

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”***POSITION STATEMENT****EXERCISE AND PREGNANCY DISCUSSION PAPER****Revised Edition Authors: Dr. Julia Alleyne and Dr. Patricia Peticca****INTRODUCTION**

Current research supports the recommendation that a moderate level of exercise on a regular basis during a low risk pregnancy has minimal risk for the fetus and beneficial metabolic and cardiorespiratory effects for the exercising woman. Many women perceive this life stage as an opportunity to improve their lifestyle and adopt healthier behaviors such as eating a balanced diet and participating in regular physical activity (4, 21, 34). An estimated forty percent of women in Western countries currently exercise during pregnancy (28), which highlights the need for research in this area to determine the safety for both mother and fetus.

Recommendations on exercise in pregnancy have undergone significant changes over the last three decades, with initial guidelines in the 1980's regarded as conservative and lacking scientific support (1) More recent guidelines have been more flexible in exercise prescription and are now evidence-based. The PARmed-X for Pregnancy tool is recommended to assess the appropriate and safe parameters for medical screening and exercise prescription.

This position paper will review the current research on exercise in pregnancy, with a discussion of fetal and maternal implications; and potential benefits in the postpartum period. The data cited throughout this paper was extracted from a large volume of research [done to date] collected from various databases including Medline, SportDiscus, PsychINFO and Cochrane Database of Systematic Reviews; expert knowledge and pertinent review articles. This position paper will also present the current guidelines for the prescription of exercise in pregnancy, as published by the Society of Obstetricians and Gynecologists of Canada (SOGC) and the Canadian Society for Exercise Physiology (CSEP) in June 2003 (22).

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”***LIMITATIONS OF RESEARCH METHODOLOGY**

The study of exercise in pregnancy is limited by the ethical issues that surround subjecting pregnant women to specific conditions which pose unknown and unpredictable harm to the unborn fetus. Therefore, research findings have been limited in their applicability and validity by the lack of scientific rigor that has been applied to this area of interest. The limitations pertaining to the research include:

- It is very difficult to differentiate physiological effects of pregnancy from exercise-induced effects.
- Specific concerns regarding exercise in pregnancy (i.e. increased neural tube defects, premature delivery) are based on adverse outcomes noted in animal studies (36, 58, 64).
- Many animal studies were performed on untrained pregnant animals that were exercised to near or complete exhaustion. Human studies typically involve physically fit pregnant women exercising at moderate levels of intensity (41, 60).
- Human studies which examine the safety of exercise in pregnancy lack well-designed, large-scale randomized controlled designs. Current recommendations are based on cohort studies, case reports, case-control, retrospective and prospective studies.
- Sample sizes are typically small which decreases the ability of the results to be representative and generalized to the larger population. Research to date is also primarily limited to healthy, non-smoking, Caucasian, previously-fit women.
- Most studies do not describe specific exercise prescriptions including type of exercise, intensity, duration and frequency. Furthermore, there is no available data which examines the safety of trendy exercise programs, such as Pilates and Yoga, in pregnant women.
- Study designs exclude women with high-risk pregnancies (i.e. multiple gestation) or co-morbidities (i.e. cardiovascular disease).
- Little research exists on the safety and effects of weight-training in low-risk pregnancy.

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”***SUMMARY OF PHYSIOLOGICAL RESEARCH:****I: FETAL IMPLICATIONS****Exercise and Early Miscarriage**

Pregnant women in the past have been advised against participating in exercise due to concerns of risk of miscarriage, either by poor implantation in early gestation or by premature labour in late gestation. These concerns were only supported by data from previous animal models, which documented an increase in fetal mortality with exercise during pregnancy (64). There are very few human studies that have investigated the effect of exercise on first trimester viability. None of the human studies to date which have demonstrated any increase in spontaneous abortion, congenital abnormalities or implantation abnormalities in exercising pregnant women (14, 20, 27). **Woman who has been previously active may continue their exercise during the first trimester to a maximum of 30-40 minutes at a frequency of 3-4 x a week as tolerated.**

**Exercise-Induced Hyperthermia**

Previous studies using pregnant rat models found that elevated maternal temperatures above 39<sup>0</sup>C, during the first trimester of pregnancy, was associated with a significant increase in fetal anomalies – particularly neural tube defects (36, 58). Human studies, however, have not supported this finding (4, 33). Researchers have established that maternal basal core temperature declines throughout pregnancy until delivery, thereby allowing for more effective thermoregulation (41). This pregnancy-induced adaptation appears to be fetoprotective; a short bout of high-intensity exercise [in late pregnancy] was not associated with a rise in maternal temperature of beyond 38<sup>0</sup>C or adverse fetal heart rate changes (41, 47).

