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About The Author

Sabrena Merrill, M.S., has been actively involved in the fitness industry since 1987. An ACE-certified Group Fitness Instructor and Personal Trainer, Merrill teaches group exercise, owns and operates her own personal training business, has managed fitness departments in commercial facilities, and lectured to university students and established fitness professionals. She has a bachelor's degree in exercise science as well as a master's degree in physical education from the University of Kansas, and has numerous certifications in exercise instruction. Merrill acts as a spokesperson for the American Council on Exercise (ACE) and is involved in curriculum development for ACE continuing education programs. Additionally, Merrill presents lectures and workshops to fitness professionals nationwide.

Pre- and Postnatal Exercise

Sabrena Merrill

An increasing amount of research on exercise in pregnancy has led to a waning debate over the maternal and fetal risks of regular physical activity during pregnancy. There is a growing trend of women entering pregnancy with regular aerobic and strength-conditioning activities as a part of their daily routines. Many women who are not physically active view pregnancy as a time to modify their lifestyles to include more health-conscious activities, including exercise.

Traditionally, the medical community has encouraged pregnant women to reduce their habitual levels of physical exertion and refrain from starting strenuous exercise programs. These restrictive guidelines were based on concerns that exercise could negatively affect pregnancy outcomes by increasing core body temperature, raising the risk of congenital anomalies, and shifting oxygenated blood and nutrients to maternal skeletal muscles—and away from the fetus [American College of Obstetricians and Gynecologists (ACOG), 1985; Shangold, 1989]. More recent investigations, however, focusing on both aerobic training and strength conditioning in pregnancy, have shown no increase in early pregnancy loss, late pregnancy complications, abnormal fetal growth, or adverse neonatal outcomes, suggesting that previous recommendations have been overly conservative (Clapp, 1989; Klebanoff et al., 1990; Hatch et al., 1993; Kardel et al., 1998; Sternfeld et al., 1995; O'Neill, 1996).

While prenatal exercise recommendations from allied healthcare professionals are becoming more commonplace, the majority of women do not get the recommended minimum amount of daily physical activity. It is estimated that only 42% of pregnant women exercise 30 minutes or more at least three times a week, and 23% of healthy, previously active women stop exercise or reduce it significantly during

pregnancy (Zhang & Savits, 1996; Ning et al., 2003). Given the current epidemic of obesity and its associated comorbidities, as well as the apparent health risks of not exercising, fitness professionals who are competent to work with this population can provide safe and effective exercise programming to promote a healthy pregnancy and healthy lifestyle after the birth.

Benefits and Risks of Exercise During Pregnancy

Evidence is increasing that regular prenatal exercise is an important component of a healthy pregnancy. Expectant mothers can maintain or even improve cardiovascular and muscular fitness. Additionally, regular exercise is associated with a lower incidence of excessive maternal weight gain, **gestational diabetes mellitus (GDM)**, pregnancy-induced **hypertension**, varicose veins, **deep vein thrombosis**, **dyspnea**, and low-back pain (Davies et al., 2003; Weissgerber et al., 2006). Furthermore, it has been shown that women who continue regular, weightbearing exercise throughout the entire duration of pregnancy tend to have easier, shorter, and less complicated deliveries (Clapp, 2002).

Maternal Fitness

Healthy women who consistently exercise throughout pregnancy show a marked reduction in weight gain, fat accumulation, and fat retention. In one study, pregnant exercisers had average increases in weight (29 pounds; 13 kg) and skin-fold thicknesses (10 mm) well within the normal range, but their body-fat mass averaged 3% lower than the control subjects who performed no exercise during pregnancy (Clapp & Little, 1995). In other words, the women who performed regular weightbearing exercise throughout their pregnancies maintained a leaner **body composition** than their **sedentary** counterparts.

Due to the many physiological adaptations that occur during pregnancy, women who continue moderate-to-high levels of endurance exercise can experience an increase in their **maximal aerobic capacity** by up to 10% postpartum, even though exercise volume is typically reduced by the added responsibility of childcare (Clapp & Capeless, 1991). Furthermore, improvements in aerobic efficiency, but not necessarily $\dot{V}O_2\text{max}$, are seen in women who begin a low-volume exercise program (moderate intensity for 20 minutes, three to five days per week) during pregnancy (Clapp, 2002).

Gestational Diabetes

Glucose intolerance that is first recognized or diagnosed during pregnancy is called gestational diabetes. Maternal muscular insulin resistance during mid-pregnancy is a normal response to hormonal adaptations that occur to ensure adequate glucose regulation for fetal growth and development. In women with GDM, this insulin increase is exacerbated, resulting in maternal **hyperglycemia**. Women with GDM are more likely to have complications such as a difficult labor and delivery, as well as delivery by Caesarean section (C-section).

Risk factors for GDM include a family history of diabetes, previous diagnosis of GDM, belonging to a high-risk ethnic group (Aboriginal, Hispanic, South Asian, Asian, or African descent), age ≥ 35 years, overweight [**body mass index (BMI)** ≥ 25], obesity (BMI ≥ 30), or a history of insulin resistance (ACOG, 2001). Once diagnosed, GDM patients are primarily treated through nutritional management by a registered dietician (R.D.). Exercise is

considered an adjunct therapy for women with GDM. Preliminary studies have found that women who participated in any type of recreational activity within the first 20 weeks of gestation decreased their risk of GDM by almost half (Dempsey et al., 2004). Research has shown that even mild exercise (30% of $\dot{V}O_2\text{max}$, regardless of modality) combined with nutritional control can help prevent GDM and excessive weight gain during pregnancy (Batada et al., 2003).

Preeclampsia

A serious maternal-fetal disease called **preeclampsia** is diagnosed after 20 weeks of gestation and characterized by persistent hypertension ($> 140/90$ mm/Hg) and **proteinuria** (24-hour urinary protein level ≥ 0.3 g) (ACOG, 2002a). Complications associated with preeclampsia include preterm birth, **abruptio placentae**, renal failure, pulmonary **edema**, cerebral hemorrhage, circulatory collapse, **eclampsia**, and the necessity for immediate delivery regardless of gestational age. Risk factors for preeclampsia include abnormal placental development, predisposing maternal constitutional factors, oxidative stress, immune maladaptation, and genetic susceptibility.

A review of the literature examining physical activity and preeclampsia risk reveals several epidemiological studies that indicate that regular leisure-time physical activity in early pregnancy is associated with a reduced incidence of preeclampsia (Weissgerber et al., 2004). Although not proven, several protective mechanisms associated with exercise are thought to play a role in preeclampsia prevention, including enhanced placental growth and vascularity, enhanced antioxidant defense systems, reduction of the systemic inflammatory response, and improved endothelial function (Weissgerber et al., 2006).

Traditional treatment of gestational hypertension and mild preeclampsia has focused on bed rest to prevent blood pressure increases associated with daily activity. However, up to one-third of women fail to comply with bed rest recommendations, and compliance does not affect pregnancy outcome in women who develop mild preeclampsia in the latter part of gestation (Magee, Ornstein, & von Dadelszen, 1999). More recent treatment

guidelines for hypertension and mild preeclampsia have shifted toward ambulatory management with careful patient monitoring (Lenfant, 2001; Moutquin et al., 1997). Exercise intervention studies in women with gestational hypertension and preeclampsia are inconclusive, and it remains unclear whether a program of regular exercise can positively affect this population. Exercise in women with high-risk pregnancy conditions, such as preeclampsia, should be closely monitored and supervised by their physicians in a clinical setting, as these situations are outside the **scope of practice** for an ACE-certified Advanced Health & Fitness Specialist (ACE-AHFS).

Maternal Obesity

In the U.S., the percentage of women of child-bearing age (20 to 39 years) who are overweight has climbed to 49% among white women and 70% among African-American women (Okosun et al., 2004). Obesity-related reproductive complications that occur before, during, and after pregnancy may be reduced through lifestyle interventions such as regular aerobic exercise.

Ovulatory infertility increases progressively with increasing BMI, as do the risks for polycystic ovarian syndrome and menstrual irregularities. The effectiveness of regular aerobic exercise (three hours per week) and educational seminars (one hour per week on weight-related topics) on restoring fertility in obese women was demonstrated by a six-month lifestyle intervention study (Clark et al., 1998). The subjects who completed the intervention lost an average of 10.2 4.3 kg (22.4 9.5 lb). Prior to the study, all subjects had been infertile for at least two years; however, 77% of the subjects conceived successfully during or after the lifestyle intervention. The authors hypothesized that improved fertility resulted from the beneficial effects of reduced insulin resistance and lower insulin concentrations on reproductive hormone profiles.

