Benefits of Physical Activity during Pregnancy and Postpartum: An Umbrella Review

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ABSTRACT

DIPIETRO, L., K. R. EVENSON, B. BLOODGOOD, K. SPROW, R. P. TROIANO, K. L. PIERCY, A. VAUX-BJERKE, and K. E. POWELL, FOR THE 2018 PHYSICAL ACTIVITY GUIDELINES ADVISORY COMMITTEE. Benefits of Physical Activity during Pregnancy and Postpartum: An Umbrella Review. *Med. Sci. Sports Exerc.*, Vol. 51, No. 6, pp. 1292–1302, 2019. **Purpose:** This study aimed to summarize the evidence from the *2018 Physical Activity Guidelines Advisory Committee Scientific Report*, including new evidence from an updated search of the effects of physical activity on maternal health during pregnancy and postpartum. **Methods:** An initial search was undertaken to identify systematic reviews and meta-analyses published between 2006 and 2016. An updated search then identified additional systematic reviews and meta-analyses published between January 2017 and February 2018. The searches were conducted in PubMed®, CINAHL, and Cochrane Library and supplemented through hand searches of reference lists of included articles and reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines. **Results:** The original and updated searches yielded a total of 76 systematic reviews and meta-analyses. Strong evidence demonstrated that moderate-intensity physical activity reduced the risk of excessive gestational weight gain, gestational diabetes, and symptoms of postpartum depression. Limited evidence suggested an inverse relationship between physical activity and risk of preeclampsia, gestational hypertension, and antenatal anxiety and depressive symptomology. Insufficient evidence was available to determine the effect of physical activity on postpartum weight loss, postpartum anxiety, and affect during both pregnancy and postpartum. For all health outcomes, there was insufficient evidence to determine whether the relationships varied by age, race/ethnicity, socioeconomic status, or prepregnancy weight status. **Conclusions:** The gestational period is an opportunity to promote positive health behaviors that can have both short- and long-term benefits for the mother. Given the low prevalence of physical activity in young women in general, and the high prevalence of obesity and cardiometabolic diseases among the U.S. population, the public health importance of increasing physical activity in women of childbearing age before, during, and after pregnancy is substantial. **Key Words:** ANXIETY, EXERCISE, GESTATIONAL DIABETES, DEPRESSION, PREECLAMPSIA, WEIGHT GAIN

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Pregnancy is a 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 the center of mass, almost always proceed normally. For women experiencing a healthy pregnancy, regular engagement in moderate-intensity physical activity for at least 20 to 30 min·d^{-1} on most or all days of the week has been recommended during pregnancy and postpartum period by the American College of Obstetricians and Gynecologists (ACOG) in 2015 (1) and reaffirmed in 2017 (2). Similarly, the *2008 Physical Activity Guidelines for Americans* recommended 150 to 300 min·wk^{-1} of moderate-intensity aerobic activity during pregnancy and postpartum spread throughout the week (3). These recommendations were made in an effort to prevent several complications that may occur during the gestational period. Such complications include the development of diabetes, gestational hypertensive disorders, and fetal growth impairments that are associated with increased risk of adult cardiovascular disease and early mortality in the mother (4) and possibly in their offspring (5).

Despite substantial advances in scientific knowledge and development of guidelines to promote physical activity in pregnancy, most pregnant women do not achieve the current physical activity recommendations, and many continue to be inactive during and after pregnancy (6,7). In fact, only 23% to 29% of pregnant women at any gestational stage in the United States met the minimum physical activity guidelines, based on the National Health and Nutrition Examination Survey data collected between 2007 and 2014 (8). Moreover, women who were active before pregnancy report that their physical activity level decreased once they became pregnant (9). There is also evidence that during postpartum, women may not return to their earlier physical activity levels for reasons such as lack of time, fatigue, or depressive symptoms (10).

The 2018 Physical Activity Guidelines Advisory Committee (PAGAC) Pregnancy and Postpartum Work Group recently conducted a systematic review of the evidence concerning the relationship between physical activity and various health outcomes during pregnancy and postpartum period (defined up to 12 months after delivery). Results of this review were published in the 2018 PAGAC Scientific Report (11). This current article summarizes the evidence from the 2018 PAGAC Scientific Report, including new evidence from an updated search of the effects of physical activity on maternal health during pregnancy and postpartum.

METHODS

The PAGAC Pregnancy Work Group addressed four major questions (11):

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 (GDM)?
3. What is the relationship between physical activity and the incidence of preeclampsia and hypertensive disorders during pregnancy?
4. What is the relationship between physical activity and affect, anxiety, and depression during pregnancy and postpartum?

Questions 1 through 4 had 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 prepregnancy weight status?

Literature search strategy and study selection. The work group first identified two high-quality existing reports: 1) the *2008 Physical Activity Guidelines Advisory Committee Report* (12) and 2) the 2015 ACOG Committee Opinion on Physical Activity and Exercise during Pregnancy and the Postpartum Period (1). After reviewing these documents, the work group decided that they could serve as a foundation for describing the relationship between physical activity and maternal heath during pregnancy and postpartum (refer to Table F8-3 in the 2018 PAGAC Scientific Report).

