Review Article

Exercise and Pregnancy

CAPT Marlene DeMaio, MD, MC, USN

CAPT Everett F. Magann, MD, MC, USN

Dr. DeMaio is Associate Professor, Department of Surgery, Uniformed Services University of the Health Sciences, Bethesda, MD, and Director, Research, Department of Orthopaedic Surgery, Naval Medical Center, Portsmouth, VA. Dr. Magann is Professor, Department of Obstetrics and Gynecology, Uniformed Services University of the Health Sciences, Bethesda, and Chairman, Department of Obstetrics and Gynecology, Naval Medical Center, Portsmouth.

Dr. DeMaio serves as a board member of the Association of Bone and Joint Surgeons and the publications *American Journal of Sports Medicine* and *Clinical Orthopaedics and Related Research* in an unpaid capacity. Neither Dr. Magann nor a member of his immediate family has received anything of value from or owns stock in a commercial company or institution related directly or indirectly to the subject of this article.

Reprint requests: Dr. DeMaio, Department of Orthopaedic Surgery, Naval Medical Center, 620 John Paul Jones Circle, Portsmouth, VA 23708.

J Am Acad Orthop Surg 2009;17: 504-514

Abstract

Exercise is an important component of a healthy lifestyle and, as such, is recommended during pregnancy. However, the response to exercise of both the expectant mother and fetus varies depending on the fitness level of the woman. The response to exercise is also affected by the known musculoskeletal and physiologic changes associated with pregnancy, such as increased ligament laxity, weight gain, change in the center of gravity, and carpal tunnel syndrome. Although the physiologic responses of the pregnant woman and fetus have been well studied, the literature contains comparatively few studies investigating response to exercise. When performed properly, activities such as aerobics, impact and nonimpact activities, resistance training, and swimming may be beneficial during pregnancy.

Many women exercise regularly leading up to pregnancy and continue a fitness routine during pregnancy. Previously inactive pregnant women may want to begin a program of regular physical activity to improve their fitness level, manage their weight, and help prevent associated medical conditions such as gestational diabetes and hypertension. Specific concerns are routinely posed to health care providers caring for pregnant women. Patients may ask questions such as, Does exercise increase the risk of first-trimester loss or of complications? What are the effects of exercise on neonatal birth weight? What are the risks of aerobic versus anaerobic exercise? What are the differences between weight-bearing and non–weight-bearing exercise? Is the length of labor or the mode of delivery affected by exercise? Can I breast-feed and continue to exercise postpartum? The answers to these questions are important to all concerned: the physically active mother-to-be, the orthopaedic physician who manages the sports injuries that occur in women who continue to exercise during pregnancy, and the previously sedentary pregnant woman who initiates an exercise program at the beginning of or during pregnancy.

Physiologic Changes in Pregnancy

Musculoskeletal

The predominant musculoskeletal changes associated with pregnancy are related to a change in the center of gravity, the effect of circulating hormones on ligaments, and weight gain and fluid increase. The effect of pregnancy on bone metabolism is complex. Although bone loss does occur with pregnancy and lactation, the occurrence of osteoporosis is rare. Transient osteoporosis of the hip and osteonecrosis of the hip may be associated with pregnancy.

Pregnancy causes an increase in lumbar lordosis, resulting in anterior displacement of the maternal center of gravity. With alteration of the cen-

ter of gravity, some patients may have difficulty maintaining their balance, and falls can occur. Perhaps to compensate for the increased lumbar lordosis, there may be increased lordosis and flexion of the cervical spine. The result is shoulder abduction, which may affect functional range of motion and the ability to participate in some activities.

Elevated levels of hormones, including relaxin, cause increased laxity in joints and ligaments. Relaxin levels increase during pregnancy, with the initial peak at week 12, followed by a decrease until week 17, when levels stabilize.[1] Relaxin causes increased laxity of the ligaments of the symphysis pubis and the sacroiliac joints. The symphysis widens during the 10th to 12th week, normally to ≤10 mm.[2]

Limited information is available on the specific effects, if any, of pregnancy on muscles and tendons. Muscles may strengthen and exhibit more endurance when exercised during pregnancy, as they do in women who are not pregnant. Specific influences of pregnancy on the exercising muscle are uncertain.

Approximately 80% of pregnant women report soft-tissue edema, especially in the last 2 months of pregnancy.[3] Edema may contribute to nerve compression and neuropathy, manifesting as carpal tunnel syndrome in the upper extremity and tarsal tunnel syndrome in the lower extremity. Diffuse pitting edema may present alone in the lower extremity. Compression neuropathy associated with pregnancy is anecdotally noted to be worse with subsequent pregnancies.

Cardiopulmonary

The cardiopulmonary changes associated with pregnancy are summarized in Table 1. The maternal position and the effects of pregnancy have a significant effect on maternal circulation. Maximum blood flow to the uterus is achieved with the mother in the knee-chest position and lying on her left side. Early in the first trimester of pregnancy, maternal blood flow can be impaired in motionless standing. Decreased venous return to the heart may also occur in the third trimester of pregnancy when the mother is in a supine position because the maternal uterus presses on the vena cava. This impaired blood flow results in hypotension, syncope, nausea, and lightheadedness.

Pregnant persons are noted to breathe deeper but not with greater frequency than nonpregnant persons because of the respiratory stimulatory effect of progesterone. This deep breathing results in a feeling of breathlessness and subsequent respiratory alkalosis, which is partially compensated for by loss of bicarbonate through the maternal kidneys.

