

Exercise in the Postpartum Period: Practical Applications

Michelle F. Mottola, PhD

Address

R. Samuel McLaughlin Foundation-Exercise & Pregnancy Lab, Room 2245, 3-M Center, School of Kinesiology, University of Western Ontario, London, Ontario N6A 3K7, Canada.

E-mail: mmottola@uwo.ca

Current Sports Medicine Reports 2002, 1:362-368

Current Science Inc. ISSN 1537-890x

Copyright © 2002 by Current Science Inc.

Pregnancy, birth, and the postpartum period are important events in the reproductive lives of women. Exercise guidelines exist for pregnancy, but recommendations for exercise during the postpartum period are virtually nonexistent. It is important to examine the theoretic concerns and potential benefits of exercise during this period, especially with respect to weight retention following pregnancy, lactation performance, and infant growth. It is recommended to increase the definition of the postpartum period to 1 year, because many physiologic changes due to pregnancy remain up to 1 year after delivery. Evidence-based guidelines are presented for postpartum exercise and lactation. Future research should address the impact of exercise and lactation on bone mineral density, nutrition status and weight loss, cardiovascular health, and how to optimize health promotion during the postpartum period.

Introduction

Regular physical activity is important to the health of women throughout their lifespan. The benefits of physical activity for women are well documented in the scientific literature, and include improved aerobic fitness [1,2], decreased body fat [3], improved bone mineralization [4], and decreased risk of colon cancer, hypertension, diabetes, osteoporotic fractures, and perhaps breast cancer [5]. Despite the health benefits cited, men are more likely to participate in vigorous physical activity than women [6], and safety issues are particularly relevant to women, because exercise of high intensity and long duration may lead to menstrual and reproductive dysfunction (*eg*, medical disorders of the "female athlete triad") [5]. Thus, cautions are in place for high-intensity and strenuous exercise for nonpregnant women during the reproductive years.

Important events occurring over the reproductive life of a woman are pregnancy, birth, and the postpartum period [7]. Guidelines now exist for women who wish to

exercise during pregnancy [8,9], but relatively little attention has been given to exercise during the postpartum period, and specific guidelines are essentially nonexistent. Benefits from postpartum exercise are improved cardiovascular fitness [1], facilitated weight loss [2,10,11], increased positive mood, decreased anxiety and depression, and more energy following exercise [12]. The relationship between increased exercise and facilitation of weight loss during the postpartum period are important, considering the increasing incidence of obesity in the North American population [13].

As exercise and active living are introduced into the postpartum period to help curb weight retention and contribute to weight loss, concern has been expressed about the compatibility of exercise and lactation. Breast feeding is strongly advocated for at least the first 12 months after delivery [14]. The issue of compatibility has recently been addressed in the scientific literature, because both exercise and lactation are energy-demanding physiologic processes [15]. It has been suggested that postpartum women are able to participate in moderate physical activity without compromise to infant breast milk acceptance [6], or infant growth [16].

This article reviews the components of postpartum care and recovery from delivery, theoretic concerns and benefits of exercise, the physiologic adaptations to pregnancy that continue into the postpartum period, and evidence-based guidelines for postpartum exercise.

Components of Postpartum Care

Once delivery has occurred, there are three main aspects of postpartum care: 1) hospital-based care (48 hours after vaginal birth and 72 hours after Cesarean birth); 2) the immediate postpartum period (2 days to 2 weeks after delivery) and 3) 6 weeks after delivery [17]. Although information given to postpartum women varies between hospitals, most hospital-based care programs focus on breast feeding, infant care and bathing, maternal episiotomy/laceration care and vaginal bleeding, home help, and "baby blues" and depression. During the immediate postpartum period, information regarding the infant, breast feeding, maternal health with regard to exercise and weight loss, symptoms of depression, and availability of help at home are emphasized. At the 6-week postpartum checkup, usually concerns regarding maternal or infant health are

examined, breast feeding is emphasized, and diet and exercise issues are raised [17]. Moran *et al.* [18] investigated postpartum issues in 1161 women and found that at 7 weeks postpartum over 75% of women wanted more information on at least one topic, with the highest percentage wanting more information on exercise, diet, and nutrition. It is interesting to note that exercise is introduced as a topic during the immediate postpartum period, yet diet and exercise is not introduced until the 6-week postpartum checkup, with no additional follow-up counseling.