To identify the most recent pertinent literature, the work group used the literature searches conducted by three of the 2018 PAGAC subcommittees that had outcomes of interest related to the pregnancy and postpartum questions. Seven searches for systematic reviews, meta-analyses, pooled analyses, and high-quality reports conducted by other PAGAC subcommittees were considered to provide potentially pertinent information (Table 1). An initial search was undertaken in October 2016 to include publications from 2006 to 2016. The searches were conducted in PubMed®, CINAHL, and Cochrane Library and supplemented through hand searches of reference lists of included articles. Findings were reported according to the Preferred Reporting Items for Systematic reviews and Meta-Analyses guidelines (13).

TABLE 1. Research questions from other subcommittees that provided evidence to answer questions related to pregnancy and postpartum (2018 PAGAC Scientific Report).

Subcommittee, Question No.	Question
Cardiometabolic Health and Weight Management, Q1	What is the relationship between physical activity and prevention of weight gain?
Cardiometabolic Health and Weight Management, Q2	In people with normal blood pressure or prehypertension, what is the relationship between physical activity and blood pressure?
Cardiometabolic Health and Weight Management, Q3	In adults without diabetes, what is the relationship between physical activity and incident type 2 diabetes?
Brain Health, Q2	What is the relationship between physical activity and quality of life?
Brain Health, Q3	What is the relationship between physical activity and 1) affect, 2) anxiety, and 3) depressed mood and depression?
Brain Health, Q4	What is the relationship between physical activity and sleep?
Aging, Q2	What is the relationship between physical activity and physical function? (The search for this question was not restricted to older age-groups).

All search results that included "gestation," "postp," "pregn," "natal," or "maternal" in the title or abstract were provided to the work group. The title, abstract, and full-text triage review process was the same as that used for other 2018 PAGAC topics (11,14). The work group relied on these publications as the sources of potential evidence regarding quantifiable benefits or risks of physical activity, as well as the dose associated with specific health outcomes. The work group also completed one supplementary search by adding "eclampsia" and "preeclampsia" to the Cardiometabolic Health and Weight Management Subcommittee search on hypertension. In March 2018, an updated systematic review was undertaken to identify additional systematic reviews and meta-analyses published between January 2017 and February 2018.

Quality assessment. The evidence to inform each of the work group's four questions and subquestions was graded as strong, moderate, limited, or "grade not assignable" based on several criteria, including applicability, generalizability, risk of bias/study limitations, quantity and consistency of results across studies, and magnitude and precision of effect. These criteria are described in Supplemental Table 1 (see Table, Supplemental Digital Content 1, 2018 Physical Activity Guidelines Advisory Committee Grading Criteria, http://links.lww.com/MSS/B531).

RESULTS

After duplicates were removed, a total of 254 articles were identified through the initial search process, and 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 (Fig. 1). The abstracts of these articles were then reviewed by at least two members of the work group. The quality for each systematic review, meta-analysis, or pooled analysis was assessed using AMSTARExBP (15). Risk of bias was assessed for each study using an adapted version of the Nutrition Evidence Library Bias Assessment Tool by the U.S. Department of Agriculture (16). Two original review articles were added to the group of articles being reviewed at full text, and thus, a total of 73 articles were determined to be potentially relevant, and the full articles were retrieved and reviewed.

The updated search (conducted in March 2018) identified 47 articles, of which 7 were deemed relevant for full-text