Table 1

Cardiopulmonary Changes Associated With Pregnancy[4,5]

System	Clinical Measurement	Change
Cardiovascular	Systemic vascular resistance	Decreases in the first trimester, then increases
	Plasma volume	Gradually increases by 50%, peaking at 32 weeks
	Cardiac output	Increases by 30% to 50% during gestation
	Stroke volume	Increases (followed by increase in heart rate)
	Heart rate	Increases; maximizes at 34 weeks with resting maternal rate of 92 beats per minute
Pulmonary	Tidal volume	Increases, with resulting overall decrease in functional residual capacity
	Oxygen uptake	Increases
	Minute ventilation	Increases 30% to 50%
	Alveolar ventilation	Increases 50% to 70%
	Respiratory rate	No change

Benefits of Exercise

Exercise during pregnancy provides several psychological and physical benefits.[4,6-12] In a study of pregnant women who exercised regularly, self-esteem was improved and physical discomforts of pregnancy, such as fatigue, varicosities, and peripheral edema, were reduced.[11] In another study, depressed pregnant women were randomized into one of three groups: aerobic exercise, relaxation, and no treatment.[9] The women in the aerobic exercise group showed greater improvement in aerobic capacity and greater decreases in depression than did the women in the other two groups.[9] Physiologic benefits included improved aerobic capacity and blood pressure, improved response to carbohydrates, and decreased blood glucose.

Exercise and Hypertension

Increased maternal blood pressure is a significant cause of maternal and fetal morbidity and mortality. Preeclampsia is characterized by high maternal blood pressure, proteinuria, and edema. A decreased risk of preeclampsia was associated with physical activity in three

Table 2

Recommendations for Exercise During Pregnancy

Society	Recommendation
The American College of Obstetricians and Gynecologists[21]	In the absence of either medical or obstetric complications, ≥30 minutes of moderate exercise a day on most, if not all, days of the week is recommended for pregnant women.
The Society of Obstetricians and Gynaecologists of Canada[12]	All women without contraindications should be encouraged to participate in aerobic and strength-conditioning exercises as part of a healthy lifestyle during pregnancy.
Royal College of Obstetricians and Gynaecologists (United Kingdom)[22]	A review of the evidence suggests that, in most cases, exercise is safe for both mother and fetus during pregnancy. Women should therefore be encouraged to initiate or continue exercise to derive the health benefits associated with such activities.
The Royal Australian and New Zealand College of Obstetricians and Gynaecologists[23]	Among the numerous benefits of remaining active during pregnancy are improved weight control and maintenance of fitness, as well as possible benefits in terms of reduced risk of development of gestational diabetes mellitus and improved psychological functioning. Moderate-intensity aerobic exercise is safe in pregnancy; for trained athletes, it may be possible to exercise at a higher level than is currently recommended by The American College of Obstetricians and Gynecologists.

studies.[13-15] In one, a case-controlled study, regular exercise in the first 20 weeks of pregnancy was associated with a 43% decrease in risk of preeclampsia compared with sedentary behavior.[13] In another study, regular participation in recreational exercise during the first 20 weeks decreased the risk of preeclampsia to 35%; decreases in the risk of preeclampsia that were associated with activity were proportionate to the intensity of the activity and the energy expended.[15] A nested case-control study corroborated the findings of these two studies.[14]

Exercise and Gestational Diabetes

Gestational diabetes, that is, carbohydrate intolerance that is first recognized in pregnancy, has a reported prevalence of 2% to 14% in the United States and appears to be steadily increasing.[16] Although exercise has long been recognized as an adjunctive therapy in the management of nonpregnant women with diabetes, its role in the prevention or treatment of gestational diabetes has been examined in only a few studies, and actual benefits are unclear.[17,18] After low- to moderate-intensity exercise in a group of women with gestational diabetes, blood glucose levels significantly declined compared with their blood glucose levels at rest ($P = 0.01$).[5] However, a recent Cochrane review found that the literature regarding exercise for the prevention or treatment of gestational diabetes was inconclusive.[19] Potentially, exercise could prevent progression from management by diet alone to the need for oral agents and/or insulin in women with gestational diabetes.[17] Patients with gestational diabetes have a ≤50% risk of developing diabetes in later life.[20] Thus, establishment and maintenance of an exercise program postpartum should be an integral part of a recognized treatment program for these patients.

Guidelines and Recommendations

Several organizations of obstetricians and gynecologists have published guidelines on exercise during pregnancy: The American College of Obstetricians and Gynecologists,[21] The Society of Obstetricians and Gynaecologists of Canada,[12] Royal College of Obstetricians and Gynaecologists (United Kingdom),[22] and The Royal Australian and New Zealand College of Obstetricians and Gynaecologists[23] (Table 2). All acknowledge that exercise during pregnancy, including strength training, can be safe and is recommended, provided that there are no medical or obstetric complications.

Exercise should be prescribed for the healthy pregnant patient after an obstetric evaluation, with verification that there are no contraindications. Women at low risk for an adverse pregnancy outcome should be encouraged to participate in an aerobic and strength-conditioning program. Women with an uncomplicated pregnancy who have been exercising since before pregnancy should continue to do so.

There has been some question about initiating an exercise program during pregnancy for women who were previously sedentary. In one study, a structured and supervised swimming program was undertaken in a group of low-risk sedentary women.[24] Baseline maternal fitness was evaluated by a standard submaximal test of physical work capacity at a heart rate of 170 beats per minute (PWC_{170}).[24] This test was re-

peated every 4 weeks to the 28th week of pregnancy. The increasing fitness of the women was demonstrated by the increased distances that the women swam during pregnancy. It was also demonstrated by a significant increase in PWC_{170} within 8 weeks (P = 0.003); this value remained elevated throughout the pregnancy. Another study compared control subjects to sedentary women with an individualized program starting at 60% maximum heart rate for 3 weeks and then 80% for the last 5 weeks.[25] The training was 15 minutes (12 minutes walk/jog and 3 minutes of calisthenics), three times a week. The trained group had a significant improvement in PWC_{170}, resting systolic blood pressure, and fat index.[25] These studies show that improvements in fitness may be achieved without any alteration in either maternal or fetal well-being. These findings suggest that exercise can be started in a woman who had not been exercising before pregnancy, although that the program must be carefully structured and supervised.