Mounting evidence would suggest that after 6 weeks postpartum, women continue to face mental and physical health issues, as well as lifestyle and parenting concerns [19]. It has been suggested that it's time to enhance maternal health promotion after childbirth by emphasizing lifestyle changes in exercise, nutrition, and psychosocial well-being [19]. In lieu of these suggestions, research on the health of women after childbirth supports rethinking the scope and duration of maternal health promotion to pushing postpartum care and support to 1 year after delivery [19]. Thus, it may be beneficial to extend the definition of the postpartum period to 1 year after giving birth, compared with just 6 weeks. This suggestion is based on the evidence that postpartum recovery extends beyond the arbitrarily defined 6-week time period, and that the duration of breast feeding should be up to at least 1 year [14]. Health promotion activities started in the postpartum period have the potential to not only improve women's health and well-being in the immediate postpartum period, but then be reinforced within the first year after birth. This may help reduce the risk of developing heart disease, obesity, and other lifestyle-related diseases for mother and baby [19].

Postpartum Recovery

The duration of postpartum recovery is affected by many physiologic factors, including fatigue and the amount of time taken from work to recover and care for the infant. In the United States, it is generally accepted that postpartum leave is of 6 to 8 weeks in length, with or without pay. In Canada, maternity leave has been extended to 17 weeks, with eligibility for unemployment insurance, and the employer may or may not make up the difference. In addition, effective January 2001, Canadian women are eligible for up to 1 year unpaid leave (partial payment by unemployment insurance), with position or equivalent position guaranteed upon return. In the United Kingdom, 18 weeks are given for maternity leave, which typically starts after 34 weeks gestation, and includes 8 weeks full pay, followed by 10 weeks at half-pay. In Norway, postpartum women have full salary to stay at home with their infants for the first 12 months after delivery [20].

Many new mothers are sleep deprived because they are up many times during the night for infant feeding and care. By 6 weeks postpartum, just 51% of women reported they

Table 1. Theoretic concerns and potential benefits of exercise in the postpartum period

Concerns	Benefits
Fatigue	Improved cardiovascular fitness
Vaginal bleeding	Facilitated weight loss
Urinary stress incontinence	Increased energy
Diastasis recti	Improved psychosocial well-being
Lactation	Decreased urinary stress incontinence
	Decreased lactation-induced bone loss

had regained their usual level of physical energy [21]. Of these, 34% who delivered by Cesarean section ($n = 40$) reported regaining their physical energy within 6 weeks after delivery, compared with 72% who delivered vaginally ($n = 30$) [21]. Thus, mode of delivery may also affect the return of functional ability.

Theoretic Concerns and Benefits

Table 1 presents a list of theoretic concerns and potential benefits of postpartum exercise. Sleep disturbances in postpartum women commonly result in feelings of fatigue and a diminished amount of energy [22]. Fatigue may be a major deterrent to return to functional ability after delivery [21]; however, exercise may help to improve psychosocial well-being and increase feelings of energy. Women who exercise during the postpartum period are more likely to have positive moods, less anxiety and depression, and increased vigor following exercise [12].

Vaginal bleeding begins immediately after delivery due to the shearing off of the placenta. Uterine discharge may persist for 3 to 8 weeks after delivery [23]. Activity, including walking up and down stairs, lifting objects, or performing muscle conditioning exercise may be resumed without delay if delivery has been uncomplicated [23]. There is no evidence that exercise increases normal bleeding after delivery, or contributes to the risk of postpartum hemorrhage.

Approximately 15% of postpartum women have urinary stress incontinence 3 months after delivery [23]. Urinary stress incontinence is prevalent in 30% to 60% of pregnant women, and the pelvic floor trauma due to vaginal delivery is believed to be the major factor leading to this condition [24]. Pelvic floor musculature can be influenced by principles in exercise physiology training [25]; by strengthening the pelvic floor muscles, urinary stress incontinence may be eliminated [25]. Kegel exercises have been widely accepted as a beneficial treatment [26].

Practice of pelvic floor muscle exercise by primiparas resulted in fewer postpartum urinary incontinence symptoms [27], and may add significantly to physical recovery after delivery [20,28]. The pelvic training program most often recommended is to perform eight to 12 maximum pelvic floor muscle contractions twice a day (three times

per week) by holding the maximal contractions for 6 to 8 seconds, adding three to four fast contractions at the end of each maximal contraction [28]. Another author recommended that the number of contractions of the pelvic floor for strength building was 30 per day at maximum or near maximum capacity [27].