**Preliminary studies indicate that the exercising pregnant woman may be able to tolerate mild changes in core body temperature within the established exercise guidelines.**

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”***Exercise, Blood Flow Redistribution and Glucose Availability**

It is well known that exercise results in the redistribution of blood flow from visceral organs to contracting skeletal muscle. Splanchnic blood flow, in particular, may decrease up to 50% of resting values at moderate intensity exercise – with an additional 30% decrease with prolonged high intensity exercise (15). Uterine blood flow depends on splanchnic circulation, which is a cause for concern in the exercising pregnant woman because shunting of blood flow could compromise blood flow to the placenta and developing fetus. Early animal studies suggest that redistribution of blood flow, during strenuous exercise, could compromise fetal blood flow thereby resulting in fetal hypoxia (17). Human studies, however, note that the magnitude of shunting from the placenta [to working skeletal muscle] is directly proportional to exercise intensity and muscle mass used (16). Pregnant women who continue to exercise throughout pregnancy demonstrate a blunted response in the third trimester to the magnitude of decrease in placental blood flow (16). A single bout of high-intensity exercise does not result in immediate adverse fetal or maternal cardiovascular effects (35). The impact of prolonged high-intensity exercise on placental perfusion and fetal well-being remains unknown.

Glucose is the primary energy substrate controlling fetal growth. It is also, however, the main energy substrate for skeletal muscle during exercise. Exercise in pregnancy has raised concerns about depletion of fetal glycogen stores due to increased demands of exercising maternal skeletal muscle. Insufficient storage of glycogen in the fetal heart and liver has negative implications for fetal growth and neonatal survival (31). Previous studies in trained pregnant rats reported that maternal exercise of moderate intensity did not compromise fetal or placental glycogen stores when compared to the control animals (30, 49). These findings may not be applicable to pregnant women of advanced maternal age (31). Exercise-induced reductions in circulating blood glucose have been reported with moderate to high intensity exercise in late pregnancy (8, 69). Wolfe et al. noted that exercise training may decrease insulin resistance that naturally occurs with advancing gestation, and increase hepatic glycogenolysis. Thus, aerobic conditioning may preserve fetal glucose supply by inducing a protective effect on the maternal blood glucose pool (69).

**These studies confirm that conservative guidelines are necessary for maternal exercise as the threshold for blood redistribution and glucose availability is altered during pregnancy and not well established with the additional effect of exercise.**

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”***Exercise and Birth Weight**

Birth weight is not significantly decreased in infants born to women who engage in exercise during pregnancy (28, 53). Beginning or continuing an exercise program of regular, moderate-intensity exercise in pregnancy appears to positively impact fetoplacental growth rate (18, 19). Larger term infants [and placentae] were associated with maintenance of a moderate-volume exercise regimen throughout a pregnancy and/or a reduction in exercise volume in mid and late pregnancy (18). Pregnant women who exercised vigorously in the third trimester were more likely to deliver infants weighing

200g to 400g less than the control group (39). Likewise, women who participated in exercise 5 or more times per week had increased likelihood of delivering low-birth weight infants compared to women who exercised 3 to 4 times per week (6). Well-conditioned female athletes, however, who continued to exercise at high-intensity throughout pregnancy, were found to have higher maternal weight gain and heavier newborn babies when compared to moderate-intensity exercisers (34).

**Current literature supports moderate intensity exercise of 2-4 x a week in a pregnant woman without adverse effect on fetal birth weight.**

**Exercise and Preterm Labour**

There have been no human studies, to date, that have shown an increased risk of preterm labour in exercising pregnant women (24, 28). Most studies suggest that exercise has no effect on the length of labour (43). Recent data suggests that participation in “vigorous” activity during the first and especially the second trimester of pregnancy is associated with a reduced risk of preterm labour (25). Likewise, the risk of post-term delivery is not significantly increased in this population (25, 40).