During pregnancy, the risk of maternal and fetal complications increases with the degree of obesity. The incidence of preeclampsia and GDM increase progressively in overweight and obese women. Additionally, overweight and obese women are more likely to deliver large-for-gestational-age infants and require C-section and instrumental

delivery. Exercise performed before conception and during pregnancy may help to prevent these obesity-related complications by decreasing BMI to a healthy range, preventing GDM and preeclampsia, and reducing the likelihood of excessive gestational weight gain. Prenatal exercise also has been associated with a timely return to pre-pregnancy weight after delivery (Rooney & Schauburger, 2002).

Maternal Exercise and the Fetal Response

In uncomplicated pregnancies, fetal injuries are highly unlikely, as most of the potential fetal risks are hypothetical. However, there are several areas of theoretical concern surrounding maternal exercise and its effects on the fetus. First, the selective redistribution of blood flow away from the fetus during regular or prolonged exercise in pregnancy may interfere with the transplacental transport of oxygen, carbon dioxide, and nutrients. To address this concern, many experts recommend aquatic exercise as an excellent choice of aerobic training during pregnancy. During immersion, women experience a smaller decrease in plasma volume as compared to exercising on land. In addition, as a result of the hydrostatic pressure in aquatic exercise, maintenance of blood flow around the central organs may provide better maintenance of uterine and placental blood flow (Watson et al., 1991).

A second concern is that during exercise, transient **hypoxia** could result in fetal **tachycardia** and an increase in fetal blood pressure. These fetal responses are protective mechanisms that occur during obstetric events and allow the fetus to facilitate the transfer of oxygen and decrease the carbon dioxide tension across the **placenta**. However, there are no reports to link such adverse events with maternal exercise. A majority of studies examining fetal responses to exercise monitored fetal heart rate as an indicator of fetal stress (Collings, Curet, & Mullin, 1983; Clapp, 1985; Artal, 1990; Carpenter et al., 1988; Wolfe et al., 1988). Most of these studies show a minimum or moderate increase in fetal heart rate by 10 to 30 beats per minute over baseline during or after maternal exercise. Fetal heart rate decelerations and **bradycardia**, with a frequency of 8.9%, have

also been reported to occur during maternal exercise. The causes of the alterations in fetal heart rate during maternal exercise are still unclear, and no associated lasting effects on the fetus have been reported.

A third concern is intrauterine growth restriction due to strenuous physical activity. Studies on the effect of exercise during pregnancy and resultant birth weights are inconclusive. Epidemiological studies have shown a link between strenuous physical activity, poor diet, and low birth weight. It has also been reported that mothers who perform strenuous physical work in their occupations, such as repetitive lifting, have a tendency to deliver earlier and have small-for-gestational-age infants (Naeye & Peters, 1982; Launer et al., 1990; McDonald et al., 1988). However, other studies have provided conflicting data suggesting that other variables, such as inefficient nutrition, have to be present for strenuous activities to affect fetal growth (Saurel-Cubizolles & Kaminski, 1987; Ahlborg Bodin, & Hogstedt, 1990). Overall, it appears that birth weight is not affected by exercise in women who have adequate energy intake.

Contraindications and Risk Factors

Research from the past several decades has produced valid and reliable evidence that supports participation in a regular exercise program during pregnancy because of the important maternal-fetal benefits it provides. In fact, the available studies show that adverse pregnancy or neonatal outcomes are not increased for exercising women (Clapp, 1989; Hall & Kaufmann, 1987; Hatch et al., 1993; Klebanoff et al., 1990; Kulpa, White, & Visscher, 1987). ACOG, the American College of Sports Medicine (ACSM), the Canadian Society for Exercise Physiology (CSEP), and the Society of Obstetricians and Gynaecologists of Canada (SOGC) all provided guidelines and recommendations for exercise during pregnancy and the postpartum period that indicate that, in uncomplicated pregnancies, women with or without a previously sedentary lifestyle should be encouraged to participate in aerobic and strength-conditioning exercises as part of a healthy lifestyle (ACSM, 2010; ACOG, 2002b; SOGC & CSEP,

2003). However, it is recommended that women with complicated pregnancies be discouraged from participating in exercise activities for fear of impacting the underlying disorder or maternal or fetal outcomes.

ACOG has established that there are some women for whom exercise during pregnancy is absolutely contraindicated (Table 23-1), while for other women the potential benefits of exercising may outweigh the risks (Table 23-2). Furthermore, fitness professionals and pregnant exercisers should familiarize themselves with specific signs or symptoms that may indicate a problem, including those items listed in Tables 23-3 and 23-4. It is imperative that an ACE-AHFS perform routine health screenings on all clients and require a physician's clearance before initiating an exercise program with a pregnant or postpartum woman.

In general, participation in a wide range of recreational activities appears safe during and after pregnancy. Overly vigorous activity in the third trimester, activities that have a high potential for contact, and activities with a high risk of falling should be avoided (Table 23-5). Additionally, women should refrain from activities with a risk of abdominal trauma, exertion at altitude greater than 6000 feet (1829 m), and scuba diving (ACOG, 2002b).

Table 23-1
Absolute Contraindications to
Aerobic Exercise During Pregnancy

- Hemodynamically significant heart disease
- Restrictive lung disease
- Incompetent cervix/cerclage
- Multiple gestation at risk for premature labor
- Persistent second- or third-trimester bleeding
- Placenta previa after 26 weeks of gestation
- Premature labor during the current pregnancy
- Ruptured membranes
- Preeclampsia/pregnancy-induced hypertension

Source: American College of Obstetricians and Gynecologists (2002). Exercise during pregnancy and the postpartum period. ACOG Committee Opinion No. 267. *Obstetrics and Gynecology*, 99, 171–173.

Table 23-2
Relative Contraindications to
Aerobic Exercise During Pregnancy

- Severe anemia
- Unevaluated maternal cardiac arrhythmia
- Chronic bronchitis
- Poorly controlled type 1 diabetes
- Extreme morbid obesity
- Extreme underweight (BMI <12)
- History of extremely sedentary lifestyle
- Intrauterine growth restriction in current pregnancy
- Poorly controlled hypertension
- Orthopedic limitations
- Poorly controlled seizure disorder
- Poorly controlled hyperthyroidism
- Heavy smoker

Source: American College of Obstetricians and Gynecologists (2002). Exercise during pregnancy and the postpartum period. ACOG Committee Opinion No. 267. *Obstetrics and Gynecology*, 99, 171–173.

Table 23-3
Reasons to Discontinue
Exercise and Seek Medical Advice

- Any sign of bloody discharge from the vagina
- Any “gush” of fluid from the vagina (premature rupture of membranes)
- Sudden swelling of the ankles, hands, or face (possible preeclampsia)
- Persistent, severe headaches and/or visual disturbances (possible hypertension)
- Unexplained spell of faintness or dizziness
- Swelling, pain, and redness in the calf of one leg (possible phlebitis)
- Excessive fatigue, palpitations, or chest pain
- Persistent contractions (more than six to eight per hour) that may suggest onset of premature labor

Source: American College of Sports Medicine (2010). *ACSM's Guidelines for Exercise Testing and Prescription* (8th ed.). Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins.

Table 23-4
Warning Signs to Cease
Exercise While Pregnant

- Vaginal bleeding
- Dyspnea prior to exertion
- Dizziness
- Headache
- Chest pain
- Muscle weakness
- Calf pain or swelling (need to rule out thrombophlebitis)
- Preterm labor
- Decreased fetal movement
- Amniotic fluid leakage

Source: American College of Obstetricians and Gynecologists (2002). Exercise during pregnancy and the postpartum period. ACOG Committee Opinion No. 267. *Obstetrics and Gynecology*, 99, 171–173.

Table 23-5
High-risk Exercises

- Snow- and waterskiing
- Rock climbing
- Snowboarding
- Diving
- Scuba diving
- Bungee jumping
- Horseback riding
- Ice skating/hockey
- Road or mountain cycling
- Vigorous exercise at altitude (non-acclimated women)

Note: Risk of activities requiring balance is relative to maternal weight gain and morphologic changes; some activities may be acceptable early in pregnancy but risky later on.

Physiological Changes During Pregnancy

During pregnancy, a woman's endocrine system signals changes in virtually every part of her body to prepare her and the fetus for gestation, delivery, and lactation. This section covers the adaptations related to exercise performance. Understanding these factors and how they impact a woman's ability to engage in prenatal physical activity is essential for safe and effective exercise programming.

