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Antenatal Depression: A Rationale for Studying Exercise

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Abstract

Background—Major Depressive Disorder (MDD) in pregnancy, or antenatal depression poses unique treatment challenges and has serious consequences for mothers, unborn babies, and families when untreated. This review presents current knowledge on exercise during pregnancy, antidepressant effects of exercise, and the rationale for the specific study of exercise for antenatal depression.

Method—A systematic literature review was performed using English language articles published in Medline, PsycINFO, CINAHL, and the Cochrane Library from 1985 to January 2010.

Results—There is a broad literature supporting the antidepressant effects of exercise, but a paucity of studies specifically for antenatal depression. A small number of observational studies have reported that regular physical activities improve self-esteem and reduce symptoms of anxiety and depression during pregnancy. To date, there have not been randomized controlled studies of exercise for the treatment of MDD in pregnant women.

Conclusions—Systematic studies are needed to assess exercise as a treatment alternative for MDD during pregnancy. In consideration of the benefits of exercise for the mother and baby, and the burden of depression, studies are needed to determine the role of exercise for pregnant women with depression.

Keywords

Exercise; Physical Activity; Pregnancy; Postpartum; Mood; Depression; Gestational Diabetes; Preeclampsia

Introduction

The onset of Major Depressive Disorder (MDD) during pregnancy, also known as antenatal depression, is neither benign nor uncommon, with an estimated prevalence rate of 10 to

13%.[1] Prenatal stress is linked to direct and indirect negative influences on various biological mechanisms in human fetal development.[2,3] Antenatal depression has been associated with a number of adverse outcomes for both mothers and babies, including poor self-care, premature labor, low birth weight, longer hospital stays, and compromised mother-child bonding. [4,5] Depression during pregnancy is also one of the strongest predictors of postpartum depression and, even when undiagnosed during pregnancy, women have retrospectively identified the onset of postpartum depressive symptoms as having occurred during pregnancy. [6,7]

Treatment for depression during pregnancy poses unique challenges, as the baby is an indirect recipient of the mother's treatment.[8,9] There are few controlled treatment studies specific to perinatal women; interventions such as psychotropic medications and psychotherapy are assumed efficacious based upon studies of the general population.[10,11] In recent years, there have been a number of reports raising questions about the prudent use of psychotropic(s) during pregnancy.[12-16] Although medication is an acceptable and rational treatment option for many women, especially those with more severe MDD, many patients and physicians alike continue to prefer the use of non-medication strategies during pregnancy.[12] Non-medication treatments like psychotherapy are usually recommended, but for a variety of reasons, psychotherapy is not highly utilized in the U.S. [13] Thus, both clinicians and patients need safe and accessible treatment alternatives for depression during pregnancy.

Exercise for depression in the general population is an active area of research, with a growing number of clinical studies reporting a positive benefit of exercise upon symptoms of MDD.[14] In other areas of health, research findings consistently suggest that regular exercise offers cardiovascular protection, maintains healthy weight, reduces the risk of cancer, and helps manage diabetes, hypertension, and other chronic conditions. [15-18] In fact, regular exercise is usually one of the first lifestyle modification strategies recommended for reductions of morbidity and mortality. Since depression is increasingly being recognized as a chronic disease, it is reasonable to infer that disease management of depression might also benefit from strategies of lifestyle change.

The aims of this review are to: 1) understand the current knowledge of the safety of exercise during pregnancy; 2) identify findings regarding the impact of exercise on obstetric outcomes; 3) investigate potential mood benefits of exercise upon pregnant women such as maternal emotional well-being and depressive symptoms; and 3) provide a scientific rationale for studying exercise as an intervention for Major Depressive Disorder during pregnancy. This review will identify gaps in our knowledge of exercise as an antidepressant intervention and identify future research priorities.

Method

We performed a systematic review of English language articles published from 1985 to present in Medline, PsycINFO, CINAHL, and Cochrane Library. Terms included in the cross-searches were: exercise, physical activity, mood, pregnancy, safety, preterm labor, preeclampsia, gestational diabetes, depression, emotional well-being, anxiety, and aerobic exercise. All studies were categorized according to the level of empirical evidence, operationalized as: Level 1- Randomized controlled studies; Level 2- Cohort studies; Level 3- Case-control studies; Level 4- Case series; Level 5- Expert opinion or commentary. This method has been employed previously in systematic reviews and is outlined in the United States Agency for Health Care Research and Quality.[19] Study results are further summarized in tables and/or figures.

