadequate catecholamine and glucagon responses and result in hypoglycemia. The hypoglycemic response may be more pronounced in pregnant IDDM patients, with such episodes occurring during or as long as several hours after the exercise. Thus exercise may not be an easy or cost-effective "intervention" in pregnant patients with IDDM. We recommend that these patients engage in medically supervised exercise only.

These same investigators developed a similar study that included 14 obese insulin-requiring Type II pregnant women; again, no significant improvements or positive effects were found in the experimental group. No objective measurements were used in these last studies to monitor patient compliance. It was assumed that one reason for the modest results was the low motivation of the mostly obese and sedentary patients. The investigators concluded that pregnant women with NIDDM and GDM would seem to have the most to gain and least to risk from a moderate exercise program that is medically supervised.

Ruderman and Schneider proposed in their article about diabetes, exercise, and atheroscle-
rosis that the high prevalence of hyperinsulinemia and insulin resistance in individuals leading a sedentary lifestyle could be modified by physical activity and prevent coronary heart disease. The success of such interventions depends on early identification of the subjects at risk before the onset of irreversible alterations. The investigators suggested that one group which could benefit from such an intervention are women with GDM. It is our strong belief that pregnancy provides a unique opportunity for behavior modification and for long-lasting effects.

In a pilot study, Jovanovic-Peterson et al. ran-

**Figure 3.** Weekly mean fasting blood glucose (FBS) over 6 weeks in a “diet-alone-group” (closed circles) and a “diet and exercise group” (open circles); the asterisk indicates a significantly statistical difference of $P < .0001$. (Reprinted with permission, from Jovanovic-Peterson L, et al: Randomized trial of diet versus diet plus cardiovascular conditioning on glucose levels in gestational diabetes. Am J Obstet Gynecol 161:415, 1989.)

Figure 2. Insulin and glucose levels before and after oral glucose load, and (---●---) before and (⋯●⋯) after physical training.
that the duration and intensity of such an interventional program may be very limited, but still provides a useful alternative treatment to obviate insulin therapy in many women with GDM.

Recently we tested the feasibility of home-based and clinic-based programs (Table 1). In an uncontrolled study, we prescribed the home-based program (Table 1) to 18 patients with GDM-A2. Of the 18 patients, 15 completed the study. Three had to be withdrawn from the program, one because she developed mild pregnancy-induced hypertension at 36 weeks, and two others because of premature labor. One of these patients was subsequently placed on insulin therapy. The compliance with the prescribed exercise program was more than 90%. None of the patients who remained in the study required insulin. Glucose control varied by less than 9%. No other maternal or fetal complications were recorded during this study. With this regular and defined exercise program, the subjects activated larger muscles that resulted in a clear improvement and normalization of the carbohydrate metabolism. The mean 1-hour post prandial challenge glucose test after a 6-week training program declined from 230 mg/dL to 105.9 ± 18.9 mg/dL. No episodes of fetal heart abnormalities were observed during this study.

Our understanding of fetal and maternal responses to physical activity in pregnancy is increasing, with the recognition that particularly non-weight-bearing activities favor carbohydrates as a fuel source, and the increasing awareness of the benefits of physical activity is reflected in the ACOG recommendations of 1994. Experience gathered with the previously mentioned studies and other theoretic considerations on GDM and exercise led to a prospective, randomized study on the efficacy and safety of a therapeutic clinic-based exercise program in pregnant diabetics.

Forty-one GDM-A2 patients with abnormal fasting glucose after a 1-week failure of intensive dietary therapy were randomized to a study protocol of either exercise and diet or insulin therapy and diet. Current management of GDM-A consists of diet and careful monitoring of fasting and postprandial glucose levels. The goal of therapy is maintenance of euglycemia. When euglycemia is not achieved by diet alone as in the GDM-A2 patients, insulin therapy is indicated. It was hypothesized that exercise will improve glucose intolerance and thus obviate the need for insulin therapy. At enrollment and then every 4 weeks, the subjects in the exercise group (n = 21) underwent a symptom-limited Vo2max test to determine appropriate workload (aerobic capacity) for exercise prescription. The testing and standardized exercise routine ensued a comparable exercise prescription for all subjects. All subjects in the exercise group were instructed to return to the exercise laboratory three times per week to exercise under medical supervision. The subjects in the exercise group were also encouraged to engage in an active lifestyle at home. While in the laboratory, the subjects exercised on a recumbent bicycle at 50% of their last determined maximum aerobic capacity. The total duration of the exercise was 45 minutes, divided into three bouts of 15 minutes, interspersed with two 5-minute rest periods to facilitate fetal moni-