**Exercise is not found to be a risk factor for pre-term labour.**

**Exercise and Fetal Stress**

Fetal stress patterns with maternal exercise continue to be monitored because of concerns that competing demands of exercise and pregnancy could result in fetal compromise. Fetal well-being is most easily assessed by changes in baseline fetal heart rate (FHR) and variability. Previous studies reported fetal bradycardia with maternal exertion during vigorous exercise; researchers speculated that the redistribution of blood flow, cord

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”*

compression or vagal reflex may account for this finding (11, 65). These findings are not consistent with those noted in subsequent studies (35, 45, 46). It is well known that the most common FHR response to a short bout of strenuous maternal exercise is tachycardia, with a rise of approximately 10 beats per minute during exercise – and a return to baseline 10 to 20 minutes after exercise is over (69). The magnitude of change in fetal stress patterns is associated with the intensity and duration of maternal exercise. **These studies confirm that guidelines are necessary for maternal exercise because there is still some controversy regarding the threshold for exercise and fetal stress.**

## II: MATERNAL IMPLICATIONS

### Exercise and Maternal Injury

Exercise in pregnancy may predispose both mother and fetus to injury due to changes to the musculoskeletal system. Balance and coordination are both altered with the enlarging uterus, due to a shift in the woman's center of gravity. Specific pregnancy-related hormones are also known to increase the relaxation and mobilization of the pelvic, sacroiliac and sacrococcygeal joints – thereby making the woman [theoretically] more vulnerable to joint injury (32). The greatest risk to the maternal-fetal unit is associated with blunt abdominal trauma. Blunt trauma to the pregnant abdomen can occur with fall injuries – posing a risk of placenta abruption, preterm labour and uterine rupture (66). To date, there have been no studies which indicate an increased rate of injury when exercising in pregnancy (15).

**Studies indicate that moderate low impact exercise during pregnancy has not been associated with a reported incidence of maternal injury; however, the risk for potential maternal injury may occur at higher impact or contact physical activity due to the musculoskeletal changes during pregnancy.**

### Exercise, Labour and Delivery Outcome

The impact of exercise in pregnancy on labour and delivery remains unclear. However, several studies have found that pregnant women who engage in regular exercise tolerate labour pain better, require less medical interventions [such as oxytocin, forceps and cesarean section] during labour and recuperate more quickly postpartum (13, 60). The effect of exercise on the length of labour remains undecided, although many studies have

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”*

found no correlation between fitness, training level and labour (60). Interestingly, Zeanah et al. reported that women who exercised regularly before conceiving, and who had uncomplicated pregnancies, did not adversely affect their own or their newborn's health by exercising in excess of the ACOG guidelines (71).

**Exercise is not detrimental to labour and may even produce benefits of less medical intervention.**

**Exercise and Psychological Well-being**

Regular exercise is important for both physical and mental health. Apart from increasing cardiorespiratory fitness, it also enhances well-being and improves body image. The exact mechanisms underlying these effects are not well understood, but are thought to involve biochemical pathways which ultimately lead to elevated circulating endorphins, norepinephrine, and serotonin (21). When compared to their sedentary counterparts, pregnant women who engaged in exercise throughout pregnancy reported less stress, insomnia, anxiety and depression (21, 59). Previous studies have also shown these women to have an improved sense of well-being and body satisfaction (59).

**There are defined psychological benefits of exercise during pregnancy that can be attained by moderate physical activity participation.**

**Exercise and Musculoskeletal Adaptations**

Low back pain is the most commonly reported musculoskeletal problem in pregnancy. Approximately 50% of women experience some kind of back and pelvic pain during pregnancy (63), with residual pain affecting 20% of women six years postpartum (50). Current research has found a significant decrease in musculoskeletal complaints (50, 60) and associated physical discomforts [such as nausea, heartburn, leg cramps, insomnia, fatigue, varicosities and swelling of the lower extremities], among women who exercise during pregnancy (32, 52).