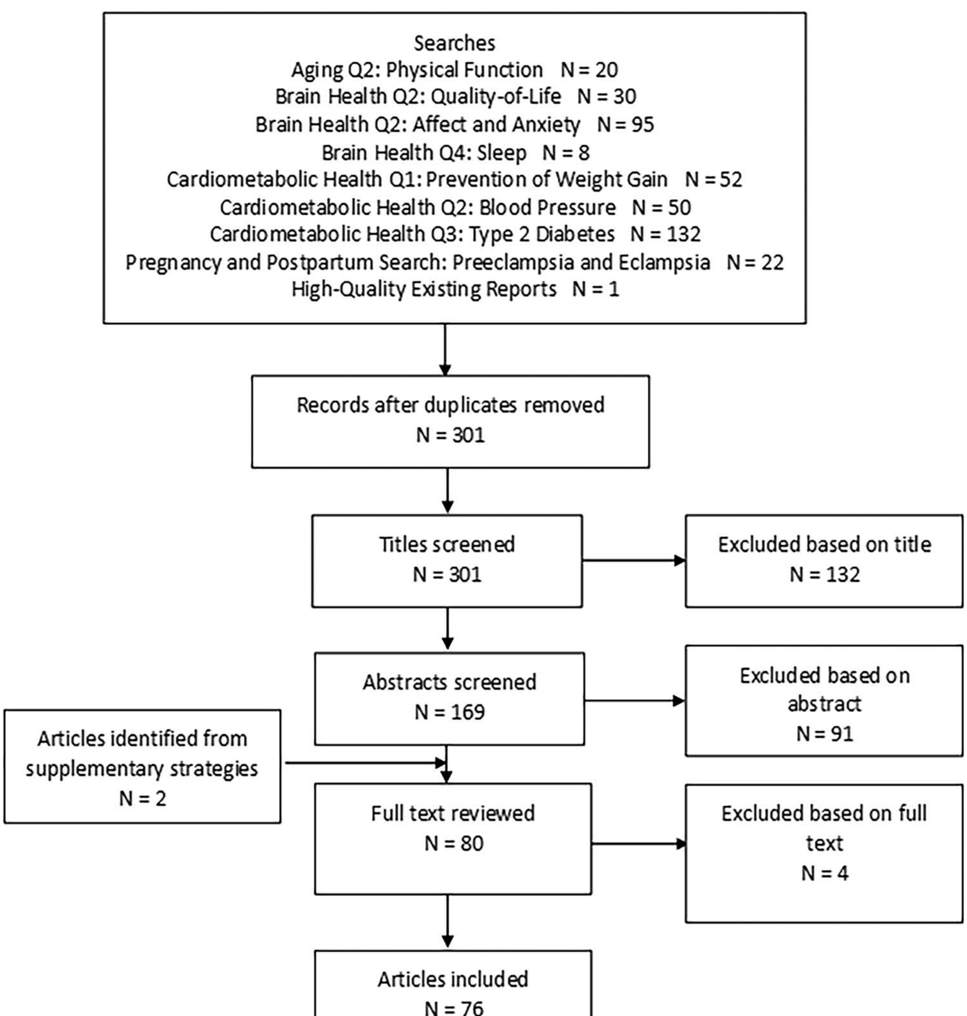

FIGURE 1—Flow diagram of search strategy and study selection for both the initial 2018 PAGAC Scientific Report and the updated search. *Articles from the updated search.

review. After full-text review by three members of the work group, four articles were excluded because they failed to meet the inclusion criteria. Of the remaining three reviews from the updated search, one provided information about gestational weight gain, GDM, and hypertensive disorders (17); one about gestational hypertensive disorders (18); and one about postpartum depression (19). Therefore, the initial and updated searches yielded a total of 76 articles, 38 of which are reported on in this current review (Fig. 1).

Table 2 summarizes the level of evidence for the relationship between physical activity and each health outcome during pregnancy and postpartum. Overall, there was strong evidence demonstrating an inverse relationship between physical activity during pregnancy and gestational weight gain, GDM, and postpartum depression.

Gestational Weight Gain

In the 2018 PAGAC Scientific Report, 11 systematic reviews provided strong evidence that women assigned to physical activity interventions gain about 1 kg less weight during pregnancy than women in comparison groups. Of the nine reviews that included meta-analyses (20–28), all but one reported significantly less weight gained in the physical activity group. The other meta-analysis included only pregnant women who were overweight or obese and reported significantly attenuated weight gain among active versus inactive women who were obese but not among those who were overweight (26).

One meta-analysis (20) reviewed 30 randomized controlled trials (RCT). On the basis of a meta-analysis of 18 of those RCT, which included 1598 women performing a structured exercise program and 1605 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. The other meta-analyses of RCT (21–28) reported similar SMD in gestational weight gain between exercising and control women, ranging from −0.36 kg (95% CI = −0.64 to −0.09; 5 studies) (24) to −2.22 kg (95% CI = −3.14 to −1.30; 3 studies) (21). The updated search identified a meta-analysis that analyzed participant-level data by the International Weight Management in Pregnancy (i-WIP) Collaborative Group (17), which further corroborated the finding that women who were physically active during pregnancy experience attenuated weight gain compared with women who are not (SMD = −0.73 kg, 95% CI = −1.11 to −0.34 kg; 15 studies).

Several of the systematic reviews and meta-analyses (20,22,23) examined the relationship between physical activity and "excess" weight gain, as defined by the Institute of Medicine Guidelines (29). 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 (ES) ranging from 18% (20) to 23% (23). On the basis of this literature review, the overall evidence was strong for an inverse association between physical activity and excess gestational weight gain. Muktabhant et al. (23) also examined the relationship between exercise during pregnancy and "low" or insufficient gestational weight gain. Women from the general population having a normal (18.5–24.9 $kg \cdot m^{-2}$) body mass index (BMI; "low risk") or any BMI ("mixed risk") experienced a marginally greater chance of "low" weight gain compared with the nonexercising control group (average relative risk [RR] = 1.20, 95% CI = 1.00 to 1.43; 3 studies). There was no relationship between exercise and insufficient weight gain among women whose pregnancies were considered high risk and who also were overweight or obese ("high risk") (average RR = 1.03, 95% CI = 0.66–1.60; 3 studies).

Dose and dose–response. The dose of physical activity prescribed in the RCT varied among the studies. Similarly, the assessment and categorization of the 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, and aerobic exercise), occurring at least three times per week for a duration of 30 to 60 min per session. This dose of physical activity is similar to the recommendations of both the ACOG Guidelines and the 2008 Physical Activity Guidelines (1,3).

Most of the reviews did not assess whether maternal physical activity and gestational weight gain had a dose–response relationship. Indirect evidence of a dose–response relationship was suggested, however, by the observation that adherence to the prescribed exercise program was significantly higher in the "successful" interventions (22), and the observation in a meta-analysis of 28 RCT in which the mean difference in gestational weight gain between the exercise and the control groups was

TABLE 2. Summary of the level of evidence for the relationship between physical activity and each health outcome during pregnancy and postpartum.

