Matern Child Health J
DOI 10.1007/s10995-014-1534-8

Exercise During Pregnancy and its Association with Gestational Weight Gain

Shericka T. Harris · Jihong Liu · Sara Wilcox · Robert Moran · Alexa Gallagher

Abstract We examined the association between exercise during pregnancy and meeting gestational weight gain recommendations. Data came from the 2009 South Carolina Pregnancy Risk Assessment Monitoring System (n = 856). Women reported their participation in exercise/sports activities before and during pregnancy, including the number of months and types of exercise. We developed an exercise index (EI), the product of the number of months spent in exercise and average metabolic equivalents for specific exercise. The 2009 Institute of Medicine's guideline was used to categorize gestational weight gain into three classes: inadequate, adequate, and excessive. Multinomial logistic regression models were used to adjust for confounders. Over 46 % of women exceeded the recommended weight gain during pregnancy. Nearly one third (31.9 %) of women reported exercising ≥3 times a week at any time during pregnancy. Compared to women who did not report this level of exercise during pregnancy, exercising women were more likely to meet gestational weight gain recommendations (32.7 vs. 18.7 %) and had a lower odds of excessive gestational weight gain [adjusted odds ratio (AOR) 0.43, 95 % confidence interval 0.24–0.78]. Women with an EI above the median value of those women who exercised or women who exercised ≥3 times a week for 6–9 months during pregnancy had lower odds of excessive gestational weight gain (AOR for EI 0.20, 0.08–0.49; AOR for months 0.26, 0.12–0.56, respectively). Our findings support the need to promote or increase exercise during pregnancy to reduce the high proportion of women who are gaining excessive weight.

Keywords Physical activity · Obesity · Maternal weight gain · Surveillance

Introduction

Adequate weight gain and proper nutrition during pregnancy are essential for growth and development of maternal and fetal tissues. Yet excessive weight gain during pregnancy is known to have a myriad of adverse health consequences for the mother and her offspring. Women who gain excessive weight during pregnancy are more likely to have a cesarean delivery [1, 2], develop preeclampsia [3], and retain excessive weight after delivery [4], increasing their risk for overweight or obesity later in life [5]. An infant born to a mother with excessive gestational weight gain is more likely to be preterm [6, 7], macrosomic [8], and overweight or obese over the course of his/her life [9, 10]. Consequently, the Institute of Medicine (IOM) released guidelines for weight gain during pregnancy in 1990, and further updated them in 2009 [3, 11]. Given that an estimated 46 % of women gain excessive weight during pregnancy [12], identifying modifiable risk factors is important. In fact, one of the *Healthy People 2020* objectives is to increase the proportion of women who achieve a recommended weight gain during pregnancy and the proportion of women with a healthy weight prior to pregnancy [13].

S. T. Harris · J. Liu (✉) · R. Moran · A. Gallagher
Department of Epidemiology and Biostatistics, Arnold School of Public Health, University of South Carolina, 800 Sumter Street, Columbia, SC 29208, USA
e-mail: jliu@gwm.sc.edu; jliu@mailbox.sc.edu

S. Wilcox
Department of Exercise Science and Prevention Research Center, Arnold School of Public Health, University of South Carolina, 921 Assembly Street, Columbia, SC 29208, USA

Published online: 10 June 2014

The American College of Obstetricians and Gynecologists (ACOG) recommends that all pregnant women engage in moderate exercise for 30 min or more per day on most, if not all, days of week in the absence of medical or obstetric complications [14]. Previous studies have shown that mothers who engage in exercise during pregnancy can reduce their risks of having complications during pregnancy [15–17]. Exercise is a known behavioral factor used to control weight among the non-pregnant population [18–20]. Yet, empirical evidence about the effectiveness of exercise during pregnancy on weight gain management during pregnancy is limited and conflicting. Several observational studies found physical activity during pregnancy to have a significant protective effect on excessive gestation weight gain [21–24]. The effect of exercise on excessive gestational weight gain was limited to late pregnancy [23], vigorous exercise for 30 min per day [22], those who met physical activity guidelines (at least 150 min of physical activity per week) [21], and those who reported being less physically active in pregnancy compared to prepregnancy [24]. However, two observational studies that used validated physical activity questionnaires and included various domains of physical activity did not observe significant associations between type or intensity of physical activity during pre, early, mid, and late pregnancy with measures of gestational weight gain among Hispanic women living in western Massachusetts [25, 26]. The majority of these observational studies were conducted in predominantly non-Hispanic white [21–24] or Hispanic women [25, 26]. None of these studies has included a large proportion of African American women, despite the fact that more African American women enter pregnancy overweight or obese [27, 28], and a higher proportion of African American women appear to gain excessive weight during pregnancy than non-Hispanic white women [29]. Additionally previous studies were restricted to full term births to avoid concern about bias between total gestational weight gain and duration of pregnancy. This restriction can still result in misclassification because women continue to gain weight in the last several weeks of pregnancy when they are considered full term. Furthermore, the findings from studies restricted to full term births are not generalizable to women with preterm deliveries. Given that the risk of preterm delivery is higher among obese women [30], these studies may have unintentionally included fewer overweight or obese women. Finally, all of these studies recruited women from prenatal care clinics in a specific geographic area [21–26] rather than using a population-based sample, thus limiting generalizability.

