

# **PART F. CHAPTER 8. WOMEN WHO ARE PREGNANT OR POSTPARTUM**

## Table of Contents

Introduction .....	F8-1
Review of the Science .....	F8-3
Overview of Questions Addressed.....	F8-3
Data Sources and Process Used to Answer Questions .....	F8-3
Question 1. What is the relationship between physical activity and: 1) weight gain during pregnancy; and 2) weight loss during postpartum? .....	F8-5
Question 2. What is the relationship between physical activity and incidence of gestational diabetes mellitus?.....	F8-9
Question 3. What is the relationship between physical activity and the incidence of (1) preeclampsia and (2) hypertensive disorders during pregnancy? .....	F8-13
Question 4. What is the relationship between physical activity and (1) affect, (2) anxiety, and (3) depression during pregnancy and postpartum (up to one year)?.....	F8-17
Summary of Main and Auxillary Findings Pertaining to Pregnancy-Related Health Outcomes .....	F8-22
Needs for Future Research .....	F8-28
References .....	F8-30

## **INTRODUCTION**

Pregnancy is a normal but unique period of life for most women. The multiple hormonal, physiologic, and biomechanical changes that occur, such as increased blood volume and heart rate, weight gain, and shift in center of gravity almost always proceed properly. All women who are pregnant should be under medical care to monitor the progress of pregnancy and assure the continued health of mother and fetus.

This chapter is about the large majority of women whose pregnancy is proceeding normally. For them, regular engagement in physical activity of moderate intensity for 20 to 30 minutes per day on most or all

days of the week has been recommended during pregnancy and the postpartum period by the American College of Obstetricians and Gynecologists (ACOG) in 2015 and reaffirmed in 2017.<sup>1</sup>

Similarly, the 2008 *Physical Activity Guidelines for Americans* recommended 150 to 300 minutes per week of moderate intensity aerobic physical activity during pregnancy and postpartum to be spread throughout the week.<sup>2</sup> However, from 2007 to 2014 only 29 percent (95% confidence interval (95% CI): 24%-34%) of pregnant women at any gestation in the United States met the minimum guideline of at least 100 minutes per week of physical activity.<sup>3</sup> However, when increasing the minimum guideline to exercise at least 150 minutes per week, only 23% (95% CI: 15%-35%) met the guideline.

Current recommendations differ markedly from 30 years ago. In 1985, an ACOG Technical Bulletin warned pregnant women to keep their heart rate below 140 beats per minute and not to exercise strenuously for more than 15 minutes.<sup>4</sup> Since then, scientific research has established not only the safety of moderate-intensity physical activity for women with a normal pregnancy but its benefits as well. The restrictions on heart rate and duration of physical activity have been lifted, and recommendations encouraging women with a normal pregnancy and postpartum period to participate in non-contact physical activities of moderate-intensity are common both in the United States<sup>1,5</sup> and around the world.<sup>6,7</sup> The normal physiologic changes occurring throughout pregnancy may make perceived exertion a better indicator of moderate intensity than heart rate parameters or estimated absolute energy requirements of specific activities.<sup>1</sup> On a personalized rating of perceived exertion scale of 0 to 10, where 0 is sitting and 10 is the greatest effort possible, moderate-intensity activity would be a middle effort of 5 to 6.<sup>2</sup> Another way to gauge moderate intensity is with a talk test, where carrying on a conversation (but not singing) is still possible while doing moderate-intensity physical activity.<sup>8</sup>

This chapter provides some information about physical activity during the postpartum period, and considers such issues as the return toward pre-pregnancy weight and postpartum depression. The postpartum is a period during which resumption of previous lifestyle practices can be challenging. For this chapter, the postpartum period is defined as the year following delivery.

The benefits and risks of muscle-strengthening physical activity and vigorous-intensity aerobic activity are two issues out of reach of the available searches performed for this Work Group. They are lightly covered by the literature pertaining to physical activity by pregnant women, yet are important to any discussion about health benefits and risks of physical activity. Muscle strengthening activity for pregnant women was not addressed in the *Physical Activity Guidelines Advisory Committee Report, 2008* but is

recommended in the 2015 ACOG Committee Opinion as well as in guidelines from other countries.<sup>1,5,6</sup>

For vigorous-intensity physical activity, the 2008 Guidelines suggested that “women who habitually engage in vigorous-intensity aerobic activity or who are highly active can continue physical activity during pregnancy and the postpartum period, provided they remain healthy and discuss with their health-care provider how and when activity should be adjusted over time.”<sup>2</sup> Whether vigorous-intensity physical activity provides unique benefits or risks beyond its contribution to total volume of physical activity has not been well researched, although some physicians still advise against physical activity at greater than 90 percent of maximum heart rate.<sup>9</sup>

## REVIEW OF THE SCIENCE

### Overview of Questions Addressed

This chapter addresses four major questions:

1. What is the relationship between physical activity and weight gain during pregnancy and weight loss during postpartum?
2. What is the relationship between physical activity and the incidence of gestational diabetes mellitus?
3. What is the relationship between physical activity and the incidence of (1) preeclampsia and (2) hypertensive disorders during pregnancy?
4. What is the relationship between physical activity and (1) affect, (2) anxiety, and (3) depression during pregnancy and postpartum (up to one year)?

Questions 1 through 4 each have the following subquestions:

- a) What dose of physical activity is associated with the reported quantitative benefit or risk?
- b) Is there a dose-response relationship? If yes, what is the shape of the relationship?
- c) Does the relationship vary by age, race/ethnicity, socioeconomic status, or weight status?

### Data Sources and Process Used to Answer Questions

The Work Group identified two high-quality existing reports, the Physical Activity Guidelines Advisory Committee Report, 2008<sup>5</sup> and 2015 ACOG Committee Opinion on Physical Activity and Exercise During Pregnancy and the Postpartum Period,<sup>1</sup> that provided summaries of the science about the relationship between physical activity and health outcomes in women who are pregnant and postpartum. After reviewing these high-quality reports and consulting with three outside experts, the Work Group decided that these two documents could serve as a foundation for summarizing the benefits and risks of light- to

moderate-intensity physical activity during pregnancy and the postpartum. The Work Group also reviewed its other research questions to identify searches from other Subcommittees that could provide evidence to answer questions related to this issue. Research questions unlikely to provide information pertaining to pregnancy or postpartum were not considered. For example, the Committee decided that all-cause mortality or coronary artery disease would not be suitable outcomes for this age group. Seven searches conducted by the Committee were considered to provide potentially pertinent information.

1. **Cardiometabolic Health and Weight Management Q1:** What is the relationship between physical activity and prevention of weight gain?
2. **Cardiometabolic Health and Weight Management Q2:** In people with normal blood pressure or pre-hypertension, what is the relationship between physical activity and blood pressure?
3. **Cardiometabolic Health and Weight Management Q3:** In adults without diabetes, what is the relationship between physical activity and type 2 diabetes?
4. **Brain Health Q2:** What is the relationship between physical activity and quality of life?
5. **Brain Health Q3:** What is the relationship between physical activity and: (1) affect, (2) anxiety, and (3) depressed mood and depression?
6. **Brain Health Q4:** What is the relationship between physical activity and sleep?
7. **Ageing Q2:** What is the relationship between physical activity and physical function? (The search for this question was not restricted to older age groups).

For each of these seven questions, the results from the searches for systematic reviews, meta-analyses, pooled analyses, and existing summary reports were reviewed. All search results that included “gestation,” “postp,” “pregn,” “natal,” or “maternal” in the title or abstract were pulled and gathered for the Pregnancy topic. The title, abstract, and full-text triage review process was the same as that used for other 2018 Advisory Committee topics. The Work Group relied on these publications as the sources of potential evidence regarding quantifiable benefits or risks and the associated dose of physical activity. The Committee also completed one supplementary search activity by adding “eclampsia” and “preeclampsia” to the Cardiometabolic Health and Weight Management Question 2 search on hypertension.

After duplicates were removed, a total of 254 articles were identified through this process. The titles were reviewed by two of the three members of the work group. A total of 122 articles were deemed potentially relevant based on the title search, and the abstracts of these papers were reviewed by two members of the Committee. Through expert consultation, two original research articles were added to the group of articles being reviewed at full text. A total of 73 articles were deemed to be potentially relevant and the full papers were retrieved and reviewed.

During the full-text triage process, the Work Group originally recorded all health outcomes addressed in the articles for pregnant and postpartum women, as well as infants at birth. After reviewing the literature, the Committee decided that the available articles adequately addressed: 1) gestational weight gain (GWG) and postpartum weight loss; 2) gestational diabetes mellitus (GDM); 3) eclampsia and preeclampsia; and 4) affect, anxiety, depression. Too few reviews of quality of life, sleep, and physical function were available to provide an adequate assessment of the relationship.

A wide range of potential health-related outcomes during pregnancy, delivery, and the postpartum period exist for both mother and child. Researchers commonly report not only on the outcome of their primary interest, such as gestational diabetes, but on other sometimes related outcomes, such as occurrence of Cesarean section or birth weight of the infant. As a result, the review articles captured in our searches provided information on the search topic and, quite often, information on other events related to the pregnancy, delivery, or the postpartum period. The Work Group saw the opportunity to compare these ancillary findings with information in the 2008 Scientific Report<sup>5</sup> to determine whether the ancillary findings were consistent. The ancillary findings are summarized and discussed after presentation of the evidence pertaining to the specific questions addressed by the Work Group (see Table F8-3).

During the Work Group's review of the meta-analyses and systematic reviews, the Work Group sometimes found it necessary to examine the original research papers included in a review to determine which studies met the Committee's requirements for inclusion. The Work Group alludes to a few of the original research articles in the text; however, these original research articles are not included in the evidence portfolio, as they were not part of the original search.