The incidence of diastasis recti abdominis (splitting of the rectus abdominis muscle strips along the linea alba) at or above the level of the umbilicus peaks during the third trimester (when 66% of subjects are diagnosed with the condition), compared with 53% in the immediate postpartum period (within 72 hours), and 36% between 5 and 7 weeks postpartum [29]. These data show that the condition of diastasis recti does not resolve spontaneously after delivery. Interestingly, this condition was absent in all women who were avid exercisers before the onset of pregnancy [29]. Weak abdominal muscles may also have a role in the pathogenesis of back pain during and after pregnancy [30]. However, back pain should be differentiated between lower back (lumbar) pain and posterior pelvic pain. Strengthening of the abdominal muscles and good physical fitness reduced the incidence of lower back pain but did not reduce the incidence of posterior pelvic pain [31]. In fact, women with posterior pelvic pain may experience worse symptoms if treated with back-strengthening exercises [31].

The ability of the abdominal muscles to stabilize the pelvis against resistance diminishes during pregnancy and remains decreased at 8 weeks postpartum [32]. Because of this decrease in functional ability, it has been suggested that abdominal muscle exercises be chosen with care and those exercises requiring high levels of torque production be avoided [32]. Pelvic stability must be maintained, and technique is important when performing abdominal exercises in order to reduce the incidence of lower back pain [32].

Effects on weight retention

Another concern of many postpartum women is weight retention. The average woman retains between 0.5 and 1.0 kg of body mass gained during each subsequent pregnancy [33,34]; weight retention may also be related to race. According to one study, black women retain more weight after pregnancy than white women [35]. However, weight retention is not related to maternal age [18] or method of infant feeding (breast vs bottle), as lactating women have not been consistently successful in postpartum weight loss [18]. It has been suggested that lactation is a minor contributor to postpartum weight loss, even though the production of milk is a high-demand energy process [36]. Two major factors have been identified that contribute to postpartum weight retention; the first is pregnancy weight gain [36]. Women who are of normal weight before pregnancy and who gain the amount of weight recommended by the Institute of Medicine are less likely to require intervention during the postpartum period [36]. The second factor is

related to additional weight gained in the postpartum period added to the existing weight retained after delivery. These women are more susceptible to greater long-term weight gains [37] and related diseases, such as obesity, heart disease, and diabetes. In addition, women who felt they did less exercise after delivery than in prepregnancy, as well as those who had low social support, were also at greater risk of long-term weight gain [37].

The type of intervention and the time at which it occurs are equally important to postpartum weight loss. Dietary information given during pregnancy did not result in a decrease in weight retention 1 year postpartum. However, postpartum weight retention was decreased as physical activity was increased between 6 months to 1 year after delivery [10]. Delayed resumption of prepregnancy physical activity and dietary patterns has been shown to contribute to postpartum weight retention [38]. Exercise is often preferred during the postpartum period as an alternative to dieting because physical activity has been shown to maintain lean body mass, enhance fat loss, and improve aerobic fitness [1]. Weight loss of more than 1.5 kg per week is not recommended for lactating women. For short term weight loss of nearly 1.0 kg per week, a combination of dieting and aerobic activity appears safe during lactation, and is preferable to dieting alone, because exercise helps conserve maternal lean body mass [39]. Long-term effects of diet and exercise on lactation performance have yet to be examined.

Effects on breast feeding

Several studies have examined the impact of postpartum exercise on lactation performance and infant growth. Carey and Quinn [40••] provided an excellent review of exercise and lactation. They concluded that compared with sedentary controls, exercising women are more apt to return more quickly to prepregnancy body weight and have a more positive sense of well-being [40••]. Mild- to moderate-intensity exercise during the postpartum period will not cause accumulation of lactic acid in breast milk, change milk volume if hydration is maintained, nor will this intensity of exercise affect infant growth [40••]. Infant acceptance of postexercise breast milk has been controversial. A recent well-controlled study confirms that moderate-intensity exercise does not change infant acceptance of breast milk consumed 1 hour after exercise [6]. Thus, human and animal data show no detrimental effects on offspring feeding or growth when mild to moderate exercise in the postpartum period is coupled with adequate nutrition. Guidelines for breast feeding and exercise in the postpartum period are listed in Table 2.