Musculoskeletal System

With the average weight gain during pregnancy in the range of 25 to 40 pounds (11 to 18 kg) (15 to 25% of pre-pregnancy weight), forces across joints are significantly increased. Such large forces may cause discomfort to normal joints and increase damage to arthritic or previously unstable joints. A woman's enlarging abdomen increases the mechanical stress on the joints of the back, pelvis, hips, and legs as her **center of gravity** moves upward and out. Because of these anatomical changes, pregnant women report a high incidence of low-back pain (up to 76%). (Brynhildsen, 1998; Kristiansson, Svardsudd, & von Schoultz, 1996).

During the first trimester, increased amounts of the hormones **relaxin** and **progesterone** are released to expand the uterine cavity. These hormones allow expansion by softening the ligaments surrounding the joints of the pelvis (hips and lumbosacral spine), thereby increasing mobility and joint laxity. Whether or not joint laxity occurs in other joints, such as the neck, shoulder, or periphery, is unclear. Theoretically, increased mechanical stress combined with joint laxity would predispose pregnant women to increased incidence of strains and sprains. However, with the exception of the reporting of low-back pain, data on the effects of increased weight of pregnancy on joint injury and pathology are lacking. While an increased incidence of falling during pregnancy has not been reported, a woman's balance may be affected by changes in posture, predisposing her to loss of balance and increased risk of falling. Despite a lack of clear evidence that musculoskeletal injuries are increased during pregnancy, these possibilities should be considered when designing prenatal exercise programs.

Cardiovascular System

During pregnancy, the entire cardiovascular system experiences dramatic changes as hormonal signals initiate relaxation and reduced responsiveness in most, if not all, of the smooth muscle cells in a woman's blood vessels. In addition to causing many of the unpleasant early symptoms of pregnancy (e.g., lightheadedness,

nausea, fatigue, cravings, constipation, bloating, and frequent urination), these hormonal changes result in an increase in the elasticity and volume of the entire circulatory system (i.e., a decrease in systemic vascular resistance). Initially, this creates a vascular "underfill" problem where the amount of blood returning to the heart decreases. To correct the underfill, the body triggers the release of several hormones, which cause a decrease in the excretion of salt and water by the kidneys. Ultimately, the retained extra salt and water expand plasma volume, allowing more venous return to the heart, thereby increasing cardiac output and improving arterial pressure and blood flow to the organs. Eventually, hormonal signals cause increases in heart volumes (chamber volume and **stroke volume**), blood volume, **heart rate**, and **cardiac output**.

By mid-pregnancy, cardiac outputs are 30 to 50% greater than before pregnancy (Morton, 1991). Additionally, maternal stroke volume increases by 10% by the end of the first trimester, and is followed by a 20% increase in heart rate during the second and third trimesters (Pivranik, 1996; Morton et al., 1985). Maternal resting heart rate can be up to 15 beats per minute higher than pre-pregnancy rates near the third trimester. Mean arterial pressure decreases 5 to 10 mmHg by the middle of the second trimester before gradually increasing back to pre-pregnancy levels. These hemodynamic changes appear to establish a circulatory reserve necessary to provide nutrients and oxygen to both mother and fetus at rest and during moderate exercise. Since heart-rate response among pregnant exercisers is variable, **ratings of perceived exertion (RPE)** should be used to assess intensity instead of traditional heart rate-based methods.

As pregnancy progresses, a woman's body position can affect her cardiovascular system both at rest and during exercise. After the first trimester, the supine position results in relative obstruction of venous return, and therefore decreased cardiac output. For this reason, supine positions should be avoided as much as possible during rest and exercise. In addition, motionless standing is associated with a significant decrease in cardiac output. Therefore, this position should be avoided.

Respiratory System

The delivery of oxygen to the mother and fetus is enhanced through improvements in lung function during pregnancy. At rest, an increase in the depth of each breath increases the amount of air inhaled by up to 50% or more (Prowse & Gaensler, 1965; Artal et al., 1986). This increase is the result of elevated levels of progesterone, which stimulates “overbreathing” by increasing the brain’s sensitivity to carbon dioxide. As a result, oxygen tension is increased and carbon dioxide tension is decreased in the alveoli. Ultimately, these directional changes in breathing gases widen the pressure gradients, which improve the efficiency of oxygen uptake from the lungs and the elimination of carbon dioxide from maternal and fetal blood and tissues.

Prenatal adaptations of the respiratory system cause women to experience an associated increase in oxygen uptake and a 10 to 20% increase in baseline oxygen consumption (Pivarnik et al., 1992; Sady et al., 1989). Peak ventilation and maximal aerobic capacity are maintained during pregnancy. As a result of this maintained function and the pregnancy-induced increase in alveolar ventilation, gas transfer at the tissue level may improve. This causes a “training effect” of pregnancy in women who maintain moderate-to-intense exercise programs throughout gestation, and may explain anecdotal reports of women who experience an improvement in competitive endurance performance after giving birth.

Thermoregulatory System

A woman’s ability to dissipate heat improves during pregnancy. The improved ability to eliminate body heat is most likely due to a decrease of the body’s set point for normal temperature in early pregnancy and a significant increase in blood flow to the skin, which increases the rate of heat loss directly into the air. Additionally, a 40 to 50% increase in tidal volume allows a pregnant woman to increase heat loss through exhalation by 40 to 50%.

During moderate-intensity aerobic exercise in thermoneutral conditions, the core temperature of non-pregnant women rises an average

of 1.5° C during the first 30 minutes of exercise, and then reaches a plateau if exercise is continued for an additional 30 minutes (Soultanakis, Artal, & Wiswell, 1996). If heat production exceeds heat dissipation capacity, as is commonly the case during exercise in hot, humid conditions or during very high-intensity exercise, a woman’s core temperature will continue to rise. During prolonged exercise, loss of fluid as sweat may compromise heat dissipation. Given that fetal body core temperatures are naturally about 1° C higher than maternal temperatures, maintenance of proper hydration, and therefore blood volume, is critical to heat balance. Research examining the effects of exercise on core temperature during pregnancy is limited. The results of some human studies suggest that **hyperthermia** in excess of 39° C (100° F) during the first 45 to 60 days of gestation may be **teratogenic** in humans (Milunsky et al., 1992; Edwards, 1986). However, there have been no reports that hyperthermia associated with exercise causes malformations of the embryo or fetus in humans.

Programming Guidelines and Considerations for Prenatal Exercise

Exercise programming guidelines for prenatal activity include the same elements as guidelines for non-pregnant women. Aerobic exercise consisting of any activity that uses large muscle groups in a continuous rhythmic manner (e.g., walking, hiking, jogging/running, aerobic dance, swimming, cycling, rowing, dancing, and rope skipping) may be appropriate. Some activities, such as scuba diving and prolonged exertion in the supine position, should be avoided due to the potential for fetal hypoxia. Activities that increase the risk of falls, such as skiing, or those that may result in excessive joint stress, such as jogging and tennis, should be engaged in only after evaluation and consultation with a physician.

Musculoskeletal conditioning appears to be safe and effective during pregnancy when low weights and multiple repetitions through a dynamic,

controlled range of motion are performed. While research is lacking, it would be prudent to limit repetitive **isometric** or heavy-resistance weightlifting, as well as any exercises that result in a large **pressor response** (i.e., a disproportionate rise in heart rate during resistance training resulting from **autonomic nervous system** reflex activity). Additionally, maintenance of normal joint range of motion through individualized stretching exercises is acceptable. However, pregnant exercisers should be aware of increased ligamentous laxity and strive to limit excessive stretching or ballistic stretching movements during pregnancy.

Several national health and medical organizations have published recommendations and guidelines on exercise and pregnancy (ACOG, 2002b; ACSM, 2010; SOGC & CSEP, 2003). Not surprisingly, the content in the guidelines from the different organizations is similar. Specifically, the ACOG Committee Opinion on exercise during pregnancy published in 2002 recommends that, barring medical or obstetric contraindications, pregnant women engage in 30 or more minutes of moderate exercise on “most” days of the week (ACOG, 2002b). This recommendation is essentially the same as that made for the general population by the CDC and ACSM (ACSM, 2010). ACOG and ACSM jointly support recommendations

stating that the mode, frequency, duration, and overload principles for cardiorespiratory, resistance, and flexibility exercise are the same for pregnant women as for non-pregnant women. According to ACSM, pregnancy-specific issues to consider when designing prenatal exercise programs focus on attaining additional calories to maintain **homeostasis**, avoiding motionless standing, preventing maternal hyperthermia and **hypoglycemia**, and avoiding high-risk exercises (Table 23-6). Furthermore, the sole use of heart-rate monitoring to assess exercise intensity is not recommended for pregnant exercisers due to the natural physiological influences of the cardiovascular system during pregnancy. The “category” RPE scale (6–20) or the “category-ratio” Borg scale (0–10) may be used. Ratings of “fairly light” to “somewhat hard” are the recommended intensity ranges for prenatal exercise (Pivernak et al., 1991; Clapp, Lopez, & Harcar-Sevcik, 1999).