Section I: Exercise and Pregnancy

Overview

Exercise has well established health benefits and has been broadly recommended as a component of a healthy lifestyle across the lifespan. According to the Centers for Disease Control and Prevention (CDC), and the American College of Sports Medicine (ACSM), adults should engage in moderate- to high-intensity exercise for 30 minutes at least five days a week. The US Department of Health and Human Services initiative, recommends vigorous exercise for 20 to 30 minutes on three or more days a week for adults. [20]

Exercise is also highly encouraged during pregnancy, with the American College of Obstetricians and Gynecologists (ACOG) recommending 20 to 30 minutes per day of moderate-intensity exercise. [21] Similarly, the Society of Obstetricians and Gynecologists of Canada (SOGC) currently recommend regular exercise for pregnant women based on the maximal heart rate target zones determined by age. [22,23]

The consensus on the role of exercise during pregnancy has evolved as obstetrical benefits have been identified. Historically, exercise was discouraged during pregnancy due to a perceived increased risk of preterm delivery and fetal growth impediment.[24,25] Many of the concerns were supported by epidemiologic studies suggesting associations between strenuous physical activity, low nutritional intake, and intrauterine growth retardation.[26] However, with increased attention given to the health benefits of exercise in the last two decades, growing numbers of pregnant women are engaging in regular physical activity. Using the 1988 National Maternal and Infant Health Survey (NMIHS) data, Zhang and colleagues reported that 42% of women in the sample (N=9953) exercised during pregnancy and half of them reported a history of exercise for at least six months or longer.[27] In contrast, the data from the 2000 Behavioral Risk Factor Surveillance System reported nearly 66% of the total sample of pregnant women (N=1979) endorsed engaging in some form of regular leisure time physical activity, and 16% of these adhered to a physician-recommended level of exercise.[28] Although these percentages are lower in a comparison group of non-pregnant women (N=44,657; 73% and 26% respectively), the findings suggest that women are increasingly engaging in exercise during pregnancy, with walking the most common form of exercise utilized by women in both studies. Perceptions of exercise are changing as well; Krans and colleagues investigated the influence of a physician's communication of ACOG's 2002 guidelines on exercise during pregnancy upon a patient's consideration of exercise, finding that 95% of their sample of women (200/211) believed prenatal exercise was helpful, and their physician's recommendation significantly influenced the decision to consider and engage in regular exercise during pregnancy. [29]

Special Considerations to Exercise during Pregnancy

The anatomical and physiological changes that accompany pregnancy are necessary for optimal fetal growth as well as maternal homeostasis. In response to the changing levels of estrogen and relaxin, physiological changes such as ligamentous laxity, soft tissue swelling, weight gain, and hyperlordosis are normal and expected, but increase strain upon the musculoskeletal system and joints, [30] often bringing discomforts such as back pain, pubic pain, and nerve entrapment in extremities. [31] The cardiovascular and respiratory systems adapt to meet the demands of a growing fetus, increasing the resting heart rate by approximately 10 beats per minute and decreasing arterial blood pressure and peripheral vascular resistance. Changes in the rates of respiration lead to increased tidal volume, oxygen uptake and ventilator volume.

Activity recommendations during pregnancy are informed by the above physiological changes, and facilitated by categorizing exercise into two areas: weight-bearing and non-

weight bearing. In a weight-bearing exercise such as walking, the total energy expenditure is directly proportional to body weight. For example, a woman in late pregnancy will burn more calories walking a mile compared to a woman in early pregnancy. In a non-weight bearing exercise such as cycling, the total energy expenditure is independent of body weight. Swimming is a particular case of non-weight bearing exercise in which hydrostatic forces are directly proportional to the depth of body immersion. [32] Body posture also contributes to energy expenditure; for example, exercise in a supine position reduces cardiac output, and is thus discouraged, particularly later in the pregnancy.

Exercise Intensity during Pregnancy

Perhaps the most commonly utilized measure of physical activity is the pedometer, an easily available inexpensive tool that quantifies the number of steps a person takes in a day, tracks how many sessions or days it is used, and converts steps to miles. Most of the commercially available pedometers have standard calibrations, and more sophisticated models interface with computer programs for analysis. However, no information is given regarding the intensity, or quality, of walking.

Intensity of physical activity and exercise is traditionally measured using energy expenditure in terms of kilocalories/kilogram (kcal/kg) of body weight or heart rate variation.[33] During normal pregnancy, there is a natural increase in energy consumption and expenditure even in the resting state. Therefore, the conventional methods of measuring physical activity such as heart rate variation or kcal/kg may not capture exercise expenditure in the same way as in non-pregnant individuals.[34] Other methods of measurement such as the maximal oxygen intake ($\text{VO}_2 \text{ MAX}$) are more accurate, but are cumbersome and may require pre-pregnancy baseline data, thus posing practical challenges for use with pregnant women.

The rate of perceived exertion (RPE) is a preferred alternative for monitoring exercise intensity during pregnancy, with a recommended RPE for pregnant women being 12 to 14 (“somewhat hard”) on the Borg RPE scale.[35] The Center for Disease Control and American College of Sports Medicine (CDC-ACSM) Guidelines recommend exercise durations of 30 minutes per session, at least five days a week, for all healthy women, regardless of pregnancy status. It is suggested that pregnant women avoid prolonged exercise (45 minutes or longer per session), and carefully maintain adequate fluid intake and monitor environmental conditions during physical activity. Women who had sedentary lifestyles prior to the pregnancy are encouraged to gradually increase their duration and frequency of physical exercise over time.

