Activity in Pregnancy for Patients with a History of Preterm Birth

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Supplementary Issue: Health Disparities in Women

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ABSTRACT: Preterm birth remains a leading cause of neonatal morbidity and mortality throughout the world. Numerous risk factors for preterm birth have been identified, including non-Hispanic black race, a variety of social and behavioral factors, infections, and history of a prior preterm delivery. Of these, a history of prior spontaneous preterm birth is one of the strongest risk factors. Traditionally, women with a history of preterm birth or those deemed at high risk for preterm delivery have been placed on bed rest or a reduced activity regimen during their pregnancy. However, there is little evidence to support this recommendation. Recent research has suggested that regular physical activity and exercise during pregnancy is safe and does not increase the risk of preterm delivery. Therefore, physicians should encourage women with a history of preterm birth to exercise throughout pregnancy according to guidelines published by the American College of Obstetricians and Gynecologists as long as they are receiving regular prenatal care and their current health status permits exercise. However, there are no randomized controlled trials evaluating exercise prescription in women with a history of preterm birth, hence additional research is needed in this area.

KEYWORDS: exercise, pregnancy, preterm birth, recurrent preterm birth, bed rest

SUPPLEMENT: Health Disparities in Women

CITATION: Satterfield et al. Activity in Pregnancy for Patients with a History of Preterm Birth. *Clinical Medicine Insights: Women's Health* 2016:9(S1) 17–21 doi:10.4137/CMWH.S34684.

TYPE: Commentary

RECEIVED: January 14, 2016. **RESUBMITTED:** March 17, 2016. **ACCEPTED FOR PUBLICATION:** March 12, 2016.

ACADEMIC EDITOR: Nicole Powell-Dunford, Editor in Chief

PEER REVIEW: Four peer reviewers contributed to the peer review report. Reviewers' reports totaled 556 words, excluding any confidential comments to the academic editor.

FUNDING: Authors disclose no external funding sources.

COMPETING INTERESTS: Authors disclose no potential conflicts of interest.

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Paper subject to independent expert single-blind peer review. All editorial decisions made by independent academic editor. Upon submission manuscript was subject to anti-plagiarism scanning. Prior to publication all authors have given signed confirmation of agreement to article publication and compliance with all applicable ethical and legal requirements, including the accuracy of author and contributor information, disclosure of competing interests and funding sources, compliance with ethical requirements relating to human and animal study participants, and compliance with any copyright requirements of third parties. This journal is a member of the Committee on Publication Ethics (COPE).

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Preterm birth remains a leading cause of neonatal morbidity and mortality in the United States.[1] Multiple risk factors for preterm birth have been identified, including non-Hispanic black race, a variety of social and behavioral factors, infections, and history of a prior preterm delivery.[2–4] Of these, a history of prior preterm birth is one of the strongest risk factors.[2] Traditionally, women with a history of preterm birth or those deemed at high risk for preterm delivery have been placed on bed rest or a reduced activity regimen during their pregnancy. However, there is little evidence to support this recommendation. Recent research has suggested that regular physical activity and exercise during pregnancy is safe and does not increase the risk of preterm delivery.[5–8] In light of this new evidence, activity recommendations for women at high risk for preterm birth need to be reevaluated. This article will review current practice recommendations and evidence regarding activity during pregnancies for women at high risk for preterm delivery.

Definition and Frequency

A preterm birth is defined as occurring after 20-0/7 weeks gestation and before 37-0/7 weeks of gestation (259 days from the first day of the mother's last menstrual period), regardless of birth weight.[4] Historically, birth weight was also included in the definition, with a premature infant defined as weighing less than 2,500 g at birth, delivered before 38 weeks gestation, or both. A report by the Expert Committee on Maternal and Child Health of the World Health Organization in the 1960s made a distinction between premature and low birth weight infants, which led to birth weight being removed from the definition of preterm birth.[9] Another important distinction is whether or not a preterm birth occurs following spontaneous initiation of parturition, as some preterm deliveries are medically indicated due to maternal/fetal complications.