An issue that needs further attention is the effect of postpartum exercise on the immune properties of breast milk following exercise. A recent study suggested that following maximal aerobic exercise, IgA levels in breast milk were depressed, but returned to pre-exercise values within 1 hour after exercise [41]. Because these values were

Table 2. Guidelines for breastfeeding and exercise in the postpartum period

<p>Exercise after baby is fed or breasts are empty Mild to moderate exercise is okay Avoid strenuous and exhaustive exercise Ensure adequate hydration before, during, and after activity Ensure adequate caloric intake to support both exercise and lactation Calcium and vitamin B6 should be supplemented if daily intake is not adequate A good support bra should be worn during exercise to support the breasts and sport bras should be avoided because of breast compression</p>

depressed for 1 hour following a maximal exercise bout, does this mean that nursing after exhaustive exercise is not recommended, or should exhaustive exercise not be recommended for lactating women? There are enormous benefits of lactation to both mother and infant [42], and the immune properties passed on from mother to infant through breast milk is one of them [43]. Thus, guidelines given to lactating women who wish to be physically active should be evidence-based from the scientific literature; however, more research is needed to examine several issues regarding lactation and exercise.

In addition to lactation performance in active women, the effect of lactation and exercise on bone mineralization must be further addressed. The profound detrimental effects of lactation on maternal bone density are due to prolonged estrogen deficiency, compounded with calcium loss in excess of 200 to 400 mg/d [44]. In addition, significant axial bone loss of over 3% occurs after only 3 to 4 months of lactation [45], in response to the lactation-induced calcium loss and estrogen deficiency [44]. Although exercise has been found to enhance bone mineralization due to mechanical forces and muscular contraction, self-selected recreational exercise had no impact on early (3 months) postpartum lactation-induced bone mineral loss [44]. However, in a longitudinal study examining calcium homeostasis and spinal trabecular bone loss during pregnancy and lactation, spinal bone mineral was recovered upon resumption of menses in postpartum women [46]. This bone remineralization of the lumbar spine may be related to hormonal and estrogen recovery as menses resumes. Although physical activity was not controlled in this study, most women resumed prepregnancy activity levels 2 months after delivery and at menses onset (on average 8 months after birth). The average lactation duration was 12 months; thus, lumbar bone recovered after resumption of menses, regardless of lactation status in active postpartum women [46]. Others have agreed that lumbar bone recovers to prepregnancy values at 6 months postpartum in lactating active women with adequate calcium intake; however, bone density at the femoral neck continued to decline from pregnancy to 6 months postpartum [47]. Although the onset of menses was not reported

in the previous study, additional research is warranted on the impact of lactation, exercise, and the resumption of menses on lumbar and femoral bone mineral density in the first postpartum year.

Breast-feeding women who initiate a weight loss and exercise program may be at risk for developing nutritional deficiencies due to the augmented metabolic demands of lactation, exercise, and dietary restriction [48]. In addition to calcium, vitamin B6 may be another nutrient of concern for lactating women. Vitamin B6 is essential to lactating women because it is essential for infant growth, and important for women's overall health; and at least 2 mg/d should be ingested by breast-feeding women [48]. Overweight women (body mass index = 25–30) were placed on an energy-restricted diet of 500 kcal less per day, containing 25% daily energy from fat, 20% from protein, and 55% from carbohydrates, supplemented with vitamin B6, and no less than 1800 kcal/d starting 4 weeks postpartum. All subjects were lactating and placed on an exercise program (four times per week, at 65% to 80% of heart rate reserve, starting at 15 minutes per session, working up to 45 minutes by the end of the 5th week of intervention). The results indicated that a moderate weight loss of 0.5 kg per week did not affect vitamin B6 status or infant growth in overweight lactating women taking dietary supplements [48].

Other mineral nutrients that have been examined after exercise in lactating women are phosphorus, calcium, magnesium, potassium, and sodium. No contraindications for exercise were found with respect to these mineral concentrations in breast milk up to 60 minutes after exercise [49].

Physiologic Adaptations to Pregnancy Continuing Postpartum

The cardiovascular remodeling of pregnancy persists for an extended period of time, and is augmented in a subsequent pregnancy in healthy active women [50]. Left ventricular mass, stroke volume, and cardiac output are greater during subsequent pregnancies and do not return to prepregnancy levels for at least 1 year after delivery in women who breast feed (for 3–9 months) and remain physically active [50]. This remodeling of the heart may occur early in pregnancy in response to plasma volume expansion seen as early as 12 to 16 weeks of gestation [51,52]. Because recent evidence suggests that many cardiovascular adaptations occurring during pregnancy continue into the postpartum period, studies that include postpartum women as “non-pregnant controls” for comparison with pregnancy research should be re-evaluated. The postpartum period, especially including lactating women, should be studied as a physiologic perturbation in its own right, and not used as a comparison with pregnancy values, because the postpartum period is not a true nonpregnant or control condition.