Impact of Exercise during Pregnancy on Obstetrical Outcomes

Occurring in about 4 to 7% of pregnancies in United States, gestational diabetes mellitus (GDM) is associated with adverse pregnancy outcomes such as macrosomia, shoulder dystocia, birth injuries, neonatal hypoglycemia and elevated perinatal mortality.[36] Further, GDM may be a precursor for Type II Diabetes later in life. It has been reported that active pregnant women lower their risk for GDM by nearly 50% in comparison to women who are sedentary during pregnancy. [37] Exercise also reduces insulin resistance and improves glucose metabolism. Several randomized controlled studies have established that the addition of regular exercise to dietary management or insulin treatment brings greater improvement in pregnant women with GDM in comparison to either diet or insulin alone. [38-41]

Regular exercise confers beneficial effects on hypertensive disorders in pregnancy as well. Preeclampsia, a severe form of hypertensive disorder occurring in pregnancy, has a prevalence rate of 3 to 7%, and is one of the leading causes of perinatal mortality and

morbidity.[42] High maternal blood pressure, proteinuria and edema are the hallmark symptoms of preeclampsia, with metabolic derangements such as impaired glucose tolerance, hypertriglyceridemia, chronic inflammatory changes and diffuse endothelial dysfunction also noted. The protective effects of exercise are mediated through physiological processes such as the restoration of lipid and glucose metabolism, the reduction of inflammatory processes, and weight control, all playing a significant role in the pathophysiology of the disease. [43,44] The overall effect of exercise upon prenatal health is determined by not only by type, intensity, and duration of the activity but, importantly, the timing during gestation. [45] Women who engage in regular physical activity, particularly just prior to, and during early pregnancy (before 20 weeks of gestation) appear to decrease the risk of preeclampsia significantly and may reduce the risk of preterm labor. [46]

Greater than Routine Monitoring of Exercise during Pregnancy

There are sub-populations of pregnant women who require careful evaluation prior to initiating or increasing physical activity and careful monitoring during the implementation of the exercise program. According to the ACOG, aerobic exercise is absolutely contraindicated in pregnant women with hemodynamically significant heart disease, restrictive lung disease, incompetent cervix/cerclage, multiple gestations at risk for premature labor, persistent second or third trimester bleeding, placenta praevia, premature labor, ruptured membranes, and pregnancy-induced hypertension. Aerobic exercise is relatively contraindicated in pregnant women with severe anemia, unevaluated maternal cardiac arrhythmia, chronic bronchitis, extreme morbid obesity, extreme underweight (body mass index <12), a historically sedentary lifestyle, intrauterine growth restriction, poorly controlled hypertension/preeclampsia, orthopedic limitation, poorly controlled type II diabetes, seizure disorder, thyroid disease, and history of heavy cigarette smoking. Warning signs and symptoms that prompt immediate termination of exercise are vaginal bleeding, dyspnea before exertion, dizziness, headache, chest pain, muscle weakness, calf pain or swelling that raises suspicion of thrombophlebitis, preterm labor, decreased fetal movement, and amniotic fluid leakage. These cases require immediate evaluation and/or continued observation.

Therefore, in response to current guidelines, exercise should be appropriately integrated into routine prenatal care. Exercise plays a key role in the prevention and management of common obstetrical complications such as gestational diabetes, and prevention of hypertensive disorders during pregnancy. A consultation with an obstetric provider is necessary prior to beginning a routine exercise during pregnancy. In cases of high obstetric risk such as prior histories of preterm birth, ongoing monitoring is highly recommended. In a routine pregnancy, moderately intense exercise is broadly recommended for pregnant women without medical contraindications.

Section II: Exercise and Depression

Clinical Evidence: Antidepressant Effects of Exercise

Given that Major Depressive Disorder is a chronic illness, treatments with efficacy and good tolerability are needed. Based upon research suggesting that a sedentary lifestyle has an inverse relationship to mental health in men and women, exercise for the treatment of Major Depressive Disorder is currently being investigated.[47] Research from our group as well as others has shown that aerobic exercise has modest efficacy in reducing depressive symptoms in MDD.[48,49] Several review articles and a recent meta-analysis highlight that exercise can be both an important monotherapy and an augmentation strategy for MDD. [14,50,51] Study designs have ranged from smaller open-series trials to randomized controlled comparisons, exploring modes of exercise such as group walking, individual brisk walking,

jogging, and cycling, with study durations ranging from six to sixteen weeks. Since the majority of studies have focused upon exercise for the acute treatment MDD, little is known about its use as a continuation or maintenance therapy. To maintain the focus of this discussion on exercise in the context of pregnancy, we refer the reader to existing reviews concerning the use of exercise for depression in non-pregnant samples.