Another set of guidelines, jointly sponsored by SOGC and CSEP, promote similar recommendations as those set forth by ACSM and ACOG, with the addition of a modified version of the conventional age-corrected heart rate target zone for pregnant exercisers (Table 23-7), and a recommendation for resistance exercise and aerobic exercise (SOGC/CSEP, 2003). Furthermore, the SOGC/CSEP

Table 23-6
Special Considerations for Prenatal Exercise Programming

- Pregnancy requires an additional 300 calories per day to maintain homeostasis. Therefore, women should ingest additional calories to meet the needs of exercise and pregnancy.
- Heat dissipation is important throughout pregnancy. Appropriate clothing, environmental considerations, and adequate hydration should be priorities during the exercise program to prevent the possibility of hyperthermia and the corresponding risk to the fetus. Pregnant women should drink ample water to prevent dehydration and avoid brisk exercise in hot, humid weather or when suffering with a fever.
- Pregnant women should avoid exercise that involves the risk of abdominal trauma, falls, and excessive joint stress. Sport activities such as softball, basketball, and racquet sports are not recommended because of the increased risk of abdominal injury. When exercising, pregnant women should be aware of the signs and symptoms for discontinuing exercise and seeking medical advice (see Table 23-3).

Source: American College of Sports Medicine (2010). *ACSM's Guidelines for Exercise Testing and Prescription* (8th ed.). Philadelphia: Wolters Kluwer/Lippincott Williams & Wilkins.

position statement provides a plan for inactive women to gradually increase their activity level (i.e., previously sedentary women should begin with 15 minutes of continuous exercise three times a week, increasing gradually to 30-minute sessions four times a week). Table 23-8 presents the joint recommendations of SOGC and CSEP for exercise in pregnancy and the postpartum period.

Biomechanical Considerations for the Pregnant Mother

Due to the wide range of postural and physiological adaptations that occur during pregnancy, the ACE-AHFS must be proficient at designing exercise programs geared toward making physical activity more comfortable for this population. Physiological adaptations include a profound increase in body mass, retention of fluid, and laxity in supporting structures. Postural adaptations correspond with these physiological changes and usually entail an alteration in the loading and alignment of, and muscle forces along, the spine and weightbearing joints. During pregnancy, production of the hormone relaxin increases tenfold. The hormone creates joint laxity, which not only allows the pelvis to accommodate the enlarging uterus, but also weakens the ability of static supports in the lumbar spine to withstand shearing forces. In the pelvis, joint laxity is most prominent in the symphysis pubis and the sacroiliac joints.

Typically, it is thought that advancing pregnancy produces a forward shift in the center of gravity followed by an anterior pelvic tilt and subsequent increase in lumbar **lordosis** and thoracic **kyphosis**. However, research on postural changes associated with prenatal weight gain does not confirm this line of thinking (Perkins, Hammer, & Loubert, 1998; Dumas et al., 1995; Moore, Dumas, & Reid, 1990). After the first trimester, the uterus can no longer be contained within the pelvis and moves superiorly and anteriorly. As pregnancy progresses, the biomechanical alterations of increased abdominal girth and weakened abdominal muscles were thought to increase

Table 23-7
Modified Heart Rate Target Zones for Aerobic Exercise in Pregnancy

Maternal Age	Heart Rate Target Zone (beats/min)	Heart Rate Target Zone (beats/10 seconds)
Less than 20	140–155	23–26
20–29	135–150	22–25
30–39	130–145	21–24
40 or greater	125–140	20–23

Note: The most appropriate use of these modified heart rate guidelines is in conjunction with RPE, as blunted, exaggerated, and normal linear responses to exercise have been observed at different stages during pregnancy.

Source: Society of Obstetricians and Gynaecologists of Canada (SOGC) & Canadian Society for Exercise Physiology (CSEP) (2003). Joint SOGC/CSEP clinical practice guideline: Exercise in pregnancy and the postpartum period. *Journal of Obstetrics and Gynaecology Canada*, 25, 6, 516–522.

Table 23-8
Recommendations for Exercise in Pregnancy and the Postpartum Period

- All women without contraindications should be encouraged to participate in aerobic and strength-conditioning exercises as part of a healthy lifestyle during their pregnancy.
- Reasonable goals of aerobic conditioning in pregnancy should be to maintain a good fitness level throughout pregnancy without trying to reach peak fitness or train for an athletic competition.
- Women should choose activities that will minimize the risk of loss of balance and fetal trauma.
- Women should be advised that adverse pregnancy or neonatal outcomes are not increased for exercising women.
- Initiation of pelvic floor exercises in the immediate postpartum period may reduce the risk of future urinary incontinence.
- Women should be advised that moderate exercise during lactation does not affect the quantity or composition of breast milk or impact infant growth.

Validation: This guideline has been approved by the Society of Obstetricians and Gynaecologists of Canada (SOGC) Clinical Practice Obstetrics Committee, the Executive and Council of SOGC, and the Board of Directors of the Canadian Society for Exercise Physiology (CSEP).

Sponsors: This guideline has been jointly sponsored by the SOGC and the CSEP.

Source: Society of Obstetricians and Gynaecologists of Canada (SOGC) & Canadian Society for Exercise Physiology (CSEP) (2003). Joint SOGC/CSEP clinical practice guideline: Exercise in pregnancy and the postpartum period. *Journal of Obstetrics and Gynaecology Canada*, 25, 6, 516–522.

lumbar lordosis; however, studies have shown that the lordosis remains the same or increases only slightly (Hummel, 1987). Instead, it appears that the entire spine shifts to a more posterior position

and the center of gravity as a whole tends to move in a posterior and caudal direction. In fact, one study showed that 75% of women demonstrated a more posterior posture, wherein the weight of the uterus was carried posterior to the normal center of gravity (Perkins, Hammer, & Loubert, 1998).

As noted previously, a large majority of women complain of low-back pain during pregnancy (Brynhildsen, 1998; Kristiansson, Svardsudd, & von Schoultz, 1996; Perkins, Hammer, & Loubert, 1998). Prenatal low-back and pelvic pain appear to be more related to pre-pregnancy postural habits that are exaggerated during gestation than to postural adaptations to pregnancy. Laxity in the supporting tissues, either pre-existing or enhanced by the hormone relaxin, becomes greater in the direction of habitual posture (Dumas et al., 1995). In other words, pronated feet may become flatter, hyperextended knees may become more pronounced, and spinal curves may soften. Increased ligament laxity has been postulated as a cause for back and pelvic pain, particularly if the pain begins early in the pregnancy before an increase in body mass is evident (Damen et al., 2002; Bullock-Saxton, 1998). During the term of their pregnancies, most women adapt to these postural and physiological changes and, following the baby's delivery, return to their pre-pregnant states.

To alleviate the postural discomforts of exercise, many pregnant women choose to work out in the water. Women who participate in a water exercise class have been shown to experience reduced symptoms of back pain during late pregnancy and miss fewer days at work compared to a control group (Kihlstrand et al., 1999). Aquatic exercise in relatively cool water decreases the rise in body temperature observed during land-based exercise, which can help minimize the risk of hyperthermia (McMurray & Katz, 1990). The hydrostatic pressure exerted on a pregnant woman's body during pool exercise may lessen fluid retention and swelling, and the buoyancy of water supports the bodyweight, relieving pressure on the weight-bearing joints and allowing the muscles relief from bearing extra mechanical stress during the pregnancy. Thus, water exercise is a valuable option for women to consider, especially as advancing

pregnancy makes other forms of physical activity uncomfortable or stressful on the joints.

In addition to low-back pain, common musculoskeletal complaints that arise during pregnancy include sacroiliac (SI) joint dysfunction, pubic pain, nerve compression syndromes, **diastasis recti**, and **stress urinary incontinence**. The remainder of this section covers each of these conditions in more detail.

Low-back and Posterior Pelvic Pain

The two most common sites of back pain in pregnancy are the lumbar and posterior pelvic areas. Back pain occurs most commonly after the sixth month and can last until the sixth month postpartum. After 12 weeks of pregnancy, the uterus can no longer be contained within the pelvis and the mass moves superiorly and anteriorly. As the abdominal muscles are stretched and tone is diminished, they lose their ability to contribute effectively to the maintenance of neutral posture. In the lumbar spine, joint laxity is most notable in the anterior and posterior longitudinal ligaments. This weakens the ability of static supports in the lumbar spine to withstand the shearing forces. As a result, there may be an increase in discogenic symptoms and/or pain coming from the facet joints.