Worldwide, an estimated 15 million preterm births occur each year, with a global preterm birth rate of 11.1% (among 184 countries).[10] While more than 60% of these preterm births occurred in sub-Saharan Africa and South Asia, this remains a significant problem in developed countries. Preterm birth rates remain as high as 9% and above for upper middle- and high-income countries. Preterm birth in the United States rose from 10.6% in 1990 to a peak rate of 12.8% in 2006. Since that time, the rate has declined to 11.39% in 2013.[1] The initial rise in preterm birth rate resulted from a combination of factors, including increased use of assisted reproductive technologies, improved pregnancy dating by ultrasound, and increased willingness of providers to deliver preterm for maternal/fetal

indications.[4] The subsequent decline in preterm birth rate has been credited to improved fertility practices to reduce the incidence of multiple gestation pregnancies and improved strategies to prevent recurrent preterm birth, as well as quality improvement programs to limit provider-initiated preterm delivery to those with appropriate medical indications.[4] Unfortunately, significant racial disparities remain, with a preterm birth rate of 16.27% among non-Hispanic black mothers compared to 10.17% among non-Hispanic white mothers.[1]

Prediction and Prevention

Women with a prior spontaneous preterm delivery have a 2.5-fold increased risk of having a subsequent preterm delivery, with an even higher risk in women with a prior preterm delivery at less than 28 weeks.[11] Racial differences also exist, with recurrent preterm birth occurring in 26% of black women compared to 15%–20% of Caucasian women.[3] Other disparities that exist include an increased risk of preterm birth among low socioeconomic status, low education levels, residence in disadvantaged areas, and lack of access/late access to prenatal care.[4] Behavioral risk factors for recurrent preterm birth include low BMI (<19.8), significant interpregnancy weight loss (decrease in one BMI category or greater than 5 kg/m^2), initiation of cigarette smoking, and short interpregnancy interval (less than 18 months).[2,12–14] Additional risk factors include systemic and genital tract infections, periodontal disease, uterine anomalies including large fibroids, cervical dysplasia, and associated treatment, as well as previous cervical injury, shortened cervical length (less than 25 mm on transvaginal ultrasound), conception using assisted reproductive technologies, persistent vaginal bleeding, and multifetal gestation.[4,15]

Women carrying a singleton gestation with history of a prior spontaneous preterm birth should be offered progesterone supplementation (weekly intramuscular 17 α-hydroxyprogesterone caproate) beginning at 16–24 weeks gestation to reduce the risk of recurrent spontaneous preterm birth.[16–18] This therapy is continued until 36 weeks gestation. In women with a current singleton pregnancy, prior preterm birth at less than 34 weeks, and a short cervical length (less than 25 mm) before 24 weeks, cerclage placement should be considered, as placement in this population is associated with significant decreases in preterm birth and reductions in perinatal morbidity and mortality.[19,20] In women without a history of preterm delivery who are diagnosed with a cervical length of less than 20 mm prior to 24 weeks, vaginal progesterone supplementation should be initiated for prevention of preterm birth.[21]

Activity Reduction and Bed Rest

Multiple interventions have been recommended to reduce the risk of recurrent preterm birth. Historically bed rest has been recommended to women at high risk for a preterm delivery, despite a lack of evidence in the literature to support its use.

A *Cochrane* review by Sosa et al[22] to evaluate the effect of bed rest for preventing preterm birth in pregnancy women at high risk found only one trial of 1,266 women for meta-analysis.[23] In the study, 432 women were prescribed bed rest and 834 women received a placebo or no intervention. Preterm birth prior to 37 weeks was similar between groups (7.9% vs 8.5%; RR 0.92, 95% confidence interval [CI] 0.62–1.37).

A second study by Elliott et al[24] was included in the Sosa et al review but not in the meta-analysis because data for singleton pregnancies were not available. In the study, 73 women being treated for preterm labor with a negative fetal fibronectin test were randomized to activity reduction (AR) (bed rest with bathroom and shower privileges while inpatient and modified on discharge to allow travel to prenatal visits) or no AR that included resuming home and work activities. No significant differences in preterm birth rate were found between groups (preterm delivery rate 44.4% patients with AR and 35.1% patients without AR, $P = 0.478$).

One randomized clinical trial studying 17-α hydroxyprogesterone caproate and omega-3 supplementation for the prevention of preterm birth also investigated the effects of activity restriction on the preterm birth rate among nulliparous women with a short cervix (less than 30 mm).[25] In this study, activity restriction was defined as any of the following: pelvic rest, reduction of work activity, or reduction of nonwork activity. Of the 646 participants, 252 (39%) were prescribed some form of activity restriction (most commonly the combination of all three listed previously) at a mean gestational age of 23.9 weeks. Preterm birth prior to 37 weeks, and prior to 34 weeks, was significantly more common among women placed on activity restriction. This difference remained significant (adjusted odds ratio [OR] 2.37 for less than 37 weeks and 2.28 for less than 34 weeks) after controlling for confounding factors, including demographics and ultrasonography findings.