**Studies are limited in defining the incidence and severity of musculoskeletal adaptations during pregnancy while participating in an exercise program. Further research is recommended.**

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”***III: IMPLICATIONS IN POSTPARTUM PERIOD****Exercise and Weight Management**

Weight gain is a healthy expectation in pregnancy, and exercise during this period should not be used for weight reduction. However, excess weight gain during pregnancy and failure to lose weight in the postpartum period are important predictors for risk of subsequent obesity (7, 55). Women with higher levels of activity at 6 months postpartum were found to retain less weight than less active counterparts (3.9kg and 5.1kg, respectively) (56). Race may also play an important role in postpartum weight retention. Black women were found to have higher pre-pregnancy weights and retain 6.4 lbs more than white women postpartum. These findings suggest that culturally-specific intervention strategies are needed in both prenatal and postpartum periods (7).

**Exercise and Postpartum Depression**

An estimated 13% of women experience some degree of postpartum depression. Few studies to date have researched the impact of exercise in the postpartum period on the incidence of postpartum depression in new mothers (37, 38). Women who engage in vigorous exercise at 6 months postpartum, however, have shown to score higher on various psychological well-being scales which assess satisfaction with life circumstances, motherhood, partner relationship and confidence in tasks of motherhood (56). Furthermore, active mothers reported increased gratification with the labour and delivery experience compared to their sedentary counterparts (56).

**Exercise and Breast Milk**

Exercise in the postpartum period has raised concerns about the potential accumulation of lactic acid (LA) in breast milk, and subsequent changes in breast milk composition and infant satisfaction (70). LA in breast milk appears to be a function of exercise intensity. Breast milk volume and composition was not shown to be affected after short term maximal exercise or 30 minutes of moderate-intensity exercise (10, 38, 54). The authors also reported no differences in body weight or growth among infants of mothers in both the exercising and control groups (38). Previous findings supported significant increases in breast milk LA concentration immediately after a period of maximal exercise to exhaustion (10, 54). Secretory IgA is the predominant immunoglobulin present in

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”*

colostrum and mature breast milk, and plays a key role in early infant immune function. High-intensity exercise, over short time intervals, was shown to alter IgA concentrations in breast milk, with recovery to normal levels 60 minutes post-exercise (26). Lovelady et al, in contrast, demonstrated that moderate-intensity exercise in lactating women improved cardiovascular fitness without affecting levels of IgA in breast milk (44).

**Exercise and Urinary Incontinence**

Pregnancy and vaginal delivery are known risk factors in the development of urinary incontinence. Consistent findings among several studies suggest that strengthening of pelvic floor muscles, as with Kegel exercises, within 6 months postpartum significantly improves continence status (12, 57). Morkved et al. demonstrated a positive outcome on symptoms of urinary incontinence in women who underwent intensive pelvic floor training during pregnancy and after delivery. At 3 months postpartum, 20% of women reported urinary incontinence symptoms versus 32% in the control group (48).

**Exercise and Bone Mineral Density Loss**

Breast-feeding places high demands on the calcium reserves of new mothers, which can potentially lead to decreased bone mineral density (BMD) in women with low body weight and inadequate dietary calcium intake. Decreases of 4-6% in lumbar spine BMD have been reported during the first 6 months of lactation (29). To date, few studies have provided strong evidence that supports a reduction in BMD loss in exercising postpartum women (23, 42). More clinical studies are needed to address the potential effect of exercise on the attenuation or prevention of lactation-induced bone loss.

**Research studies related to exercise in the Post-partum currently support exercise as a therapeutic intervention for healthy lifestyle without adverse effects. It is recommended that detailed post partum guidelines be developed.**

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”***SUMMARY OF CLINICAL RECOMMENDATIONS:**

The current Joint SOGC/CSEP Clinical Practice Guidelines for exercise in pregnancy encourage all women, without known contraindications (see Appendix 1), to participate in regular moderate-intensity exercise during their pregnancy. The recommendations are specific to low-risk and uncomplicated pregnancies, irrespective of the women's pre-pregnancy level of fitness (22). Pregnant women, before the start of any exercise program, should be made aware of the warning signs (see Appendix 2) to stop exercise and seek medical attention (51).

Current guidelines recommend the use of the PARmed-X for Pregnancy (see Appendix 3) as a tool for screening women interested in participating in physical activity during pregnancy (22). Parts A and B are completed by the patient and aim to supply their obstetric care providers with knowledge of underlying medical problems, and/or previous or current pregnancy complications. The patient's current fitness status, future exercise goals and lifestyle factors are also identified in Part B. Absolute and relative contraindications to exercise in pregnancy are presented in Part C. If absolute contraindications are identified, the risk to both mother and fetus outweighs any exercise-associated benefits. If relative contraindications are identified, the safety of exercise must be assessed on an individual basis with careful and continual maternal-fetal surveillance.