	Overall Evidence	Dose	Dose–response	Effect Modification by Sociodemographic Factors or Weight
Gestational weight gain	Strong	Limited	Limited	Not assignable
Weight loss during postpartum	Not assignable	Not assignable	Not assignable	Not assignable
Gestational diabetes	Strong	Limited	Limited	Not assignable
Preeclampsia/gestational hypertension	Limited	Limited	Limited	Not assignable
Antenatal affect, anxiety, and depression	Not assignable	Not assignable	Not assignable	Not assignable
	Limited	Not assignable	Not assignable	Not assignable
	Limited	Not assignable	Not assignable	Not assignable
Postpartum affect, anxiety, and depression	Not assignable	Not assignable	Not assignable	Not assignable
	Not assignable	Not assignable	Not assignable	Not assignable
	Strong	Not assignable	Not assignable	Not assignable

inversely correlated with both the duration (wk) of the intervention (Pearson product moment correlation coefficient [r] = −0.51, P = 0.023) and the volume ($h \cdot wk^{-1}$) of exercise prescribed (r = −0.45, P = 0.05) (28). The evidence grade for the dose and dose–response relationship between physical activity and gestational weight gain was limited.

Sociodemographic factors and weight status. None of the systematic reviews or meta-analyses from the 2018 PAGAC Scientific Report assessed whether the purported relationship between physical activity and gestational weight gain varied by age, race/ethnicity, socioeconomic status, or prepregnancy weight status. The i-WIP Collaborative Group meta-analysis (17), which analyzed participant-level data from 15 RCT (N = 2915), reported that the inverse relationship between physical activity and gestational weight gain did not vary by age, race/ethnicity, or prepregnancy weight status.

With regard to weight status, most of the findings were reported among women of normal weight (i.e., BMI = 18.5–24.9 $kg \cdot m^{-2}$). However, four systematic reviews (22,23,26,28) stratified their data by prepregnancy weight status (i.e., normal weight, overweight [BMI = 25–29.9 $kg \cdot m^{-2}$], or obese [BMI ≥30 $kg \cdot m^{-2}$]). Three of these studies observed stronger effects among pregnant women of normal weight, compared with those who were overweight or obese (22,23,28). One meta-analysis of women who were overweight or obese (26) reported a greater difference in gestational weight gain between the exercise and the control groups among women with obesity (SMD = −0.91 kg, 95% CI = −1.66 to −0.16; 3 studies), but not in women who were overweight (SMD = −0.12, 95% CI = −0.52 to 0.26; 3 studies). By contrast, the meta-analysis from the i-WIP Collaborative Group (17) reported that the inverse relation between physical activity and gestational weight gain did not vary across different subgroups of women categorized by BMI (normal weight, overweight, and obese). Thus, the evidence grade for effect modification on the relationship between physical activity and gestational weight gain was not assignable.

Weight loss during the postpartum period. A total of five systematic reviews and meta-analyses (21,30–33) 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 reported no significant difference in weight loss between women who performed physical activity during postpartum (alone, without dietary restriction) and the control group. Because of the insufficient number of studies linking physical activity to postpartum weight loss, an evidence grade for this relationship was not assignable.

GDM

Of the 13 meta-analyses from the 2018 PAGAC Scientific Report, 8 described higher levels of physical activity to be associated with statistically significant reductions in the risk of GDM (Table 3) (20,24,34–39), 4 reported nonsignificant reductions (40–43), and 1 reported a nonsignificant increase (44). The reduced RR of GDM (regardless of statistical significance) ranged from 0.45 to 1.01, with a median value of RR = 0.73. The updated search identified one additional meta-analysis of 10 RCT (N = 2700 women) that also reported a significantly lower risk of GDM among women participating in physical activity interventions compared with those in a control condition (odds ratio [OR] = 0.67, 95% CI = 0.46 to 0.99) (17). Notably, this risk reduction in the incidence of GDM reported in many of these meta-analyses is similar to the 25%–30% reduction in the risk of type 2 diabetes among the general population that is associated with 150 to 300 $min \cdot wk^{-1}$ of moderate-intensity physical activity (for more details, refer to the 2018 PAGAC Scientific Report, Part F, Chapter 5).

TABLE 3. Summary of findings from 14 meta-analyses of the relationship between prepregnancy and early pregnancy physical activity and risk of GDM.

Author, yr	Study Design	Effect (95% CI)
Prepregnancy physical activity		
Aune et al. (2016)	**Cohort (N = 8)**	**sRR = 0.78 (0.61–1.00)**
Tobias et al. (2011)	**RCT (N = 7)**	**pOR = 0.45 (0.28–0.75)**
Early pregnancy physical activity		
i-WIP Collaborative Group (2017)[a]	**RCT (N = 10)**	**OR = 0.67 (0.46–0.99)**
Aune et al. (2016)	Cohort (N = 5)	sRR = 0.97 (0.73–1.28)
	RCT (N = 12)	**sRR = 0.69 (0.50–0.96)**
	Combined (N = 17)	**sRR = 0.80 (0.64–1.00)**
da Silva et al. (2017)	Cohort (N = 6)	sOR = 0.75 (0.55–1.01)
	RCT (N = 10)	**sOR = 0.67 (0.49–0.92)**
Di Mascio et al. (2016)	**RCT (N = 4)**	**sRR = 0.51 (0.31–0.82)**
Han et al. (2011)	RCT (N = 3)	sRR = 1.10 (0.66–1.84)
Madhuvrata et al. (2015)	RCT (N = 3)	pOR = 0.77 (0.33–1.79)
Oostdam et al. (2011)	RCT (N = 3)	Risk difference = −0.05 (−0.20 to 0.10)
Russo et al. (2015)	**RCT (N = 10)**	**sRR = 0.72 (0.58–0.91)**
Sanabria-Martinez et al. (2015)	**RCT (N = 8)**	**sRR = 0.69 (0.52–0.91)**
Song et al. (2016)	RCT (N = 10)	sRR = 0.77 (0.54–1.09)
Tobias et al. (2011)	**RCT (N = 5)**	**pOR = 0.76 (0.70–0.83)**
Yin et al. (2014)	RCT (N = 6)	sRR = 0.91 (0.57–1.44)
Yu et al. (2017)	**RCT (N = 5)**	**SMD = 0.59 (0.39–0.88)**
Zheng et al. (2017)	**RCT (N = 4)**	**SMD = 0.62 (0.43–0.89)**