All these studies demonstrate that bed rest and AR do not significantly reduce the risk for preterm birth and may in fact have numerous adverse effects, including emotional distress, venous thromboembolism, deconditioning and increased weight gain, and financial consequences.[26,27] Providers must consider these risks before prescribing bed rest and activity reduction (AR) to their patients.

Exercise and Risk of Preterm Birth

Many epidemiologic and observational studies have examined the effects of occupational activities such as prolonged standing, heavy lifting, and exertion, as well as regular exercise on preterm delivery rates and obstetric outcomes with mixed results. Mozurkewich et al[28] performed a meta-analysis on 29 studies and concluded that physically demanding work, defined as heavy and/or repetitive lifting or load carrying, manual labor, or significant physical exertion, was associated with an increased risk for preterm delivery (pooled OR 1.22, 95% CI 1.16–1.29), as well as small for gestational age, hypertension, and preeclampsia. As stated by the authors, these results were modest and derived mainly from observational studies; therefore, the results need to be interpreted with

caution. A second review by Bonzini et al[29] included 49 studies and investigated the relationship between five occupational exposures (prolonged work hours, shift work, lifting, standing, and heavy physical work load) and three adverse obstetric outcomes (preterm birth, low birth weight, and preeclampsia/gestational hypertension). When evaluating risk for preterm birth, the findings ruled out a "more than moderate effect" (defined as a RR > 1.4) for each exposure and pooled estimates of risk pointed to only modest or null effects; therefore, no work activity restrictions could be justified.

A more recent prospective cohort study in the Netherlands,[30] evaluating associations between physically demanding work and obstetric outcomes among 4,680 pregnant women, identified no significant effects from long periods of walking, standing, lifting greater that 25 kg, nightshifts, and long work hours on the occurrence of preterm birth. Many of these reviews make an important note: women that work physically demanding jobs tend to be healthier prior to conception and may therefore be at lower risk for adverse obstetric outcomes. Due to a lack of empirical evidence based on randomized controlled trials, recommendations for work activity during pregnancy remain a challenge for obstetricians.

Several studies have investigated the effects of exercise during pregnancy on preterm delivery and adverse obstetric outcomes. Clapp found that labor began 5 days earlier among the exercise group (277 ± 6 vs 282 ± 6 days) with no difference in the incidence of preterm delivery in a study of 131 recreational athletes who continued their exercise regimen in pregnancy compared to recreational athletes who discontinued exercise during pregnancy.[6] A randomized controlled trial by Barakat et al,[7] which randomized 290 pregnant women to either exercise (55–60 minute general fitness classes three times per week, weeks 8–10 to 38–39) or not exercise, found no significant differences in gestational age at delivery between groups (EG = 39.7 ± 1.3 vs CG = 39.6 ± 1.1 weeks, $P = 0.81$). There were no significant differences in preterm deliveries and in fact fewer preterm deliveries among the exercise group (4.3%) relative to the control group (7.2%). Additionally, Jukic et al[8] reported lower incidence of preterm delivery among women who performed vigorous recreational activities during pregnancy.

Since the risk factors for preterm birth are exclusion criteria for many studies, the true risk for preterm birth due to performing short-term or chronic exercise greater than 85% of their maximum oxygen uptake (VO_2 max) is not well studied. Human and animal studies demonstrate potential concerns when the athlete goes beyond the ventilator threshold or to the point of exhaustion.[31–33] These concerns are transitory contractions and fetal heart rate deceleration. The woman at high risk for preterm birth may be at higher risk for complications with strenuous exercise taken to exhaustion.

Current Recommendations

The American College of Obstetricians and Gynecologists recently released a Committee Opinion on physical activity and exercise during pregnancy recommending women with uncomplicated pregnancies engage in at least 150 minutes of moderate intensity aerobic exercise per week.[5] The American College of Sports Medicine (ACSM) defines moderate intensity as any activity equivalent to brisk walking.[34] More specifically, the ACSM recommends that intensity should be 50%–85% of VO_2 max with a target of 60%–70% VO_2 max for women who were sedentary prior to pregnancy and above 70% VO_2 max for pregnant women wanting to maintain fitness.[34] Research has shown exercise during pregnancy helps control weight gain,[35–37] reduces the risk of gestational diabetes and preeclampsia in obese women,[38–42] and improves psychological well-being.[43,44]

Absolute contraindications to aerobic exercise in pregnancy include incompetent cervix or cerclage, multiple gestation at risk of premature labor, premature labor during the current pregnancy, and ruptured membranes.[5] It is important to note that a history of preterm delivery is not listed among the absolute or relative contraindications.