**General Rules:**

1<sup>st</sup> Trimester: Maintenance of pre-pregnancy activity level

2<sup>nd</sup> Trimester: Increase training, if desired, by 5-10%

3<sup>rd</sup> Trimester: Maintain exercise level and reduce impact

- Warm-up and cool-down exercises are recommended with each exercise sessions, including range of motion exercises and static stretching for major joints and muscle groups, respectively (22, 67).

**Frequency:**

- Women who have been exercising prior to pregnancy may continue their regular exercise regimen during pregnancy, by following the PARmed-X guidelines.
-

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”*

- Women who did not exercise regularly prior to pregnancy should not start an exercise program until the second trimester.
- It is currently recommended to exercise at a frequency of 3 times per week, progressing to a maximum of 4 to 5 times per week.

**Intensity:**

- Heart rate is less reliable in pregnancy for determining exercise intensity.
- The modified heart rate target zones, as outlined in the PARmed-X, are recommended for use in measuring exercise intensity in pregnant women.
- Borg's 15-point *Rating of Perceived Exertion* (RPE) scale and the “talk test” are recommended as alternate methods of quantifying exercise intensity. A target range of 12 to 14 is suggested in pregnancy.
- The “talk test” implies that a pregnant woman can carry on a verbal conversation during exercise, if she is exercising at a safe intensity.

**Time:**

- When first beginning an exercise program, it is recommended that the woman begin with 15 minutes of continuous exercise.
- The duration of exercise may be gradually increased, as pregnancy progresses, to 30 minute sessions.

**Type:**

- Aerobic and strength-conditioning exercises are recommended in pregnancy.
- Less strenuous but continuous aerobic exercise (i.e. brisk walking, stationary cycling, cross-country skiing and swimming) are recommended.
- Avoid any exposure to hyperbaric, hyperthermic, humid or hypoxic environmental conditions.
- Avoid aerobic activities with increased risk of blunt abdominal trauma and loss of balance (i.e. downhill skiing, horse-back riding, gymnastics).
- Avoid exercises in supine position after the fourth month of pregnancy, to prevent hypotensive episodes. Avoid breath-holding during weight-training exercise.
- Abdominal exercises are not recommended if diastasis recti develops.

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”***REFERENCES AND READING LIST as of 2008**

1. American College of Obstetricians and Gynecologists. Exercise during pregnancy and the postnatal period. Washington, DC: American College of Obstetricians and Gynecologists, 1985.
2. American College of Obstetricians and Gynecologists. Exercise during pregnancy and the postnatal period. Technical Bulletin No.189. Washington, DC: American College of Obstetricians and Gynecologists, 1994.
3. Arena B, and Maffulli N. Exercise in Pregnancy: How Safe Is It? Sports Medicine and Arthroscopy Review. 2002; 10(1): 15-22.
4. Artal, R., Buckenmeyer, P. Exercise during pregnancy and postpartum. Contemporary Ob/Gyn. 1995; 62-90.
5. Artal, R and Sherman, C. Exercise During Pregnancy: Safe and Beneficial for Most. The Physician and Sports medicine. 1999; 27(8): 51-60.
6. Bell RJ, Palma SM and Lumley JM. The effect of vigorous exercise during pregnancy on birth-weight. Aust N Z J Obstet Gynecol. 1995; 35(1): 46-51.
7. Boardley DJ, Sargent RG, Coker AL, Hussey JR and Sharpe PA. The Relationship between Diet, Activity, and Other Factors, and Postpartum Weight Change by Race. Obstet Gynecol. 1995; 86:834-838.
8. Bonen A, Campagna A, Gilchrist L, Young DC and Beresford P. Substrate and endocrine responses during exercise at selected stages of pregnancy. J Appl Physiol. 1992; 73: 134-142.
9. Canadian Society for Exercise Physiology. Physical Activity Readiness Medical Examination for Pregnancy (PARmed-X for Pregnancy). [www.csep.ca](http://www.csep.ca). 2002.
10. Carey GB, Quinn TJ, and Goodwin SE. Breast milk composition after exercise of different intensities. J Hum Lact. 1997; 13(2): 115-120.