Any disorder that may cause decreased blood flow or oxygen to the fetus and placenta or that is associated with premature labor is a contraindication to exercise. Absolute contraindications to exercise during pregnancy have been identified (eg, placenta previa, incompetent cervix, preterm labor), and women who exhibit them should be discouraged from exercising altogether[1-3,21] (Table 3).

Exercise Regimen and Intensity

The goals of aerobic exercise during pregnancy are to maintain a level of physical fitness in those who were exercising before pregnancy and to increase maternal fitness in a carefully structured and supervised program in those who were not previously exercising. Aerobic exercise has been defined as repeated exercise that depletes cellular oxygen and places the body in a state of stress. The level of exercise to be attained is determined by the maternal heart rate:

(220 – age) × 60% to 80% = target heart rate range[26]

In several studies, aerobic training has been shown to increase submaximal exercise capacity and fitness level. One study documented the increase in submaximal exercise capacity in overweight (ie, body mass index, 26 to 31) pregnant women and in normal-weight pregnant women.[27] Sedentary women in their first pregnancy significantly improved their fitness level after 15 weeks of training three times a week.[8] One study evaluated high- and medium-volume intense exercise in elite competitive athletes. Maintaining a high level of fitness was thought to promote rapid return to previous level of fitness in 41 women without risk to mother and fetus.[28]

However, in general, pregnancy is not the time to reach peak fitness or to train for athletic competitions. Brief submaximal exertion (≤70% maximal aerobic power) does not appear to affect fetal heart rate.[29] However, maximal exertion does. Although maximal maternal exertion in pregnancy has not been linked to an adverse pregnancy outcome, studies are limited. Transient fetal bradycardia and placental steal syndrome, in which blood goes to exercising muscles and away from the placenta, have been observed in two studies.[25,29] For high-performance athletes, the emphasis is on safety. Shorter workouts and moderate-intensity exercise reflect the studies to date. Elite pregnant athletes who wish to train and compete should get regular obstetric follow-up, be careful of hydration status, monitor their nutritional requirements, and be aware of heat stress.[22]

Table 3

Absolute Contraindications to Exercise During Pregnancy[1-3,21]

Preeclampsia/eclampsia
Preterm premature rupture of the membranes
Antepartum hemorrhage
Placenta previa
Vasa previa
Preterm labor
Incompetent cervix/cerclage
Significant maternal cardiac disease
Restrictive lung disease
Growth-restricted fetus
Chronic placental abruption
Multiple gestation

Non–weight-bearing exercises may be preferable to weight-bearing exercises in the late second trimester and throughout the third trimester. Two types of exercise that fulfill this criterion are cycling and swimming. There are several physiologic adaptations with water exercise that are not observed with land exercise. The hydrostatic pressure of the water forces fluid from the extravascular spaces, resulting in decreased edema, increased central blood volume, and, possibly, increased uterine perfusion. These changes do not have a negative effect on the fetus. Fetal responses to maximal exercise and uterine activity (ie, contractions) may be fewer in swimming than in cycling, making swimming the preferred form of exercise.[24,30,31] Immersion is associated with significant diuresis that is not seen in either males or nonpregnant females, or with land exercise.[32] The mechanism for the diuresis is unclear. Water assists in the thermoregulation of the maternal core temperature. Because the water supports the exercising woman, fewer weight-bearing injuries should occur.

Table 4

Prescription for Safe Exercise During Pregnancy

The unfit patient should begin exercising in a carefully structured and supervised program
Transition from weight-bearing to non–weight-bearing exercises as pregnancy progresses (eg, cycling and swimming in the second half of pregnancy)
Avoid collision sports and deep-water diving
Do not exercise in the heat of the day
Wear loose-fitting clothes
Adequately hydrate
Stretch before and after exercise
The patient should stop exercising if she becomes tired, dizzy, nauseated, short of breath, or overheated. Pregnancy is not the time to test endurance.
With a pregnancy that is other than low-risk, exercise should be done only with the consent of the obstetrician or gynecologist in consultation with an experienced trainer or a sports medicine specialist

Risks and Safeguards

The gravid uterus must be protected from trauma; avoiding collision sports or sports with unintentional rigorous contact is paramount. Certain activities have the potential to harm the mother, fetus, or placenta (Table 4).

Maintaining hydration and avoiding heat illness are important because pregnancy increases core body temperature. Maternal hyperthermia in early pregnancy has been linked to an increased risk of neural tube defects and may be a teratogen.[33,34] The overall basal metabolic rate increases with pregnancy, which increases core body temperature 0.5°C to 1°C. Nonpregnant women exercising at 70% of capacity on a treadmill will increase their core body temperature by as much as 1.5°C.[35] The increase that may occur in the core body temperature of an exercising pregnant woman is not as well-defined. This has led to concern about the additional effect of exercise on maternal core body temperature. In a study of fit pregnant women, Clapp et al[35] observed that thermoregulation improved as pregnancy advanced. In a follow-up investigation of fit women who were exercising, Clapp[36] observed a decrease in peak rectal temperature of 0.3°C in the first trimester of pregnancy and 0.1°C each month after the first trimester through the 37th week of pregnancy. Thus, the pregnant patient can effectively regulate the heat generated by exercise. However, a common-sense approach to exercise in pregnancy should be followed: the patient should wear loose-fitting clothing, hydrate adequately, and avoid exercising when there is a high heat index. For example, yoga is an excellent activity for tone, balance, and stretching. However, Bikram yoga, which is classically performed in a very warm environment with water restriction, is not recommended for the novice pregnant woman.

Cycling in a semirecumbent and erect position has been investigated in females with low-risk singleton pregnancy from 34 to 38 weeks gestation.[37] The participants cycled for 12 minutes in either position, with the maximal heart rate between 135 and 145 beats per minute. There was no negative effect on fetal heart rate. This suggests that neither posture is preferable with respect to uterine blood flow in the third trimester.