Recommended activities include walking, swimming, stationary cycling, aerobics, modified yoga and Pilates, running or jogging, racquet sports, and strength training. Activities to avoid include contact sports, activities with high risk of falling or impact (downhill skiing, horseback riding, water skiing, etc.), scuba diving, sky diving, *hot yoga*, and *hot pilates*.[5] Additionally, women should avoid exercise in the supine position after 20 weeks gestation to prevent hypotension.[45] It is important that pregnant women stay well hydrated during exercise and rest when needed. There is no gestational age limit on exercise, and women may continue to exercise until they deliver.

Based on the literature available, women with a history of preterm delivery who are receiving regular prenatal care and indicated progesterone therapy should be encouraged to continue working with minimal restrictions and participate in 30 minutes of moderate intensity exercise most days of the week. This recommendation would not apply to women with a short cervix (less than 25 mm) who undergo cerclage placement, as exercise is contraindicated in that population. For patients who are hospitalized for preterm labor, regardless of whether they have a history of preterm birth, aerobic exercise is not recommended and work activity may need to be restricted depending on the patient's occupation. Many obstetricians may recommend women in that situation stop working but should be cautioned against prescribing bed rest. Given the modest occupational risks on preterm labor, it is reasonable for women with a history of preterm birth to reduce their amount of time standing and heavy lifting at work. In women with history of a medically indicated preterm birth, exercise in the current pregnancy may help prevent a recurrent medically indicated preterm delivery in certain circumstances, particularly in the setting of poorly controlled hypertension and diabetes. Additional research is needed in this particular population, and physicians need to follow current guidelines

while tailoring recommendations to each individual patient, considering their history and current health status.

Conclusion

In the United States, and worldwide, preterm birth remains a leading cause of neonatal morbidity and mortality. While a history of preterm birth is one of the strongest risk factors,[2] significant racial disparities exist with a preterm birth rate of 16.27% among non-Hispanic black mothers compared to 10.17% among non-Hispanic white mothers.[1] A variety of other disparities exist, including an increased risk of preterm birth among low socioeconomic status, low education levels, residence in disadvantaged areas, and lack of access/late access to prenatal care.[4]

As continued research demonstrates the benefits of exercise during pregnancy, specific recommendations for high-risk populations need to be addressed. One such population is women with a history of preterm birth. Historically, these women were placed on bed rest or a reduced activity regimen during pregnancy, despite a lack of evidence supporting this practice. Recent studies have demonstrated regular physical activity and exercise during pregnancy is safe and does not increase the risk of preterm delivery.[5–8] Women with a history of preterm delivery who are receiving regular prenatal care should be encouraged to continue working with minimal restrictions and participate in 30 minutes of moderate intensity exercise most days of the week.

Author Contributions

Wrote the first draft of the manuscript: NAS. Contributed to the writing of the manuscript: NAS, LEM, and ERN. Agree with manuscript results and conclusions: NAS, LEM, and ERN. Jointly developed the structure and arguments for the paper: NAS, LEM, and ERN. Made critical revisions and approved final version: NAS, LEM, and ERN. All authors reviewed and approved of the final manuscript.