Lumbar pain during pregnancy is defined as back pain from the lumbar area only, with or without radiation to the legs. **Sciatica** is rare and thought to account for only 1% of low-back pain in pregnancy (Östgaard, Andersson, & Karlsson, 1991; Hainline, 1994). In general, lumbar pain during pregnancy is similar to low-back pain experienced by non-pregnant women. This type of pain typically increases with such prolonged postures as sitting, standing, and repetitive lifting.

Exercises appropriate for pregnant women with lumbar pain include mobility and stretching movements that emphasize relaxing and lengthening the back extensors, hip flexors, scapulae protractors, shoulder internal rotators, and neck flexors. Strengthening exercises should focus on the abdominals, gluteals, and scapulae retractors to reinforce their ability to support proper alignment.

Posterior pelvic pain is four times more prevalent than lumbar pain in pregnancy and is thought to be caused by SI joint dysfunction. Sacroiliac pain is felt distal and lateral to the lumbar spine, with or without lower-extremity radiation, and can occur on one or both sides of the sacrum. Women with sacroiliac pain as their primary complaint tend to have low-back pain for a longer duration than those who simply have lumbar pain. They also tend to experience symptoms for several months after delivery (Hainline, 1994). Occupational activities that involve prolonged postures at extreme ranges, such as sitting at a computer and leaning forward or standing and leaning over a desk or workstation, increase the risk of developing posterior pelvic pain during pregnancy. Unlike other forms of low-back pain during pregnancy, a previous high level of fitness does not necessarily prevent this problem.

The hypothetical origins of SI joint dysfunction during pregnancy focus on decreased stability of the pelvic girdle. It is assumed that the stability of the pelvic girdle is provided, in part, by the coarse texture of the SI cartilage surfaces, the undulated shape of the joint, and the compressive forces of the muscles, ligaments, and thoracolumbar fascia. Muscles that generate a force perpendicular to the SI joints or increase tension on the sacroiliac ligaments or thoracolumbar fascia generate forces that may act to stabilize the SI joint. These include the internal and external abdominal obliques, the latissimus dorsi, the transversospinal parts of the erector spinae muscle (especially the multifidus), and the gluteus maximus. Therefore, functional exercise programs that target this musculature may benefit women with prenatal pelvic pain, partly by increasing muscle force and endurance (Snijders, Vleeming, & Stoeckart, 1993a; Snijders, Vleeming, & Stoeckart, 1993b; Vleeming et al., 1995; Vleeming, Stoeckart, & Snijders, 1989; Vleeming et al., 1989; Vleeming et al., 1996).

Pubic Pain

The irritation of the pubic symphysis caused by increased motion at the joint is called **symphysis**. Symptoms include mild to severe pain in the pubic region, groin, and medial aspect of the thigh (unilateral or bilateral), frequently accompanied

by sacroiliac, low-back, and suprapubic pain. Weightbearing activities, particularly those that involve lifting one leg, intensify the pain. Women also may hear or feel a clicking or grinding sensation in the joint, and there is often difficulty walking, so that a “waddling” gait is adopted.

As noted previously, it has been suggested that pelvic instability is the primary cause of pelvic (sacroiliac and symphysis pubis) joint pain during pregnancy (Fast et al., 1990; Svensson et al., 1990). Pregnancy-related connective tissue changes and the change in the center of gravity result in lengthening, and thus weakening of the ligaments of the pelvic joints, the thoracolumbar fascia, and the surrounding muscles, all of which provide stability to the pelvic ring. Normally, the pre-pregnancy width of the pubic symphysis is 0.5 mm. As pregnancy progresses, the symphysis pubis continues to widen to a maximum of approximately 12 mm. With this widening, there is the risk of vertical displacement of the pubis, and the possibility of rotatory stress on the sacroiliac joints. During delivery, partial symphyseal separations and complete dislocations are possible, resulting in a greater concern for postnatal exercisers.

Treatment of pubic symphysis dysfunction includes avoidance of weightbearing activities that intensify pain, a physician evaluation, and physical therapy. Pelvic belts, which compress the pelvis and minimize motion in the symphysis pubis and SI joint, may be prescribed.

Carpal Tunnel Syndrome

The most common neurological disorder during pregnancy is **carpal tunnel syndrome**. Symptoms include pain and **paresthesias** in the median nerve distribution (thumb, index, and middle fingers), as the nerve becomes depressed as it passes through the carpal tunnel in the wrist. Carpal tunnel syndrome is very common and most often occurs in women aged 30 to 50. Emergence or worsening of carpal tunnel syndrome may occur during pregnancy. The presumed mechanism is pressure on the median nerve within the carpal compartment at the wrist as a result of tissue swelling, secondary to the fluid retention that occurs during pregnancy. Women who develop carpal tunnel syndrome in pregnancy

are not likely to develop it again, unless there is another pregnancy. The condition usually discontinues after delivery.

Treatments include ergonomic improvements, analgesia, splinting, and sometimes corticosteroid injection or surgery. Since activities or jobs that require repetitive **flexion** and **extension** of the wrist may contribute to carpal tunnel syndrome, these activities should be minimized. Care should be taken to avoid loading the wrist in hyperextension, grasping objects tightly, and repetitive flexion and extension of the wrist during exercise. Keeping the wrist in its neutral position during physical activities such as weightlifting should provide a comfortable, non-aggravating option for pregnant exercisers.

Diastasis Recti

Diastasis recti is a partial or complete separation between the left and right sides of the rectus abdominis muscle. During pregnancy, the maternal inferior thoracic diameter is increased, thus altering the spatial relationship between the superior and inferior abdominal muscle attachments. In addition, anterior and lateral dimensions of the abdomen during pregnancy increase the distance between muscle attachments, producing increases in muscle length. In some women, the rectus abdominis muscles move laterally and may remain separated in the immediate post-delivery period.

Diastasis recti is commonly seen in women who have multiple pregnancies, because the muscles have been stretched many times. Extra skin and soft tissue in the front of the abdominal wall may be the only signs of this condition in early pregnancy. In late pregnancy, the top of the pregnant uterus is often seen bulging out of the abdominal wall. Three main factors contribute to the incidence and severity of diastasis recti during pregnancy: maternal hormones (relaxin, estrogen, and progesterone), mechanical stress within the abdominal cavity due to increasing girth, and weak abdominal muscles (strong abdominal muscles are more likely to resist this condition).

While some rectus abdominis separation is a normal part of every pregnancy, too much separation may lead to diminished muscular force production and even more separation during

physical exertion. The most common test for diastasis recti is performed by placing two fingers horizontally on the suspected location while the client lies supine with the knees bent and performs a curl-up. If the fingers can penetrate at the location, there is probably a split. The degree of separation is measured according to the number of fingerwidths of the split. One to two fingerwidths is considered normal, whereas greater than three fingerwidths is excessive and care should be taken to avoid placing a direct line of stress on the area. Abdominal compression exercises and curl-ups in a semirecumbent position may be helpful for strengthening the rectus abdominis in this situation.

Stress Urinary Incontinence

Stress urinary incontinence (SUI) is the involuntary loss of urine that occurs with physical exertion and a rise in abdominal pressure. Coughing, sneezing, straining, laughing, and impact activities such as jumping and running are events commonly associated with SUI. The pelvic-floor muscles are considered important in maintaining pelvic organ support and bowel and bladder continence. Several studies have shown that women with urinary incontinence have decreased pelvic floor muscle thickness and electromyographic activity, and less muscle strength compared with control subjects without urinary incontinence (Bernstein, 1997; Hoyte et al., 2004; Aanestad & Flink, 1999; Morkved, Schei, & Salvesen, 2003; Morin et al., 2004).

During pregnancy and delivery, the prolonged stretching and trauma sustained by the pelvic floor musculature and the concomitant neural damage thought to accompany this stretching can reduce the strength of the pelvic floor. These changes interfere with the normal transmission of information regarding changes in abdominal pressure to the proximal urethra, thereby predisposing the woman to SUI. Five risk factors predispose a woman to postpartum SUI: Multiple pregnancies, vaginal delivery, high infant birth weight (>8.1 lb; 3.7 kg), large infant cranial circumference (>13.8 inches; 35.5 cm), high maternal weight gain during pregnancy (>28.6 lb; 13 kg), and tearing of the perineum during delivery.

Women experiencing SUI during pregnancy and/or childbirth are generally thought to have a greater risk of developing the condition later in life.