Scuba diving is not advised because of the risk of decompression sickness. In one study, 129 women reported 1,465 dives during 157 pregnancies over a 10-year period, of which more than half of the dives were deeper than 15 m.[38] Of these, 22 resulted in spontaneous abortions. This reflects a similar rate reported in a similar group in the United Kingdom.[39,40] Although no data correlate deep dives to fetal anomalies, the bubbles of inert gases (eg, nitrogen) that may form in the bloodstream on ascent may affect the placenta, fetal tissue, and the venous system. The percentage of reported dives decreased from 11% to 3% from the authors' previous retrospective review.[38]

A common-sense approach is advised for other activities for which little information is available (eg, resistive training).[28,41-43] For resistive training, the supine position should be avoided so as to maintain blood flow to the uterus and decrease possible compression of the inferior vena cava. Use of light weights, particularly in the third trimester, when relaxin levels remain elevated, may help avoid joint injury. With running, walking, and swimming, gradual increases from low to moderate intensity appear to be safe. High-intensity training in elite runners during pregnancy has been documented in one study; no spontaneous abortions or perinatal deaths occurred during the investigation.[28] There is also little information on women who have exercised beyond duration and intensities recommended in the guidelines of The American College of Obstetricians and Gynecologists.[10] In one study, such persons appear to have remained safe.[28]

Effects of Exercise on Pregnancy and Perinatal Outcomes

The most recent Cochrane Review found that although exercise in pregnancy allows for a woman to main-

tain or improve her physical fitness, the overall information currently available is insufficient to determine the important risks or benefits of exercise during pregnancy.[43] Klebanoff et al[44] observed in a large prospective observational trial of 7,101 pregnant women that increased levels of physical activity were not associated with an increased risk of preterm delivery or intrauterine growth restriction. Two studies reported the correlation between endurance exercise in physically fit women and pregnancy outcomes.[45,46] In the first study, Clapp and Dickstein[45] found that women who continued endurance exercise gained less weight and delivered earlier than did women who stopped exercising before 28 weeks. In a follow-up study, women who continued to exercise had a lower incidence of surgical vaginal deliveries, fewer cesarean sections, shorter active labors, and fewer fetuses with intolerance of labor than did women who discontinued their exercise.[46]

The effect of exercise in 750 low-risk working women, stratified by level of exercise, was evaluated by Magann et al.[26] Exercise did not appear to affect antepartum, intrapartum, or perinatal complications. Compared with sedentary women, the neonates of the exercising women were smaller but suffered no adverse consequences. Clapp et al[47] also observed that lighter-weight babies were born to women who continued to exercise during pregnancy compared with a group of women who reduced their exercise after the 20th week of pregnancy (3.39 kg vs 3.81 kg). The lighter neonates were the result of decreased body fat at the time of delivery. The effect of physical exertion in pregnancy was calculated in 2,743 women.[48] These women were then assigned to one of five groups based on their daily kilocalorie expenditure. Results indicated that women with a medium energy expenditure may experience the best outcomes. The authors concluded that zealous counseling of those who did not exercise and of women who exercised to extreme was not justified.

Exercise Postpartum and Breast Feeding

The physiologic changes that occur in pregnancy resolve during the first 4 to 6 weeks postpartum, and exercise may be resumed in a stepwise fashion. There is no evidence that moderate exercise will compromise lactation or neonatal weight gain.[12,49] Dewey et al[50] found no adverse effect on lactation (P = 0.8), and cardiovascular fitness significantly improved for mothers who performed aerobic exercise four to five times per week beginning 6 to 8 weeks postpartum. Lactation increased caloric requirements, and exercise further increases this requirement in the absence of a weight loss program.

Other Considerations

Nutrition and Pregnancy

The National Research Council developed recommendations for daily intake of iron, vitamins, and other elements for both pregnant and nonpregnant women.[51] Adherence to these guidelines should be helpful in preventing congenital anomalies and promoting optimal fetal growth and development.[52-55]

Caloric requirements during pregnancy are difficult to estimate, but appropriate fat stores are known to be essential for fetal growth and lactation. At least an additional 300 kcal per day is recommended for the second and third trimester. Even more calories are required for the exercising pregnant woman. One study used calorimetry to evaluate 63 healthy women during and after pregnancy for basal metabolic rate, total energy expenditure, and activity energy expenditure according to weight.[56] The weight of the women varied; 17 were underweight, 34 were normal weight, and 12 were overweight. Basal metabolic rate and total energy expenditure increased during pregnancy. Activity energy expenditure decreased slightly. Energy cost changes were found to differ significantly (P = 0.02) per trimester among the three body-mass groups. For example, for a normal-weight woman, increased energy requirement was 32 ± 461 kcal/day in the first trimester, 356 ± 416 kcal/day in the second trimester, and 496 ± 368 kcal/day in the third trimester, whereas in the low-body-mass group, the increases per day by trimester were 137 ± 368 kcal, 163 ± 512 kcal, and 294 ± 602 kcal, respectively.

Drugs and Pregnancy

During pregnancy and lactation, drugs may be required for the exercising mother in response to acute or overuse injury. Judicious use is advisable. Local modalities, such as ice and compressive ice therapy, are helpful adjuncts. Modalities that are contraindicated over or near the gravid uterus include electrotherapy, electric stimulation, low-level laser therapy, shock wave therapy, and ultrasonography. The concern is the function of the uterus and the development of the fetal open physes. Certain pregnancy-associated conditions, such as immune disorders, may demand medications (eg, corticosteroids) that affect the musculoskeletal system (ie, may cause muscle weakness).

