HHS Public Access

Author manuscript

Am J Obstet Gynecol MFM. Author manuscript; available in PMC 2023 January 01.

Published in final edited form as:

Am J Obstet Gynecol MFM. 2023 January ; 5(1): 100758. doi:10.1016/j.ajogmf.2022.100758.

Physical activity and pregnancy outcomes: An expert review

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Abstract

The objective of this expert review is to assess current literature on the impact and tracking of physical activity during pregnancy and associated outcomes. Self-reported physical activity may be inaccurate given the subjective nature of questionnaires. The accelerometer ActiGraph is considered the “gold standard” to objectively measure physical activity. However, other more user-friendly wearable devices are now widely available and may accurately track physical activity. Conclusive data from both validated activity questionnaires and accelerometers indicate that physical activity is safe during pregnancy. In addition, studies of physical activity during pregnancy that evaluate pregnancy outcomes have found reduced risks of preterm birth, preeclampsia, and gestational diabetes and improved mental health among individuals who regularly engage in physical activity. In the United States, approximately 48% of pregnant individuals gain more than the recommended amount of weight during pregnancy; excessive gestational weight gain is associated with an increased risk of maternal and fetal complications including preterm birth, preeclampsia, and gestational diabetes and corresponding higher adverse short- and long-term maternal and offspring health outcomes. Although physical activity is safe during pregnancy and may reduce excessive gestational weight gain and resultant pregnancy complications, further research is needed to determine the frequency and duration of specific types of physical activity during pregnancy. Providers should encourage physical activity before and during pregnancy and educate patients regarding the benefits and safety of physical activity.

Condensation:

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Conflict of interest: The authors report no conflict of interest.

Specific duration and frequency recommendations of physical activity during pregnancy may reduce the risk of pregnancy-related complications.

Keywords

obesity; preterm birth; gestational diabetes; preeclampsia; pregnancy complications; activity trackers

Introduction

Physical activity is promoted in nearly all fields of medicine as a strategy to reduce a variety of adverse health outcomes. The term 'physical activity' includes both intentional (e.g., exercise) and non-intentional (e.g., activities of daily life) movement. Indeed, individuals who are physically active have reduced risks of premature morbidity and mortality and multiple chronic medical conditions including cardiovascular disease.[1,2] Further, physical activity is consistently and reproducibly associated with reduced stress, improved mental health, and sleep.[3–5] Though benefits appear to increase in a dose-dependent fashion, recent data from a large systematic review support the notion that relatively small increases in physical activity are beneficial, and benefits are appreciated even if the 150 minutes per week of activity recommended by professional societies are not attained.[1]

Physical activity, including regular aerobic exercise, is associated with a reduced risk of overweight and obesity and developing related comorbidities in both pregnant and non-pregnant populations.[6] The epidemic of overweight and obesity and the related sequelae are of particular concern to pregnant individuals. In the U.S., pre-pregnancy body mass index (BMI) is used as a key parameter to determine weight gain recommendations during pregnancy.[7,8] Using established American College of Obstetricians and Gynecologists and Institute of Medicine parameters, it is estimated that 48% of pregnant individuals gain 'excessive' weight during pregnancy.[9,10] Excessive gestational weight gain – regardless of pre-pregnancy BMI – is associated with a wide range of maternal and fetal complications, including gestational diabetes, preeclampsia, spontaneous preterm birth, and fetal macrosomia or large for gestational age.[11–13] Of concern, patients with pregnancies complicated by gestational diabetes and preeclampsia carry an elevated life-long risk of nearly all subtypes of cardiovascular disease, including stroke,[14,15] myocardial infarction,[16–19] thromboembolism,[18,19] and death[19,20] as compared to those who do not develop these pregnancy complications.

Pregnancy is a time when individuals are in regular contact with health professionals, and may be motivated to change, and therefore is a unique and critical window when healthcare interventions or recommendations are more likely to be adapted. Ultimately, recommendations regarding physical activity, which may in turn impact weight management, may impact both pregnancy outcomes and future cardiovascular health.[21] However, though physical activity may confer multiple benefits, including helping to moderate gestational weight gain, some pregnant individuals have concerns regarding adverse effects of exercise on the pregnancy itself. Indeed, in a cross-sectional study of 1,279 patients, 55% of participants stopped their usual physical exercise due to pregnancy,