The benefits of aerobic exercise during pregnancy may also continue into the postpartum period. The altered

Table 3. General guidelines for exercise during the postpartum period after uncomplicated delivery

Stretching, pelvic floor exercises and relaxation and breathing exercises are safe to perform in the immediate postpartum period
Newborn can be taken for a walk
Do not rush getting back into shape
Do not overly fatigue, rest intervals may be helpful
Women should use fatigue as their guide to participation in exercise activity
Abdominal exercises should be started slowly and torque exercise should be avoided
Maintain proper nutrition and hydration
Beginning a moderate intensity aerobic exercise program should be delayed until after the first postpartum checkup

cardiovascular responses to aerobic exercise during pregnancy persist at least up to 12 weeks into the postpartum period [53]. Women who exercise during pregnancy can maintain their fitness levels when evaluated at 2 months after delivery [54]. When active lactating women 2 months postpartum were compared with nonpregnant women in the luteal phase of the menstrual cycle, the postpartum women had lower resting blood pressure, and a lower peak heart rate at the same relative work rate. It may be that the cardiovascular remodeling of the heart and the persistent elevation in stroke volume in the postpartum period may blunt peak heart rate responses at the same relative work rate [54]. This may be an advantage in that the heart may not have to work as hard, and is reflected in the lower heart rate responses in the postpartum women. It was also found that women who were active during pregnancy appear to start back to aerobic activity prior to 6 weeks, and the major activity was walking for up to 60 minutes with or without a baby stroller (Mottola, Unpublished data).

In a retrospective study examining the training patterns of competitive athletes during pregnancy and postpartum, it was found that aerobic and resistance training were reduced during pregnancy and in the postpartum period compared with prepregnancy levels [55]. The main training goal during the postpartum period was to return to prepregnancy fitness and weight levels (81%). However, lack of time and lack of energy were the two most common barriers to training in the postpartum period [55]. In addition, the overwhelming form of social support needed to facilitate training in the postpartum period was childcare [55]. In examining factors associated with quitting exercise during pregnancy, Mottola and Campbell [56] found that women with children were 1.67 times more likely to quit an exercise program. These findings have tremendous implications to postpartum exercise programs, in that in order for exercise programs to succeed in the postpartum period, exercise education, social support, and childcare should be incorporated. As an addendum to childcare, a postpartum exercise program that incorporates the infant in the exercise sessions has a better chance of success.

Guidelines for Exercise

Many guidelines are based on common sense and not evidence-based from the scientific literature. In a recent statement from the American College of Obstetricians and Gynecologists [9], prepregnancy exercise routines may be resumed postpartum slowly, as soon as it is medically and physically safe. However, there are no conclusions and recommendations for postpartum exercise listed in the document. In Canada, the current recommendations suggest that if pregnancy and delivery are uncomplicated, a mild exercise program consisting of walking, pelvic floor exercises, and stretching of all muscle groups may begin immediately (Table 3) [57••]. However, if delivery was complicated or included a Cesarean section, consultation from a medical care giver should be given before resuming physical activity, usually after the first postpartum checkup (6–8 weeks) [57••]. Other activities, including walking up and down stairs, lifting heavy objects, and performing muscle-toning activities can begin without delay after uncomplicated vaginal delivery [23]. After Cesarean section delivery, maternal activities at home for the first week should be limited to personal care and care of the infant, and by the third to fourth week, most activities at home can be resumed [58]. Care must be given to the incision site, and stretching exercises should be avoided until the incision is healed.

Guidelines for Aerobic Activity

In general, physician approval is indicated before starting a moderate aerobic exercise program, and vaginal bleeding from delivery should be minimal. Every aerobic conditioning program should be based on the Frequency, Intensity, Time, and Type of activity (FITT) principle [57••]. Once medical approval has been obtained, a moderate exercise program can begin slowly at three times per week, and depending on fatigue can be increased to five times per week. Intensity can be monitored by the “talk test” (the exercise is at the appropriate level as long as the individual can carry on a conversation). If this is not possible, then intensity should be reduced to the appropriate level. Another way to monitor intensity is to take 220 minus the mother’s age, multiplied by an intensity level of approximately 70% to 85% of maximum heart rate [57••]. For example, if the mother is 30 years old, the exercise target heart rate would be $220 - 30 = 190$, multiplied by 0.7 (or 70%), which equals 133 beats per minute. The actual target heart rate range for this individual would be 133 to 162 beats per minute (85% of maximum heart rate). For women who are breastfeeding and just starting an exercise program, exercising at the lower heart rate range may be more beneficial in order to avoid fatigue. More fit women may exercise at the higher end of the target heart rate range; however, fatigue must be avoided. The time of activity can vary, however. To start an exercise program, 15 minutes of moderate activity, with a 5- to 10-minute warm-up of lower