Nearly all pharmacologic agents taken by the mother pass through the placenta to the fetus and to breast milk. In 1979, the US Food and Drug Administration (FDA) in-

Table 5

US Food and Drug Administration Pharmaceutical Pregnancy Categories*[57]

Category	Statement
A	No risk to the fetus in adequate and well-controlled studies during the first trimester of pregnancy and no evidence of risk in later trimesters
B	No risk in animal studies, no adequate and well-controlled studies in pregnant women *or* Adverse effect in animal studies, but adequate and well-controlled studies in pregnant women have failed to demonstrate a risk to the fetus in any trimester
C	Adverse effect in animal studies and no adequate and well-controlled studies in humans, but potential benefits may warrant use of the drug in pregnant women despite potential risks
D	Positive evidence of human fetal risk based on adverse-reaction data from investigational or marketing experience or studies in humans, but potential benefits may warrant use of the drug in pregnant women despite potential risks
X	Fetal abnormalities in animals and humans and/or positive evidence of human fetal risk based on adverse-reaction data from investigational or marketing experience. Risks involved in use of the drug in pregnant women clearly outweigh potential benefits

* The categories (A-D, X) were developed in 1979 and have not changed. Category A has the least risk. Each subsequent category has increasing risk, with category X being potentially the most hazardous. Revisions to FDA statements are reflected in the table.

troduced a classification system of the fetal risks resulting from drugs taken during pregnancy.[57] This system serves as a general guide to health care providers regarding the administration of drugs during pregnancy (Table 5). However, the general guideline is that through the 23rd week of pregnancy, benefits of the medication must clearly outweigh the risks to the fetus. Oral acetaminophen in moderation remains the anti-inflammatory agent of choice.

Nonsteroidal Anti-inflammatory Drugs

The use of nonsteroidal anti-inflammatory drugs (NSAIDs) during pregnancy is generally avoided unless the benefits outweigh the risk. Two large epidemiologic studies have suggested an excess of mild cardiac defects to be associated with NSAIDs, primarily largely ventricular and atrial septal defects.[58,59] There was an increased risk of cardiac septal defects (OR, 3.34; 95% CI, 1.87-5.98) in Canadian women who received a prescription for an NSAID during early pregnancy.[47] There is also some information suggesting a link between use of NSAIDs in early pregnancy and midline defects, specifically gastroschisis, but the reports are conflicting.[60] NSAIDs are best avoided in late pregnancy because of their association with premature constriction of the ductus arteriosus.

Cyclooxygenase-2 Inhibitors

Celecoxib, rofecoxib, valdecoxib, and etoricoxib are NSAIDs that selectively inhibit cyclooxygenase-2 (COX-2). These drugs are primarily rated by the FDA as pregnancy category C. The use of the COX-2 inhibitor nimesulide has been associated with irreversible fetal end-stage renal failure[61] and reversible fetal oligohydramnios in a twin pregnancy.[62] The labeling of COX-2 inhibitors as pregnancy category C, and their potential adverse renal effects in the second and third trimesters, dictate that these drugs are best avoided during pregnancy.

Corticosteroids

Corticosteroids are used to manage several conditions that complicate pregnancy, including autoimmune disorders (eg, lupus, rheumatoid arthritis) and asthma. Cortisone, prednisone, and prednisolone have all been used extensively by teratologists as a tool to study the mechanisms by which corticosteroids produce cleft lip and palate in animal studies. Fraser and Sajoo[63] analyzed the literature that evaluated the association between corticosteroid use and congenital defects. They concluded that in humans, the teratogenic potential of corticosteroids is too low to be detected, based on the available data. Because there is a potential for corticosteroid-associated cleft lip and palate in the first trimester of pregnancy, this class of drug should be used only when the benefits clearly outweigh the risk of use. It is best to consult the obstetrician before prescribing corticosteroids, particularly for the patient with a nonchronic musculoskeletal condition.

Anesthesia

Maintaining blood flow and oxygenation are primary concerns in using anesthesia. During the administration of anesthesia (ie, local, conduction, general), the health care provider must always be vigilant to ensure that the uterus is displaced off the vena cava and aorta, particularly during cesarean delivery and labor. Use of epinephrine with other agents for pain relief in pregnant women is controversial because of concern that it will increase uterine activity and decrease uterine blood flow. During

Table 6

Examples of Safe Activity During Pregnancy

Goal	Type or Condition	Activity
Improve or maintain overall fitness	Impact	Walking, jogging, running
	Low-impact	Bicycling (seated, recumbent, semirecumbent), elliptical trainer, cross-country ski machine, rowing machine, climbing machine, upper extremity cycle
	Aquatic	Swimming, water aerobics
	Stretching	Arm and shoulder stretch, Achilles/calf stretch, hamstring stretch
	Balance	Tai chi, yoga, modified squat (mini-squat)
	Resistive	Aerobic weight training, light weights in upright or seated position
Adapt to pregnancy and assist with delivery	Core exercises (back and abdomen)	Abdominal curl and abdominal crunches in the first trimester, modified squat
	Stretching	Low back and hamstring, tailor/cobbler position and tailor press
	Pelvic floor, buttock, and abdominal strengthening	Kegel exercises, pelvic tilt, lateral bends
Prevent or lessen extent of pregnancy-related conditions	Diuresis	Aquatic exercise
	Low back pain	Aquatic exercise
	Gestational diabetes, hypertension, excessive weight gain	Any submaximal exercise three to four times a week for ≥15 minutes

any procedure in a pregnant woman, irrespective of the type of anesthesia, it is essential to maintain oxygenation. Pregnant patients have a decreased residual capacity and a greater likelihood than do nonpregnant females to rapidly become hypoxemic, particularly as the pregnancy progresses.