Treatment of SUI during and after pregnancy includes the performance of **Kegel exercises** to strengthen the pelvic-floor muscles. Since the introduction of Kegel exercises in 1948, the efficacy of pelvic-floor muscle strengthening in the treatment of SUI has been supported by the findings of several randomized controlled studies and systematic reviews (Burns et al., 1993; Bo, Talseth, & Holm, 1999; Henalla et al., 1989; Goode et al., 2003; Hay-Smith et al., 2002). The benefits of an effective Kegel exercise regimen include providing support for the pelvic organs; preventing prolapse (falling) of the bladder, uterus, and rectum; supporting proper pelvic alignment; reinforcing sphincter control; enhancing circulation to the pelvic floor muscles; and providing a healthy environment for the healing process after labor and delivery (Dunbar, 1992). Women who exercise during pregnancy and resume it early in the postpartum period have a shorter duration of SUI than those who do not (Morkved & Bo, 2000).

Nutritional Considerations

After the thirteenth week of pregnancy, approximately 300 additional calories per day are required to meet the metabolic needs of pregnancy. Weightbearing exercise, such as walking, increases the energy requirement even further. Furthermore, as the pregnancy progresses, the caloric needs of the mother progressively increase in correspondence with the increase in body weight. An added concern related to nutrition during pregnancy is adequate carbohydrate intake. Pregnant women use carbohydrates at a greater rate both at rest and during exercise than do non-pregnant women (Clapp et al., 1988; Soultanakis, Artal, & Wiswell, 1996). Since maternal blood glucose is the fetus' primary energy source, there is concern that low maternal blood glucose could compromise fetal energy supply. However, intrauterine growth retardation, or other short- or long-term effects on newborns of exercising mothers, have not

been reported (ACOG, 2002b; Clapp, Lopez, & Harcar-Sevcik, 1999). As a precaution to help avoid hypoglycemia, pregnant women should be reminded to consume a pre-exercise snack and eat frequent small meals throughout the day, especially later in pregnancy. Pregnant exercisers should be made aware of the signs of hypoglycemia, such as weakness, dizziness, fatigue, and nausea.

The position of the American Dietetic Association (ADA) on nutrition during pregnancy maintains that the key components of a healthy lifestyle during pregnancy include appropriate weight gain (Table 23-9); consumption of a variety of foods in accordance with the MyPlate Food Guidance System; appropriate and timely vitamin and mineral supplementation; avoidance of tobacco, alcohol, and other harmful substances; and safe food-handling practices (ADA, 2002). The ADA recommends that pregnant women eat a total of 2500 to 2700 calories per day, and that those calories should come from a variety of healthy foods. Additionally, women considering becoming pregnant need to ensure that they are consuming adequate amounts of folic acid, iron, calcium, vitamin D, and water to sustain health before, during, and after pregnancy. The ACE-AHFS should encourage pregnant clients to consult with their physicians in the area of nutrition during pregnancy. For a more detailed analysis of nutrition concerns in pregnancy,

Table 23-9
Appropriate Weight Gain During Pregnancy

Weight Classification	Weight Gain Goal*
Underweight	About 28 to 40 pounds (13 to 18 kg)
Normal weight	About 25 to 35 pounds (11 to 16 kg)
Overweight	About 15 to 25 pounds (7 to 11 kg)
Obese	At least 15 pounds (7 kg)

* Women should talk to their healthcare providers about how much weight they should gain during pregnancy. The general weight-gain recommendations listed here refer to weight before pregnancy and are for women expecting only one baby.

Source: U.S. Department of Health and Human Services, National Institutes of Health. *Fit for Two: Tips for Pregnancy*. win.niddk.nih.gov/publications/two.htm.

refer to the American Dietetic Association's position statement: "Nutrition and Lifestyle for a Healthy Pregnancy Outcome" (ADA, 2002).

Psychological Considerations

Pregnancy is associated with increased psychological distress for many women, which includes increased **anxiety**, **depression**, and fatigue. Investigations that measured depressive symptoms throughout pregnancy have shown that depression is more common during the third trimester and that an overwhelming majority (97%) of women report fatigue as a concern at some point during their pregnancy (Evans et al., 2001; Zib, Lim, & Walters, 1999). In most societies, it is a long-held belief that a mother's psychological state can influence her unborn baby. Some studies have shown that babies of stressed or anxious mothers have a significantly lower average birth weight for gestational age and tend to be born early (Perkin et al., 1993; Wadwa et al., 1993; Copper et al., 1996; Hedegaard et al., 1996). This is an area of concern because low birth weight seems to be associated with health problems in later life (e.g., hypertension and ischemic heart disease) (Barker, 1995). Furthermore, ultrasound studies have shown that fetal behavior is affected by maternal anxiety (Ianniruberto & Tajani, 1981; Groome et al., 1995). It has been proposed that maternal stress or anxiety might affect the fetus through increased concentrations of maternal hormones being transported directly across the placenta (Gitau et al., 1998). In addition, blood flow to the baby may be impaired through the uterine arteries with high levels of maternal anxiety, which would contribute to the low birth weights associated with psychologically distressed mothers (Teixeira, Fisk, & Glover, 1999).

Another major psychological concern for many women is postpartum or postnatal depression. Postnatal depression affects approximately 10 to 13% of women in the early weeks postpartum, with episodes typically lasting two to six months. This depressive disorder has well-documented health consequences for the mother, child, and

family. Women who have postpartum depression are significantly more likely to experience future episodes of depression (Cooper & Murray, 1995), and infants and children are particularly vulnerable to difficulties with maternal bonding and developmental problems because of impaired maternal-infant interactions and negative perceptions of infant behavior. The cause of postnatal depression is unclear. However, research suggests the influence of psychosocial and psychological risk factors, such as life stress, unemployment, marital conflict, maternal self-esteem, and lack of social support (O'Hara & Swain, 1996; Cooper & Murray, 1997; Beck, 2001; Bernazzani et al., 1997; O'Hara et al., 1991; Gotlib et al., 1991).

A disorder related to postpartum depression, but considered not as severe, is called "maternity blues." Maternity blues refers to the tearfulness, irritability, **hypochondriasis**, sleeplessness, impairment of concentration, and headache that occurs in the 10 days or so postpartum. A peak in symptoms typically occurs around the fourth to fifth day after delivery, coinciding with maximal hormonal changes, which include falling concentrations of progesterone, estradiol, and cortisol and rising prolactin concentrations. During pregnancy, progesterone concentrations slowly rise to a maximum until they reach levels several hundred times higher than normal. After delivery and the withdrawal of the placenta, there is a precipitous drop in progesterone concentration. It is hypothesized that the symptoms of maternity blues are related to progesterone withdrawal (Harris et al., 1994). Cortisol concentrations also rise during pregnancy to several times their normal values. They rise further during the stress of labor and then slowly return to normal within 15 days of delivery.

As noted earlier, many previously active women stop exercise or significantly reduce it during pregnancy (Zhang & Savits, 1996; Ning et al., 2003). Given the known links between physical inactivity and reduced mental health, it is plausible that a relationship exists between pregnancy-related reductions in physical activity and psychological distress. A small number of investigations have found that low physical activity is associated with higher scores on anxiety, depression, and fatigue

scales during pregnancy (DaCosta et al., 2003; Goodwin, Astbury, & McMeeken, 2000; Koniak-Griffin, 1994; Wallace et al., 1986). In a study that measured physical activity and mood during pregnancy, it was shown that healthy women who maintain an above-average level of physical activity during the second and third trimesters enjoy more mood stability (Poudevigne & O'Connor, 2005). These findings support the theory that regular endurance exercise throughout pregnancy not only improves maternal and fetal physical health, but may enhance psychological health as well.

Benefits and Risks of Exercise Following Pregnancy

Regular exercise is as beneficial in the postpartum period as it is at other times in a woman's life. The possible benefits include the following:

- Preventing obesity (or overweight) through promotion of body fat/body weight loss
- Promoting aerobic fitness and strength, leading to an improved ability to perform activities of mothering
- Optimizing bone health by increasing bone mineral density and/or preventing lactation-associated bone loss
- Improving mood or self-esteem

Furthermore, a mother's participation in regular exercise after childbirth may encourage regular physical activity in her children.

A theoretical risk of postpartum exercise is that strenuous activity in women who breastfeed may alter the quality (e.g., macronutrient and micronutrient composition, immunological properties, accumulation of exercise by-products) or quantity of their milk. However, a review of the literature pertaining to breast milk production and composition in relation to postnatal exercise revealed that there were no remarkable differences in the breast milk of women who performed submaximal exercise, maximal exercise, or who were physically inactive (Larson-Meyer, 2002). The author of the review concluded that several studies have collectively determined that neither acute nor regular exercise has adverse effects on

a mother's ability to successfully breastfeed. Another potential risk of postnatal exercise involves new mothers who deliver their babies via C-section. If physical activity is resumed prematurely, there is a risk of disrupting post-surgery healing.