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”*

11. Carpenter MW, Sady SP, Hoegsberg B, Sady MA, Haydon B, Cullinane EM, Couston DR and Thompson PD. Fetal heart rate response to maternal exercise. JAMA. 1988; 259(20): 3006-3009.
12. Chiarelli, P and Cockburn, J. Promoting urinary continence in women after delivery: randomized controlled trial. BMJ. 2002; 324: 1241-1247.
13. Clapp, JF. The course and outcome of labour following endurance exercise during pregnancy. American Journal of Obstetrics and Gynecology. 1990; 163: 1799-1805.
14. Clapp JF. The effects of maternal exercise on early pregnancy outcome. Am J Obstet Gynecol. 1989; 161: 1453-1457.
15. Clapp JF. Exercise in Pregnancy: Good, Bad or Indifferent? In: Lee RV, Cotton DB, Barron W, et al. (eds): Current Obstetric Medicine. Vol 2. Chicago: Mosby-Year Book Inc.1993; 25-49.
16. Clapp JF. The effects of maternal exercise on fetal oxygenation and fetoplacental growth. European Journal of Obstetrics & Gynecology and Reproductive Biology. 2003; 110: S80-S85.
17. Clapp JF. Acute exercise stress in the pregnant ewe. Am J Obstet Gynecol. 1980; 136: 489-494.
18. Clapp JF, Kim H, Burciu B, Schmidt S, Petry K and Lopez B. Continuing regular exercise during pregnancy: Effect of exercise volume on fetoplacental growth. Am J Obstet Gynecol. 2002; 186: 142-147.
19. Clapp JF, Kim H, Burciu C and Lopez B. Beginning regular exercise in early pregnancy: Effect on fetoplacental growth. Am J Obstet Gynecol. 2000; 183: 1484-1488.
20. Clapp JF. Exercise and Fetal Health. Journal of Developmental Physiology. 1991; 15: 9-14.

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”*

21. DaCosta, D., Rippen, N., Dritsa, M., Ring, A. Self-reported leisure-time physical activity during pregnancy and relationship to psychological well-being. *Journal of Psychosom Obstet Gynecol.* 2003; 24: 111-119.
22. Davies, G., Wolfe, L., Mottola, M., MacKinnon, C. Joint SOGC/CSEP Clinical Practice Guideline: Exercise in Pregnancy and the Postpartum Period. *Can. J. Appl. Physiol.* 2003; 28(3): 329-341.
23. Drinkwater BL, and Chestnut CH. Bone density changes during pregnancy and lactation in active women: a longitudinal study. *Bone Miner.* 1991; 14: 153-160.
24. Dye, TD and Oldenettel, D. Physical Activity and the Risk of Preterm Labour: An Epidemiological Review and Synthesis of Recent Literature. *Seminars in Perinatology.* 1996; 20(4): 334-339.
25. Evenson KR, Siega-Riz AM, Savitz DA, Leiferman JA, and Thorp JM. Vigorous Leisure Activity and Pregnancy Outcome. *Epidemiology.* 2002; 13(6): 653-659.
26. Gregory R, Wallace J, Gfell L, Marks J, and King B. Effect of exercise on milk immunoglobulin A. *Medicine and Science in Sports and Exercise.* 1997; 29(12): 1596-1601.
27. Hall DC and Kaufmann DA. Effects of aerobic and strength conditioning on pregnancy outcomes. *Am J Obstet Gynecol.* 1987; 157: 1199-1203.
28. Hatch, M., Levin, B., Shu, X., Susser, M. Maternal Leisure-Time Exercise and Timely Delivery. *Am J Public Health.* 1998; 88: 1528-1533.
29. Hopkinson J, Butte N, Ellis K, and O'Brian Smith E. Lactation Delays Postpartum Bone Mineral Accretion and Temporarily Alters Its Regional Distribution in Women. *J Nutr.* 2000; 130: 777-783.
30. Houghton PE, Mottola MF, Mezzapelli J, Vandermolen R and Christopher PD. Glycogen storage in fetuses of trained pregnant rats. *Can J Appl Physiol.* 1997; 22: 383-393.