**Question 1. What is the relationship between physical activity and: 1) weight gain during pregnancy; and 2) weight loss during postpartum?**

a) What dose of physical activity is associated with the reported quantitative benefit or risk?

- b) Is there a dose-response relationship? If yes, what is the shape of the relationship?
- c) Does the relationship vary by age, race/ethnicity, socioeconomic status, or weight status?

**Sources of evidence:** Systematic reviews, meta-analyses, and two existing reports

### **Conclusion Statements**

#### Weight Gain During Pregnancy

Strong evidence demonstrates a significant inverse relationship between physical activity and weight gain during pregnancy. **PAGAC Grade: Strong.**

Limited evidence suggests that a dose of physical activity similar to the 2015 American College of Obstetricians and Gynecologists Guidelines and the 2008 *Physical Activity Guidelines for Americans* is associated with minimized weight gain and a lower risk of excess gestational weight gain. **PAGAC Grade: Limited.**

Limited evidence suggests a dose-response relationship between physical activity and gestational weight gain. **PAGAC Grade: Limited.**

Insufficient evidence is available to determine whether the relationship between physical activity and gestational weight gain varies by age, race/ethnicity, socioeconomic status, or weight status. **PAGAC Grade: Not assignable.**

#### Weight Loss During the Postpartum Period

Insufficient evidence is available to determine whether physical activity is associated with weight loss during the postpartum period. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine what dose of physical activity is effective for weight loss during postpartum. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine whether a dose-response relationship exists between physical activity and weight loss during postpartum. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine whether any relationship between physical activity and weight loss during postpartum varies by age, race/ethnicity, socioeconomic status, or weight status.

**PAGAC Grade: Grade not assignable.**

## **Review of the Evidence**

### **Weight Gain During Pregnancy**

Sources of evidence included systematic reviews, meta-analyses, and two existing reports published between 2006 and 2017. Nine meta-analyses,<sup>10-18</sup> and two systematic reviews<sup>19, 20</sup> were ultimately included in the Work Group's evidence review. Nine of the reviews included only studies with experimental designs,<sup>10, 11, 13-18, 20</sup> one included only cohort studies,<sup>19</sup> and one included both experimental designs and cohort studies.<sup>10</sup> The number of studies included in each of the reviews ranged from 3<sup>12</sup> to 44.<sup>17</sup> The specifics of the exercise interventions varied but most were similar to the volume recommended by 2008 Physical Activity Guidelines and the 2015 ACOG Committee Opinion.<sup>1, 2</sup>

### *Evidence on the Overall Relationship*

The 11 reviews provided strong evidence that women assigned to the physical activity interventions gain about 1 kilogram (kg) less weight during pregnancy than women in the control groups. Of the eight meta-analyses,<sup>10, 11, 13-18</sup> seven reported significantly less weight gained for the experimental group.<sup>10, 11, 13-15, 17, 18</sup> The other meta-analysis included only women with overweight or obesity and reported significantly lower weight gain in pregnant women with obesity, but not in those with overweight, compared with women in the control groups.<sup>16</sup>

The meta-analysis by [da Silva et al](#)<sup>10</sup> reviewed 30 randomized controlled trials (RCTs). Based on a meta-analysis of 18 of those RCTs, which included 1,598 women performing a structured exercise program and 1,605 receiving standard care, the standardized mean difference (SMD) in gestational weight gain was -1.11 kg (95% confidence interval (CI): -1.59 to -0.69), with women in the exercise group gaining less weight than women receiving standard care. Seven other meta-analyses of RCTs<sup>11, 13-16, 17, 18</sup> reported similar standardized mean differences in gestational weight gain between exercising and control women, ranging from -0.36 kg (95% CI: -0.64 to -0.09)<sup>16</sup> to -2.22 kg (95% CI: -3.14 to -1.30).<sup>11</sup>

A systematic review by [McDonald et al](#)<sup>20</sup> considered 21 RCTs (18 exercise only and 3 exercise and diet combined). Of the 18 exercise-only interventions in the review, only 6 were deemed "successful" based on statistically significant ( $P < 0.05$ ) differences in weight gain between the exercise and control groups. However, these differences were modest in size. The meta-analysis by [Han et al](#)<sup>12</sup> reported findings from each of 3 RCTs because they differed sufficiently to preclude combining them for a meta-analysis. With sample sizes of 12, 83, and 84, each study reported that women in the more active group gained less weight. The differences were not statistically significant for any of the three.

One systematic review paper by [Fazzi et al<sup>19</sup>](#) considered the role of sedentary behavior on gestational weight gain. Of the three cohort studies considered, only one observed a significant relation between sedentary behavior and amount of gestational weight gain,<sup>21</sup> in which the “Active” group (labeled according to author’s categorization) gained significantly less weight during the second and third trimesters than the “Sedentary” group (named according to author’s categorization).

Several systematic reviews and meta-analyses<sup>10, 13, 20</sup> examined the relationship between physical activity and “excess” weight gain (defined by the Institute of Medicine (IOM) Guidelines).<sup>22</sup> In general, women who reported physical activity during pregnancy experienced a significantly lower risk of excess weight gain compared with women who did not, with pooled effect sizes ranging from an 18 percent lower risk (odds ratio [OR]=0.82; 95% CI: 0.68-0.99)<sup>10</sup> to 23% (OR=0.77; 95% CI: 0.66-0.88).<sup>13</sup>

**Dose-response:** The dose of physical activity prescribed in the RCTs varied among the studies. Similarly, the assessment and categorization of reported leisure-time physical activity was not consistent. It appears, however, that most RCT interventions used an exercise regimen involving primarily aerobic activity of moderate-intensity (walking, swimming, aerobic exercise), occurring at least three times per week for a duration of 30 to 60 minutes per bout. This dose of physical activity appears similar to both ACOG Guidelines and the 2008 Physical Activity Guidelines recommendations.<sup>1, 2</sup>

Most of the reviews did not assess whether maternal physical activity and gestational weight gain had a dose-response relationship. The one review that attempted to answer this question<sup>20</sup> reported that prescribed doses of exercise in the RCTs did not differ between those interventions observing significant ( $P<0.05$ ) differences in weight gain between the exercise and control groups and those that did not. However, indirect evidence of a dose-response is suggested by the observation that adherence to the prescribed exercise program was significantly higher in the “successful” interventions,<sup>20</sup> and the observation in a meta-analysis of 28 RCTs in which the mean difference in gestational weight gain between the exercise and control groups was inversely correlated with both the duration (in weeks) of the intervention ( $r=-0.51$ ;  $P=0.023$ ) and the volume (hours per week) of exercise prescribed ( $r=-0.45$ ;  $P=0.05$ ).<sup>18</sup>

### *Evidence on Specific Factors*

**Demographic factors and weight status:** Virtually none of the systematic reviews or meta-analyses assessed whether the purported relationship between physical activity and gestational weight gain varied by age, race/ethnicity, or socioeconomic status. With regard to weight status, the Work Group



observed that most of the findings were reported among women of normal weight. However, several systematic reviews<sup>13, 16, 18, 20</sup> stratified their data by weight status (i.e., normal weight, overweight, or obese). These studies tended to observe larger effect sizes among women of normal weight, compared with those with overweight or obesity.<sup>13, 18, 20</sup> In contrast, one review of women, all of whom had overweight or obesity<sup>16</sup> reported a greater standardized mean difference in gestational weight gain between the exercise and control groups among women with obesity (SMD=-0.91 kg; 95% CI: -1.66 to -0.16) compared with women with overweight (SMD=-0.12; 95% CI: -0.52 to 0.26).

### Weight Loss during the Postpartum Period

A total of five systematic reviews and/or meta-analyses<sup>11, 23-26</sup> that included only six original research articles and a total of 287 participants addressed the relationship between physical activity and weight loss during the postpartum period. Most of these reviews report no significant difference in weight loss between women who performed physical activity (alone without dietary restriction) up to 1 year during the postpartum period and the control group.

#### *Evidence on the Overall Relationship*

In a meta-analysis of 2 studies that included 53 breastfeeding women, [Amorim Adegboye and Linne<sup>23</sup>](#) report no significant difference in postpartum weight loss between women who did and did not exercise (SMD=-0.10 kg; 95% CI: -1.90 to 1.71). [Nascimento et al<sup>25</sup>](#) reported that the postpartum weight loss observed in three studies between women who exercised (with no dietary intervention) and those who did not was not statistically significant (SMD= -0.79 kg; 95% CI: -2.54 to 0.97). A more recent meta-analysis<sup>11</sup> in 128 women also reported that exercise did not result in significant weight loss during postpartum compared with usual care (SMD= -1.74 kg; 95% CI: -3.59 to 0.10). Similarly, exercise did not cause a significant reduction in body mass index during the postpartum period compared to usual care (SMD= -0.54 kg/m<sup>2</sup>; 95% CI: -1.17 to 0.08).

***For additional details on this body of evidence, visit: <https://health.gov/paguidelines/second-edition/report/supplementary-material.aspx> for the Evidence Portfolio.***

### **Question 2. What is the relationship between physical activity and incidence of gestational diabetes mellitus?**

- a) What dose of physical activity is associated with the reported quantitative benefit or risk?
- b) Is there a dose-response relationship? If yes, what is the shape of the relationship?
- c) Does the relationship vary by age, race/ethnicity, socioeconomic status, or weight status?