and only 20.1% of participants reported engaging in any exercise during pregnancy.[22] Qualitative studies evaluating barriers to physical activity during pregnancy have noted that environmental (access to opportunities for exercise), education (including misconceptions regarding the safety of activity), sociocultural, socioeconomic, and individual factors (including physical and emotional barriers) serve as the largest obstacles to participating in physical activity during pregnancy.[23,24] Thus, pregnancy may be associated with a hesitancy to engage in any type of, or certain subsets of physical activity due to concerns regarding an elevated risk of pregnancy complications including miscarriage, preterm birth, and preeclampsia, though these concerns are not supported by data. The aim of this review is to summarize current literature regarding physical activity during pregnancy and subsequent pregnancy outcomes; to do so, we provide a review of the history of physical activity recommendations during pregnancy, methods used to quantify physical activity during pregnancy, and provide a summary of data regarding the association between physical activity and common adverse pregnancy outcomes. Finally, we provide a brief overview of approaches aimed at increasing physical activity levels during pregnancy.

History of physical activity recommendations in pregnancy in the US

The earliest recommendations for prenatal physical activity were primarily reflective of the social and cultural norms of the time rather than scientific evidence. The first scientific studies on physical activity and nutrition and their effects on pregnancy were published in the late 19th century and early 20th century.[25,26] Pregnancy outcomes varied during this period, and higher live birth rates were attributed to maternal rest. During this time, it was believed that maternal exercise disrupted placental blood flow and that exercise would result in fetal deprivation.[25] This has since been disproven, as studies evaluating umbilical artery blood flow, fetal heart rates, and biophysical profiles before and after strenuous activity have shown no adverse effects on the pregnant gravida nor the fetus.[27,28] In the 1920s and 1930s, a prenatal exercise program was introduced in the U.S.[29] However, no standard recommendations for prenatal physical activity were issued until 1949 when the U.S. Children's Bureau suggested that pregnant individuals be permitted to continue household tasks, gardening, and walks, but should refrain from participating in sports while pregnant.[30] The main focus of these recommendations was to improve the ease of labor and delivery.

In 1985, The American College of Obstetricians and Gynecologists (ACOG) created the first guidelines for prenatal physical activity. These guidelines cautioned against high impact activities that would increase maternal heart rate and core body temperature.[31] In 1994, revised ACOG guidelines removed recommendations to limit maternal heart rate elevation and also specified that exercise should occur in "moderation but not to exhaustion" due to newer evidence.[32] In 2002, these guidelines were updated to recommend 30 minutes of moderate-intensity physical activity most days of the week during pregnancy, and stated that moderate physical activity is not associated with an increased risk of early pregnancy loss, low birth weight, or preterm birth.[33] In 2015, ACOG guidelines were further revised to specify that aerobic or strength conditioning physical activity are both acceptable.[34] The most recent ACOG guideline regarding activity and exercise in pregnancy was issued in 2020 and recommends that pregnant individuals engage in 150 minutes of

moderate-intensity aerobic, resistance, and stretching activities distributed throughout the week, similar to recommendations from the U.S. Department of Health and Human Services Physical Activity Guidelines for non-pregnant Americans.[2,35,36] These guidelines include the caveat that individuals with certain medical conditions (e.g., heart and lung disease) or pregnancy complications (e.g., significant risk factors for preterm birth) may not be appropriate candidates for this degree of activity.[35] Further, if an individual is consistently exercising prior to pregnancy, the same habits can be maintained in pregnancy. A summary of the evolution of recommended physical activity guidelines over the last 30 years by major professional organizations is provided in Table 1.

Methods to Evaluate Physical Activity During Pregnancy

Multiple questionnaires have been developed and designed to evaluate an individual's activity level in daily life, although, as with all survey data, a major limitation is recall bias. Many surveys span multiple aspects of life, including home, work, and leisure activities. Some surveys have been validated using objective accelerometry data, but most validation studies included only a very small subset of individuals. Several of these surveys were designed specifically to evaluate activity during pregnancy, shown in Table 2.