intensity, followed by a 5- to-10 minute cool down is recommended. Exercise time at the target heart rate can increase by 5 minutes per week, as long as the individual is not overly fatigued. The type of activity can also vary; walking is a popular activity, and pushing a stroller will also help improve muscular strength.

Guidelines for Muscular Conditioning

Muscle conditioning exercises that incorporate the infant are fun for both mother and baby, and may help to overcome barriers to exercise by initiating maternal infant interaction. The infant can be used as a resistance tool (carefully, as the baby's head must be supported at all times prior to 6 months of age) for strengthening upper body muscles. By placing the infant on the floor the mother can do push-ups toward and interact with the baby. This interaction can also occur in a side-lying position with the infant on the floor lying beside the mother while the mother does hip and thigh exercises. In addition, the infant can be placed on the abdominal muscles of the mother, with the mother holding on to her thighs for support, and curl-ups can be performed. General rules for muscle conditioning exercises apply, in that fatigue, any exercise that is painful, and breath-holding should all be avoided. Suggestions for postpartum exercise guidelines using the infant are outlined by Kochan-Vintinner [57••].

Conclusions

The postpartum period and postpartum care should be expanded to 1 year in length rather than just 6 to 8 weeks because many physiological changes from pregnancy exist to at least that length of time, and breast feeding is now advocated for at least 1 year after delivery. Exercise during the postpartum period has many benefits to both mother and baby, including improved cardiovascular fitness, facilitated weight loss, more energy, and improved psychosocial well-being for the mother. In addition, pelvic floor exercise may help to decrease the incidence of urinary stress incontinence. Incorporating the baby into the postpartum exercise routine promotes maternal infant interaction. Along with these potential benefits to exercise during the postpartum period are some theoretic concerns related to fatigue, vaginal bleeding, diastasis recti, lactation performance, and infant growth. Postpartum exercise has been shown to increase energy levels following activity, but has not been shown to increase vaginal bleeding or postpartum hemorrhage. Women who are more active are less likely to be diagnosed with diastasis recti. Postpartum exercise of mild to moderate intensity does not change lactation performance or offspring feeding and growth when hydration and nutrition are maintained. Most aerobic and muscle conditioning activities can be enjoyed by postpartum women, and should be promoted in the first postpartum

year in order to reduce the risk of developing obesity, heart disease, and other lifestyle-related diseases. Future research should address the impact of exercise and lactation on bone mineral density, nutrition status and weight loss, cardiovascular health, and how to optimize health promotion during the postpartum period.

References and Recommended Reading

Papers of particular interest, published recently, have been highlighted as:

- Of importance
 - Of major importance
1. Dewey KG, McCrory MA: **Effects of dieting and physical activity on pregnancy and lactation.** *Am J Clin Nutr* 1994, 59:446S-452S.
 2. Lovelady CA, Nommsen-Rivers LA, McCrory MA, Dewey KG: **Effects of exercise on plasma lipids and metabolism of lactating women.** *Med Sci Sports Exerc* 1995, 27:22-28.
 3. Murphy MH, Hardman AE: **Training effects of short and long bouts of brisk walking in sedentary women.** *Med Sci Sports Exerc* 1999, 30:152-157.
 4. Clapp JE, Little KD: **The interaction between regular exercise and selected aspects of women's health.** *Am J Obstet Gynecol* 1995, 173:2-9.
 5. Manson JE, Lee I-M: **Exercise for women- how much pain for optimum gain?** *New Engl J Med* 1996, 334:1325-1327.
 6. Wright KS, Quinn TJ, Carey GB: **Infant acceptance of breast milk after maternal exercise.** *Pediatrics* 2002, 109:585-589.
 7. Gennaro S, Fehder W: **Health behaviors in postpartum women.** *Fam Commun Health* 2000, 22:16-26.
 8. Wolfe LA, Mottola MF: *PARmed-X for Pregnancy. Physical Activity Readiness Medical Examination.* Ottawa: Canadian Society for Exercise Physiology and Health Canada; 1996.
 9. American College of Obstetricians and Gynecologists: **Exercise during pregnancy and the postpartum period.** *Obstet Gynecol* 2002, 99:171-173.
 10. Ohlin A, Rossner S: **Trends in eating patterns, physical activity and socio-demographic factors in relation to postpartum body weight development.** *Br J Nutr* 1994, 71:457-470.
 11. Sampsel CM, Seng J, Yeo S, et al.: **Physical activity and postpartum well-being.** *JOGNN* 1999, 28:41-49.
 12. Koltyn KE, Schultes SS: **Psychological effects of an aerobic exercise session and a rest session following pregnancy.** *J Sports Med Phys Fitness* 1997, 37:287-290.
 13. Ballor DL, Keesey RE: **A meta-analysis of the factors affecting exercise-induced changes in body mass, fat mass and fat-free mass in males and females.** *Int J Obesity* 1991, 15:717-726.
 14. American Academy of Pediatrics: **Breastfeeding and the use of human milk.** *Pediatrics* 1997, 100:1035-1039.
 15. Spaaij C, van Raaij J, de Groot L, Boekholt HA: **Effect of lactation on resting metabolic rate and on diet- and work-induced thermogenesis.** *Am J Clin Nutr* 1994, 59:42-50.
 16. Lovelady CA, Lonnerdal D, Dewey KG: **Lactation performance of exercising women.** *Am J Clin Nutr* 1990, 52:103-109.
 17. Stover AM, Marnejon JG: **Postpartum care.** *Am Fam Physician* 1995, 52:1465-1472.
 18. Moran CE, Holt VL, Martin DP: **What do women want to know after childbirth?** *Birth* 1997, 24:27-34.
 19. Walker LO, Wilging S: **Rediscovering the "M" in "MCH": maternal health promotion after childbirth.** *JOGNN* 2000, 29:229-236.
 20. Morkved S, Bo K: **Effect of postpartum pelvic floor muscle training in prevention and treatment of urinary incontinence: a one-year follow up.** *Br J Obstet Gynecol* 2000, 107:1022-1028.
 21. Tulman L, Fawcett J: **Return of functional ability after childbirth.** *Nurs Res* 1988, 37:77-81.