**Sources of evidence:** Systematic reviews, meta-analyses, existing reports

### **Conclusion Statements**

Strong evidence demonstrates a significant inverse relationship between physical activity and risk of gestational diabetes mellitus. **PAGAC Grade: Strong**

Limited evidence suggests that a dose of physical activity similar to the 2015 ACOG Guidelines and the 2008 Physical Activity Guidelines is associated with a lower risk of gestational diabetes mellitus. **PAGAC Grade: Limited.**

Limited evidence suggests that a dose-response relationship exists between physical activity and gestational diabetes mellitus. **PAGAC Grade: Limited.**

Insufficient evidence is available to determine whether the relationship between physical activity and gestational diabetes mellitus varies by age, race/ethnicity, socioeconomic status, or weight status. **PAGAC Grade: Not assignable.**

### **Review of the Evidence**

Sources of evidence included systematic reviews, meta-analyses, and two existing reports published between 2006 and 2017. Thirteen meta-analyses [10, 12, 14, 27-36](#) and 2 systematic reviews [37, 38](#) addressed physical activity and gestational diabetes mellitus (GDM). The number of studies included in each of the reviews ranged from 3<sup>12</sup> to 41<sup>37</sup> and comprised a mixture of RCTs and observational cohort studies. In general, the physical activity exposure in RCTs was an aerobic exercise program, whereas in the observational cohort studies the exposure was self-reported leisure-time physical activity.

#### *Evidence on the Overall Relationship*

Eight of 13 meta-analyses reported higher levels of physical activity to be associated with statistically significant reductions in the risk of GDM (Table F8-1), [10, 14, 27, 28, 31, 33, 35, 36](#) 4 of 13 meta-analyses reported non-significant reductions, [29, 30, 32, 34](#) and 1 reported a non-significant increase.<sup>12</sup> The reduced risk of GDM, including all estimates regardless of statistical significance (Table F8-1), ranged from 0.45 to 1.01 with a median value of 0.73. This risk reduction in the incidence of GDM is essentially the same as the 25 percent to 30 percent reduction in the risk of incident type 2 diabetes in the general population associated with physical activity in the current target range. (See *Part F. Chapter 5. Cardiometabolic Health and Prevention of Weight Gain* for more details.) The preponderance of articles included in the systematic reviews reported statistically significant reductions in risk.<sup>37, 38</sup>

**Table F8-1. Summary of Findings from 13 Meta-Analyses of the Relationship Between Pre-Pregnancy and Early Pregnancy Physical Activity and Risk of Gestational Diabetes Mellitus**

Author, year*	Study Design	Effect (95% CI)
<b>PRE-PREGNANCY PHYSICAL ACTIVITY</b>		
Aune et al., 2016 <sup>27</sup>	Cohort (N=8)	sRR=0.78 (0.61-1.00)
Tobias et al., 2011 <sup>33</sup>	RCT (N=7)	pOR=0.45 (0.28-0.75)
<b>EARLY PREGNANCY PHYSICAL ACTIVITY</b>		
Aune et al., 2016 <sup>27</sup>	Cohort (N=5) RCT (N=12) Combined (N=17)	sRR=0.97 (0.73-1.28) <b>sRR=0.69 (0.50-0.96)</b> <b>sRR=0.80 (0.64-1.00)</b>
da Silva et al., 2017 <sup>40</sup>	Cohort (N=6) RCT (N=10)	sOR=0.75 (0.55-1.01) <b>sOR=0.67 (0.49-0.92)</b>
Di Mascio et al., 2016 <sup>28</sup>	RCT (N=4)	<b>sRR=0.51 (0.31-0.82)</b>
Han et al., 2011 <sup>12</sup>	RCT (N=3)	sRR=1.10 (0.66-1.84)
Madhuvrata et al., 2015 <sup>29</sup>	RCT (N=3)	pOR=0.77 (0.33-1.79)
Oostdam et al., 2011 <sup>30</sup>	RCT (N=3)	risk difference= -0.05 (-0.20-0.10)
Russo et al., 2015 <sup>31</sup>	RCT (N=10)	<b>sRR=0.72 (0.58-0.91)</b>
Sanabria-M et al., 2015 <sup>14</sup>	RCT (N=8)	<b>sRR=0.69 (0.52-0.91)</b>
Song et al., 2016 <sup>32</sup>	RCT (N=10)	sRR=0.77 (0.54-1.09)
Tobias et al., 2011 <sup>33</sup>	RCT (N=5)	<b>pOR=0.76 (0.70-0.83)</b>
Yin et al., 2014 <sup>34</sup>	RCT (N=6)	sRR=0.91 (0.57-1.44)
Yu et al., 2017 <sup>35</sup>	RCT (N=5)	<b>SMD=0.59 (0.39-0.88)</b>
Zheng et al., 2017 <sup>36</sup>	RCT (N=4)	<b>SMD=0.62 (0.43-0.89)</b>

Legend: sRR=standardized relative risk, sOR=standardized odds ratio, pOR=pooled odds ratio, and SMD=standardized mean difference.

Note: Studies with statistically significant findings are in bold type.

[Aune et al<sup>27</sup>](#) reviewed 23 studies of *total* physical activity (leisure-time, occupational, and household activity combined) and of leisure-time activity performed before or during early pregnancy and the incidence of GDM. Those women who reported performing high levels of total physical activity before pregnancy experienced a significantly lower risk of GDM compared with women reporting low levels of total activity (relative risk (RR)=0.62; 95% CI: 0.41-0.94; 4 studies), whereas high versus low levels of total activity performed during early pregnancy did not significantly lower the risk of GDM (RR=0.66; 95% CI: 0.36-1.21; 3 studies).

On the other hand, women performing higher levels of moderate-intensity leisure-time physical activity either before (RR=0.78; 95% CI: 0.61–1.00; 8 studies) or during pregnancy (RR=0.80; 95% CI: 0.64, 1.00; 12 studies) significantly lowered their risk of GDM by about 20 percent.<sup>27</sup> Women who performed such physical activity both before **and** during pregnancy lowered their risk by 59 percent (RR=0.41; 95% CI: 0.23–0.73; 2 studies) compared with those reporting no physical activity during both time-periods. High versus low levels of vigorous activity performed before pregnancy significantly lowered the risk of GDM by nearly 25 percent (summary RR=0.76; 95% CI: 0.66-0.88; 3 studies), but this was not the case for vigorous activity performed during pregnancy (RR=0.95; 95% CI: 0.55-1.63; 2 studies).

Findings from the other meta-analyses for the overall relationship were similar, with the statistically significant findings ranging from an odds ratio of 0.45; 95% CI: 0.28-0.75 (7 studies),<sup>33</sup> to a relative risk of 0.72; 95% CI 0.58-0.91 (10 studies).<sup>31</sup> The three nonsignificant reductions and the nonsignificant increase ranged from a relative risk of 0.77 (0.54-1.09) (10 studies),<sup>32</sup> to a relative risk of 1.10 (0.66-1.84) (3 studies)<sup>12</sup> (Table F8-1).

The meta-analysis by [Aune et al<sup>27</sup>](#) also evaluated the independent role of walking, household, or occupational activity on GDM before and during early pregnancy. Women reporting high versus low levels of walking before (RR=0.66; 95% CI: 0.48-0.91; 2 studies) and during (RR=0.80; 95% CI: 0.66-0.97; 2 studies) pregnancy significantly lowered their risk of GDM. The relationship between high versus low levels of household activity and GDM risk was not statistically significant (RR=0.36; 95% CI: 0.12-1.08; 2 studies). Women who reported performing high versus low levels of occupational physical activity were found to have an increase in risk of GDM for occupational activity performed both before pregnancy (RR=1.90; 95% CI: 0.97-3.74; 2 studies) and during pregnancy (RR=0.78; 95% CI: 0.21-2.93; 2 studies), though this increase did not achieve statistical significance.

**Dose-response:** The dose of physical activity of physical activity prescribed in the RCTs varied among the studies. Similarly, the assessment and categorization of reported leisure time physical activity from observational studies was not detailed nor consistent. It appears, however, that most RCT interventions used a physical activity regimen involving primarily aerobic activity of at least moderate-intensity (walking, cycling, swimming, aerobic dance), occurring at least three times per week for a duration of 30 to 60 minutes per bout. This dose of activity appears similar to both ACOG Guidelines and the 2008 Physical Activity Guidelines<sup>1, 2</sup>

[Aune et al<sup>27</sup>](#) performed a dose-response analysis and reported that each 5 hours per week increment in pre-pregnancy physical activity lowered the risk of GDM by about 30 percent (RR=0.70; 95 % CI: 0.49-1.01; 3 studies), with significant evidence of non-linearity ( $P<0.005$ ). A similar relationship was not observed for physical activity performed during early pregnancy (RR=0.98; 95% CI: 0.87-1.09; 3 studies). Evidence from two observational studies in the meta-analysis by [Tobias et al<sup>33</sup>](#) suggests that women who walked at a brisk pace before pregnancy and for a longer duration significantly lowered their risk of GDM compared with women who walked at a casual pace for shorter durations (pooled OR=0.59; 95% CI: 0.30-0.87).

#### *Evidence on Specific Factors*

**Demographic factors and weight status:** Almost none of the systematic reviews or meta-analyses assessed whether the purported relationship between physical activity and GDM varied by age, race/ethnicity, or socioeconomic status. The review by [Song et al<sup>32</sup>](#) reported that physical activity during pregnancy had a significant impact on GDM risk in women ages 30 years and older, but not in women younger than age 30 years.

***For additional details on this body of evidence, visit: <https://health.gov/paguidelines/second-edition/report/supplementary-material.aspx> for the Evidence Portfolio.***

### **Question 3. What is the relationship between physical activity and the incidence of (1) preeclampsia and (2) hypertensive disorders during pregnancy?**

- a) What dose of physical activity is associated with the reported quantitative benefit or risk?
- b) Is there a dose-response relationship? If yes, what is the shape of the relationship?
- c) Does the relationship vary by age, race/ethnicity, socioeconomic status, or weight status?