In contrast, accelerometry provides a more objective assessment than survey data and is one of the oldest and most traditional methods used to evaluate physical activity. Accelerometers are small movement monitoring devices that capture the intensity of physical activity by converting movement into quantifiable metrics that are proportional to the muscular force producing motion, thereby providing more objective information than self-reported activity data.[37] Use of accelerometry as a tool to assess physical activity has increased in recent years, and accelerometers are now widely available; the majority of modern cellular smartphones contain built-in accelerometers. Accelerometers range from simple pedometers that cost only a few dollars to more advanced devices that capture 3-dimensional (3D) data. These more advanced 3D accelerometers can accurately differentiate displacement and velocity, which enhances data collection accuracy and reduces errors.[38] However, accelerometry does have limitations. For example, most devices do not accurately capture swimming, cycling, and other low vertical impact activity, many of which are common activities undertaken during pregnancy, though technology is evolving.[39]

Bell, et al., and colleagues compared accelerometer data to activity survey data in a cohort of overweight and obese pregnant individuals at a median of 12 weeks' gestation. These researchers found low correlation between accelerometer (ActiGraph GT1M) and survey data.[39] The two activity surveys used by the researchers (the Australian Women's Activity Survey and the Recent Physical Activity Questionnaire) overestimated moderate vigorous physical activity compared to the amount of activity detected by the accelerometer. In addition, both surveys poorly differentiated between moderate vigorous physical activity duration at the individual versus group level. Thus, while low-fidelity and low-cost, physical activity questionnaires may have limited validity compared to objective accelerometry assessments during pregnancy.[39]

In pregnant and non-pregnant individuals, the intensity of physical activity is commonly rated by the activity's metabolic equivalent (MET), which quantifies energy expenditure

associated with activity based on the amount of oxygen consumed. METs are higher with more intense activity.[40] Heart rate training 'zones' are also used to quantify activity, but may be non-specific.[41] Prior research suggests that evaluation of activity intensity by the Borg scale, a continuous measure ranging from 6 (no exertion) to 20 (very, very hard), which is based on perceived exertion, may be more valid in pregnancy than use of METs or heart rate values.[42] This is due to the normal physiologic changes that occur in pregnancy that result in higher resting heart rates.

Use of Activity Monitors During Pregnancy

The ActiGraph accelerometer is considered the "gold standard" of physical activity monitoring.[43] This validated device remains the most reliable and accurate accelerometer device and objectively measures physical activity, sleep, mobility, and sedentary behavior. More than 17,000 published scientific articles worldwide report studies that use the ActiGraph; this includes high profile studies and pooled accelerometry databanks such as the U.S. National Health and Nutrition Examination Survey (NHANES) and the Women's Health Study.[44]

However, the ActiGraph is not without limitations; it is bulky, not aesthetically appealing, may be uncomfortable for some users to wear (particularly those with smaller wrists), and does not provide direct feedback to the user, which may reduce compliance.[45] Thus, other innovative solutions are needed to objectively measure activity during pregnancy. Multiple studies have been conducted to evaluate the effectiveness of other commercially available, smaller devices that may be more comfortable and aesthetically appealing. Some of the most widely studied devices in pregnant populations are Fitbit® (Fitbit, Inc., San Francisco, CA) brand products. In one study that sought to validate the Fitbit Zip (model: FB301) and Fitbit Flex (mode: FB401) compared to the ActiGraph GT3X in pregnant participants in the third trimester, both Fitbit devices overestimated sedentary time compared to the ActiGraph GT3X.[43] In addition, the Fitbit Zip device overestimated moderate and vigorous activity, though moderate and vigorous activity were similar between the FitBit Flex and the ActiGraph. Finally, though steps were also overestimated by the Fitbit Flex compared to the ActiGraph, there were no significant differences between steps tracked by the Fitbit Zip and the ActiGraph. Although there were overestimations of the FitBit devices compared to the ActiGraph, both FitBit devices were preferred by individuals due to aesthetics, comfort, and ease of wear compared to the ActiGraph.[43]

In another study evaluating whether wearable Fitbit devices might be associated with altered behavior during pregnancy, investigators used a Fitbit Ultra (model: FB102). In this study, 30 pregnant individuals between 10–20 weeks of gestation were recruited and randomized to a 'physical activity' arm or a 'usual care' arm.[46] Fifteen participants received a Fitbit Ultra and a daily message encouraging physical activity. Fifteen participants in the control arm were given a Fitbit Ultra but did not receive any physical activity recommendations. There were no statistically significant effects on physical activity between the intervention and control group. However, this study was limited by a small sample size. Notably, participants who received the physical activity intervention reported fewer barriers to physical activity and reported more time and motivation to be physically active compared to the control

group. Additionally, participants who sought to increase their physical activity during pregnancy found mobile technologies promoting physical activity acceptable.[46]