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”*

31. Houghton PE, Mottola MF, Plust JH and Schachter CL. Effect of Maternal Exercise on Fetal and Placental Glycogen Storage in the Mature Rat. *Can J Appl Physiol.* 2000; 25(6): 443-452.
32. Ireland, M.L., Ott, S. The Effects of Pregnancy on the Musculoskeletal System. *Clinical Orthopedics and Related Research.* 2000; 372: 169-179.
33. Jones RL, Botti JJ, Anderson WM and Bennett NL. Thermoregulation During Aerobic Exercise in Pregnancy. *Obstet Gynecol.* 1985; 65(3): 340-345.
34. Kardel, K., Kase, T. Training in pregnant women: Effects on fetal development and birth. *Am J Obstet Gynecol.* 1998; 178: 280-286.
35. Kennelly MM, Geary M, McCaffrey N, McLoughlin P, Staines A, McKenna P. Exercise-related changes in umbilical and uterine artery waveforms as assessed by Doppler ultrasound scans. *Am J Obstet Gynecol.* 2002; 187: 661-666.
36. Kilham, L and Ferm, VH. Exencephaly in fetal hamsters following exposure to hyperthermia. *Teratology.* 1976; 14: 323-326.
37. Koltyn KF, and Schultes SS. Psychological effects of an aerobic exercise session and a rest session following pregnancy. *J Sports Med Phys Fitness.* 1997; 37(4): 287-291.
38. Larson-Meyer, DE. Effect of Postpartum Exercise on Mothers and their Offspring: A Review of the Literature. *Obesity Research.* 2002; 10: 841-853.
39. Leet T and Flick L. Effect of Exercise on Birth weight. *Clinical Obstetrics and Gynecology.* 2003; 46(2): 423-431.
40. Leiferman JA and Evenson KR. The Effect of Regular Leisure Physical Activity on Birth Outcomes. *Maternal and Child Health Journal.* 2003; 7(1): 59-64.
41. Lindqvist PG, Marsal K, Merlo J and Pirhonen JP. Thermal response to submaximal exercise before, during and after pregnancy: a longitudinal study. *The Journal of Maternal-Fetal and Neonatal Medicine.* 2003; 13: 152-156.

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”*

42. Little KD, and Clapp JF. Self-selected recreational exercise has no impact on early postpartum lactation-induced bone loss. *Medicine and Science in Sports and Exercise*. 1998; 30: 831-836.
43. Lokey EA, Tran ZV, Wells CL, Meyers BC and Tran AC. Effects of physical exercise on pregnancy outcomes: a meta-analytic review. *Medicine and Science in Sports and Exercise*. 1991; 23(11): 1234-1239.
44. Lovelady C, Hunter C, Geigerman C. Effect of Exercise on Immunologic Factors in Breast Milk. *Pediatrics*. 2003; 111: e148-e152.
45. Macphail A, Davies G, Victory R, Wolfe L. Maximal Exercise Testing in Late Gestation: Fetal Responses. *Obstet Gynecol*. 2000; 96: 565-70.
46. Manders M, Sonder G, Mulder E, Visser G. The effects of maternal exercise on fetal heart rate and movement patterns. *Early Human Development*. 1997; 48: 237-247.
47. McMurray RG, Berry MJ, Katz VL, Graetzer DG, Cefalo RC. The thermoregulation of pregnant women during aerobic exercise in the water: a longitudinal approach. *Eur J Appl Physiol Occup Physiol*. 1990; 61(1-2): 119-123.
48. Morkved S, Bo K, Schei B, Salvesen K. Pelvic Floor Muscle Training During Pregnancy to Prevent Urinary Incontinence: A Single-Blind Randomized Controlled Trial. *Obstet Gynecol*. 2003; 101: 313-319.
49. Mottola MF, Mezzapelli J, Schachter CL, McKenzie K. Training effects on maternal and fetal glucose uptake following acute exercise in the rat. *Med Sci Sports Exerc*. 1993; 25(7) 841-846.
50. Ostgaard HC, Zetherstrom G, Roos-Hansson E, Svanberg B. Reduction of back and posterior pelvic pain in pregnancy. *Spine*. 1994; 19(8): 894-900.
51. Paisley, J. Mellion, M. Exercise during Pregnancy. *Am Fam Phys*. 1988; 38(5): 143-150.