Epidemiological studies have shown an association between higher levels of physical activity in the postpartum period and a return to pre-pregnancy body weight, as well as an increased loss of pregnancy-associated weight gain (Ohlin & Rossner, 1996; Sampselle et al., 1999; Harris, Ellison, & Clement, 1999). A randomized control study that compared the effect of a combination of diet (500 calories less than predicted total energy expenditure) plus exercise to no intervention on weight loss and body composition in overweight lactating women found that the combined diet and exercise intervention resulted in significantly greater weight and fat loss compared with the control group (Lovelady et al., 2000).

Research is lacking on maternal aerobic fitness and strength during the postpartum period. However, two randomized controlled trials have found a significant increase in aerobic capacity resulting from an endurance-exercise intervention during the first 10 to 12 weeks postpartum (Dewey et al., 1994; Lovelady et al., 2000). To date, studies have not assessed the effect of strength training (with or without aerobic exercise) during the postpartum period on muscle strength and endurance or the preservation of lean body mass. It seems reasonable to state, however, that the possible benefit of maternal fitness on the daily physical activities of mothering, including lifting, carrying, or running after a child, is worth the effort of beginning or maintaining regular exercise during the postpartum period.

Lactation in the two-to-six-month postpartum period is associated with axial bone loss. It is speculated that these changes result from the prolonged lactation-induced estrogen deficiency, combined with the "calcium drain" of breastfeeding (an additional 200 to 400 mg per day of calcium is required during lactation). It is unclear whether exercise can attenuate or prevent lactation-associated bone loss. Research demonstrates, however, that bone loss recovers in

healthy women with the cessation of lactation and the return of normal menses (Cross et al., 1995; Sowers et al., 1993; Ritchie et al., 1998).

As noted previously, dealing with the hormonal changes and fatigue associated with becoming a new mother often results in emotional distress. Some women have trouble finding the time or energy to exercise, and some feel guilty about being away from the baby to exercise. Longitudinal studies suggest that the incidence of significant postpartum depression is lower in exercising women compared with inactive controls (Clapp, 2002). The author hypothesized that depression occurs less in physically active women because exercise gives them a regular break from the 24-hour, seven-day-a-week commitment that comes with a new infant. In other words, physically active postpartum women appear less overwhelmed and more ready to master motherhood. It has also been reported that exercising women have a more positive self-image during and after pregnancy than do non-exercising women (Clapp, 2002). Additionally, among postnatal women, an acute bout of aerobic exercise has been shown to lead to decreases in acute transitory anxiety and depression as well as increases in vigor (Koltyn & Schultes, 1997).

Research on the quantity and quality of breast milk in physically active women has found no affect on the volume (adjusted for infant's weight) or the energy density or energy composition (protein, lipid, and lactose) of breast milk in non-overweight women training vigorously or in overweight women randomly assigned to an exercise and calorie-restriction intervention (Lovelady, Lonnerdal, & Dewey, 1990; Lovelady et al., 2000). These investigations also found no differences in body weight or growth among infants whose mothers were in either the exercise or control groups. As a result of anecdotal reports from mothers who claimed that their babies often had a difficult time breastfeeding post-workout, researchers examined the levels of lactic acid accumulation in breast milk after exercise (Wallace, Inbar, & Ernsthausen, 1992). Lactic acid may have initially been targeted among other metabolites that increase with exercise (e.g., hydrogen ion and ammonia) because it readily diffuses into the

water compartments of the body (making it likely to diffuse into breast milk). Research in this area has been inconclusive due to inconsistent reports of lactic acid concentrations in breast milk and study results showing that infant acceptance of breast milk is not reduced after submaximal or maximal exercise (Carey, Quinn, & Goodwin, 1997; Quinn & Carey, 1999; Carey & Quinn, 2001; Wright, Carey, & Quinn, 1999).

With regard to exercising after childbirth, a major consideration is the method of delivery. Women who have undergone C-section have had major abdominal surgery that results in pain and tenderness in the abdomen, as well as considerable fatigue. The current thinking on recovery and rehabilitation after C-section is that walking as soon as possible after the surgery helps to minimize muscle wasting, increase circulation, and speed the healing process. Additionally, deep breathing, abdominal compression exercises, and Kegels can be resumed early in the recovery process. Many women are ready to introduce intermittent walking or other gentle forms of exercise by two weeks postpartum, with the degree of discomfort, fatigue, and motivation guiding activity levels. Vigorous exercise is contraindicated after a C-section until the recovery and rehabilitation process is complete. Re-entry into a structured fitness program should be postponed until a physician's clearance has been obtained after the six-week postpartum check-up.

Physiological Changes Following Pregnancy

As in pregnancy, the physiological changes following pregnancy are primarily determined by the endocrine system. The hormones that dominate during pregnancy return to pre-pregnancy levels after childbirth, which results in concomitant changes in the musculoskeletal, cardiovascular, and respiratory systems.

The hormone relaxin, responsible for producing laxity in the collagenous structures of the pelvis and other areas in preparation for childbirth, rises to 10 times its normal level during pregnancy. While the research is not clear on

how long it takes for relaxin to subside to pre-pregnancy levels after delivery, ligamentous overstretching can remain in a new mother for up to eight months postpartum. For this reason, a new mother should learn how to correctly lift and carry her baby, put the baby in the crib, and take the baby out of the crib to reduce the risk of back pain due to the relaxed soft-tissue structures supporting the joints.

During pregnancy, the cardiovascular system adapts by increasing blood volume, heart rate, and cardiac output. Plasma volume increases by as much as 40 to 50% and red cell volume goes up by 15 to 20% to maintain the increased circulatory need of the enlarging uterus and fetoplacental unit, fill the ever-increasing venous reservoir, and protect the mother from the blood loss at the time of delivery. It takes about eight weeks after delivery for the blood volume to return to pre-pregnancy levels. Cardiac output increases by 30 to 40% during pregnancy, with the maximum increase attained at 24 weeks of gestation. The increase in heart rate lags behind the increase in cardiac output initially, and then ultimately increases by 10 to 15 bpm by 28 to 32 weeks of gestation. Cardiac output, heart rate, and stroke volume decrease to pre-labor values 24 to 72 hours after birth and return to non-pregnant levels within six to eight weeks after delivery.

The respiratory system exhibits adaptations to pregnancy starting as early as the fourth week of gestation. A woman can expect minute ventilation to increase by about 50% above non-pregnant values and tidal volume and respiratory rate to also increase during pregnancy. Within six to 12 weeks postpartum, all respiratory parameters return to non-pregnant values.

Because of the gradual return to pre-pregnancy musculoskeletal, cardiovascular, and respiratory parameters, and the detraining effect that occurs for most women during pregnancy, postpartum exercise programs should be individualized and resumed gradually. There are no known maternal complications associated with the resumption of exercise training postpartum (Hale & Milne, 1996). Furthermore, moderate weight reduction while nursing is considered safe

and does not compromise neonatal weight gain (McCrory et al., 1999).

Programming Guidelines and Considerations for Postnatal Exercise

From an analysis of the available physiological data in the perinatal period, ACOG has developed guidelines for postpartum exercise. The guidelines are very general and state that many of the physiological and morphological changes of pregnancy persist four to six weeks postpartum, and recommend that pre-pregnancy exercise routines be resumed gradually based on the woman's physical capabilities (ACOG, 2002b). A more detailed set of guidelines for postnatal exercise has been developed by Clapp (2002), who suggests that the initial goal of exercise (within the first six weeks) is to obtain personal time and redevelop a sense of control. This can be accomplished by doing the following:

- Beginning slowly and increasing gradually
- Avoiding excessive fatigue and dehydration
- Supporting and compressing the abdomen and breasts
- Stopping to evaluate if it hurts
- Stopping exercise and seeking medical evaluation if the postpartum client is experiencing bright red vaginal bleeding that is heavier than a menstrual period

Clapp goes on to suggest that after six weeks postpartum, the goal of the exercise regimen in the remainder of the first year following birth is to improve physical fitness. Other recommendations suggest that, if pregnancy and delivery are uncomplicated, a mild exercise program consisting of walking, pelvic floor exercises, and stretching may begin immediately (Kochan-Vintinner, 1999). However, if delivery was complicated or was by C-section, a physician should be consulted before resuming pre-pregnancy levels of physical activity, usually after the first postpartum check-up at six to eight weeks (Kochan-Vintinner, 1999).