Exercise Prescription

Recommendations to the pregnant patient for activity and exercise should emphasize safety for the mother and fetus and promote fitness. Optimal activities are those that are interesting to the patient, easily incorporated into a routine, and most likely to be continued postpartum. Submaximal exercise at least three times a week for ≥15 minutes is the minimum goal,[4] increasing to at least four times a week for 30 minutes. Most pregnant women in the United States do not meet this goal. Nonpregnant women were most likely to meet activity recommendations;[64] many pregnant women do not meet basic physical activity recommendations.[64,65] A telephone survey of 1,979 pregnant and 44,657 nonpregnant women aged 18 to 44 years found that walking was the most common form of exercise for both groups.[64,65] Walking is also medically recommended by consensus and was a preferred activity by pregnant women.[65] It is a relatively safe activity, is easy to monitor, and does not require special equipment or a gym. Other forms of reported activity were swimming laps, weight lifting, gardening, and aerobics.[65]

Devising a safe exercise program based on the published literature is difficult because of biases and lack of uniformity in study design (eg, different baseline fitness levels, different types of exercise, predominance of Caucasian upper- and middle-class women).[41,66] However, the overall health benefit of exercise has been well-documented, and there are enough data for a generalized exercise prescription.

Duration, Frequency, and Type

A regular submaximal exercise regimen of 30 minutes a day on most days is advised. Sedentary women may safely begin an exercise program during pregnancy and should be encouraged to continue after delivery. Many types of physical activity may be prescribed during pregnancy, including jogging, aerobic weight training, and yoga (Table 6).

One recent study measured respiratory gas exchange and heart rate in 30 pregnant women doing four household tasks.[67] Laundry was moderate-intensity, and dusting, vacuuming, and window washing were light activities. The Society of Obstetricians and Gynaecologists of Canada and the Canadian Society for Exercise Physiology recommend 15 minutes of continuous exercise three times a week, increasing to 30 min-

utes four times a week, for pregnant women.[4]

Goals

Consideration should be given to improving overall fitness and to activities that decrease the severity or incidence of disorders associated with pregnancy, such as low back pain, lumbopelvic pain, and peripheral edema. Several studies have shown the effectiveness of exercise in alleviating these symptoms. In a multicenter randomized controlled trial of 390 pregnant women, participation in water aerobics resulted in less sick leave as a result of low back pain (P = 0.03) and less low back pain (P = 0.04) compared with land exercise.[42] In another study, 148 women prescribed a daily program of pelvic floor exercises (8 to 12 contractions/day) and weekly group aerobic exercises for up to 60 minutes (15 to 20 minutes, low impact; 30 to 35 minutes, strength training of pelvic floor, core, and extremity muscles; and 5 to 10 minutes, light stretching) compared with a control group of 153 women given general information.[68] In this randomized controlled trial, the training occurred between 20 and 36 weeks of pregnancy. After 12 weeks, there was a significant decrease in reported low back pain in the exercise-intervention group (P = 0.03). Age, body mass index, and leisure-time physical activity did not affect the results, and there was no difference in sick leave between the cohorts. For pregnant patients with edema, particularly in the lower extremities, the diuretic effect of water-immersion activity, including swimming and water aerobics, may offer relief.[30,32]

Summary

Many women are already engaged in exercise at the onset of pregnancy, and others initiate an exercise regimen after becoming pregnant. Many physiologic changes take place when a woman becomes pregnant. Although these changes do not prevent women from continuing to exercise during pregnancy, careful consideration is required when making recommendations about the type and intensity of an exercise program. Obstetrics and gynecology governing bodies around the world encourage exercise. Carefully structured exercise programs are associated with low risk, but none is without risk. Core body temperature elevation and the overall effects of exercise on maternal complications of pregnancy and perinatal outcomes are minimal. Exercise programs may be continued postpartum, including with breast feeding. The benefits of exercise are improved psychological and physical well-being. However, more studies are required to better understand the effect of exercise on the pregnant female and the fetus.

Acknowledgment

The authors would like to thank June Brockman for her assistance in the preparation of this manuscript.

References

Evidence-based Medicine: Levels of evidence are described in the table of contents. References 8, 27, 42, 47, 49, 65, 66, and 68, below, are level I studies. References 9, 11, 26, 28, 46, 48, 56, 58, and 65 are level II studies; references 19, 43, and 60 are level II/III. References 1, 5, 7, 10, 13-15, 18, 25, 32, 37, 53, 55, 59, and 66 are level III studies. References 2, 24, 31, 33, 35, 36, 38, 44, 45, 54, 61-64, and 67 are level IV studies. References 3, 4, 6, 12, 16, 17, 21-23, 29, 30, 39-41, 51, 52, and 57 are expert opinion.

Citation numbers printed in **bold type** indicate references published within the past 5 years.

1. Kristiansson P, Svärdsudd K, von Schoultz B: Serum relaxin, symphyseal pain, and back pain during pregnancy. *Am J Obstet Gynecol* 1996;175:1342-1347.
2. Young J: Relaxation of the pelvic joints in pregnancy: Pelvic arthropathy of pregnancy. *J Obstet Gynaecol Br Emp* 1940;47:493-524.
3. Ritchie JR: Orthopedic considerations during pregnancy. *Clin Obstet Gynecol* 2003;46:456-466.
4. Wolfe LA, Davies GA, School of Physical and Health Education, Department of Obstetrics and Gynaecology and Physiology, Queen's University, Kingston, Ontario, Canada: Canadian guidelines for exercise in pregnancy. *Clin Obstet Gynecol* 2003;46:488-495.
5. Torgersen KL, Curran CA: A systematic approach to the physiologic adaptations of pregnancy. *Crit Care Nurs Q* 2006; 29:2-19.
6. Impact of physical activity during pregnancy and postpartum on chronic disease risk. *Med Sci Sports Exerc* 2006; 38:989-1006.
7. Avery MD, Walker AJ: Acute effect of exercise on blood glucose and insulin levels in women with gestational diabetes. *J Matern Fetal Med* 2001;10: 52-58.
8. Marquez-Sterling S, Perry AC, Kaplan TA, Halberstein RA, Signorile JF: Physical and psychological changes with vigorous exercise in sedentary primigravidae. *Med Sci Sports Exerc* 2000;32:58-62.
9. McCann IL, Holmes DS: Influence of aerobic exercise on depression. *J Pers Soc Psychol* 1984;46:1142-1147.
10. Morris SN, Johnson NR: Exercise during pregnancy: A critical appraisal of the literature. *J Reprod Med* 2005;50:181-188.
11. Wallace AM, Boyer DB, Dan A, Holm K: Aerobic exercise, maternal self-esteem, and physical discomforts during pregnancy. *J Nurse Midwifery* 1986;31: 255-262.
12. Davies GA, Wolfe LA, Mottola MF, et al: Exercise in pregnancy and the postpartum period. *J Obstet Gynaecol Can* 2003;25:516-529.
13. Marcoux S, Brisson J, Fabia J: The effect of leisure time physical activity on the risk of pre-eclampsia and gestational hypertension. *J Epidemiol Community Health* 1989;43:147-152.