**Sources of evidence:** Systematic reviews and meta-analyses, existing reports

### **Conclusion Statements**

Limited evidence suggests that leisure-time physical activity or exercise training lowers the risk of preeclampsia. **PAGAC Grade: Limited**

Limited evidence suggests that a dose of physical activity similar to the 2015 American College of Obstetricians and Gynecologists Guidelines and the 2008 Physical Activity Guidelines is associated with a lower risk of preeclampsia. **PAGAC Grade: Limited.** Limited evidence suggests that a dose-response relationship exists between physical activity and the incidence of preeclampsia. **PAGAC Grade: Limited.**

Insufficient evidence is available to determine whether the relationship between physical activity and preeclampsia varies by age, race/ethnicity, socioeconomic status, or weight status. **PAGAC Grade: Not assignable.**

### **Review of the Evidence**

Sources of evidence included systematic reviews, meta-analyses, and two existing reports published between 2006 and 2017. Six meta-analyses<sup>10, 13, 28, 36, 39, 40</sup> and three systematic reviews<sup>19, 41, 42</sup> addressed physical activity and blood pressure during pregnancy. Five meta-analyses<sup>10, 13, 36, 39, 40</sup> and two systematic reviews<sup>41, 42</sup> focused on preeclampsia; one meta-analysis<sup>28</sup> and one systematic review<sup>19</sup> focused on incident hypertension. The nine reviews included a mixture of study designs. Three reviews included only experimental designs,<sup>13, 28, 36</sup> one review included experimental designs and cohort studies,<sup>10</sup> one included experimental, cohort, and case-control studies,<sup>40</sup> two included cohort and case-control studies,<sup>39, 42</sup> and two included cohort and cross-sectional studies.<sup>19, 41</sup> The physical activity exposures were primarily aerobic and mostly leisure-time physical activity. One review<sup>41</sup> focused entirely on occupational physical activity, and two others<sup>19, 40</sup> included information about leisure-time physical activity and occupational exposures. [Fazzi et al<sup>19</sup>](#) examined sedentary behavior. The experimental studies within the reviews included a mixture of supervised physical activity or prescribed and structured aerobic physical activity programs.<sup>10, 13, 28, 36</sup>

#### *Evidence on the Overall Relationship*

The nine reviews provided limited evidence of an inverse relationship between volume of physical activity and risk of preeclampsia or incident hypertension. (Table F8-2) summarizes the findings from the five meta-analyses about preeclampsia. One meta-analysis that included cohort and case-control studies reported a beneficial association between higher levels of physical activity and reduced risk of preeclampsia from both pre-pregnancy (RR=0.65; 95% CI: 0.47-0.89; 5 studies) and early pregnancy

physical activity (RR=0.79; 95% CI: 0.70-0.91; 11 studies).<sup>39</sup> Another meta-analysis reported a beneficial association between pre-pregnancy and early pregnancy physical activity and reduced risk of preeclampsia for case-control studies, but not for cohort studies.<sup>40</sup> Three meta-analyses using RCTs and cohort studies found no association; one of them examined pre-pregnancy physical activity,<sup>10</sup> the other two, early pregnancy physical activity.<sup>13, 36</sup>

The meta-analysis of 10 cohort studies by [Kasawara et al](#)<sup>40</sup> also reported no association between leisure time physical activity and preeclampsia (OR=0.99; 95% CI: 0.93-1.05). In contrast, their meta-analysis of 6 case-control studies reported a significantly lower odds of preeclampsia (OR=0.77; 95% CI: 0.64-0.91) with physical activity performed in pre-pregnancy (summarized from two studies) being even more effective (OR=0.56; 95% CI: 0.41-0.76).

[Muktabhant et al](#)<sup>13</sup> also observed no difference in incident preeclampsia between women who exercised during pregnancy and those who did not (average RR=0.99; 95% CI: 0.58-1.66), based on data from four RCTs (N=1,253). The authors further analyzed data according to weight status: normal weight; overweight or obese; and combined normal and overweight or obese. Even among women with overweight or obesity, there was no difference in risk of preeclampsia in two studies between those in the exercise groups and those in the control groups (RR=1.60; 95% CI: 0.38-6.73). Concurrent evidence from another recent meta-analysis of two RCTs<sup>36</sup> provides additional support of a null association (pooled OR=1.05; 95% CI: 0.53-2.07;  $P=0.88$ ).

[da Silva et al](#)<sup>10</sup> reviewed 30 RCTs that examined the relationship between structured exercise programs and the incidence of preeclampsia and provided a meta-analysis of data from three of them. Their findings indicated that exercise training had no effect on lowering this risk (pooled RR=0.93; 95% CI: 0.55 to -1.57), with no evidence of heterogeneity. Their meta-analysis of eight cohort studies (involving 155,414 women) also found that moderate to vigorous leisure-time physical activity did not significantly lower the risk of preeclampsia compared with low or no leisure-time activity (pooled OR=0.88; 95% CI: 0.73-1.06), with low evidence for heterogeneity.

One systematic review examined four case-control studies and seven cohort studies, and reported no observed relationship between physical activity and preeclampsia.<sup>42</sup>

One systematic review<sup>19</sup> and one meta-analysis<sup>28</sup> examined the relationship between physical activity and “hypertensive disorders” during pregnancy. Hypertensive disorders during pregnancy include

preeclampsia and gestational hypertension. Gestational hypertension is elevated blood pressure without concomitant signs of preeclampsia such as proteinuria, and its relationship, if any, with preeclampsia is unknown. Of the three pertinent original studies in [Fazzi et al,<sup>19</sup>](#) two ([Loprinzi et al<sup>43</sup>](#) N=206 and [Chasan-Taber et al<sup>44</sup>](#) N=1,240) reported no association between sedentary behavior and gestational hypertension, whereas one study ([Li and Zhao<sup>45</sup>](#) N=405) observed that women with persistent sedentary work developed more gestational hypertension than did women in the referent group.<sup>19</sup> [Di Mascio et al<sup>28</sup>](#) reported a risk ratio of 0.21 (95% CI: 0.09-0.45; 3 studies) for hypertensive disorders for more active women compared with less active women.<sup>28</sup>

**Table F8-2. Summary of Findings from Five Meta-Analyses of the Relationship Between Physical Activity and Risk of Preeclampsia**

Author, year	Study Design	Effect (95% CI)
<b>PRE-PREGNANCY PHYSICAL ACTIVITY</b>		
<a href="#">Aune et al., 2014<sup>39</sup></a>	Cohort (n=4) + Case-control (n=1)	<b>sRR=0.65 (0.47-0.89)</b>
<a href="#">da Silva et al., 2017<sup>10</sup></a>	Cohort (n=8) RCT (n=3)	sOR=0.88 (0.73-1.06) sOR=0.93 (0.55-1.57)
<a href="#">Kasawara et al., 2012<sup>40</sup></a>	Cohort (n=3) Case-control (n=2)	sOR=0.85 (0.67-1.09) <b>sOR=0.56 (0.41-0.76)</b>
<b>EARLY PREGNANCY PHYSICAL ACTIVITY</b>		
<a href="#">Aune et al., 2014<sup>39</sup></a>	Cohort (n=7) + Case-control (n=4)	<b>sRR=0.79 (0.70-0.91)</b>
<a href="#">Kasawara et al., 2012<sup>40</sup></a>	Cohort (n=10) Case-control (n=6)	OR=0.99 (0.93-1.05) <b>OR=0.77 (0.64-0.91)</b>
<a href="#">Muktabhant et al., 2015<sup>13</sup></a>	RCTs (n=4)	avgRR: 0.99 (0.58-1.66)
<a href="#">Zheng et al., 2017<sup>36</sup></a>	RCTs (n=2)	pOR=1.05 (0.53-2.07)

Legend: sRR=standardized relative risk, sOR=standardized odds ratio, avgRR= average relative risk, and pOR=pooled odds ratio.

Note: Studies with statistically significant findings are in bold type.

In contrast to studies of leisure-time physical activity, the reviews examining occupational activity reported an increased risk of preeclampsia. When occupational physical activity was explored separately



from leisure-time activity and in relation to the development of preeclampsia, in two of the case-control studies in the [Kasawara et al<sup>40</sup>](#) meta-analysis, the risk of preeclampsia was significantly elevated. Similarly, [Bonzini et al<sup>41</sup>](#) observed a higher risk of preeclampsia for lifting heavy loads (1 study) and higher amounts of physical activity (2 studies). The authors note, however, that all these studies were rated as having higher potential for inflationary bias due to the retrospective data collection. It is important to consider that the relationship between occupational activity and preeclampsia may be confounded by factors such as low socioeconomic status, low educational attainment, and obesity.

**Dose-response:** The systematic review by [Aune et al<sup>39</sup>](#) was the only paper to report on the dose-response relation between physical activity and risk of pre-eclampsia. In their analysis of **pre-pregnancy** physical activity, the summary relative risk was 0.72 (95% CI: 0.53–0.99; n=3 studies) per 1 hour per day and 0.78 (95% CI: 0.63–0.96; n=2 studies) per 20 MET-hours per week, indicating a 22 to 28 percent lower risk of pre-eclampsia per unit increase in physical activity. This relationship appeared non-linear with a flattening of the curve at higher levels of activity, with a 40% reduction in risk up to 5–6 hours per week but no further reductions at higher activity levels. With regard to physical activity performed during **early pregnancy**, the summary relative risk per 1 hour per day was 0.83 (95% CI: 0.72–0.95; n=7 studies) and 0.85 (95% CI: 0.68–1.07; n=3 studies) per 20 Met-hours per week. This dose-response relationship appeared to be linear.