Table 1. Essentials of Home-Based and Hospital-Based Exercise Programs for Women Who Have Gestational Diabetes

<table>
<thead>
<tr>
<th>Home-based program</th>
<th>Hospital-based program</th>
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<tr>
<td>Patient is informed of potential complications</td>
<td>Three times per week, patient exercises at 50% Vo2max for 45 minutes total, divided into three 15-minute bouts with 5-minute rests between each bout</td>
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<tr>
<td>Patient rests for 30 minutes before breakfast, lunch, and dinner and fetal activity is monitored</td>
<td>Fetus is monitored during 5-minute rest periods</td>
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<tr>
<td>Patient monitors fasting and 2-hour postprandial plasma glucose level</td>
<td>Plasma glucose and blood pressure are recorded before and immediately after each exercise session; maternal heart rate and uterine activity are monitored during and after exercise</td>
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<tr>
<td>If fetal activity and glucose level are okay, she exercises for 20 to 30 minutes at 50% Vo2max (percent exertion fairly light to somewhat hard) after each prescribed meal</td>
<td>Beginning at 32 weeks of gestation, non-stress-testing is done weekly; further fetal tests conducted as indicated</td>
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<tr>
<td>Patient rests for 30 minutes and counts fetal movements</td>
<td>Patient keeps accurate records of blood glucose, food intake, physical activities, and fetal movements</td>
</tr>
<tr>
<td>If uterine contractions become regular or occur ≥ 15 minutes apart, patient notifies obstetrician</td>
<td>Beginning at 32 weeks of gestation, non-stress-testing is done weekly; further fetal tests conducted as indicated</td>
</tr>
<tr>
<td>Patient keeps accurate records of blood glucose, food intake, physical activities, and fetal movements</td>
<td>Beginning at 32 weeks of gestation, non-stress-testing is done weekly; further fetal tests conducted as indicated</td>
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Figure 4. Mean blood glucose varies in the insulin group (■) and exercise-diet group (□). (Reprinted with permission.26)

toring. The exercise routine was judged to be moderate and to generate an energy demand of about 5 to 7.5 times the resting metabolic rate, sufficient to result in a normalization of plasma glucose levels (Fig 4). Prior and immediately after the exercise sessions, the subjects' plasma glucose concentrations and the vital signs were recorded. Maternal heart rate and uterine activity were continuously monitored during exercise.

Seventeen of the 21 subjects in the exercise group and 17 of the 20 subjects in the insulin group completed the study. The exercise subjects had a compliance rate of more than 90%. The average gestational age at delivery was 38.9 ± 1.7 weeks for the exercise group and 38.2 ± 2 weeks for the insulin group. No episodes of hypoglycemia were recorded, and no significant differences between the groups were observed in the blood glucose levels (Fig 4). Both groups had comparable complications rates, body composition variables, and neonatal outcomes.

These study results indicate a persistent decrease in blood glucose levels by an assumed increase in insulin sensitivity induced by the regular physical activity. Also, no significant changes in uterine activity after the exercise sessions were observed, suggesting that such an exercise regimen seems to be a safe and efficient therapeutic option for patients with GDM.

In conclusion, all of the physiological considerations presented in this article and the current data on exercise in pregnancy, particularly in women with GDM support, promote the concept that exercise may be considered a safe and efficient intervention as either an adjunctive therapy or for promoting cardiovascular fitness. However, it must be stressed that several factors need to be considered before encouraging such a program in patients with diabetes mellitus. A different approach is necessary for patients with IDDM versus NIDDM, the initial metabolic state in which the patient is identified, i.e., the extent of the carbohydrate disturbance, the level of fitness, and the exclusion of any other medical or obstetric complications that may contraindicate this type of intervention. It is important to emphasize that most GDM patients live a sedentary lifestyle and thus need an individualized program that accounts for these differences.

This last study provides proof that an exercise program could offer a multitude of advantages including, in the short term, the avoidance of insulin therapy, a safer and less expensive program, and, long-term, the potential change in lifestyle with clear long-lasting health benefits. However, exercise prescription requires a thorough understanding of the physiology of exercise and its potential complications. The Third International Workshop on GDM and the current ACOG Guidelines provide adequate background information for this purpose.1,2 Additional studies will need to be completed to confirm these very encouraging preliminary reports.

References