One area of concern for many women after childbirth is strengthening the pelvic floor. It is estimated that up to three months after delivery, 20 to 30% of women have SUI and about 4%

have fecal incontinence (Wilson, Herbison, & Herbison, 1996; MacArthur, Lewis, & Bick, 1993; MacArthur, Bick, & Keighley, 1997; Sultan et al., 1993). The pelvic-floor muscles form the pelvic basin and help maintain continence by actively supporting the pelvic organs and closing the pelvic openings when contracting. The pelvic-floor muscles are composed of the pelvic diaphragm muscles (together known as the levator ani), which can be referred to as the deep layer; the urogenital diaphragm muscles (together known as the perineal muscles), which can be referred to as the superficial layer; and the urethral and anal sphincter muscles (Figure 23-1). The pelvic-floor muscles are encased in fascia, which is connected to the endopelvic (parietal) fascia surrounding the pelvic organs and assists in pelvic organ support.

Correct action of the pelvic-floor muscles has been described as a squeeze around the pelvic openings and an inward lift (such as the action performed during a Kegel exercise). Pelvic-floor muscle training can increase the strength of the pelvic-floor muscles, thereby enhancing the structural support, timing, and strength of automatic contraction and resulting in the reduction or elimination of leakage. Initially, Kegel exercises can be performed utilizing the following three steps:

- Tightening the pelvic floor muscles and holding a static contraction for a count of 10
- Relaxing the muscles completely for a count of 10
- Performing 10 Kegel exercise sets, three times per day

Another option is to perform the Kegel exercises quickly (tighten, lift up, and let go) to work the muscles in a way that mimics shutting off the flow of urine to help prevent accidents. Many women prefer to do these exercises while lying down or sitting in a chair, but they can be performed anywhere. After four to six weeks, there is usually some improvement, but it may take up to three months to see a significant change.

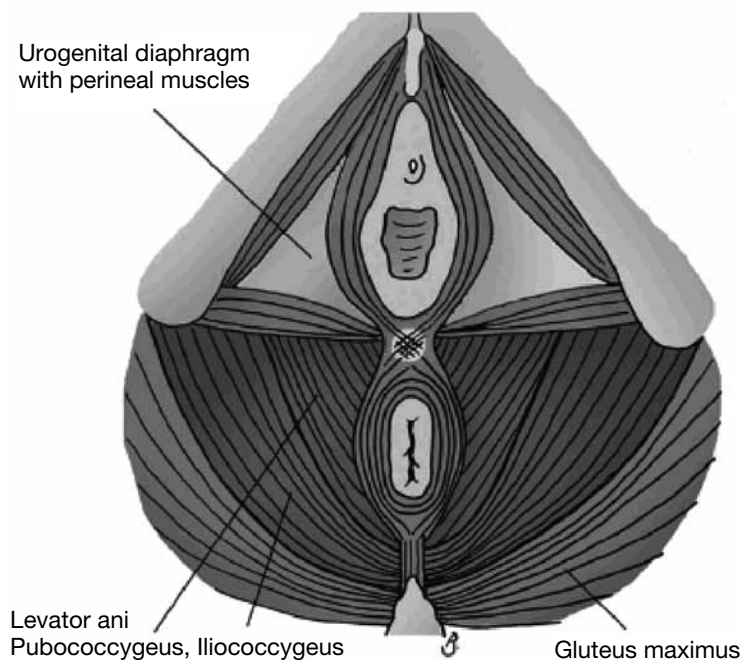
Training the pelvic-floor musculature goes hand-in-hand with performing exercises to strengthen the core. Research findings have shown that maximum pelvic-floor muscle contractions are not possible without a co-contraction of the abdominal muscles, specifically the transversus abdominis and internal oblique muscles (Bo et al., 1990; Neumann & Gill, 2002). This abdominal contraction can be observed as a small inward movement of the lower abdomen. Prior to any strenuous abdominal exercise, postnatal clients should perform transversus abdominis work (i.e., a drawing-in maneuver), pelvic tilts, and spinal stabilization exercises. Since traditional abdominal crunches compress the abdominal space and increase pressure on the pelvic floor, they should be reserved for exercise regimens after the postnatal client has had time to re-educate the pelvic floor muscles through Kegel training and core stabilization work.

Biomechanical Considerations for the Lactating Mother

Increased weight in the breasts from lactation, coupled with the forward-rounded postures associated with holding, feeding, and cuddling the baby, may lead to upper-back pain in a new mother. Additionally, lifting car seats and pushing strollers with handles that are set too low can contribute to the back pain often reported after childbirth. Stretches for the anterior shoulder girdle, followed by scapular retraction and external

Figure 23-1
Pelvic floor muscles
(inferior view)

Source: ©
Anatimedia Pty Ltd.
(www.anatimedia.com)



shoulder rotation exercises, are appropriate for new mothers looking to improve posture post-delivery and ease the pain associated with these biomechanical concerns.

Good breast support is important for comfort during postpartum exercise. It is recommended that postnatal exercisers wear a very supportive exercise bra, or two bras together if necessary. Furthermore, breastfeeding women are advised to avoid exercise with a breast abscess or with painful, engorged breasts. Nursing or expressing milk before exercise has also been suggested to increase comfort during exercise.

Case Study

Jacki S. is 37 years old and has recently discovered she is pregnant. She is in her first trimester and would like to continue her exercise program. Currently, Mrs. S. runs 3 to 4 (5 to 6 km) miles per workout for a total of about 12 to 15 (19 to 24 km) miles per week, and lifts weights two days a week. She has been cleared by her physician to continue her current routine as long as she reduces her exercise as overall discomfort dictates. Mrs. S. has two children already, and during both pregnancies suffered from mild diastasis recti and lumbar back pain.

Frequency: Mrs. S. may continue to exercise at least three times per week following her typical exercise routine.

Intensity: Mrs. S. should use RPE to monitor the intensity of her workout and aim for a rating of “fairly light” to “somewhat hard,” or 11 to 13 on Borg’s 6 to 20 scale. She should also be instructed to avoid hot and humid conditions and remain properly hydrated.

Time: Mrs. S. should be encouraged to exercise in accordance with her regular exercise program. However, she should be instructed not to continue an exercise session to the point of fatigue or exhaustion.

Type: Mrs. S. may continue to perform weight-bearing exercise, including running, as long as she is comfortable. As her pregnancy progresses, she may want to perform non-weightbearing exercise such as cycling or water aerobics, especially if she notices a recurrence of the low-back pain she

experienced in her first two pregnancies. Mrs. S. may continue her resistance-training program, but may find lighter resistance and higher repetitions more comfortable than a higher-intensity program. She should be instructed to avoid prolonged exercise in the supine position after the first trimester.

Exercises appropriate for Mrs. S. that will help her avoid low-back pain include mobility and stretching movements that emphasize relaxing and lengthening the back extensors, hip flexors, scapulae protractors, shoulder internal rotators, and neck flexors. Strengthening exercises should focus on the abdominals, gluteals, and scapulae retractors to reinforce their ability to support proper alignment. Specifically, abdominal compression exercises and curl-ups in a semirecumbent position may be helpful for strengthening the rectus abdominis without exacerbating her diastasis recti.

Summary

An increasing amount of research on exercise in pregnancy has led to less debate regarding the maternal and fetal risks of regular physical activity during pregnancy. Women entering pregnancy with regular aerobic and strength-conditioning activities as a part of their daily routines is a growing trend, and many women who are not physically active view pregnancy as a time to modify their lifestyles to include more health-conscious activities.

Evidence that regular prenatal exercise is an important component of a healthy pregnancy is increasing. The positive affects of exercise during pregnancy on the musculoskeletal, cardiovascular, respiratory, and thermoregulatory systems have been reported. Several national health and medical organizations have published recommendations and guidelines on exercise and pregnancy (ACOG, 2002b; ACSM, 2010; SOCG & CSEP, 2003). According to ACOG (2002b), there are some women for whom exercise during pregnancy is absolutely contraindicated, and others for whom the potential benefits associated with exercise may outweigh the risks.

Due to the wide range of postural and physiological adaptations that occur during and after

pregnancy, the ACE-AHFS must be proficient at designing exercise programs geared toward making physical activity more comfortable for this population. Physiological adaptations include a profound increase in body mass, retention of fluid, and laxity in supporting structures. Postural adaptations correspond with these physiological

changes and usually entail an alteration in the loading and alignment of, and muscle forces along the spine and weightbearing joints.

For more detailed information on exercise and pregnancy, refer to *Pre- and Post-Natal Fitness: A Guide for Fitness Professionals from the American Council on Exercise*, available at www.acefitness.org.

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