REFERENCES

1. Martin JA, Hamilton BE, Osterman MJ, Curtin SC, Matthews TJ. Births: final data for 2013. *Natl Vital Stat Rep*. 2015;64(1):1–65.
2. Spong CY. Prediction and prevention of recurrent spontaneous preterm birth. *Obstet Gynecol*. 2007;110(2 pt 1):405–415.
3. Adams MM, Elam-Evans LD, Wilson HG, Gilbertz DA. Rates of and factors associated with recurrence of preterm delivery. *JAMA*. 2000;283(12):1591–1596.
4. Gabbe SG. *Obstetrics: Normal and Problem Pregnancies*. 6th ed. Philadelphia: Elsevier/Saunders; 2012.
5. Committee Opinion No. 650: physical activity and exercise during pregnancy and the postpartum period. *Obstet Gynecol*. 2015;126(6):e135–e142.
6. Clapp JF III. The course of labor after endurance exercise during pregnancy. *Am J Obstet Gynecol*. 1990;163(6 pt 1):1799–1805.
7. Barakat R, Pelaez M, Montejo R, Refoyo I, Coteron J. Exercise throughout pregnancy does not cause preterm delivery: a randomized, controlled trial. *J Phys Act Health*. 2014;11(5):1012–1017.
8. Jukic AMZ, Evenson KR, Daniels JL, Herring AH, Wilcox AJ, Hartmann KE. A prospective study of the association between vigorous physical activity during pregnancy and length of gestation and birthweight. *Matern Child Health J*. 2012;16(5):1031–1044.
9. Fleischman AR, Oinuma M, Clark SL. Rethinking the definition of "term pregnancy". *Obstet Gynecol*. 2010;116(1):136–139.
10. Blencowe H, Cousens S, Oestergaard MZ, et al. National, regional, and worldwide estimates of preterm birth rates in the year 2010 with time trends since 1990 for selected countries: a systematic analysis and implications. *Lancet*. 2012; 379(9832):2162–2172.
11. Mercer BM, Goldenberg RL, Moawad AH, et al. The preterm prediction study: effect of gestational age and cause of preterm birth on subsequent obstetric outcome. National Institute of Child Health and Human Development Maternal-Fetal Medicine Units Network. *Am J Obstet Gynecol*. 1999;181(5 pt 1): 1216–1221.
12. Merlino A, Laffineuse L, Collin M, Mercer B. Impact of weight loss between pregnancies on recurrent preterm birth. *Am J Obstet Gynecol*. 2006;195(3):818–821.
13. Fuentes-Afflick E, Hessol NA. Interpregnancy interval and the risk of premature infants. *Obstet Gynecol*. 2000;95(3):383–390.
14. Conde-Agudelo A, Rosas-Bermudez A, Kafury-Goeta AC. Birth spacing and risk of adverse perinatal outcomes: a meta-analysis. *JAMA*. 2006;295(15):1809–1823.
15. Levine LD, Sammel MD, Hirshberg A, Elovitz MA, Srinivas SK. Does stage of labor at time of cesarean delivery affect risk of subsequent preterm birth? *Am J Obstet Gynecol*. 2015;212(3):e361–e367.
16. Meis PJ, Klebanoff M, Thom E, et al. Prevention of recurrent preterm delivery by 17 alpha-hydroxyprogesterone caproate. *N Engl J Med*. 2003;348(24):2379–2385.
17. ACOG Committee Opinion number 419 October 2008 (replaces no. 291, November 2003). Use of progesterone to reduce preterm birth. *Obstet Gynecol*. 2008;112(4):963–965.
18. Tita AT, Rouse DJ. Progesterone for preterm birth prevention: an evolving intervention. *Am J Obstet Gynecol*. 2009;200(3):219–224.
19. Owen J, Hankins G, Iams JD, et al. Multicenter randomized trial of cerclage for preterm birth prevention in high-risk women with shortened midtrimester cervical length. *Am J Obstet Gynecol*. 2009;201(4):e371–e378.
20. Berghella V, Rafael TJ, Szychowski JM, Rust OA, Owen J. Cerclage for short cervix on ultrasonography in women with singleton gestations and previous preterm birth: a meta-analysis. *Obstet Gynecol*. 2011;117(3):663–671.
21. Hassan SS, Romero R, Vidyadhari D, et al. Vaginal progesterone reduces the rate of preterm birth in women with a sonographic short cervix: a multicenter, randomized, double-blind, placebo-controlled trial. *Ultrasound Obstet Gynecol*. 2011; 38(1):18–31.
22. Sosa CG, Althabe F, Belizan JM, Bergel E. Bed rest in singleton pregnancies for preventing preterm birth. *Cochrane Database Syst Rev*. 2015;3:CD003581.
23. Hobel CJ, Ross MG, Bemis RL, et al. The West Los Angeles preterm birth prevention project. I. Program impact on high-risk women. *Am J Obstet Gynecol*. 1994;170(1 pt 1):54–62.
24. Elliott JP, Miller HS, Coleman S, et al. A randomized multicenter study to determine the efficacy of activity restriction for preterm labor management in patients testing negative for fetal fibronectin. *J Perinatol*. 2005;25(10): 626–630.
25. Grobman WA, Gilbert SA, Iams JD, et al. Activity restriction among women with a short cervix. *Obstet Gynecol*. 2013;121(6):1181–1186.
26. Maloni JA. Lack of evidence for prescription of antepartum bed rest. *Expert Rev Obstet Gynecol*. 2011;6(4):385–393.
27. Sciscione AC. Maternal activity restriction and the prevention of preterm birth. *Am J Obstet Gynecol*. 2010;202(3):e231–e235.
28. Mozurkewich EL, Luke B, Avni M, Wolf FM. Working conditions and adverse pregnancy outcome: a meta-analysis. *Obstet Gynecol*. 2000;95(4):623–635.
29. Bonzini M, Coggon D, Palmer KT. Risk of prematurity, low birthweight and pre-eclampsia in relation to working hours and physical activities: a systematic review. *Occup Environ Med*. 2007;64(4):228–243.
30. Snijder CA, Brand T, Jaddoe V, et al. Physically demanding work, fetal growth and the risk of adverse birth outcomes. The Generation R Study. *Occup Environ Med*. 2012;69(8):543–550.
31. Heenan AP, Wolfe LA, Davies GA. Maximal exercise testing in late gestation: maternal responses. *Obstet Gynecol*. 2001;97(1):127–134.
32. MacPhail A, Davies GA, Victory R, Wolfe LA. Maximal exercise testing in late gestation: fetal responses. *Obstet Gynecol*. 2000;96(4):565–570.
33. Szymanski LM, Satin AJ. Strenuous exercise during pregnancy: is there a limit? *Am J Obstet Gynecol*. 2012;207(3):e171–e176.
34. American College of Sports Medicine, Whaley MH, Brubaker PH, Otto RM, Armstrong LE. *ACSM's Guidelines for Exercise Testing and Prescription*. 7th ed. Philadelphia, PA: Lippincott Williams & Wilkins; 2006.
35. Hui A, Back L, Ludwig S, et al. Lifestyle intervention on diet and exercise reduced excessive gestational weight gain in pregnant women under a randomised controlled trial. *BJOG*. 2012;119(1):70–77.
36. Nascimento SL, Surita FG, Parpinelli MA, Siani S, Pinto e Silva JL. The effect of an antenatal physical exercise programme on maternal/perinatal outcomes and quality of life in overweight and obese pregnant women: a randomised clinical trial. *BJOG*. 2011;118(12):1455–1463.
37. Haakstad LA, Bo K. Effect of regular exercise on prevention of excessive weight gain in pregnancy: a randomised controlled trial. *Eur J Contracept Reprod Health Care*. 2011;16(2):116–125.