We examined the association between exercise during pregnancy and gaining weight within the IOM recommendation among women who recently gave birth in the state of South Carolina. This manuscript contributes to the literature and addresses limitations of previous studies by using a multi-ethnic, population-based sample and by using a measure of gestational weight gain appropriate for participants with differing gestational ages at delivery.

Methods and Procedures

Data Source

Data came from the 2009 South Carolina Pregnancy Risk Assessment Monitoring System (PRAMS), an ongoing population-based surveillance of the Centers for Disease Control and Prevention (CDC) and the South Carolina Department of Health and Environmental Control (DHEC). PRAMS was created to collect, monitor, analyze, and disseminate information on a wide variety of maternal behaviors and health experiences before, during, and shortly after pregnancy that may be associated with pregnancy outcomes. Every month, a stratified, systematic random sample of 150–250 mothers who delivered live infants within the past 2–6 months is randomly selected from the birth registry. Mothers of low birth weight infants and those from racial/ethnic minority groups are oversampled to ensure adequate data is available in the subgroups with higher risk for adverse birth outcomes. The mail survey is sent to sampled mothers up to three times, with non-respondents followed up by telephone. Data from the birth certificates were linked to the PRAMS data to provide additional information about maternal and infant characteristics and outcomes. Additional information regarding the PRAMS methodology has been published elsewhere [31]. The PRAMS protocol and informed consent process have been approved by the Institutional Review Boards at CDC and DHEC.

Gestational Weight Gain (GWG) Measures

South Carolina birth certificates collect information on maternal pre-pregnancy weight, height, maternal weight at delivery, and gestational age at delivery, which was abstracted from medical records or prenatal records by trained staff at birthing hospitals [32]. Using this information, we calculated prepregnancy body mass index (BMI) and total GWG. We examined the adequacy of GWG according to the 2009 IOM's guideline for GWG [11]. Considering that total GWG varies by gestational weeks at delivery, we used a measure of adequacy of GWG which takes into account gestational age at delivery. Specifically, we calculated the ratio of actual weight gain to expected weight gain for each gestational week. The expected GWG is based on the recommended mean and range of the rate of weight gain for the last two trimesters. It assumes that, on average, women with BMI < 25 gain

2 kg during the first 12 weeks of pregnancy compared to 1 kg if they are overweight (BMI 25.0–29.9) and 0.5 kg if they are obese (BMI $\geq$ 30). If the ratio of actual to the expected weight gain fell within the recommended range (0.79–1.14 underweight, 0.86–1.2 normal weight, 0.81–1.34 for overweight, 0.78–1.41 for obese women), then women were defined as gaining adequate weight during pregnancy. If the ratio fell above or below these ranges, the total weight gain was coded as above (excessive) or below (inadequate) the recommendation, respectively. A similar method has been used in previous studies [33, 34]. A sensitivity analysis was conducted to see if our findings were consistent when the sample included only full term births ($\geq$37 weeks) (unweighted sample size = 376).

Exercise Participation Measures

The 2009 South Carolina PRAMS included, for the first time, four new questions on exercise participation before and during pregnancy. These questions were adapted from the 1988 National Maternal and Infant Health Survey and have been used in previous studies [35, 36]. Specifically, each respondent was asked, "thinking back to 3 months before you found out you were pregnant, did you exercise or play sports at least 3 times a week? (Include walking briskly for ½ hour or more, jogging, aerobics, swimming, etc. (yes, or no)." The next question, with analogous wording, was used to collect information about exercise after the respondent found out she was pregnant. Based on this information, patterns of participation in exercise before and during pregnancy were created to determine changes in the women's exercising behavior: both before and during, before but not during, during but not before, and none in either period.