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”*

52. Paisley, T., Joy, E. Price, R. Exercise During Pregnancy: A Practical Approach. Current Sports Medicine Reports. 2003; 2: 325-330.
53. Pivarnik, J. Potential effects of maternal physical activity on birth weight: brief review. Medicine and Science in Sports and Exercise. 1998; 30(3): 400-406.
54. Quinn, TJ and Carey, GB. Does exercise intensity or diet influence lactic acid accumulation in breast milk? Med Sci Sports Exerc. 1999; 31: 105-110.
55. Rooney BL, and Schauburger CW. Excess Pregnancy Weight Gain and Long-Term Obesity: One Decade Later. Obstet Gynecol. 2002; 100: 245-52.
56. Sampsel C, Seng J, Yeo S, Killion C, Oakley D. Physical Activity and Postpartum Well-Being. Journal of Obstetric, Gynecologic & Neonatal Nursing. 1999; 28(1): 41-49.
57. Sampsel C, Miller J, Mims B, Delancey J, Aston-Miller J, Antonakos C. Effect of Pelvic Muscle Exercise on Transient Incontinence during Pregnancy and After Birth. Obstet Gynecol. 1998; 91: 406-412.
58. Sasaki, J., Yamaguchi, A., Nabeshima, Y., Shigemitsu, S., Mesaki, N., Kubo, T. Exercise at high temperatures causes maternal hyperthermia and fetal anomalies in rats. Teratology. 1995; 51: 233-236.
59. Sterling-Marquez S, Perry A, Kaplan T, Halberstein R, Signorile J. Physical and psychological changes with vigorous exercise in sedentary primigravidae. Medicine & Science in Sports & Exercise. 2000; 32(1): 58-62.
60. Sternfeld B, Quesenberry JR, Eskenazi B, Newman LA. Exercise during pregnancy and pregnancy outcome. Medicine and Science in Sports and Exercise. 1995; 27(5): 634-640.
61. Stevenson, L. Exercise in pregnancy. Part 1: Update on pathophysiology. Can Fam Physician. 1997; 43: 97-104.

**CANADIAN ACADEMY OF SPORT MEDICINE  
ACADÉMIE CANADIENNE DE MÉDECINE DU  
SPORT***“Committed to Excellence • L'excellence dans la pratique”*

62. Stevenson, L. Exercise in pregnancy. Part 2: Recommendations for individuals. *Can Fam Physician*. 1997; 43: 107-111.
63. Stuge B, Hilde G, Vollestad N. Physical therapy for pregnancy-related low back and pelvic pain: a systematic review. *Acta Obstet Gynecol*. 2003; 82: 983-990.
64. Terada, M. Effect of physical activity before pregnancy on fetuses of mice exercised forcibly during pregnancy. *Teratology*. 1974; 10: 141-144.
65. Webb KA, Wolfe LA, McGrath MJ. Effects of acute and chronic maternal exercise on fetal heart rate. *J Appl Physiol*. 1994; 77(5): 2207-2213.
66. Williams JK, McClain L, Rosemurgy AS, Colorado NM. Evaluation of blunt abdominal trauma in the third trimester of pregnancy: maternal and fetal considerations. *Obstet Gynecol*. 1990; 75(1): 33-37.
67. Wolfe L, and Davies G. Canadian Guidelines for Exercise in Pregnancy. *Clinical Obstetrics and Gynecology*. 2003; 46(2): 488-495.
68. Wolfe L, Heenan A, Bonen A. Aerobic conditioning effects on substrate responses during graded cycling in pregnancy. *Can J Physiol Pharmacol*. 2003; 81: 696-703.
69. Wolfe L, Brenner IKM, Mottola MF. Maternal exercise, fetal well-being and pregnancy outcome. *Exercise Sports Science Reviews*. 1994; 22: 145-194.
70. Wright K, Quinn T, Carey G. Infant Acceptance of Breast Milk After Maternal Exercise. *Pediatrics*. 2002; 109: 585-589.
71. Zeanah M and Schlosser SP. Adherence to ACOG guidelines on exercise during pregnancy: effect on pregnancy outcome. *Journal of Obstetric, Gynecologic & Neonatal Nursing*. 1993; 22(4): 329-335.