#### *Evidence on Specific Factors*

**Demographic factors and weight status:** There was no available evidence that tested whether the relationship between physical activity and preeclampsia varies by age, race/ethnicity, socioeconomic status, or weight status.

**For additional details on this body of evidence, visit: <https://health.gov/paguidelines/second-edition/report/supplementary-material.aspx> for the Evidence Portfolio.**

#### **Question 4. What is the relationship between physical activity and (1) affect, (2) anxiety, and (3) depression during pregnancy and postpartum (up to one year)?**

- a) What dose of physical activity is associated with the reported quantitative benefit or risk?
- b) Is there a dose-response relationship? If yes, what is the shape of the relationship?
- c) Does the relationship vary by age, race/ethnicity, socioeconomic status, or weight status?

**Sources of evidence:** Systematic reviews, meta-analyses, existing reports

## **Conclusion Statements**

### **Affect During Pregnancy or the Postpartum Period**

Insufficient evidence is available to determine whether a relationship exists between physical activity and affect during pregnancy and the postpartum period. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine whether a specific dose of physical activity is associated with affect during pregnancy and the postpartum period. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine whether a dose-response relationship exists between physical activity and affect during pregnancy and the postpartum period. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine whether the relationship between physical activity and affect varies by age, race/ethnicity, socioeconomic status, or weight status. **PAGAC Grade: Not assignable.**

### **Anxiety During Pregnancy**

Limited evidence suggests that higher levels of physical activity are associated with reduced symptoms of anxiety during pregnancy. **PAGAC Grade: Limited.**

Insufficient evidence is available to determine the dose of physical activity that is associated with reduced symptoms of anxiety during pregnancy. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine whether a dose-response relationship exists between physical activity and reduced symptoms of anxiety during pregnancy. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine whether the relationship between physical activity and symptoms of anxiety during pregnancy varies by age, race/ethnicity, socioeconomic status, or weight status. **PAGAC Grade: Not assignable.**

### **Anxiety During the Postpartum Period**

Insufficient evidence is available to determine whether a relationship exists between physical activity and symptoms of anxiety during the postpartum period. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine whether a specific dose of physical activity is associated with symptoms of anxiety during postpartum. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine whether a dose-response relationship exists between physical activity and symptoms of anxiety during postpartum. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine whether the relationship between physical activity and symptoms of anxiety during postpartum varies by age, race/ethnicity, socioeconomic status, or weight status. **PAGAC Not assignable.**

### Depression During Pregnancy

Limited evidence suggests that higher levels of physical activity are associated with reduced symptoms of depression during pregnancy. **PAGAC Grade: Limited.**

Insufficient evidence is available to determine whether a specific dose of physical activity is associated with reduced symptoms of depression during pregnancy. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine whether a dose-response relationship exists between physical activity and reduced symptoms of depression during pregnancy. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine whether the relationship between physical activity and symptoms of depression during pregnancy varies by age, race/ethnicity, socioeconomic status, or weight status. **PAGAC Grade: Not assignable.**

### Depression During the Postpartum Period

Strong evidence demonstrates an inverse relationship between physical activity and reduced symptoms of depression during postpartum. **PAGAC Grade: Strong.**

Insufficient evidence is available to determine whether a specific dose of physical activity is associated with reduced symptoms of depression during the postpartum period. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine whether there is a dose-response relationship between physical activity and reduced symptoms of depression during postpartum. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine whether the relationship between physical activity and symptoms of depression during postpartum varies by age, race/ethnicity, socioeconomic status, or weight status. **PAGAC Not assignable.**

## **Review of the Evidence**

Sources of evidence included 1) systematic reviews, meta-analyses, and two existing reports published between 2006 and 2017; and 2) the relevant original research articles cited by the systematic reviews and meta-analyses. Three systematic reviews<sup>46-48</sup> and two meta-analyses<sup>49, 50</sup> addressed affect, anxiety, and depression during pregnancy and the postpartum period. Three of the reviews included only experimental trials,<sup>46, 49, 50</sup> and two of the reviews included experimental trials, longitudinal studies, and cross-sectional studies.<sup>47, 48</sup> The physical activity exposure in four of the reviews was aerobic activity usually commensurate with current recommendations<sup>47-50</sup> and in one it was yoga.<sup>46</sup>

### *Evidence on the Overall Relationship*

#### Affect During Pregnancy and the Postpartum Period

No systematic reviews or meta-analyses were found that examined the relationship between physical activity and affect during pregnancy or the postpartum period.

#### Anxiety During Pregnancy

Two systematic reviews were found examining the relationship between symptoms of anxiety during pregnancy.<sup>46, 47</sup> [Sheffield and Woods-Giscombe](#)<sup>46</sup> provided a systematic review of 13 studies (7 of which were RCTs) that examined the effects of yoga on symptoms of anxiety and depression during pregnancy. Of the five studies that evaluated anxiety symptomology, all of them reported statistically significant improvements in the State/Trait Anxiety Inventory (STAI) scores following a yoga intervention. Of note is that three of five studies reported between-group differences, whereas two of five studies reported within-group changes only. [Shivakumar et al](#)<sup>47</sup> reported that more physically active women reported reduced symptoms of anxiety in one of three studies that examined symptoms of anxiety.

#### Anxiety During the Postpartum Period

No systematic reviews or meta-analyses were found that examined the relationship between physical activity and anxiety during the postpartum period.

#### Symptoms of Depression During Pregnancy

Two systematic reviews were found examining the relationship between symptoms of depression during pregnancy.<sup>46, 47</sup> In the same study described above about symptoms of anxiety, [Sheffield and Woods-Giscombe](#)<sup>46</sup> reported that six of seven studies all using the Center for Epidemiologic Studies of Depression (CES-D) scale, reported a statistically significant improvement in depression score. Four of

the seven studies reported between-group differences in depressive symptoms score and two of six reported within-group changes only. In another systematic review, two of two studies reported reduced symptoms of depression in the higher physical activity group.<sup>47</sup> These findings should be interpreted cautiously, however, as all of these studies had some methodological limitations, such as small samples sizes, inappropriate or no control group, or lack of control for confounding variables, thereby underscoring the need for more research in this area.

### Symptoms of Depression During the Postpartum Period

Two meta-analyses<sup>49, 50</sup> and one systematic review<sup>48</sup> examined the relationship between physical activity and symptoms of depression during the postpartum period. [Teychenne and York<sup>48</sup>](#) provided a systematic review of 17 studies, 10 of which were observational studies and 7 of which were intervention trials. Five of the studies examined physical activity performed during pregnancy and 12 examined postpartum activity. Only 2 of 5 studies of physical activity during pregnancy reported a significant inverse relation with postpartum depression, whereas 4 of 10 observational studies and 5 of 7 intervention trials of postpartum physical activity reported beneficial effects, suggesting that physical activity during the postpartum period may be more likely to prevent postpartum depression than physical activity before postpartum.

[McCurdy et al<sup>49</sup>](#) examined 16 RCTs comparing exercise to standard care in postpartum women (N=1,327) with (10 trials) and without (6 trials) depression. In general, depressive symptoms scores (based on the Edinburgh Postnatal Depression Scale (EPDS)) were lower among those in exercise intervention groups compared with those in control groups (pooled SMD= -0.34; 95% CI: -0.50 to -0.19). Among the 10 treatment trials in woman with postpartum depression, a moderate beneficial effect of exercise on depressive symptoms was observed (SMD= -0.48; 95% CI: -0.73 to -0.22) relative to the control group. Moreover, in women with depression pre-intervention (defined as an EPDS score greater than 12), exercise increased the odds of resolving depression post-intervention by 54 percent (OR=0.46; 95% CI: 0.25–0.84) compared with the control group. In the six prevention trials (i.e., women without depression) a beneficial effect of exercise was observed in the EPDS score (SMD= -0.22; 95% CI: -0.36 to -0.08) compared with standard care. These findings are consistent with a smaller review and meta-analysis by [Poyatos-León et al.<sup>50</sup>](#) Indeed, among women performing physical activity during pregnancy and the postpartum period, there was a decrease in postpartum depressive symptom scores (measured by EPDS or by the Beck Depression Inventory) in favor of the physical activity compared with the control group (effect size (ES)=0.41; 95% CI: 0.28-0.54). In the subgroup analysis, the effect size was smaller for

women who did not meet criteria for postpartum depression (ES=0.29; 95% CI: 0.14-0.45), but was more pronounced in women who did (ES=0.67; 95% CI: 0.44-0.90). Most (10 of 12) of the interventions were begun during the postpartum period and involved a variety of activities, such as walking, aerobics, Pilates, yoga, and stretching.

In sum, consistent with findings for the general population (see *Part F. Chapter 3. Brain Health*, Question 3), the evidence demonstrates that physical activity has a beneficial effect on postpartum depressive symptoms. The benefits appear to be more pronounced in women who have greater depressive symptomology and when activity is performed during the postpartum period rather than during pregnancy or before.