Wearable activity trackers from other companies are currently commercially available, including Garmin (Garmin Ltd, Olathe, KS) and Apple Watch (Apple, Inc., Cupertino, CA), among others. Limited reports of participants using these devices have been published in the pregnant population. However, studies in non-pregnant individuals assessing the validity and reliability of the wearables do not suggest that any single device or brand is superior (or inferior) when directly compared.[47–49] Notably, all brands of wrist-worn activity devices appear to be most valid in evaluation of the number of steps but have lower validity and greater inter-device reliability for energy expenditure, detection of activity intensity, and sleep.[49,50]

Physical activity and pregnancy outcomes

Preterm birth—Though physical activity itself and dehydration that may occur secondary to exertion may increase contractions during pregnancy, there is no association between exercise and prematurity.[51] Multiple studies have found that individuals who are physically active during pregnancy have a lower risk of preterm birth, regardless of their *a priori* risk of prematurity.[52] In a meta-analysis of physical activity and preterm birth that included 21 cohort studies and 20 randomized trials (n=171,595 pregnant individuals), those who reported higher leisure time physical activity had a statistically significant 14% decrease in the relative risk of preterm birth.[52] Additionally, a modest (3 hour) increase in leisure time physical activity per week was associated with a 10% reduction in the risk of preterm birth. However, the association between physical activity and preterm birth was non-linear; the lowest risk of preterm birth was observed for those who engaged in 2–4 hours of physical activity per week. This nonlinear association was significant in the cohort studies analyzed but non-significant in the randomized controlled trials.[52] In a North Carolina cohort of 1,699 pregnant individuals, vigorous leisure-related physical activity during the first and second trimesters was relatively uncommon (14% and 8%, respectively) but was associated with a lower risk of preterm birth.[53] Notably, no specific activity patterns (e.g., intensity, amount) were associated with a *higher* risk of preterm birth. These data suggest an association between increased physical activity and a reduced risk of preterm birth with no concern for harm with increased activity.

Physical activity *interventions* during pregnancy for individuals with a low *a priori* risk of preterm birth may similarly be associated with a reduction in prematurity. A meta-analysis of 2,059 normal-weight participants (from 9 randomized clinical trials) carrying singleton pregnancies and at low-risk for adverse pregnancy outcomes evaluated the association between exercise interventions in pregnancy and preterm birth.[54] Of these, 1,022 were randomized to exercise (cases) and 1,037 had no exercise instructions provided (controls). In all included trials, the exercise group performed aerobic exercise for 35–90 minutes 3–4 times a week. Randomization to exercise was not associated with preterm birth less than 37 weeks' gestation (RR 1.01, 95% CI 0.68 to 1.50) or a change in the mean gestational age of delivery (mean difference 0.05 weeks, 95% CI −0.07 to 0.17) compared to controls. However, individuals randomized to exercise were more likely to deliver vaginally

(73.6% vs. 67.5%; RR, 1.09, 95% CI 1.04–1.15).[54] The findings from this meta-analysis confirmed ACOG's recommendations regarding exercise – including aerobic exercise – during pregnancy.[35]

Pregnant patients at high risk for preterm birth are often prescribed a variety of activity restriction(s). Though there is limited high-quality (prospective, randomized controlled trial) evidence, in one secondary analysis of data from the NICHD Maternal Fetal Medicine Unit's (MFMU) Network Short Cervix and Nulliparity trial, 252 pregnant nulliparous patients with a transvaginal cervical length <30mm were prescribed activity restriction at a median 23.9 weeks' gestational age. Those with restricted activity were significantly more likely to deliver preterm (37%) compared to those without activity restriction [37% vs. 17%, OR 2.91 (95% CI 2.0, 4.21)].[55] Additionally, individuals placed on activity restriction were significantly more likely to deliver before 34 weeks of gestation [aOR 2.37 (95% CI 1.60, 3.53)]. This study was limited by the retrospective design and the inability to account for the reasons why some individuals restricted their activity. Nonetheless, it is biologically plausible that activity restriction could result in an increased risk of preterm birth through increased stress, anxiety, and other issues associated with sedentary behavior.[55]

Additionally, in a pilot prospective cohort study including 49 patients with a short transvaginal cervical length (<20mm) in the mid-trimester, 24% delivered preterm; those who delivered preterm had fewer median steps per day compared to those who delivered at term [median 3576 (IQR 2478, 4775) vs. 4554 (IQR 3632, 6337) steps per day, p=0.02].[56] The number of steps per day remained inversely associated with preterm birth in adjusted models, suggesting that reductions in activity may be associated with preterm birth.[56]