Studies with statistically significant findings are in bold type.
[a]Identified in the updated search.
sRR, standardized relative risk; sOR, standardized odds ratio; pOR, pooled odds ratio.

Aune et al. (34) reviewed 23 studies of total physical activity (leisure time, occupational, and household activity combined) and of leisure time physical activity performed before or during early pregnancy and the incidence of GDM. Those women who reported performing highest levels of total physical activity before pregnancy experienced a significantly lower risk of GDM compared with women reporting lowest levels of total activity (RR = 0.62, 95% CI = 0.41 to 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 to 1.21; 3 studies). On the other hand, women performing the highest levels of moderate-intensity leisure time physical activity either before (RR = 0.78, 95% CI = 0.61 to 1.00; 8 studies) or during pregnancy (RR = 0.80, 95% CI = 0.64 to 1.00; 12 studies) significantly lowered their risk of GDM by about 20% (34). Women who performed such physical activity both before and during pregnancy lowered their risk by 59% (RR = 0.41, 95% CI = 0.23 to 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% (summary RR = 0.76, 95% CI = 0.66 to 0.88; 3 studies), but this was not the case for vigorous activity performed during pregnancy (RR = 0.95, 95% CI = 0.55 to 1.63; 2 studies). On the basis of this review of literature, the overall evidence was strong for an inverse association between physical activity and GDM.

Dose and dose–response. The dose of physical activity prescribed in the RCT varied among the studies. Similarly, the assessment and categorization of reported leisure time physical activity from observational studies was not detailed nor consistent. Most RCT interventions used a physical activity regimen involving primarily aerobic activity of at least moderate intensity (walking, cycling, swimming, and aerobic dance), occurring at least three times per week for a duration of 30 to 60 min per session, which is similar to both ACOG Guidelines and the 2008 Physical Activity Guidelines (1,3).

Aune et al. (34) performed a dose–response analysis and reported that each 5 $h \cdot wk^{-1}$ increment in prepregnancy physical activity lowered the risk of GDM by about 30% (RR = 0.70, 95% CI = 0.49–1.01; 3 studies), with significant evidence of nonlinearity ($P < 0.005$). 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. (37) 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 to 0.87). The evidence grade for the dose and dose–response relationship between physical activity and GDM was limited.

Sociodemographic factors and weight status. Almost none of the systematic reviews or meta-analyses assessed whether the relationship between physical activity and GDM varied by age, race/ethnicity, or socioeconomic status. The review by Song et al. (42) reported that physical activity during pregnancy had a significant effect on GDM risk in women ages 30 yr and older, but not in women younger than age 30 yr. The i-WIP Collaborative Group reported that the benefits of physical activity to the reduction in risk of GDM were similar across the different subgroups of women categorized by age, race/ethnicity, or BMI (17).

Preeclampsia and Gestational Hypertension

Hypertensive disorders during pregnancy include preeclampsia and gestational hypertension. Preeclampsia is characterized by high blood pressure, high levels of protein in the urine (proteinuria), and swelling in the hands and feet. Gestational hypertension is elevated blood pressure without concomitant signs of preeclampsia such as proteinuria. Its relationship, if any, with preeclampsia is unclear.

Nine reviews from the 2018 PAGAC Scientific Report provided only limited evidence of an inverse relationship between total volume of physical activity and risk of preeclampsia or incident gestational hypertension (20,23,35,39,45–49). 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 prepregnancy (RR = 0.65, 95% CI = 0.47 to 0.89; 5 studies) and early pregnancy physical activity (RR = 0.79, 95% CI = 0.70 to 0.91; 11 studies) (45). The meta-analysis of 10 cohort studies by Kasawara et al. (46) reported no association between leisure time physical activity and preeclampsia (OR = 0.99, 95% CI = 0.93 to 1.05). By contrast, their meta-analysis of six case–control studies reported a significantly lower odds of preeclampsia (OR = 0.77, 95% CI = 0.64 to 0.91) with physical activity performed in prepregnancy (summarized from only two studies) being more effective (OR = 0.56, 95% CI = 0.41–0.76) than physical activity performed during pregnancy (OR = 0.77, 95% CI:0.64 to 0.91). Three meta-analyses comprising RCT and cohort studies found no association between physical activity and preeclampsia; one of the studies examined prepregnancy physical activity (20), whereas the other two studies examined early pregnancy physical activity (23,39).