14. Saftlas AF, Logsden-Sackett N, Wang W, Woolson R, Bracken MB: Work, leisure-time physical activity, and risk of preeclampsia and gestational hypertension. *Am J Epidemiol* 2004;160: 758-765.

15. Sorensen TK, Williams MA, Lee IM, Dashow EE, Thompson ML, Luthy DA: Recreational physical activity during pregnancy and risk of preeclampsia. *Hypertension* 2003;41:1273-1280.

16. American College of Obstetricians and Gynecologists Committee on Practice Bulletins–Obstetrics: ACOG Practice Bulletin: Clinical management guidelines for obstetrician-gynecologists. Number 30, September 2001 (replaces Technical Bulletin Number 200, December 1994). Gestational diabetes. *Obstet Gynecol* 2001;98:525-538.

17. Carpenter MW: The role of exercise in pregnant women with diabetes mellitus. *Clin Obstet Gynecol* 2000;43:56-64.

18. Dempsey JC, Butler CL, Williams MA: No need for a pregnant pause: Physical activity may reduce the occurrence of gestational diabetes mellitus and preeclampsia. *Exerc Sport Sci Review* 2005;33:141-149.

19. Ceysens G, Rouiller D, Boulvain M: Exercise for diabetic pregnant women. *Cochrane Database Syst Rev* 2006;3: CD004225.

20. O'Sullivan JB: Subsequent morbidity among gestational diabetic women, in Sutherland HW, Stowers JM, eds: *Carbohydrate Metabolism in Pregnancy and the Newborn.* New York, NY, Churchill Livingstone, 1984, pp 174-180.

21. ACOG Committee Obstetric Practice: ACOG Committee opinion: Number 267, January 2002. Exercise during pregnancy and the postpartum period. *Obstet Gynecol* 2002;99:171-173.

22. Royal College of Obstetricians and Gynaecologists: RCOG Statement No. 4: Exercise in pregnancy. Royal College of Obstetricians and Gynaecologists, January 1, 2006. Available at: http://www.rcog.org.uk/womens-health/clinical-guidance/exercise-pregnancy. Accessed April 20, 2009.

23. SMA statement the benefits and risks of exercise during pregnancy: Sport Medicine Australia. *J Sci Med Sport* 2002;5:11-19.

24. Lynch AM, McDonald S, Magann EF, et al: Effectiveness and safety of a structured swimming program in previously sedentary women during pregnancy. *J Matern Fetal Neonatal Med* 2003;14:163-169.

25. Davies B, Daggett A: Responses of adult women to programmed exercise. *Br J Sports Med* 1977;11:122-126.

26. Magann EF, Evans SF, Weitz B, Newnham J: Antepartum, intrapartum, and neonatal significance of exercise on healthy low-risk pregnant working women. *Obstet Gynecol* 2002;99:466-472.

27. Santos IA, Stein R, Fuchs SC, et al: Aerobic exercise and submaximal functional capacity in overweight pregnant women: A randomized trial. *Obstet Gynecol* 2005;106:243-249.

28. Kardel KR: Effects of intense training during and after pregnancy in top-level athletes. *Scand J Med Sci Sports* 2005; 15:79-86.

29. Carpenter MW, Sady SP, Hoegsberg B, et al: Fetal heart rate response to maternal exertion. *JAMA* 1988;259: 3006-3009.

30. Katz VL: Water exercise in pregnancy. *Semin Perinatol* 1996;20:285-291.

31. Watson WJ, Katz VL, Hackney AC, Gall MM, McMurray RG: Fetal responses to maximal swimming and cycling exercise during pregnancy. *Obstet Gynecol* 1991; 77:382-386.

32. Katz VL: Exercise in water during pregnancy. *Clin Obstet Gynecol* 2003; 46:432-441.

33. Milunsky A, Ulcickas M, Rothman KJ, Willett W, Jick SS, Jick H: Maternal heat exposure and neural tube defects. *JAMA* 1992;268:882-885.

34. Moretti ME, Bar-Oz B, Fried S, Koren G: Maternal hyperthermia and the risk for neural tube defects in offspring: Systematic review and meta-analysis. *Epidemiology* 2005;16:216-219.

35. Clapp JF III, Wesley M, Sleamaker RH: Thermoregulatory and metabolic responses to jogging prior to and during pregnancy. *Med Sci Sports Exerc* 1987; 19:124-130.

36. Clapp JF III: The changing thermal response to endurance exercise during pregnancy. *Am J Obstet Gynecol* 1991; 165(6 pt 1):1684-1689.

37. O'Neill ME, Cooper KA, Boyce ES, Hunyor SN: Postural effects when cycling in late pregnancy. *Women Birth* 2006;19:107-111.