Gestational Diabetes—Gestational diabetes mellitus (GDM) is one of the most common pregnancy complications.[57] A meta-analysis consisting of 5 prospective cohort, 2 retrospective case-control, and 2 cross-sectional studies sought to synthesize current evidence between physical activity and the development of GDM, and included 34,929 individuals within one year of conception or in the first trimester.[58] Physical activities that were evaluated included walking, stair climbing, and vigorous physical activity. Overall, those with higher pre-pregnancy physical activity had a 55% lower risk of GDM compared to those with the lowest levels of physical activity, pooled OR 0.45 (95% CI 0.28, 0.75); pre-pregnancy vigorous activity was also associated with a significant reduction in GDM [pooled OR 0.47 (95% CI 0.19, 0.75)].[58] In early pregnancy, those in the highest activity group had a 24% lower risk of GDM compared to the lowest activity, pooled OR 0.76, (95% CI 0.70, 0.83), but vigorous activity in the first trimester was not associated with GDM [pooled OR 0.55 (95% CI 0.21 to 1.43)].[58] In this study, there was no association between 'overall' walking and subsequent GDM diagnosis, walking *briskly* for longer durations was associated with a lower risk of GDM compared to walking at a usual pace for a shorter duration [pooled OR 0.59 (95% CI 0.30, 0.87)].[58] There was also a significant inverse relationship between stair climbing and GDM risk [pooled OR 0.49 (95% CI 0.26, 0.72)].[58] However, in the one prospective cohort study that evaluated physical inactivity, there was no association between sedentary activity (less than 2 hours of physical activity per week) pre-pregnancy or early pregnancy and GDM [OR 1.4 (95% CI 0.7, 3.0) and OR 1.4 (95% CI 0.8, 2.6)], respectively.[58]

To examine the relationship between physical activity and GDM more closely, a case-control study compared the type, intensity, and duration of exercise during the first 20 weeks of pregnancy in 100 patients who subsequently developed GDM and 100 patients who did not, grouping patients into dichotomized ‘low’ or ‘high’ physical activity groups using median scores for their cohort on the Pregnancy Physical Activity Questionnaire.[59] Patients with low total physical activity levels were more than four times as likely to develop GDM compared to those with high total physical activity levels (OR 4.12, 95% CI 2.28 to 7.43). Activities were further categorized into various domains of life and classified as sedentary, light, moderate, or vigorous. Those with lower activity in the domains of household and caregiving (OR 3.91, 95% CI 2.10 to 7.28) and transportation (OR 6.79, 95% CI 3.63 to 12.69) also had a higher risk of GDM compared to patients who were more active in these domains. Finally, participants with low-intensity sedentary (OR 2.32, 95% CI 1.21 to 4.43), light (OR 6.26, 95% CI 2.95 to 13.30), and moderate (OR 6.73, 95% CI 3.15 to 14.38) physical activity were more likely to develop GDM compared to those with high-intensity sedentary, light, and moderate physical activity.[59]

Social determinants of health are important to consider when attempting to understand the relationship between physical activity and pregnancy outcomes such as GDM. Factors such as income, occupation, and food stability can have a large impact on risk. In a prospective cross-sectional study from Brazil, 544 low-income pregnant participants were recruited <20 weeks’ gestation, and physical activity levels were classified using the Pregnancy Physical Activity Questionnaire. Of these individuals, 95 (17.4%) were diagnosed with GDM; 58 were ‘physically inactive’ and 37 ‘physically active.’ Patients who were physically inactive had a 80% higher risk of developing GDM compared to those who were physically active (OR 1.8, 95% CI 1.1 to 2.9). As expected, low-income overweight or obese pregnant individuals had higher incidences of GDM compared to low-income normal or underweight individuals [62.1% vs 37.9%, p=0.001, OR 3.1 (95% CI 1.81 to 5.20)].[60] Although the rate of GDM in this cohort was similar to other studies, it is worth noting that low-income patients are more likely to be affected by obesity, and thus, the intersection of social determinants of health such as low-income status with physical inactivity and body mass index is important to consider when evaluating GDM risk.