Biological Plausibility for Antidepressant Effects of Exercise

The proposed biological mechanisms by which exercise may influence antidepressant benefits are neurotransmitter enhancement and hippocampal neurogenesis. Although the neurobiological underpinnings of depression are poorly understood, hypotheses of etiology include impaired neurotransmitter activity and hippocampus dysfunction. Antidepressant treatment is largely directed toward facilitating the uptake of the neurotransmitters dopamine, serotonin, and norepinephrine, based upon the assumption that the rate of uptake is impaired in mood and anxiety disorders. Interestingly, exercise has been found to potentiate dopamine, serotonin and noradrenergic activity in the Central Nervous System. [52]

New neuronal growth in the adult brain, termed “adult neurogenesis,” particularly in the hippocampus, appears to play a possible role in the treatment of psychiatric conditions including depression.[53-55] The hippocampus is involved in “emotional memory” and is linked to visual spatial memory, learning and affective regulation. Animal studies have shown that antidepressants up-regulate hippocampal neurogenesis. [56] Up-regulation of hippocampal neurogenesis demonstrated in animal models may explain antidepressant effects of exercise, as well as antidepressant effects of antidepressant medications, estrogen, deep brain stimulation, and electroconvulsive therapy.[57-58] Exercise is also believed to positively influence the surrogate measures of adult hippocampal neurogenesis such as β -endorphins, vascular endothelial growth factor (VEGF), brain-derived neurotrophic factor (BDNF), and serotonin (5-HT). Future studies in humans are needed to discern these underlying mechanisms. [59]

Section III: Exercise, Pregnancy, and Depression

Exercise Studies during Pregnancy in Non-Psychiatric Subjects

Six studies were identified by search criteria that explored the relationship between regular physical activities during pregnancy and mood symptoms (see Table 2).[60-65] The investigations included cross-sectional and cohort designs, with varying levels of exercise measured in healthy pregnant women, and comparisons including sedentary pregnant women or non-pregnant women.

Wallace et al (1986) surveyed a group of pregnant women participating in either aerobic or non-aerobic organized exercise programs in three facilities (YMCA, childbirth preparation classes, and private exercise facilities). Self-esteem, as measured by the Rosenberg Self-Esteem Scale, was one of the endpoints of interest.[60] Pregnant women participating in aerobic exercise (N = 31) reported significantly higher self-esteem compared to those participating in non-aerobic exercise (N = 22; 68.2 ± 23.8 vs. 96.6 ± 30.2 respectively, $p = 0.008$). Study limitations included single time-point data collection, self-report style questionnaires, convenience samples, highly self-selected groups, and inadequate controls for potential confounding variables. In another small exercise study of pregnant (N=10) and non-pregnant women (N=6), the pregnant group reported greater emotional and cognitive changes (measured by Mood Adjective Check List- MDCL) although these were not statistically significant.[61] Koniak-Griffin and colleagues (1994) investigated a sample of adolescent pregnant girls living in residential maternity homes. The group exercising regularly (N =35; exercise operationalized as aerobic exercise at least two sessions per week

with minimum of forty five minutes each session for a total of six weeks) reported fewer depressive symptoms (as reported on the CES-D) than the group maintaining a sedentary life style (N =23; no exercise at all).[62] In an Australian study of body image and psychological well-being in pregnancy, Goodwin and colleagues found that the exercise group (N =25; exercise operationalized as at least two sessions per week in the preceding four-week period) had lower anxiety symptoms (GHQ-A 4.70 ± 4.88) in comparison to the no-exercise group (N=18; 7.33 ± 4.19 ; $p \leq 0.04$).[63] Although this study was limited by the retrospective nature of data collection, a prospective study examining the relationship between regular physical activity to mood during pregnancy reported similar findings; pregnant women who maintained an active lifestyle experienced relatively lesser severity of mood states such as fatigue, depression, and tension.[65] The majority of studies reviewed were limited by the lack of information supplied regarding the type, intensity, and/or duration of the exercise intervention.

Exercise Studies during Pregnancy in Psychiatric Subjects

No studies systematically examining exercise (structured physical activity) in an antenatal population diagnosed with Major Depressive Disorder (or any other formal diagnoses as defined by the Diagnostic and Statistical Manual for Mental Disorders [DSM-IV] or the International Classification of Diseases [ICD] were found in the extant literature. This contrasts strikingly with the large number of studies available investigating exercise in non-pregnant psychiatric samples for various conditions, particularly Major Depressive Disorder.

Rationale for Exercise Studies in Antenatal Depression

As discussed, antenatal depression is a major health concern with few rigorously studied treatment alternatives. Choosing an optimal treatment for women who are both pregnant and depressed is a complex process for both the clinician and patient, and must take into account efficacy of existing treatment options as well as patient preferences.[66,67] The joint recommendations from the American Psychiatric Association (APA) and the American College of Obstetricians and Gynecologists (ACOG) provide an overview of managing depression during pregnancy, and outline the presentation of risks and benefits to patients. [68] However, debate surrounding the acute and/or long term consequences of antidepressant medication upon the fetus continue. Although many women have benefitted from antidepressant medication during pregnancy, the unknown risks prevent a significant group of depressed women from accepting or adhering to psychotropic treatment.[69-71]. Recent reviews have also highlighted the paucity of evidence regarding the effectiveness of psychosocial interventions for perinatal depression, with few randomized controlled trials sufficiently tested. [10,72] Placing the weak evidence base aside, women with limited financial and temporal resources may have difficulty accessing traditional psychotherapy treatment. [70] Thus, there is both need and demand for treatment alternatives for pregnant women experiencing MDD.