38. St Leger Dowse M, Gunby A, Moncad R, Fife C, Bryson P: Scuba diving and pregnancy: Can we determine safe limits? *J Obstet Gynaecol* 2006;26:509-513.

39. Stirrat GM: Recurrent miscarriage. *Lancet* 1990;336:673-675.

40. Stirrat GM: Recurrent miscarriage: II. Clinical associations, causes, and management. *Lancet* 1990;336:728-733.

41. Pivarnik JM, Perkins CD, Moyerbrailean T: Athletes and pregnancy. *Clin Obstet Gynecol* 2003;46:403-414.

42. Granath AB, Hellgren MS, Gunnarsson RK: Water aerobics reduces sick leave due to low back pain during pregnancy. *J Obstet Gynecol Neonatal Nurs* 2006; 35:465-471.

43. Kramer MS, McDonald SW: Aerobic exercise for women during pregnancy. *Cochrane Database Syst Rev* 2006;3: CD000180.

44. Klebanoff MA, Shiono PH, Carey JC: The effect of physical activity during pregnancy on preterm delivery and birth weight. *Am J Obstet Gynecol* 1990; 163(5 pt 1):1450-1456.

45. Clapp JF III, Dickstein S: Endurance exercise and pregnancy outcome. *Med Sci Sports Exerc* 1984;16:556-562.

46. Clapp JF III: The course of labor after endurance exercise during pregnancy. *Am J Obstet Gynecol* 1990;163(6 pt 1):1799-1805.

47. Clapp JF III, Kim H, Burciu B, Schmidt S, Petry K, Lopez B: Continuing regular exercise during pregnancy: Effect of exercise volume on fetoplacental growth. *Am J Obstet Gynecol* 2002;186:142-147.

48. Magann EF, Evans SF, Newnham JP: Employment, exertion, and pregnancy outcome: Assessment by kilocalories expended each day. *Am J Obstet Gynecol* 1996;175:182-187.

49. McCrory MA, Nommsen-Rivers LA, Molé PA, Lönnerdal B, Dewey KJ: Randomized trial of the short-term effects of dieting compared with dieting plus aerobic exercise on lactation performance. *Am J Clin Nutr* 1999;69: 959-967.

50. Dewey KG, Lovelady CA, Nommsen-Rivers LA, McCrory MA, Lönnerdal B: A randomized study of the effects of aerobic exercise by lactating women on breast-milk volume and composition. *N Engl J Med* 1994;330:449-453.

51. Subcommittee on the Tenth Edition of the RDAs, Food and Nutrition Board, Commission on Life Sciences, National Research Council: *Recommended Dietary Allowances*, ed 10. Washington, DC, National Academies Press, 1989.

52. Nelson M: Vitamin A, liver consumption, and risk of birth defects. *BMJ* 1990;301:1176.

53. Rosa FW, Wilk AL, Kelsey FO: Teratogen update: Vitamin A congeners. *Teratology* 1986;33:355-364.

54. Marx SJ, Swart EG Jr, Hamstra AJ, DeLuca HF: Normal intrauterine development of the fetus of a woman receiving extraordinarily high doses of

1,25-dihydroxyvitamin D3. *J Clin Endocrinol Metab* 1980;51:1138-1142.

55. Tran T, Wax JR, Philput C, Steinfeld JD, Ingardia CJ: Intentional iron overdose in pregnancy: Management and outcome. *J Emerg Med* 2000;18:225-228.

56. Butte NF, Wong WW, Treuth MS, Ellis KJ, O'Brian Smith E: Energy requirements during pregnancy based on total energy expenditure and energy deposition. *Am J Clin Nutr* 2004;79: 1078-1087.

57. US Food and Drug Administration: Labelling and prescription drug advertising: Content and format for labeling for human prescription drugs. *Fed Regist* 1979;44:37434-37467.

58. Ericson A, Källén BA: Nonsteroidal anti-inflammatory drugs in early pregnancy. *Reprod Toxicol* 2001;15:371-375.

59. Ofori B, Oraichi D, Blais L, Rey E, Bérard A: Risk of congenital anomalies in pregnant users of non-steroidal anti-inflammatory drugs: A nested case-control study. *Birth Defects Res B Dev Reprod Toxicol* 2006;77:268-279.

60. James AH, Brancazio LR, Price T: Aspirin and reproductive outcomes. *Obstet Gynecol Surv* 2008;63:49-57.

61. Peruzzi L, Gianoglio B, Porcellini MG, Coppo R: Neonatal end-stage renal failure associated with maternal ingestion of cyclo-oxygenase-type-1 selective inhibitor nimesulide as tocolytic. *Lancet* 1999;354:1615.

62. Holmes RP, Stone PR: Severe oligohydramnios induced by cyclooxygenase-2 inhibitor nimesulide. *Obstet Gynecol* 2000;96(5 pt 2):810-811.

63. Fraser FC, Sajoo A: Teratogenic potential of corticosteroids in humans. *Teratology* 1995;51:45-46.

64. Petersen AM, Leet TL, Brownson RC: Correlates of physical activity among pregnant women in the United States. *Med Sci Sports Exerc* 2005;37:1748-1753.

65. Evenson KR, Savitz DA, Huston SL: Leisure-time physical activity among pregnant women in the US. *Paediatr Perinat Epidemiol* 2004;18:400-407.

66. Wolfe LA, Weissgerber TL: Clinical physiology of exercise in pregnancy: A literature review. *J Obstet Gynaecol Can* 2003;25:473-483.

67. Chasan-Taber L, Freedson PS, Roberts DE, Schmidt MD, Fragala MS: Energy expenditure of selected household activities during pregnancy. *Res Q Exerc Sport* 2007;78:133-137.

68. Mørkved S, Salvesen KA, Schei B, Lydersen S, Bø K: Does group training during pregnancy prevent lumbopelvic pain? A randomized clinical trial. *Acta Obstet Gynecol Scand* 2007;86:276-282.