***For additional details on this body of evidence, visit: <https://health.gov/paguidelines/second-edition/report/supplementary-material.aspx> for the Evidence Portfolio.***

## **Summary of Main and Auxillary Findings Pertaining to Pregnancy-Related Health Outcomes**

The above paragraphs summarize information about the relationship between primarily moderate-intensity physical activity during pregnancy and the postpartum period and: 1) gestational weight gain, 2) return to normal weight after delivery, 3) risk of gestational diabetes, 4) risk of preeclampsia and eclampsia, and 5) symptoms of depression. These are questions that could be directly addressed by the systematic reviews and meta-analyses brought in by searches conducted by the Pregnancy Work Group. Several of these studies also provided information about other pregnancy-related outcomes. For example, because women who develop gestational diabetes are more likely than other mothers to have larger-than-normal babies, several reviews focusing on gestational diabetes also provided information about the proportion of newborns who were larger than expected. In this section, we summarize this auxiliary information: for 1) ease of delivery, 2) preterm birth and gestational age at delivery, 3) birth weight, 4) small for gestational age and low birth weight, and 5) large for gestational age and high birth weight. It is important to note that we did not conduct searches to address these specific questions. Our findings cannot be considered conclusive and we have not “graded” the evidence as we have done for questions for which a specific literature search was conducted. We have noted in Table F8-3, however, how the auxiliary information compares with information in the 2008 Advisory Committee Report and the ACOG Committee Opinion of 2015.<sup>1,5</sup> Significance was interpreted at  $P<0.05$ .

### **Ease of Delivery**

The auxiliary information suggests that generally, women who are more physically active during pregnancy are less likely than women who are less active to have a Cesarean section at the time of delivery. Five meta-analyses<sup>12, 13, 17, 18, 28</sup> provided information about physical activity level and risk of Cesarean section. Two meta-analyses reported statistically significant reductions in the risk of Cesarean section among women assigned to intervention arms that included aerobic activity and/or resistance training during pregnancy.<sup>18, 28</sup> Two meta-analyses reported statistically non-significant reductions.<sup>13, 17</sup> One meta-analysis reported a statistically non-significant increase in risk of Cesarean section,<sup>12</sup> but it included only 2 studies whereas the other four meta analyses included 5 to 20 studies.

### **Preterm Birth and Gestational Age at Delivery**

The auxiliary information suggests no difference between more active and less active pregnant women in the risk of preterm delivery or gestational age of infant at delivery. One meta-analysis reported a decreased risk of preterm delivery among more physically active women<sup>10</sup>; five meta-analyses reported no difference.<sup>13, 17, 28, 35, 36</sup> Similarly, five meta-analyses reported no difference in gestational age at delivery between women who were more physically active during pregnancy than women who were less physically active.<sup>10, 12, 17, 28, 36</sup> The search also captured one meta-analysis of occupational physical activity and pregnancy outcomes.<sup>41</sup> The exposures of interest were long periods of standing (greater than 3 hours) and heavy lifting. The analysis found a significant association between standing for at least 3 hours and an elevated risk of preterm birth.

### **Birth Weight**

The auxiliary information suggests minimal to no difference in the birth weight of babies born to more physically active women than less physically active women. Three meta-analyses reported that babies of more active women weighed fewer grams than babies of less active women; -1.05 grams (95% CI: -1.49 to -0.62),<sup>10</sup> cohort studies only, -60 grams (95% CI: -120 to -10)<sup>17</sup> and -30.60 gm (95% CI: -56.83 to -4.37).<sup>18</sup> Five meta-analyses reported a non-significantly reduced birth weight for babies born to more active women,<sup>10</sup> for RCT only.<sup>12, 28, 35, 36</sup> One systematic review of sedentary behavior and birth weight reported two studies finding no association and one study reporting that more sedentary women were more likely to have low birth weight babies.<sup>19</sup>

### Small for Gestational Age and Low Birth Weight

Three meta-analyses reported no difference between more and less active women and the risk of the newborn to be small for gestational age.<sup>10, 17, 18</sup> One reported no difference in the risk for low birth weight between intervention participants engaging in aerobic exercise compared to control participants.<sup>28</sup>

### Large for Gestational Age and High Birth Weight

The auxiliary information suggests that babies of more physically active women are less likely to be large for gestational age at birth than babies of less physically active women.<sup>10, 18</sup> However, three meta-analyses reported no statistical differences between babies born to more or less active women,<sup>12, 13, 17</sup> although one reported that the reduction in large for gestational age risk for babies born to more active women became significant if three studies at high risk of bias were removed from the analysis.<sup>13</sup> One meta-analysis reported a statistically significant lower relative risk of macrosomia (newborn weighing greater than 4000 grams) for babies born to more physically active women, but this was based on only two studies.<sup>30</sup>

### Apgar Score

Four meta-analyses reported no significant difference in mean Apgar score or risk of Apgar score less than 7 at 5 minutes for babies born to women who were physically more active during pregnancy than women who were less active.<sup>12, 35, 36, 51</sup>

**Table F8-3. Effects of Physical Activity on Pregnancy- and Postpartum-Related Events**

Events	2008 PAGAC Report	2015 ACOG Committee Opinion	2018 PAGAC Report
<b>Topic-specific searches for PAGAC Report 2018</b>			
Gestational weight gain		Modest decrease in weight gain (page e138)	Strong evidence of reduced risk of excess weight gain
Return to normal weight	Appears not to help (page G11-38)		Insufficient evidence
Gestational diabetes	Probable reduced risk of gestational diabetes (page G11-37)	Reduced risk (page e137)	Strong evidence of reduced risk of gestational diabetes
Preeclampsia	Possible reduced risk of preeclampsia (page G11-37)	Possible reduced risk of preeclampsia (page e138)	Moderate evidence of no association with preeclampsia



Part F. Chapter 8. Women Who Are Pregnant or Postpartum

<b>Events</b>	<b>2008 PAGAC Report</b>	<b>2015 ACOG Committee Opinion</b>	<b>2018 PAGAC Report</b>
Affect, anxiety, and depression during pregnancy	Appears to improve mood and increase self-esteem (page G11-37-8)	Enhances psychological well-being (page e135)	Limited evidence of reduced anxiety and depression
Affect, anxiety, and depression during postpartum	Enhanced mood (page G11-38)		Strong evidence of reduced symptoms of depression; limited evidence for anxiety; insufficient evidence for affect
Quality of life during pregnancy or postpartum			Insufficient evidence, grade not assignable
Quality of sleep during pregnancy or postpartum			Insufficient evidence, grade not assignable

Events	2008 PAGAC Report	2015 ACOG Committee Opinion	2018 PAGAC Report
<b>Incidental outcomes from searches (partial searches)</b>			
Labor & delivery	Uncertain impact (page G11-38)	Reduced risk of operative delivery (Cesarean or vaginal) (page e137)	<u>Partial search</u> : evidence suggests reduced risk of Cesarean section
Postpartum recovery		Decreased postpartum recovery time (page e138)	<u>Partial search</u> : no auxiliary evidence on this topic; decreased recovery time still applies.
Lactation	No impact (page G11-38)	No impact (page e139)	<u>Partial search</u> : no auxiliary evidence on this topic; no effect on lactation.
Physical fitness during pregnancy	Maintains (page G11-37)	Improves or maintains (page e137)	<u>Partial search</u> : no auxiliary evidence on this topic; maintains or improves fitness.
Physical fitness during postpartum	Improved (page G11-38)	Improves cardiovascular fitness (page e139)	<u>Partial search</u> : no auxiliary evidence on this topic; improves fitness.
Preterm delivery, difference in gestational age	No risk from moderate intensity physical activity (page G11-37)		<u>Partial search</u> : evidence suggests no risk of preterm delivery or difference in gestational age
Low birth weight, small for gestational age	No risk from moderate intensity physical activity (page G11-37) <sup>1</sup>	Minimal to no difference in birth weight (page e137)	<u>Partial search</u> : evidence suggests minimal to no difference in birth weight
High birth weight, Large for gestational age			<u>Partial search</u> : evidence suggests a reduction in risk of high birth weight or large for gestational age
Apgar			<u>Partial search</u> : evidence suggests no difference in Apgar scores

Source: 2008 Scientific Report,<sup>5</sup> 2015 ACOG Committee Opinion.<sup>1</sup>

### Comparing 2018 Findings with the 2008 Physical Activity Guidelines Advisory Committee Report

The 2008 Advisory Committee Report concluded that for women with a normal pregnancy, regular physical activity probably reduces the risk of gestational diabetes, possibly reduces the risk of preeclampsia, and appears to improve mood both during and after pregnancy (Table F8-3).<sup>5</sup> The Committee's findings in 2018 support the findings of 2008 and extend them in several ways. Strong

evidence now shows that physical activity commensurate with the current target range reduces the risk of excessive weight gain, gestational diabetes, and symptoms of depression postpartum. Physically active pregnant women gain about 1 kg less than their less active peers, reduce their risk of gestational diabetes by 25 percent to 30 percent, and have significantly fewer depressive symptoms. The Committee's findings in 2018 also provide support for the observations in 2008 that moderate-intensity physical activity provides no risk of preterm birth or low birth weight.

The 2008 Physical Activity Guideline reported that "habitual exercisers undergoing a healthy pregnancy need not drastically reduce their physical activity, provided that they remain asymptomatic and maintain open communication with their health care providers so that adjustments can be made if necessary."<sup>5</sup> However, certain activities should be avoided including contact sports, activities with a high risk of falls, hot yoga/pilates, scuba diving, and sky diving.<sup>1</sup> This same communication should be continued into the postpartum period, where the time needed before a woman returns to performing regular physical activity should be governed by medical safety concerns, rather than a set time period.

### **Public Health Impact**

Only about 23-29 percent of women are sufficiently physically active during pregnancy to be in the recommended target range for substantial health benefits.<sup>3</sup> Of course, some of the other women engage in at least some activities of moderate relative intensity and, thereby, accrue some benefits. Nevertheless, around one-half of women who are pregnant receive few or none of the physical and emotional health benefits of habitual physical activity.