Hypertensive disorders of pregnancy—Hypertensive disorders of pregnancy are the leading causes of maternal morbidity and mortality worldwide.[61] It has been hypothesized that physical activity may reduce the risk of preeclampsia, but study results are mixed.[62] In 2014, a combined systematic review and meta-analysis (11 cohort studies, 4 case-control studies; 168,602 individuals) evaluating physical activity pre-pregnancy or during pregnancy time reported an inverse relationship between activity levels and preeclampsia risk. This was a nonlinear association; the optimal reduction (40%) in preeclampsia risk was observed among individuals who exercised 5–6 hours per week. In contrast, data from early pregnancy found a linear relationship between physical activity and the risk of preeclampsia. There was also evidence that walking during pregnancy was associated with a lower risk of preeclampsia (RR 0.68, 95% CI 0.51 to 0.89).[63] A more recent meta-analysis (2017) included only randomized studies of low-risk pregnant individuals and included 17 randomized controlled trials and 5,075 patients carrying singleton pregnancies.

Those assigned to exercise regimens during pregnancy were compared to those who were not provided guidance regarding deliberate exercise. The exercise regimens consisted of 30–60 minutes of aerobic (walking or aquatic) physical activity 2–7 times per week starting before 23 weeks' gestation until at least 35 weeks' gestation. The incidence of hypertensive disorders of pregnancy was significantly lower among those randomized to exercise [5.9% vs 8.5%, RR 0.70 (95% 0.53 to 0.83)].[64] Furthermore, the incidence of cesarean delivery was 16% lower in those in the exercise group.[64]

The specific effects of walking as an intervention to reduce the risk of hypertensive disorders of pregnancy has been evaluated in additional studies. In one randomized controlled trial, 72 pregnant individuals were recruited between 12–34 weeks' gestation; 36 were assigned to participate in a walking program that included 20–30 minutes of walking 4 times per week. The 'usual care' group did not receive any activity recommendations.[65] Among those randomized to walking, 3 (8%) patients were diagnosed with any hypertensive disorder of pregnancy, compared to 13 (36%) in the usual care group. The incidence of gestational hypertension and preeclampsia (evaluated separately) were lower in the walking group, $p<0.05$. Additionally, the mean systolic and diastolic blood pressures were lower in the walking group compared to the usual care group, $p<0.05$.[65]

Maternal mental health—In non-pregnant individuals, physical activity is associated with mental health benefits including improved sleep and reduced rates of depression and anxiety.[3–5] Limited studies regarding the effects of pregnancy on maternal mental health have yielded similar findings. In one randomized controlled trial of 639 individuals, 213 pregnant participants were randomized to a 16-week supervised exercise program of aerobic and resistance training (60 minutes, 3 times per week) and 426 pregnant participants were randomized to the usual care control group. Though no differences were noted in postpartum depression score by group, compliance to the protocol (engagement in at least 70% of exercise sessions) was low (40%).[66] In contrast, in a multicenter randomized controlled trial of 294 low-risk pregnant individuals, subjects were randomized 1:1 to moderate aquatic aerobic exercise or usual care. This program was designed for participants to maintain an estimated heart rate of 55–65% of the maximum (based on American College of Sports Medicine recommendations). Those who were in the activity intervention group had lower self-reported rates of anxiety and depression and a lower mean Edinburgh Perinatal Depression Scale score at 6 weeks postpartum, though sleep problems and quality of life at one month postpartum were similar between groups. Interestingly, compliance with the proscribed regimen was not reported, though the authors commented that "supervised" activity classes compared to simply a recommended regimen may improve compliance among individuals randomized to activity in studies such as this one.[67] An observational study of 155 pregnant individuals had participants self-report their physical activity via the International Fitness Scale. At 16 weeks of gestation, individuals who reported greater overall physical fitness displayed fewer depressive symptoms (ß=0.20, p=0.035) and those who reported greater muscular strength had significantly lower levels of anxiety (ß=−0.22, p=0.014). At 34 weeks of gestation, those that reported greater physical fitness, cardiovascular fitness, muscular strength, and speed-agility were associated with lower anxiety levels (ß=−0.20, p=0.041; ß=−0.21, p=0.030; ß=−0.22, p=0.014; ß=−0.25,

p=0.009, respectively), although there was no significant difference in overall reported physical fitness and depression symptoms at 34 weeks' gestation.'[68]