In summary, exercise is an innovative and cost-effective approach treatment alternative for antenatal depression that deserves further research. In a recent worldwide web search, the search engine yielded more than three million sites disseminating information about exercise during pregnancy, including guidance for specific modalities (*e.g.*, Yoga, Pilates, weight training, walking), indicating the popularity of the topic. Structured physical activity has already demonstrated antidepressant effects in non-pregnant samples, providing a basis for future investigations in pregnant samples. Although the exact mechanism of action that exercise has upon mood symptoms is still unclear, research suggests that exercise potentiates the dopamine, serotonin and noradrenergic activity in the Central Nervous System. [52] Definitive evidence that exercise has positive effects upon gestational diabetes exists and, given the findings that gestational diabetes doubles the risk of perinatal depression, [73]

antenatal exercise could be particularly important in view of its potential to address both illnesses simultaneously. Since there are virtually no investigations of exercise for the treatment of mood disorders during pregnancy and the postpartum period, particularly for MDD, studies that explore the safety parameters and impact on depressive symptoms would both add to scientific knowledge and inform treatment. Exercise is also an important intervention to consider for women who have histories of MDD and wish to become pregnant, and for postpartum women, who often wish to minimize medication exposure while breastfeeding. Finally, in view of the important part structured physical activity play in optimizing the health of mothers-to-be and their babies, future studies of exercise for the treatment of depression have wide public health implications.

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References

1. Gaynes B, Gavin N, Meltzer-Brody S, et al. Perinatal depression: prevalence, screening accuracy, and screening outcomes. *Evid Rep Technol Assess.* 2005; 119:1–8.
2. Wadhwa PD. Psychoneuroendocrine processes in human pregnancy influence fetal development and health. *Psychoneuroendocrinology.* 2005; 30(8):724–743. [PubMed: 15919579]
3. Wadhwa PD, Sandman CA, Porto M, Dunkel-Schetter C, Garite TJ. The association between prenatal stress and infant birth weight and gestational age at birth: A prospective investigation. *American Journal of Obstetrics and Gynecology.* 1993; 169:858–865. [PubMed: 8238139]
4. Wisner KL, Sit DKY, Hanusa BH, et al. Major Depression and Antidepressant Treatment: Impact on Pregnancy and Neonatal Outcomes. *Am J Psychiatry.* 2009; 166(5):557–566. [PubMed: 19289451]
5. Cooper PJ, Murray L, Wilson A, Romaniuk H. Controlled trial of the short- and long-term effect of psychological treatment of post-partum depression. 1. Impact on maternal mood. *Br J Psychiatry.* 2003; 182(5):412–419. [PubMed: 12724244]
6. Yonkers KA, Ramin SM, Rush AJ, et al. Onset and persistence of postpartum depression in an inner-city maternal health clinic system. *Am J Psychiatry.* 2001; 158(11):1856–1863. [PubMed: 11691692]
7. Stowe ZN, Hostetter AL, Newport DJ. The onset of postpartum depression: Implications for clinical screening in obstetrical and primary care. *American Journal of Obstetrics & Gynecology.* 2005; 192(2):522–526. [PubMed: 15695997]
8. Wisner KL, Zarin D, Holmboe ES, et al. Risk-benefit decision making for treatment of depression during pregnancy. *Am J Psychiatry.* 2000; 157:1933–1940. [PubMed: 11097953]
9. Rubinow DR. Antidepressant Treatment During Pregnancy: Between Scylla and Charybdis. *Am J Psychiatry.* 2006; 163(6):954–956. [PubMed: 16741191]
10. Dennis CL, Ross LE. Psychosocial and psychological interventions for treating antenatal depression. *Cochrane Database of Systematic Reviews.* 2007; (3):CD006309.
11. Einarson A. Antidepressants and pregnancy: complexities of producing evidence-based information. *Can Med Assoc J.* 2009; 182(10):1017–1018. [PubMed: 20513775]