One systematic review (47) and one meta-analysis (35) examined the relationship between physical activity and hypertensive disorders during pregnancy. Di Mascio et al. (35) reported an RR of 0.21 (95% CI = 0.09–0.45; 3 studies) for hypertensive disorders among women performing moderate-intensity leisure activities (aerobic dance, cycling, hydrotherapy, and resistance exercises) during pregnancy, compared with women performing no activity. The updated search identified two additional meta-analyses (17,18) about physical activity and hypertensive disorders during pregnancy. The i-WIP Collaborative Group (17) reported null findings (OR = 0.74, 95% CI = 0.42 to 1.33); however, Magro-Malosso et al. (18) reported a significantly lower incidence of gestational hypertensive disorders (RR = 0.39, 95% CI = 0.20 to 0.73; 7 studies) and gestational hypertension (RR = 0.54, 95% CI = 0.32 to 0.91; 16 studies) and a similar incidence of preeclampsia (RR = 0.37, 95% CI = 0.12 to 1.15; 6 studies) in pregnant women assigned to aerobic exercise (without dietary counseling) groups compared with women assigned to standard care control groups. On the basis of this review of literature, the overall evidence was limited for an inverse association between physical activity and both preeclampsia and gestational hypertension.

Dose and dose–response. The meta-analysis by Aune et al. (45) was the only review to report on the dose–response relation between physical activity and risk of preeclampsia. In their analysis of prepregnancy physical activity, the results indicated a 28% lower risk of preeclampsia for each 1 $h \cdot d^{-1}$ increment in physical activity (OR = 0.72, 95% CI = 0.53 to 0.99; 3 studies) and a 22% lower risk for each 20-$MET \cdot h \cdot wk^{-1}$ increment (OR = 0.78, 95% CI = 0.63 to 0.96; 2 studies). This relationship appeared nonlinear, with a flattening of the curve at higher levels of physical activity. Indeed, there was a 40% reduction in risk up to 5–6 $h \cdot wk^{-1}$ but no further reductions at higher physical activity levels (Fig. 2). With regard to physical activity performed

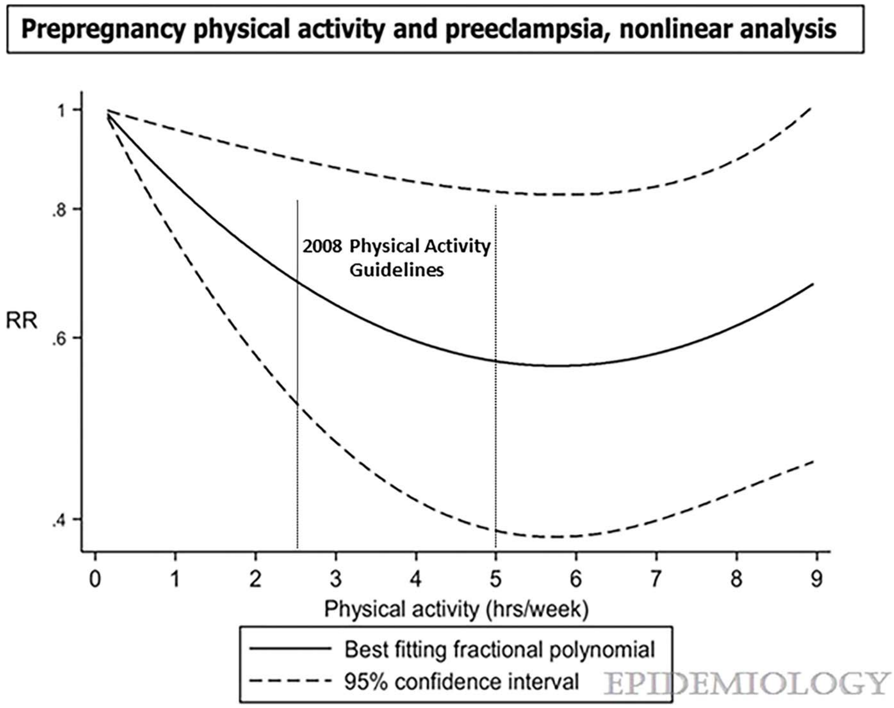

FIGURE 2—The dose–response relationship between prepregnancy physical activity and risk of preeclampsia. The results indicate a 28% lower risk of preeclampsia for each 1 h·d^{-1} increment in activity, compared with no activity (OR = 0.72, 95% CI = 0.53 to 0.99). Adapted with permission from Aune D, 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. Copyright © 2014 Wolters Kluwer Health, Inc.

during early pregnancy, the risk of preeclampsia was reduced in a linear manner by 17% for each 1 h·d^{-1} increment in physical activity (OR = 0.83, 95% CI = 0.72 to 0.95; 7 studies) and by 15% for every 20 MET·h·wk^{-1} increment (OR = 0.85, 95% CI = 0.68 to 1.07; 3 studies). The evidence grade for the dose and dose–response relationship between physical activity and both preeclampsia and gestational hypertension was limited.

Sociodemographic factors and weight status. There was no available evidence that evaluated whether the relationship between physical activity and preeclampsia varied by age, race/ethnicity, socioeconomic status, or weight status. Mutkabhant et al. (23) analyzed their data according to prepregnancy weight status (normal weight, overweight, or obese) and observed that even among pregnant women with overweight or obesity, there was no difference in risk of preeclampsia (based on two studies) between women in the exercise groups and those in the control groups (RR = 1.60, 95% CI = 0.38 to 6.73). The i-WIP Collaborative Group reported that the relationship between physical activity and hypertensive disorders during pregnancy were similar across the different age, race/ethnicity, and BMI subgroups of women (17). The evidence grade for effect modification on the relationship between physical activity and both preeclampsia and gestational hypertension was not assignable.