22. Lee KA, DeJoseph JE: Sleep disturbances, vitality and fatigue among a select group of employed childbearing women. *Birth* 1992, 19:208-213.
23. Bowes WA, Katz VL: Postpartum care. In *Obstetrics: Normal and Problem Pregnancies*. Edited by Gabbe SG, Niebyl JR, Simpson JL. New York: Churchill Livingstone; 2002:701-726.
24. Meyer S, Hohlfeld P, Ahtari C, DeGrandi P: Pelvic floor education after vaginal delivery. *Obstet Gynecol* 2001, 97:673-677.
25. Johnson V: How the principles of exercise physiology influence pelvic floor muscle training. *J WOCN* 2001, 28:150-155.
26. Dattilo J: A long-term study of patient outcomes with pelvic muscle re-education for urinary incontinence. *J WOCN* 2001, 28:199-205.
27. Sampsel CM, Miller J, Mims BL, et al.: Effect of pelvic muscle exercise on transient incontinence during pregnancy and after birth. *Obstet Gynecol* 1998, 91:406-412.
28. Morkved S, Bo K: The effect of post-natal exercises to strengthen the pelvic floor muscles. *Acta Obstet Gynecol Scand* 1996, 75:382-385.
29. Boissoneault JS, Blaschak MJ: Incidence of diastasis recti abdominis during the childbearing year. *Phys Ther* 1998, 68:1082-1086.
30. Fast A, Weiss L, Ducommun EJ, Medina E, Butler JG: Low-back pain in pregnancy: abdominal muscles, sit-up performance, and back pain. *Spine* 1990, 15:28-30.
31. Ostgaard HC, Zetherstrom G, Roos-Hansson E, Svanberg B: Reduction of back and posterior pelvic pain in pregnancy. *Spine* 1994, 19:894-900.
32. Gilleard WL, Brown JM: Structure and function of the abdominal muscles in primigravid subjects during pregnancy and the immediate postbirth period. *Phys Ther* 1996, 76:750-762.
33. Johnson EM: Weight changes during pregnancy and the postpartum period. *Prog Food Nutr Sci* 1991, 15:117-127.
34. Wolfe WS, Sobal J, Olson CM, Frongillo EA: Parity-associated body weight: modification by sociodemographic and behavioral factors. *Obesity Res* 1997, 5:131-141.
35. Boardley DJ, Sargent RG, Coker AL, et al.: The relationship between diet, activity and other factors and postpartum weight change by race. *Obstet Gynecol*, 1995, 86:834-838.
36. Butte NF: Dieting and exercise in overweight, lactating women. *N Engl J Med* 2000, 342:502-503.
37. Harris HE, Ellison G, Clement S: Do the psychosocial and behavioral changes that accompany motherhood influence the impact of pregnancy on long-term weight gain? *J Psychosom Obstet Gynecol* 1999, 20:65-79.
38. Devine CM, Bove CF, Olson CM: Continuity and change in women's weight orientations and lifestyle practices through pregnancy and the postpartum period: the influence of life course trajectories and transitional events. *Soc Sci Med* 2000, 50:567-582.
39. McCrory MA, Nommsen-Rivers LA, Mole PA, et al.: 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.
- 40.●● Carey GB, Quinn TJ: Exercise and lactation: are they compatible? *Can J Appl Physiol* 2001, 26:55-74.
A review article that presents recent animal and human data on exercise and lactation.
41. Gregory RL, Wallace JP, Gfell LE, et al.: Effect of exercise on milk immunoglobulin A. *Med Sci Sports Exerc* 1997, 29:1596-1601.
42. Carey GB, Quinn TJ: Effect of exercise on milk and nursing babies. *Med Sci Sports Exerc* 1998, 30:1659.
43. Newman J: How breast milk protects newborns. *Sci Am* 1995, 273:76-79.
44. Little KD, Clapp JF: Self-selected recreational exercise has no impact on early postpartum lactation-induced bone loss. *Med Sci Sports Med* 1998, 30:831-836.
45. Sowers M, Randolph J, Shapiro B, Jannausch M: A prospective study of bone density and pregnancy after an extended period of lactation with bone loss. *Obstet Gynecol* 1995, 85:285-289.
46. Ritchie LD, Fung EB, Halloran BP, et al.: A longitudinal study of calcium homeostasis during human pregnancy and lactation and after resumption of menses. *Am J Clin Nutr* 1998, 67:693-701.
47. Drinkwater BL, Chesnut CH: Bone density changes during pregnancy and lactation in active women: a longitudinal study. *Bone Min* 1991, 14:153-160.
48. Lovelady CA, Williams JP, Garner KE, et al.: Effect of energy restriction and exercise on vitamin B-6 status of women during lactation. *Med Sci Sports Exerc* 2001, 33:512-518.
49. Fly AD, Uhlir KL, Wallace JP: Major mineral concentrations in human milk do not change after maximal exercise testing. *Am J Clin Nutr* 1998, 68:345-349.
50. Clapp J, Capeless E: Cardiovascular function before, during and after the first and subsequent pregnancies. *Am J Cardiol* 1997, 80:1469-1473.
51. Bernstein IM, Ziegler W, Badger GJ: Plasma volume expansion in early pregnancy. *Obstet Gynecol* 2001, 97:669-672.
52. Veille JC, Kitzman DW, Millsaps PD, Kilgo PD: Left ventricular diastolic filling response to stationary bicycle exercise during pregnancy and the postpartum period. *Am J Obstet Gynecol* 2001, 185:822-827.
53. Pivarnik J: Cardiovascular responses to aerobic exercise during pregnancy and postpartum. *Semin Perinatol* 1996, 20:242-249.
54. Mottola ME, Inglis S, Brun C, et al.: Cardiorespiratory responses to peak treadmill exercise in active pregnant women. *Can J Appl Physiol* 2001, 26:499.
55. Beilock S, Feltz DL, Pivarnik JM: Training patterns of athletes during pregnancy and postpartum. *RQ Exerc Sport* 2001, 72:39-46.
56. Mottola ME, Campbell MK: Activity patterns during pregnancy. *Can J Appl Physiol* 2000, 25:393.
- 57.●● Kochan-Vintinner A: *Active Living During Pregnancy: Physical Activity Guidelines for Mother and Baby*. Edited by Wolfe LA, Mottola ME. Ottawa: Canadian Society for Exercise Physiology and Health Canada; 1999.
An in-depth guide for exercise during pregnancy and the postpartum period. Includes pictures of postpartum women exercising with babies.
58. Depp R: Cesarean delivery. In *Obstetrics: Normal and Problem Pregnancies*. Edited by Gabbe SG, Niebyl JR, Simpson JL. New York: Churchill Livingstone; 2002:539-606.