Strategies and interventions to increase physical activity during pregnancy— A comprehensive discussion regarding the effectiveness of interventions to increase physical activity during pregnancy is beyond the scope of this review. However, here we highlight a few of the most common approaches. As described above, multiple study protocols that include pregnant individuals with a particular medical problem (e.g., obesity) or those who are at high risk for a specific adverse pregnancy outcome (e.g., gestational diabetes) incorporate patient education, technology, and other techniques aimed at increasing physical activity; the goal of most studies is to reduce gestational weight gain, adverse pregnancy outcome(s) rather than quantifying the actual level of physical activity. Most studies that are not disease- or outcome-specific evaluate the association between specific behavioral and educational interventions or prenatal counseling and activity levels during pregnancy. Unfortunately, results are mixed, without a clear 'best' approach to increase physical activity.

When considering counseling and education, in one RCT in Ireland, 109 low-risk, nulliparous patients were randomized to receive face-to-face individual physical activity consultations or usual care; there was no difference in physical activity during any trimester.[69] Similar results are reported[70] in other studies evaluating the effect of prenatal counseling on physical activity level, including one study that found a counseling intervention reduced perceived intrapersonal barriers to activity in pregnancy but that changes did not persist postpartum.[71] One secondary analysis of a cluster-randomized multicenter trial aimed at reducing excessive gestational weight gain found that patients randomized to receive four (3 antepartum, 1 postpartum) counseling sessions on diet and physical activity were more likely to meet international physical activity recommendations in late pregnancy (64% vs. 49%, $p<0.001$).[72]

Another common approach that is used with the goal of increasing physical activity during pregnancy includes supervised, in-person individual or group exercise programs incorporating aerobic, strength training, and flexibility and stretching components either singly or in combination. In one study of 257 patients who were randomized to participate in either a supervised group exercise sessions or a home-based exercise program, those in the group exercise sessions reported lower intensities of back and pelvic pain.[73] Another similar study of 855 patients who were randomized to supervised group exercise or a home-based exercise program found no differences in back pain intensity, but fewer participants randomized to group exercise missed work due to lumbopelvic pain.[74] Multiple other studies of supervised group exercise sessions have mixed results.[75–77] In studies that include group exercise, it is important to note that it may also be difficult to disentangle the (typically positive) psychosocial effects of belonging to and receiving support from a group vs. the exercise activities themselves.

Conclusions

Physical activity – ideally at moderate intensity, incorporating both aerobic and strength training and performed regularly prior to and during pregnancy is associated with a lower

risk of preterm birth, GDM, and hypertensive disorders of pregnancy, and may improve maternal mental well-being.[58,59,63] Benefits appear greatest in decreasing the risk of GDM and hypertensive disorders of pregnancy. Exercise during pregnancy is also associated with a significantly higher incidence of vaginal delivery.[54] Importantly, long-term research over the past century has concluded that physical activity is safe during pregnancy, and there is no evidence to suggest physical activity is harmful. Multiple professional societies and other health care organizations, including the American College of Obstetricians and Gynecologists, recommend a minimum 150 minutes of aerobic physical activity per week, and engagement in some physical activity most days of the week.[35,78,79] Despite this evidence and these recommendations, it is estimated that only a small proportion of pregnant individuals meet recommended activity targets.[80] The reasons for this inactivity are unclear, and efforts to increase physical activity through education, counseling, and supervised education programs have produced mixed results. Obstetric providers should review the benefits of physical activity and address misconceptions regarding safety of physical activity as a key portion of counseling throughout pregnancy.[81] Future research to determine effective interventions to motivate pregnant individuals to obtain adequate physical activity may reduce adverse obstetric outcomes.

Funding:

Funded, in part, by K24-ES031131 and R01-MD011609

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AJOG at a Glance:

Why was this study conducted?

- To critically review the current literature regarding methods to evaluate physical activity during pregnancy and the association between physical activity during pregnancy and pregnancy outcomes.
- To summarize the evolution of and current recommendations of professional societies regarding physical activity during pregnancy

What are the key findings?

- Multiple wearable technology options for tracking activity during pregnancy are currently commercially available; activity is difficult to quantify objectively.
- Only 10–15% of individuals achieve current physical activity recommendations during pregnancy.
- Physical activity is associated with a reduced risk of several adverse obstetric outcomes, including preterm birth, gestational diabetes, and preeclampsia; benefit may be achieved even with activity levels less than the recommended 150 minutes per week

What does this study add to what is already known?