Physical activity, affect, anxiety, and depression during pregnancy and postpartum. We identified no systematic reviews or meta-analyses that examined the relationship between physical activity and affect, either during pregnancy or during the postpartum period. We found limited evidence that yoga performed during pregnancy significantly reduced anxiety symptomology (50,51); however, no systematic reviews or meta-analyses were found that examined this relationship during the postpartum period. There was also limited evidence to suggest that higher levels of physical activity were associated with reduced symptoms of depression during pregnancy (50,51). On the other hand, strong evidence demonstrated that there was an inverse relationship between physical activity and reduced symptoms of depression during postpartum.

With regard to antenatal anxiety and depressive symptoms, Sheffield et al. (50) provided a systematic review of 13 studies (7 of which were RCT) that examined the effects of practicing yoga during pregnancy on symptoms of anxiety and depression during that same period. Of the five studies that evaluated anxiety symptomology, all of them reported statistically significant improvements in the State/Trait Anxiety Inventory scores after a yoga intervention, and six of seven studies observed a statistically significant improvement in the Center for Epidemiologic Studies Depression scale score. Shivakumar et al. (51) reported that women who were more physically active during pregnancy reported reduced symptoms of anxiety in one of three studies that examined symptoms of anxiety, whereas two other studies in the same review both reported reduced symptoms of depression in pregnant adolescent girls who performed physical activity compared with their sedentary counterparts.

Two meta-analyses (52,53) and one systematic review (54) examined the relationship between physical activity and symptoms of depression during the postpartum period. The updated search identified an additional meta-analysis of 13 RCT (19). McCurdy et al. (52) examined 16 RCT comparing light- to moderate-intensity aerobic exercise (initiated in the first year postpartum) to standard care in postpartum women (N = 1327) with (10 RCT) and without (6 RCT) mild to moderate depression. In general, depressive symptom scores (based on the Edinburgh Postnatal Depression Scale [EPDS]) were lower among those in postpartum exercise intervention groups compared with those in control groups (pooled SMD = −0.34, 95% CI = −0.50 to −0.19). Among the 10 treatment RCT in women with postpartum depression, a moderate beneficial effect of exercise on depressive symptoms also was observed (SMD = −0.48, 95% CI = −0.73 to −0.22) relative to the control group. Moreover, in women classified with depression preintervention (defined as an EPDS score greater than 12), exercise increased the odds of resolving depression postintervention by 54% (OR = 0.46, 95% CI = 0.25 to 0.84; 3 trials; N = 173) compared with the control group. It is not clear, however, whether these benefits were independent of medication or social support. In the six prevention trials (i.e., women without depression), a beneficial effect of postpartum exercise was observed based on the EPDS score (SMD = −0.22, 95% CI = −0.36 to −0.08) compared with standard care.

These findings are consistent with those from a smaller review and meta-analysis by Poyatos-Leon and colleagues (53), which reported improved postpartum depressive symptomology (measured by EPDS or by the Beck Depression Inventory [BDI]) among women performing physical activity during pregnancy and the postpartum period, compared with those who were not (ES = 0.41, 95% CI = 0.28 to 0.54; 12 studies). Of note, the benefits of physical activity were more pronounced in women who met criteria for postpartum depression (ES = 0.67, 95% CI = 0.44–0.90; 6 studies) compared with those who did not (ES = 0.29, 95% CI = 0.14 to 0.45). Most (10 of 12) of the interventions started during the postpartum period and involved a variety of activities, such as walking, aerobics, Pilates, yoga, and stretching. Similarly, Pritchett et al. (19) performed a meta-analysis of 13 RCT (7 trials recruited postpartum women with depression; 6 trials recruited postpartum women from the general population). In general, postpartum aerobic exercise interventions significantly reduced depressive symptoms (assessed by EPDS, BDI, or *Diagnostic and Statistical Manual of Mental Disorders IV*) in women with postpartum depression (SMD = −0.32, 95% CI = −0.63 to −0.00) as well as in postpartum women without it (SMD = −0.57, 95% CI = −1.12 to −0.02). In the exercise-only interventions (i.e., no cointerventions of social support or dietary counseling; N = 8 RCT), exercise had a marginal effect in reducing postpartum depressive symptoms (SMD = −0.56, 95% CI = −1.13 to 0.01).

Dose and dose–response. Insufficient information was available to determine the dose of physical activity associated with improved affect and reduced anxiety and depressive symptomology. Most of the RCT reviewed in the recently added meta-analysis by Pritchett et al. (19) observed improvements in postpartum depressive symptoms from about 30 min of moderate-intensity activity, performed 3 to 5 times weekly, for 4 wk to 6 months duration. The evidence grade for the dose and dose–response relationship between physical activity and affect, anxiety, and depression was not assignable.

Sociodemographic factors and weight status. There was no available evidence that tested whether the relationship between physical activity and affect, anxiety, or depression during pregnancy or postpartum varied by age, race/ethnicity, socioeconomic status, or prepregnancy weight status. The evidence grade for effect modification on the relationship between physical activity and both antenatal and postpartum affect, anxiety, and depression was not assignable.