Quantifying the benefits not accrued is difficult, but it is clear that a substantial number of current and future health problems and costs could be avoided with regular physical activity during pregnancy. Strong evidence in this Report demonstrates that physically active pregnant women are less likely to exceed the Institute of Medicine recommendations for healthy weight gain during pregnancy than their less active peers.<sup>22</sup> Because they gain less weight, they are at less risk of excessive postpartum weight retention, future obesity, and birth of an infant with macrosomia.<sup>52</sup> They also appear to be at lower risk of Cesarean section, and at no greater risk of preterm delivery.

Strong evidence in this Report demonstrates that physically active women are about 25 percent to 30 percent less likely to develop gestational diabetes than their inactive peers. Gestational diabetes occurs in around 5 percent to 9 percent of women who are pregnant. Women with gestational diabetes have a

seven-fold increased risk of developing type 2 diabetes after pregnancy; they also are at increased risk of delivery by Cesarean section and having an infant with macrosomia and/or neonatal hypoglycemia.<sup>53</sup>

Strong evidence in this Report demonstrates that physically active women experience fewer symptoms of depression during the postpartum. About 10 percent of women experience postpartum depression, with nearly 25 percent of them still in treatment after 1 year.<sup>54</sup> The data in the Report do not enable a quantitative estimate of the reduction in incidence of postpartum depression, but habitual physical activity will help.

Thus, the benefits documented in this Scientific Report—reduced gestational weight gain, reduced risk of gestational diabetes, and a reduction in postpartum depression—confirm the public health importance of physical activity before, during, and after pregnancy.

## NEEDS FOR FUTURE RESEARCH

1. Conduct observational and experimental studies of the effects of vigorous-intensity physical activity before and during pregnancy on maternal and fetal outcomes.

**Rationale:** The safety and benefits of moderate-intensity physical activity during pregnancy and the postpartum period are now generally accepted. The safety and benefits of vigorous-intensity (absolute and perceived) physical activity are less well-documented and this type of activity may be discouraged by some health care providers. For women who have not been physically active, a program of moderate-intensity physical activity would be recommended. On the other hand, substantial numbers of women participate regularly in vigorous physical activity (e.g., running, stationary cycling, rowing) before pregnancy and may want to continue such activity for as long as possible throughout pregnancy. Information from such studies would provide valuable information on minimal effective levels of vigorous activity and maximal threshold levels for safety.

2. Continue to conduct large-scale observational studies to investigate longitudinally the relationship between various types and volumes of physical activity before and during pregnancy and during the postpartum period on short- and long-term weight status.

**Rationale:** Although it is established that habitual moderate-intensity physical activity of a volume in the recommended target zone is associated with reduced weight gain during pregnancy, information about the relationship between various types and volumes of physical activity and

weight change during pregnancy and the postpartum period would help guide the development of clinical and public health recommendations.

3. Conduct experimental and observational studies to investigate the effects of various types, intensities, and volumes of regular physical activity on quality of life and symptoms of anxiety and depression and during pregnancy, and quality of life and symptoms of anxiety during the postpartum period.

**Rationale:** Although strong evidence demonstrates that regular moderate-intensity physical activity reduces depressive symptoms during the postpartum period, little information exists about the role of physical activity on perceived quality of life and symptoms of anxiety and depression symptoms during pregnancy and quality of life and symptoms of anxiety during the postpartum period. Emerging evidence suggests that maternal mental health affects the health of the developing fetus. Knowledge about the benefits of even low doses of physical activity, as well as about the benefits of various modes of physical activity for women with anxiety or depression can help to promote a healthy pregnancy for both mother and fetus.

4. Conduct experimental and observational studies to determine the influence of regular physical activity on quality of sleep during pregnancy and the postpartum period.

**Rationale:** Although regular physical activity is known to improve sleep and feelings of quality of life in the general population, little is known about the effect of regular physical activity on quality of sleep during pregnancy and the postpartum period. Getting enough sleep, especially during the postpartum period, is a common problem for new mothers. If women during pregnancy and postpartum benefit from acute episodes and regular participation in physical activity as do those in the general population, it could improve overall level of energy and quality of life.

5. Conduct large observational studies to determine whether specific types, intensities, and doses of physical activity affect maternal and fetal outcomes, such as preterm birth, low birth weight, and preeclampsia differentially.

**Rationale:** Most of the experimental research on physical activity during pregnancy relies on the 2008 Physical Activity Guidelines<sup>5</sup> or the 2015 American College of Obstetricians and Gynecologists<sup>1</sup> recommendations of 150 minutes per week of moderate-intensity activity. Limited evidence suggests that certain types of physical activity, such as prolonged standing or lifting heavy loads

performed in an occupational setting, may have different health effects for pregnant women than when performed during leisure time. The veracity of the observation needs to be determined, and, if confirmed, it will be important to determine whether the results are caused by the nature of the activities or the setting or perhaps other confounding factors (socioeconomic status, education level, age). Observing the impact of varying types, intensities, and doses of physical activity in varying domains (leisure-time, occupational, household, transportation) on a range of maternal and fetal outcomes would significantly advance current knowledge and inform both clinical and public health practice.

6. Conduct observational and/or experimental research that has adequate statistical power to determine whether the associations between physical activity and maternal or fetal outcomes vary by age, race/ethnicity, socioeconomic status, or weight status.

**Rationale:** Most of the studies reviewed in this report were not designed or powered to test for effect modification by various sociodemographic factors or by body weight. Such information is important for making more specific physical activity recommendations for various population subgroups in efforts to reduce health disparities among pregnant women.

## REFERENCES

1. American College of Obstetricians and Gynecologists. Physical activity and exercise during pregnancy and the postpartum period. Committee Opinion No. 650 (Reaffirmed 2017). *Obstet Gynecol*. December 2015;126:e135–e142.
2. U.S. Department of Health and Human Services. *2008 Physical Activity Guidelines for Americans*. Washington, DC: U.S. Department of Health and Human Services; 2008.
3. Hesketh KR, Evenson, KR. Prevalence of U.S. pregnant women meeting ACOG 2015 physical activity guidelines. *Am J Prev Med*. 2016;41:387-389. doi:10.1016/j.amepre.2016.05.023.
4. American College of Obstetricians and Gynecologists (ACOG). Technical bulletin: exercise during pregnancy and the postnatal period. Washington, DC: ACOG; 1985.
5. Physical Activity Guidelines Advisory Committee. *Physical Activity Guidelines Advisory Committee Report, 2008*. Washington, DC: U.S. Department of Health and Human Services; 2008. <https://health.gov/paguidelines/guidelines/report.aspx>. Published 2008. Accessed January 4, 2018.
6. Evenson KR, Barakat R, Brown WJ, et al. Guidelines for physical activity during pregnancy: comparisons from around the world. *Am J Lifestyle Med*. 2014;8(2):102-121. doi:10.1177/1559827613498204.

7. Evenson KR, Mottola MF, Owe KM, Rousham EK, Brown WJ. Summary of international guidelines for physical activity following pregnancy. *Obstet Gynecol Survey*. 2014;69(7):407-414. doi:10.1097/OGX.000000000000077.
8. Persinger R, Foster C, Gibson M, Fater DC, Porcari JP. Consistency of the talk test for exercise prescription. *Med Sci Sports Exerc*. 2004;36(9):1632-1636.
9. Perales M, Artal R, Lucia A. Exercise during pregnancy. *JAMA*. 2017;317:1113-1114. doi:10.1001/jama.2017.0593.
10. da Silva SG, Ricardo LI, Evenson KR, Hallal PC. Leisure-time physical activity in pregnancy and maternal-child health: a systematic review and meta-analysis of randomized controlled trials and cohort studies. *Sports Med*. 2017;47(2):295–317. doi:10.1007/s40279-016-0565-2.
11. Elliott-Sale KJ, Barnett CT, Sale C. Systematic review of randomised controlled trials on exercise interventions for weight management during pregnancy and up to one year postpartum among normal weight, overweight and obese women. *Pregnancy Hypertens*. 2014;4(3):234. doi:10.1016/j.preghy.2014.03.015.
12. Han S, Middleton P, Crowther CA. Exercise for pregnant women for preventing gestational diabetes mellitus. *Cochrane Database Syst Rev*. 2012;(7):Cd009021. doi:10.1002/14651858.CD009021.pub2.
13. Muktabhant B, Lawrie TA, Lumbiganon P, Laopaiboon M. Diet or exercise, or both, for preventing excessive weight gain in pregnancy. *Cochrane Database Syst Rev*. 2015;(6):Cd007145. doi:10.1002/14651858.CD007145.pub3.
14. Sanabria-Martinez G, Garcia-Hermoso A, Poyatos-Leon R, Alvarez-Bueno C, Sanchez-Lopez M, Martinez-Vizcaino V. Effectiveness of physical activity interventions on preventing gestational diabetes mellitus and excessive maternal weight gain: a meta-analysis. *BJOG*. 2015;122(9):1167–1174. doi:10.1111/1471-0528.13429.
15. Streuling I, Beyerlein A, Rosenfeld E, Hofmann H, Schulz T, von Kries R. Physical activity and gestational weight gain: a meta-analysis of intervention trials. *BJOG*. 2011;118(3):278–284. doi:10.1111/j.1471-0528.2010.02801.x.
16. Sui Z, Grivell RM, Dodd JM. Antenatal exercise to improve outcomes in overweight or obese women: a systematic review. *Acta Obstet Gynecol Scand*. 2012;91(5):538–545. doi:10.1111/j.1600-0412.2012.01357.x.
17. Thangaratinam S, Rogozinska E, Jolly K, et al. Effects of interventions in pregnancy on maternal weight and obstetric outcomes: meta-analysis of randomised evidence. *BMJ*. 2012;(344):e2088. doi:10.1136/bmj.e2088.
18. Wiebe HW, Boule NG, Chari R, Davenport MH. The effect of supervised prenatal exercise on fetal growth: a meta-analysis. *Obstet Gynecol*. 2015;125(5):1185–1194. doi:10.1097/AOG.0000000000000801.
19. Fazzi C, Saunders DH, Linton K, Norman JE, Reynolds RM. Sedentary behaviours during pregnancy: a systematic review. *Int J Behav Nutr Phys Act*. 2017;14(1):32. doi:10.1186/s12966-017-0485-z.