- The optimal frequency, type, and duration of physical activity prior to and during pregnancy to optimize pregnancy outcomes remains unknown.
- Professional society physical activity recommendations in pregnancy, though recently updated, have remained largely unchanged for over 15 years.
- Published studies do not report evidence to suggest activity is harmful; providers should counsel patients regarding the benefits of physical activity

Am J Obstet Gynecol MFM. Author manuscript; available in PMC 2023 January 01.

Table 1.

Summary of recommendations over time in the United States regarding physical activity in pregnancy. Data are presented chronologically.

Guidelines	Exercise ok during pregnancy?	Frequency and duration	Intensity	Recommended type(s) of exercise	Heart rate / temperature limitations
ACOG, 1985 [82]	Yes, only for individuals with active pre-pregnancy lifestyle; exercise discouraged for those with sedentary pre-pregnancy lifestyle	Regular exercise ≥ 3 times/ week	Regular exercise to strenuous/vigorous activity Vigorous activity for 15 minutes maximum	Any vigorous activity should have a 5-minute period of muscle warmup and cool down (slow walking, stationary cycling low resistance)	<140 beats/min Core body temperature <100.4° F (38° C)
ACOG Technical Bulletin, 1994 [83]	Yes	Regular exercise ≥ 3 times/ week	Moderate; avoid exercising to exhaustion	Weight-bearing activities, if continued at pre-pregnancy intensity, cycling, swimming	Not specified
ACOG Committee for Obstetric Practice, 2002 [84]	Yes	≥ 30 minutes/day most days of the week	Moderate	'Physical activity'; avoid scuba diving and activities with high-risk of abdominal trauma	Not specified
ACOG Committee Opinion, 2015 [35]	Yes	20–30 minutes per day on most or all days of the week	Moderate	Aerobic or Strength-conditioning exercises	Not specified
ACOG Committee Opinion, 2020 [85]	Yes, for majority of patients, provided no medical or pregnancy contraindication	30–60 minutes per session, 150 minutes per week, spread throughout the week, aerobic and strength training, though figure provides guidelines regarding limiting lifting by trimester	Moderate perceived exertion, defined as 12–14 on the Borg scale	Walking, stationary cycling, aerobic exercises, dancing, resistance exercises, stretching exercises, hydrotherapy	Not specified, though table with a 'recommended exercise regimen' suggests an intensity level resulting in 'less than 60–80% of age-predicted maximum maternal heart rate, usually <140 beats per minute' and 'thermoneutral or controlled conditions (air conditioning), avoiding prolonged exposure to heat'
World Health Organization guidelines on physical activity and sedentary behavior 2020 [86]	Yes	At least 150 minutes per week	Moderate-intensity aerobic physical activity. Limit the amount of time being sedentary. Physical activity of 'any intensity' provides health benefits.	Incorporate a variety of aerobic and muscle-strengthening; adding gentle stretching 'may also be beneficial'	Not specified

Abbreviations: ACOG = American College of Obstetricians and Gynecologists

Table 2.

Examples of surveys previously used to assess physical activity during pregnancy that have been validated using accelerometry data.

Survey Name	Method of administration	Recall period	Physical activity assessment				Validation vs. accelerometry data	
			Type of activities	Frequency?	Duration?	Intensity?	Correlation coefficient	Sample size
Pregnancy physical activity questionnaire (PPAQ)[87,88]	Self-administered	Current trimester	Household, sport, transportation, work, inactivity	Yes	Yes	No	Spearman = 0.27	N=54
Australian Women's Activity Survey (AWAS) [89]	Interviewer administered	1 week in the past month	Planned activities, employment, childcare, domestic responsibilities, transport	Yes	Yes	Yes	Spearman = 0.32	N=75
Modified Kaiser Physical Activity Survey[87,90]	Interviewer administered	Current trimester	Active living, household, sport, work	Yes	Yes	No	Spearman = 0.52	N=54
Pregnancy, Infection, and Nutrition Study – 3 Physical Activity Questionnaire[53,87]	Interviewer administered	Past week	Any activity at least 'fairly light' in intensity	Yes	Yes	Yes	Spearman = 0.28–0.34	N=177
Exercise Diary (based on the University of Minnesota modified self-reported food and activity diary)[87,91]	Self-administered, paper	Daily for 3 consecutive days	Exercise, sleeping, resting	Yes	Yes	Yes	Pearson = 0.49	N=94