DISCUSSION

The gestational period is an opportunity to promote positive health behaviors that can have both short- and long-term benefits for the mother. Given the low prevalence of physical activity in young women in general (55) and the high prevalence of obesity and cardiometabolic diseases among the U.S. population (56), the importance of increasing physical activity levels in women of childbearing age, before, during, and after pregnancy is substantial. The 2018 PAGAC Scientific Report concluded that for women with a healthy 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 (12). Our findings in 2018 support those from 2008 and extend them in several ways. Strong evidence now shows that moderate-intensity physical activity commensurate with the current recommendations (150–300 min·wk^{-1}) reduces the risk of excessive gestational weight gain, GDM, and symptoms of postpartum depression. Unfortunately, only about 23% to 29% of pregnant women living in the U.S. meet even the minimum physical activity recommendations (8), and therefore, the majority of pregnant women receive few or none of the physical and emotional health benefits of being physically active.

We found strong evidence that physically active pregnant women (i.e., those meeting at least the minimum ACOG or 2008 Physical Activity Guidelines of 150 min·wk^{-1} of moderate-intensity activity) gain less weight than their nonactive counterparts and are about 18% to 23% less likely to exceed the Institute of Medicine recommendations for healthy weight gain (29). Because gestational weight gain is attenuated in women who are active during pregnancy, they are also at lower risk of excessive postpartum weight retention, future obesity, and birth of an infant with macrosomia (57). Although not systematically examined by the 2018 PAGAC, active pregnant women also appear to be at lower risk of undergoing a cesarean section (23,27,28,35,44) and appear at no greater risk of preterm delivery (23,27,35,38,39) than are inactive women. Additional information on weight gain patterns in physically active pregnant women, according to IOM recommendations and their prepregnancy weight status, would increase the clinical value of these findings substantially.

There was also strong evidence demonstrating that women who meet ACOG Physical Activity Guidelines during prepregnancy or during pregnancy are about 25% to 30% less likely to develop GDM than their inactive peers. This is significant because GDM occurs in approximately 5% to 9% of women, and those with GDM are also at increased risk of delivery by cesarean section and having an infant with macrosomia and/or neonatal hypoglycemia (58). Gestational diabetes also is associated with a 7-fold increase in the risk of developing type 2 diabetes after pregnancy (58).

Finally, about 10% of women experience postpartum depression, with nearly 25% of them still in treatment after 1 yr (59). This review provides strong evidence that physically active women experience significantly fewer symptoms of depression during the postpartum period compared with their inactive counterparts. In fact, the benefits of physical activity to postpartum depression are consistent with those for depressive symptoms among the general population as indicated in the 2018 PAGAC Scientific Report (see Part F, Chapter 3; Brain Health; Question 3).

The need for future research. In sum, the health benefits documented in this review confirm the substantial public health importance of regular participation in moderate-intensity physical activity before, during, and after pregnancy. However, both the 2018 Scientific Report (11) and this umbrella review underscore the need for future research in several areas. For example, there is a need to investigate longitudinally the timing of the physical activity exposure (e.g., prepregnancy, early pregnancy, and throughout pregnancy postpartum) relative to specific maternal outcomes of interest. For some pregnancy outcomes like excessive weight gain, GDM, or preeclampsia, prepregnancy or early pregnancy physical activity may be sufficient for reducing risk during the entire gestational period. For other issues such as postpartum weight loss or depression, however, postpartum physical activity may be more important than activity at other stages of pregnancy for promoting weight loss, mitigating depressive symptoms, and improving quality of life. The determinants and barriers to postpartum exercise also need further study.

Second, the safety and benefits of vigorous-intensity physical activity to maternal health are less well-documented than those for light- to moderate-intensity activity, and this type of activity may be discouraged by some health care providers. There are substantial numbers of women who participate regularly in vigorous-intensity physical activity (e.g., running, cycling, and rowing) before pregnancy, who 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, as well as on maximal threshold levels for safety concerns (e.g., insufficient gestational weight gain, hyperthermia, musculoskeletal injuries, or low birth weight) that may affect the health of mothers and their offspring.

Finally, most of the experimental research on physical activity during pregnancy relies on the 2008 Physical Activity Guidelines or the 2015 ACOG recommendations of 150 $\text{min}\cdot\text{wk}^{-1}$ 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 (48). The validity of this claim needs to be determined, as well as whether these differential findings are caused by the nature of the activities and the setting itself, or perhaps by confounding factors such as socioeconomic status, educational attainment, or age. Also, there are limited data concerning the dose–response relationships between any type of physical activity (performed before, during, or after pregnancy) and important pregnancy outcomes such as GDM and preeclampsia. Some data suggest a nonlinear relation between prepregnancy activity and these outcomes (34,45), whereas data on early pregnancy physical activity show a more linear dose–response curve (45). Examining the effect of different types, intensities, doses, and timing of physical activity across various domains (leisure time, occupational, household, and transportation) on a range of maternal outcomes would significantly advance current knowledge and inform both clinical and public health practice.

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HHS staff provided general administrative support to the committee and assured that the committee adhered to the requirements for Federal Advisory Committees. HHS also contracted with ICF, a global consulting services company, to provide technical support for the literature searches conducted by the committee. HHS and ICF staff collaborated with the committee in the design and conduct of the searches by assisting with the development of the analytical frameworks, inclusion/exclusion criteria, and search terms for each primary question; using those parameters, ICF performed the literature searches.

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