20. McDonald SM, Liu J, Wilcox S, Lau EY, Archer E. Does dose matter in reducing gestational weight gain in exercise interventions? A systematic review of literature. *J Sci Med Sport*. 2016;19(4):323–335. doi:10.1016/j.jsams.2015.03.004.
21. Jiang H, Qian X, Li M, et al. Can physical activity reduce excessive gestational weight gain? Findings from a Chinese urban pregnant women cohort study. *Int J Behav Nutr Phys Act*. 2012;9:12. doi:10.1186/1479-5868-9-12.
22. Institute of Medicine and National Research Council. Weight gain during pregnancy: reexamining the guidelines. Washington, DC: The National Academies Press; 2009.
23. Amorim Adegboye AR, Linne YM. Diet or exercise, or both, for weight reduction in women after childbirth. *Cochrane Database Syst Rev*. 2013;(7):CD005627. doi:10.1002/14651858.CD005627.pub3.
24. Berger AA, Peragallo-Urrutia R, Nicholson WK. Systematic review of the effect of individual and combined nutrition and exercise interventions on weight, adiposity and metabolic outcomes after delivery: evidence for developing behavioral guidelines for post-partum weight control. *BMC Pregnancy Childbirth*. 2014;14:319. doi:10.1186/1471-2393-14-319.
25. Nascimento SL, Pudwell J, Surita FG, Adamo KB, Smith GN. The effect of physical exercise strategies on weight loss in postpartum women: a systematic review and meta-analysis. *Int J Obes (Lond)*. 2014;38(5):626–635. doi:10.1038/ijo.2013.183.
26. van der Pligt P, Willcox J, Hesketh KD, et al. Systematic review of lifestyle interventions to limit postpartum weight retention: implications for future opportunities to prevent maternal overweight and obesity following childbirth. *Obes Rev*. 2013;14(10):792–805. doi:10.1111/obr.12053.
27. Aune D, Sen A, Henriksen T, Saugstad OD, Tonstad S. Physical activity and the risk of gestational diabetes mellitus: a systematic review and dose-response meta-analysis of epidemiological studies. *Eur J Epidemiol*. 2016;31(10):967–997. doi:10.1007/s10654-016-0176-0.
28. Di Mascio D, Magro-Malosso ER, Saccone G, Marhefka GD, Berghella V. Exercise during pregnancy in normal-weight women and risk of preterm birth: a systematic review and meta-analysis of randomized controlled trials. *Am J Obstet Gynecol*. 2016;215(5):561–571. doi:10.1016/j.ajog.2016.06.014.
29. Madhuvrata P, Govinden G, Bustani R, Song S, Farrell TA. Prevention of gestational diabetes in pregnant women with risk factors for gestational diabetes: a systematic review and meta-analysis of randomised trials. *Obstet Med*. 2015;8(2):68–85. doi:10.1177/1753495X15576673.
30. Oostdam N, van Poppel MN, Wouters MG, van Mechelen W. Interventions for preventing gestational diabetes mellitus: a systematic review and meta-analysis. *J Womens Health (Larchmt)*. 2011;20(10):1551–1563. doi:10.1089/jwh.2010.2703.
31. Russo LM, Nobles C, Ertel KA, Chasan-Taber L, Whitcomb BW. Physical activity interventions in pregnancy and risk of gestational diabetes mellitus: a systematic review and meta-analysis. *Obstet Gynecol*. 2015;125(3):576–582. doi:10.1097/AOG.0000000000000691.
32. Song C, Li J, Leng J, Ma RC, Yang X. Lifestyle intervention can reduce the risk of gestational diabetes: a meta-analysis of randomized controlled trials. *Obes Rev*. 2016;17(10):960–969. doi:10.1111/obr.12442.



33. Tobias DK, Zhang C, van Dam RM, Bowers K, Hu FB. Physical activity before and during pregnancy and risk of gestational diabetes mellitus: a meta-analysis. *Diabetes Care*. 2011;34(1):223–229. doi:10.2337/dc10-1368.
34. Yin YN, Li XL, Tao TJ, Luo BR, Liao SJ. Physical activity during pregnancy and the risk of gestational diabetes mellitus: a systematic review and meta-analysis of randomised controlled trials. *Br J Sports Med*. 2014;48(4):290–295. doi:10.1136/bjsports-2013-092596.
35. Yu Y, Xie R, Shen C, Shu L. Effect of exercise during pregnancy to prevent gestational diabetes mellitus: a systematic review and meta-analysis. *J Matern Fetal Neonatal Med*. May 2017:1–6. doi:10.1080/14767058.2017.1319929.
36. Zheng J, Wang H, Ren M. Influence of exercise intervention on gestational diabetes mellitus: a systematic review and meta-analysis. *J Endocrinol Invest*. April 2017. doi:10.1007/s40618-017-0673-3.
37. Dode MA, dos Santos IS. Non classical risk factors for gestational diabetes mellitus: a systematic review of the literature. *Cad Saude Publica*. 2009;25(suppl 3):S341–S359.
38. DiNallo JM, Downs DS. The role of exercise in preventing and treating gestational diabetes: a comprehensive review and recommendations for future research. *J Appl Biobehav Res*. 2008;12(3-4):141–177. doi:10.1111/j.1751-9861.2008.00019.x.
39. Aune D, Saugstad OD, Henriksen T, Tonstad S. Physical activity and the risk of preeclampsia: a systematic review and meta-analysis. *Epidemiology*. 2014;25(3):331-343. doi:10.1097/EDE.000000000000036.
40. Kasawara KT, do Nascimento SL, Costa ML, Surita FG, e Silva JL. Exercise and physical activity in the prevention of pre-eclampsia: systematic review. *Acta Obstet Gynecol Scand*. 2012;91(10):1147–1157. doi:10.1111/j.1600-0412.2012.01483.x.
41. 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. doi:10.1136/oem.2006.026872.
42. Wolf HT, Owe KM, Juhl M, Hegaard HK. Leisure time physical activity and the risk of pre-eclampsia: a systematic review. *Matern Child Health J*. 2014;18(4):899-910. doi:10.1007/s10995-013-1316-8.
43. Loprinzi PD, Fitzgerald EM, Woekel E, Cardinal BJ. Association of physical activity and sedentary behavior with biological markers among U.S. pregnant women. *J Womens Health (Larchmt)*. 2013;22(11):953-958. doi:10.1089/jwh.2013.4394.
44. Chasan-Taber L, Silveira M, Lynch KE, Pekow P, Solomon CG, Markenson G. Physical activity and gestational weight gain in Hispanic women. *Obesity (Silver Spring)*. 2014;22(3):909-918. doi:10.1002/oby.20549.
45. Li CR, Zhao SX. The impact of persistent sedentary work on outcome pregnancy [in Chinese]. *Zhonghua Lao Dong Wei Sheng Zhi Ye Bing Za Zhi [Chinese Journal of Industrial Hygiene & Occupational Diseases]*. 2007;25(8):506-507.

46. Sheffield KM, Woods-Giscombe CL. Efficacy, feasibility, and acceptability of perinatal yoga on women's mental health and well-being: a systematic literature review. *J Holist Nurs.* 2016;34(1):64–79. doi:10.1177/0898010115577976.
47. Shivakumar G, Brandon AR, Snell PG, et al. Antenatal depression: a rationale for studying exercise. *Depress Anxiety.* 2011;28(3):234–242. doi:10.1002/da.20777.
48. Teychenne M, York R. Physical activity, sedentary behavior, and postnatal depressive symptoms: a review. *Am J Prev Med.* 2013;45(2):217–227. doi:10.1016/j.amepre.2013.04.004.
49. McCurdy AP, Boule NG, Sivak A, Davenport MH. Effects of exercise on mild-to-moderate depressive symptoms in the postpartum period: a meta-analysis. *Obstet Gynecol.* 2017;129(6):1087–1097. doi:10.1097/AOG.0000000000002053.
50. Poyatos-León R, García-Hermoso A, Sanabria-Martínez G, Álvarez-Bueno C, Cavero-Redondo I, Martínez-Vizcaíno V. Effects of exercise-based interventions on postpartum depression: a meta-analysis of randomized controlled trials. *Birth.* 2017;44(3):200–208. doi:10.1111/birt.12294.
51. Thangaratinam S, Rogozinska E, Jolly K, et al. Interventions to reduce or prevent obesity in pregnant women: a systematic review. *Health Technol Assess.* 2012;16(31):iii–iv, 1–191. doi:10.3310/hta16310.
52. Deputy NP, Sharma AJ, Kim SY. Gestational weight gain – United States, 2012 and 2013. *Morb Mortal Wkly Rep.* 2015;64:1215–1220. doi:10.15585/mmwr.mm6443a3.
53. DeSisto CL, Kim SY, Sharma AJ. Prevalence estimates of gestational diabetes mellitus in the United States, Pregnancy Risk Assessment Monitoring System (PRAMS), 2007–2010. *Prev Chronic Dis.* 2014;11:E104. doi:10.5888/pcd11.130415.
54. Rasmussen MH, Strom M, Wohlfahrt J, Videbech P, Melbye M. Risk, treatment duration, and recurrence risk of postpartum affective disorder in women with no prior psychiatric history: a population-based cohort study. *PLoS Med.* 2017;14(9):e1002392. doi:10.1371/journal.pmed.1002392.