12. Bonari L, Koren G, Einarson TR, Jasper JD, Taddio A, Einarson A. Use of antidepressants by pregnant women: evaluation of perception of risk, efficacy of evidence based counseling and determinants of decision making. *Arch Women Ment Health*. 2005; 8(4):214–220.
13. Olfson M, Marcus SC. National trends in outpatient psychotherapy. *American Journal of Psychiatry*. 2010 *AJP in Advance*(In press).
14. Barbour KA, Edenfield TM, Blumenthal JA. Exercise as a treatment for depression and other psychiatric disorders: a review. *J Mol Signal*. 2007; 27(6):359–367.
15. Rosendorff C, Black HR, Cannon CP, et al. Treatment of Hypertension in the Prevention and Management of Ischemic Heart Disease: A Scientific Statement From the American Heart Association Council for High Blood Pressure Research and the Councils on Clinical Cardiology and Epidemiology and Prevention. *Circulation*. 2007; 115(21):2761–2788. [PubMed: 17502569]
16. Blair S, Church T. The fitness, obesity, and health equation: is physical activity the common denominator? *JAMA*. 2004; 292(10):1232–1234. comment. [PubMed: 15353537]
17. Church T, Earnest C, Skinner J, Blair S. Effects of different doses of physical activity on cardiorespiratory fitness among sedentary, overweight or obese postmenopausal women with elevated blood pressure: a randomized controlled trial. *JAMA*. 2007; 297(19):2081–2091. [PubMed: 17507344]
18. LaMonte M, Blair S, Church T. Physical activity and diabetes prevention. *J Appl Physiol*. 2005; 99(3):1205–1213. [PubMed: 16103523]
19. AHRQ. Systems to Rate the Strength of Scientific Evidence. Evidence Report/Technology Assessment. 2002. Available from: www.ahrq.gov/clinic/epcix.htm
20. Physical Activity Guidelines Advisory Committee. Physical Activity Guidelines Advisory Committee Report, 2008. Washington, DC: U.S. Department of Health and Human Services; 2008.
21. Artal R, O'Toole M. Guidelines of the American College of Obstetricians and Gynecologists for exercise during pregnancy and the postpartum period. *Br J Sports Med*. 2003; 37(1):6–12. [PubMed: 12547738]
22. Davies G, Wolfe L, Mottola M, et al. Exercise in pregnancy and the postpartum period. *J Obstet Gynaecol Can*. 2003; 25(6):516–529. [PubMed: 12806453]
23. Davies G, Wolfe L, Mottola M, MacKinnon C, Society of Obstetricians and gynecologists of Canada SCPOC. Joint SOGC/CSEP clinical practice guideline: exercise in pregnancy and the postpartum period. *Can J Appl Physiol*. 2003; 28(3):330–341. [PubMed: 12955862]
24. Clapp JF 3rd, Capeless EL. Neonatal morphometrics after endurance exercise during pregnancy. *Am J Obstet Gynecol*. 1990; 163:1805–1811. [PubMed: 2256486]
25. Launer LJ, Villar J, Kestler E, deOnis M. The effect of maternal work on fetal growth and duration of pregnancy: a prospective study. *Br J Obstet Gynecol*. 1990; 97:62–70.
26. Ahlborg G Jr, Bodin L, Hogstedt C. Heavy lifting during pregnancy—a hazard to the fetus? A prospective study. *Int J Epidemiol*. 1990; 19:90–97. [PubMed: 2351529]
27. Zhang J, Savitz DA. Exercise during pregnancy among US women. *Annals of Epidemiology*. 1996; 6(1):53–59. [PubMed: 8680626]
28. Evenson K, Savitz D, Huston S. Leisure-time physical activity among pregnant women in the US. *Paediatric and Perinatal Epidemiology*. 2004; 18(6):400–7. [PubMed: 15535815]
29. Krans E, Gearhart J, Dubbert P, Klar P, Miller A, Replogle W. Pregnant women's beliefs and influences regarding exercise during pregnancy. *Journal of the Mississippi State Medical Association*. 2005; 46(3):67–73. [PubMed: 15822648]
30. Ritchie J. Orthopedic considerations during pregnancy. *Clin Obstet Gynecol*. 2003; 46(2):456–466. [PubMed: 12808395]
31. Borg-Stein J, Dugan S, Gruber J. Musculoskeletal aspects of pregnancy. *Am J Phys Med Rehabil*. 2005; 84(3):180–192. [PubMed: 15725792]
32. Katz V. Exercise in water during pregnancy. *Clin Obstet Gynecol*. 2003; 46(2):432–441. [PubMed: 12808393]
33. Weissgerber T, Wolfe L, Davies G, Mottola M. Exercise in the prevention and treatment of maternal-fetal disease: a review of the literature. *Appl Physiol Nutr Metab*. 2006 Dec; 31(6):661–674. [PubMed: 17213880]