38. Dye TD, Knox KL, Artal R, Aubry RH, Wojtowycz MA. Physical activity, obesity, and diabetes in pregnancy. *Am J Epidemiol*. 1997;146(11):961–965.
39. Cordero Y, Mottola MF, Vargas J, Blanco M, Barakat R. Exercise is associated with a reduction in gestational diabetes mellitus. *Med Sci Sports Exerc*. 2015; 47(7):1328–1333.
40. Dempsey JC, Sorensen TK, Williams MA, et al. Prospective study of gestational diabetes mellitus risk in relation to maternal recreational physical activity before and during pregnancy. *Am J Epidemiol*. 2004;159(7):663–670.
41. Liu J, Laditka JN, Mayer-Davis EJ, Pate RR. Does physical activity during pregnancy reduce the risk of gestational diabetes among previously inactive women? *Birth*. 2008;35(3):188–195.
42. Meher S, Duley L. Exercise or other physical activity for preventing pre-eclampsia and its complications. *Cochrane Database Syst Rev*. 2006;(2):CD005942.
43. Robledo-Colonia AF, Sandoval-Restrepo N, Mosquera-Valderrama YF, Escobar-Hurtado C, Ramirez-Velez R. Aerobic exercise training during pregnancy reduces depressive symptoms in nulliparous women: a randomised trial. *J Physiother*. 2012;58(1):9–15.
44. Songoygard KM, Stafne SN, Evensen KA, Salvesen KA, Vik T, Morkved S. Does exercise during pregnancy prevent postnatal depression? A randomized controlled trial. *Acta Obstet Gynecol Scand*. 2012;91(1):62–67.
45. Nascimento SL, Surita FG, Cecatti JG. Physical exercise during pregnancy: a systematic review. *Curr Opin Obstet Gynecol*. 2012;24(6):387–394.