34. Stein A, Rivera J, Pivarnik J. Measuring energy expenditure in habitually active and sedentary pregnant women. *Medicine & Science in Sports & Exercise*. 2003; 35(8):1441–1446. [PubMed: 12900702]
35. Pivarnik J. Maternal exercise during pregnancy. *Sports Med*. 1994; 18(4):215–217. [PubMed: 7817061]
36. Clinical Management Guidelines for Obstetrician-Gynecologists: Gestational Diabetes. *Obstet Gynecol*. 2001; 98(3):525–538. 2001 September 1. [PubMed: 11547793]
37. Dempsey J, Butler C, Williams M. No need for a pregnant pause: physical activity may reduce the occurrence of gestational diabetes mellitus and preeclampsia. *Exerc Sport Sci Rev*. 2005; 33(3): 141–149. [PubMed: 16006822]
38. Avery M, Leon A, Kopher R. Effects of a partially home-based exercise program for women with gestational diabetes. *Obstetrics & Gynecology*. 1997; 89(1):10–15. [PubMed: 8990428]
39. Brankston G, Mitchell B, Ryan E, Okun N. Resistance exercise decreases the need for insulin in overweight women with gestational diabetes mellitus. *Am J Obstet Gynecol*. 2004; 190(1):188–193. [PubMed: 14749658]
40. Bung P, Artal R, Khodiguian N, Kjos S. Exercise in gestational diabetes. An optional therapeutic approach? *Diabetes*. 1991; 40 2:182–185. [PubMed: 1748256]
41. Jovanovic-Peterson L, Durak E, Peterson C. Randomized trial of diet versus diet plus cardiovascular conditioning on glucose levels in gestational diabetes. *Am J Obstet Gynecol*. 1989; 161(2):415–419. [PubMed: 2764059]
42. Sibai B, Dekker G, Kupferminc M. Pre-eclampsia. *Lancet*. 2005; 365(9461):785–799. [PubMed: 15733721]
43. Pivarnik J, Chambliss H, Clapp J, et al. Impact of physical activity during pregnancy and postpartum on chronic disease risk. *Medicine & Science in Sports & Exercise*. 2006; 38(5):989–1006. [PubMed: 16672855]
44. Hegaard H, Pedersen B, Nielsen B, Damm P. Leisure time physical activity during pregnancy and impact on gestational diabetes mellitus, pre-eclampsia, preterm delivery and birth weight: a review. *Acta Obstet Gynecol Scand*. 2007; 86(11):1290–1296. [PubMed: 17851805]
45. O'Toole M. Physiologic aspects of exercise in pregnancy. *Clin Obstet Gynecol*. 2003; 46(2):379–389. [PubMed: 12808388]
46. Evenson K, Siega-Riz A, Savitz D, Leiferman J, Thorp J Jr. Vigorous leisure activity and pregnancy outcome. *Epidemiology*. 2002; 13(6):653–659. [PubMed: 12410006]
47. Galper D, Trivedi M, Barlow C, Dunn A, Kampert J. Inverse association between physical inactivity and mental health in men and women. *Medicine & Science in Sports & Exercise*. 2006; 38(1):173–178. [PubMed: 16394971]
48. Dunn AL, Trivedi MH, Kampert JB, Clark CG, Chambliss HO. The DOSE study: a clinical trial to examine efficacy and dose response of exercise as treatment for depression. *Control Clin Trials*. 2002; 23(5):584–603. [PubMed: 12392873]
49. Blumenthal JA, Babyak MA, Doraiswamy PM, et al. Exercise and Pharmacotherapy in the Treatment of Major Depressive Disorder. *Psychosom Med*. 2007; 69(7):587–596. [PubMed: 17846259]
50. Dunn A, Trivedi M, O'Neal H. Physical activity dose-response effects on outcomes of depression and anxiety. *Medicine & Science in Sports & Exercise*. 2001; 33(6 Suppl):S587–597. [PubMed: 11427783]
51. Lawlor DA, Hopker SW. The effectiveness of exercise as an intervention in the management of depression: systematic review and meta-regression analysis of randomised controlled trials. *Bmj*. 2001; 322(7289):763–767. [PubMed: 11282860]
52. Meeusen R, De MK. Exercise and brain neurotransmission. *Sports Med*. 1995; 20(3):160–188. [PubMed: 8571000]
53. Nestler EJ, Barrot M, DiLeone RJ, Eisch AJ, Gold SJ, Monteggia LM. Neurobiology of depression. *Neuron*. 2002; 34(1):13–25. [PubMed: 11931738]
54. Drew MR, Hen R. Adult hippocampal neurogenesis as target for the treatment of depression. *CNS Neurol Disord Drug Targets*. 2007; 6(3):205–218. [PubMed: 17511617]

55. Eisch AJ. Adult neurogenesis: implications for psychiatry. *Prog Brain Res.* 2002; 138:315–342. [PubMed: 12432777]
56. Duman RS, Nakagawa S, Malberg J. Regulation of adult neurogenesis by antidepressant treatment. *Neuropsychopharmacology.* 2001; 25(6):836–844. [PubMed: 11750177]
57. Eisch AJ, Cameron HA, Encinas JM, Meltzer LA, Ming GL, Overstreet-Wadiche LS. Adult neurogenesis, mental health, and mental illness: hope or hype? *J Neurosci.* 2008; 28(46):11785–11791. [PubMed: 19005040]
58. Malberg JE, Duman RS. Cell proliferation in adult hippocampus is decreased by inescapable stress: reversal by fluoxetine treatment. *Neuropsychopharmacology.* 2003; 28(9):1562–1571. [PubMed: 12838272]
59. Ernst C, Olson A, Pinel J, Lam R, Christie B. Antidepressant effects of exercise: evidence for an adult-neurogenesis hypothesis? *J Psychiatry Neurosci.* 2006; 31(2):84–92. [PubMed: 16575423]
60. Wallace A, Boyer D, Dan A, Holm K. Aerobic exercise, maternal self-esteem, and physical discomforts during pregnancy. *J Nurse Midwifery.* 1986; 31(6):255–262. [PubMed: 3641886]
61. Williams A, Reilly T, Campbell I, Sutherst J. Investigation of changes in responses to exercise and in mood during pregnancy. *Ergonomics.* 1988; 31(11):1539–1549. [PubMed: 3229404]
62. Koniak-Griffin D. Aerobic exercise, psychological well-being, and physical discomforts during adolescent pregnancy. *Res Nurs Health.* 1994; 17(4):253–263. [PubMed: 8036273]
63. Goodwin A, Astbury J, McMeeken J. Body image and psychological well-being in pregnancy. A comparison of exercisers and non-exercisers. *Aust N Z J Obstet Gynaecol.* 2000; 40(4):442–447. [PubMed: 11194433]
64. Da Costa D, Rippen N, Dritsa M, Ring A. Self-reported leisure-time physical activity during pregnancy and relationship to psychological well-being. *J Psychosom Obstet Gynaecol.* 2003; 24(2):111–119. [PubMed: 12854395]
65. Poudevigne M, O'Connor P. Physical activity and mood during pregnancy. *Medicine & Science in Sports & Exercise.* 2005; 37(8):1374–1380. [PubMed: 16118585]
66. Wisner, KL.; Perel, JM. *Psychopharmacological treatment during pregnancy and lactation.* Washington, DC: American Psychiatric Association; 1996.
67. Freeman MP. Antenatal Depression: Navigating the Treatment Dilemmas. *Am J Psychiatry.* 2007; 164(8):1162–1165. [PubMed: 17671277]
68. Yonkers KA, Wisner KL, Stewart DE, et al. The management of depression during pregnancy: a report from the American Psychiatric Association and the American College of Obstetricians and Gynecologists. *Obstetrics & Gynecology.* 2009; 114(3):703–713. [PubMed: 19701065]
69. Andrade SE, Raebel MA, Brown J, et al. Use of antidepressant medications during pregnancy: a multisite study. *American Journal of Obstetrics & Gynecology.* 2008; 198(2):194.e191–195. [PubMed: 17905176]
70. Goodman JH. Women's attitudes, preferences, and perceived barriers to treatment for perinatal depression. *Birth.* 2009; 36(1):60–69. [PubMed: 19278385]
71. Bonari L, Koren G, Einarson T, Jasper J, Taddio A, Einarson A. Use of antidepressants by pregnant women: Evaluation of perception of risk, efficacy of evidence based counseling and determinants of decision making. *Archives of Women's Mental Health.* 2005; 8(4):214–220.
72. Spinelli M, Endicott J. Controlled clinical trial of interpersonal psychotherapy versus parenting education for depressed pregnant women. *American Journal of Psychiatry.* 2003; 160(3):555. [PubMed: 12611838]
73. Kozhimannil KB, Pereira MA, Harlow BL. Association between diabetes and perinatal depression among low-income mothers. *JAMA.* 2009; 301(8):842–847. [PubMed: 19244191]

Table 1
Joint SOGC/CSEP Recommendation

Maternal Age (yr)	Modified Heart Rate Target Zone	
	beats/min	beats/10sec
<20	140-155	23-26
20-29	135-150	22-25
30-39	130-145	21-24
≥ 40	125-140	20-23

SOGC Society of Obstetrics and Gynecologists of Canada; CSEP Canadian Society of Exercise Physiology

Table 2
Summary of Exercise Studies and Psychological Wellbeing in Pregnant Non-Psychiatric Subjects

Study	N (Active/Control)	Design	Subject Characteristics	Active Group	Control Group	Study Outcome Measure and Results	Level of Evidence/Limitation(s)
Wallace et al (1986) [60]	31/22	Cross-sectional	Convenience sample of women enrolled in exercise facilities	Aerobic Exercise (2x week for at least 20 min per session)	Non-aerobic exercise	Rosenberg Self-Esteem Scale, 68.2 ± 23.8 vs. 96.6 ± 30.2 ($p = 0.008$)	Level 2/Confounding variables ignored, recall bias, results are based on cross sectional view
Williams et al (1988) [61]	10/6	Prospective	Patients seen at OB clinics	Pregnant exercise group	Non-pregnant exercise group	Mood Adjective Check List (MACL) and no group differences (actual data not shown)	Level 2/Small sample size MACL was a secondary outcome
Koniak-Griffin et al (1994) [62]	35/23	Prospective	Adolescents from a residential maternity home	Supervised aerobic exercise, 2-times per week, 45-min per session $\times$ 6 weeks	No Exercise	CES-D greater change in depressive symptoms in exercise group than the control group	Level 2/Adolescent age group
Goodwin et al (2000) [63]	25/18	Retrospective	Convenient sample of women enrolled in hospital based prenatal courses	2 or more exercise sessions per week for the prior 4 weeks	No exercise	General Health Questionnaire-28; GHQ-A (Anxiety subscale) 4.70 ± 4.88 vs. 7.33 ± 4.19 ($p = 0.04$)	Level 3/Lack of validated exercise history questionnaire, data collected at one time during pregnancy
Da Costa et al (2003) [64]	230	Prospective, repeated exercise measures in 1st, 2nd and 3rd trimester	OB-Clinics	Leisure time physical activity measured by recall during an interview	None	State Anxiety Inventory, Lubin Depression Adjective Checklist: Higher anxiety and depressive symptoms in sedentary pregnant women	Level 2/Lack of validated physical activity measures, and failure to account for other potential confounders
Poudevigne et al (2005) [65]	12/12	Prospective, cohort Study, repeated measures- 12, 16, 20, 24, 28, 32 and 36 weeks of gestation	Community sample	Healthy pregnant women completed physical activity diary, and exercise intensity measured by accelerometer	Non-pregnant women	65-item Profile of Mood States (POMS); no group differences (comparison not shown)	Level 2/Small sample size, multiple comparisons with no correction