For those women who reported "yes" on the question, the number of months she engaged in exercises/sports at least three times a week and the specific type of exercise that she did during pregnancy was asked. Using this information, we examined participation in exercise during pregnancy in two ways: number of months of exercise (0, 1–5, 6–9) and an exercise index (EI). The EI was used to measure the dose of exercise participation, which was calculated as the product of the number of months of exercise and the average metabolic equivalent (MET) scores for the specified exercise using published values [36, 37]. The EI was grouped into the following categories based on the sample distribution: 0, $\leq$19, >19, where the number 19 represented the median of EI for women who reported exercising during pregnancy in our unweighted data. An EI of 19 represents a woman who walks briskly (3.8 METS) for at least five months during pregnancy.

Statistical Analyses

A Chi square test of independence was used to examine the bivariate associations between exercise participation, GWG, and maternal characteristics. Because the outcome has three categories (inadequate, adequate, and excessive GWG), multinomial logistic regression was used to evaluate the association between exercise participation and GWG while controlling for confounders. The adequate GWG category was chosen as the reference. In our models, we considered the following factors as potential confounders: maternal age (<20, 20–29, 30–34, $\geq$35 years), race (non-Hispanic white, non-Hispanic black, other), education (<12, 12, 13–15, $\geq$16 years), marital status (married, not married), smoking status during last trimester of pregnancy, parity (0, 1, $\geq$2), gestational age (<37, $\geq$37 weeks), and complications during pregnancy (gestational diabetes and hypertension). All control variables came from birth certificates except smoking status which was taken from PRAMS. Both the crude and adjusted odds ratios and 95 % confidence intervals (CI) were presented. In our sensitivity analysis, we restricted our sample to women who had full-term births ($\geq$37 weeks). For all analyses, an alpha level of 0.05 was used to make inferences.

A total of 1,054 women participated in the 2009 South Carolina PRAMS survey (weighted response rate 58.7 %). Plural births (n = 108) were removed from the analysis. Additional exclusions were made for mothers with missing information on race (n = 3), education (n = 5), marital status (n = 3), smoking status (n = 30), hypertension (n = 6), prepregnancy BMI (n = 39), and exercise during pregnancy (n = 4). A final sample of 856 women was available for analysis. The characteristics of these 856 women were not significantly different from all 1,054 respondents.

Database management was done using SAS software version 9.2 (SAS Institute, Cary, NC). The analyses were all conducted using SAS-callable SUDAAN version 10.0 (Research Triangle Institute, Research Triangle Park, NC) to take into account the complex survey design and weighted South Carolina PRAMS data. Responses were weighted for oversampling, nonresponse, and noncoverage, making our results representative of all live births in 2009 in South Carolina.

Results

The majority of women included in our analyses were between 20 and 29 years of age, non-Hispanic white, married, first time mothers with a high school education or higher. Most women (85.8 %) reported no history of

Table 1 Characteristics of women by exercise during pregnancy, South Carolina PRAMS, 2009

Characteristics	All women (%[b])	Did not exercise 3 times or more per week (%[a])	Exercised 3 times or more per week (%[a])	*p* value[b]
Total [% (n)[a]]	100.0 (856)	68.1 (611)	31.9 (245)	
Age (years)				0.1208
<20	14.4	16.7	9.5	
20–29	54.0	55.3	51.3	
30–34	16.8	14.6	21.4	
≥35	14.8	13.5	17.8	
Race				0.0698
Non-Hispanic white	60.7	58.4	65.8	
Non-Hispanic black	31.4	35.2	23.4	
Other	7.9	6.5	10.8	
Education (years)				0.0483
<12	21.4	22.1	20.1	
=12	26.5	29.5	20.0	
13–15	27.3	27.9	26.1	
≥16	24.8	20.5	33.8	
Marital status				0.0048
Yes	52.6	47.3	63.8	
No	47.4	52.7	36.2	
Parity				0.3658
None	45.9	45.6	46.6	
One	31.9	34.1	27.3	
≥Two	22.2	20.4	26.2	
Gestational age				0.5767
<37 weeks	10.3	10.8	9.2	
≥37 weeks	89.7	89.2	90.8	
Smoked in the last 3 months of pregnancy				0.6087
Yes	14.2	14.9	12.7	
No	85.8	85.1	87.3	
Gestational hypertension				0.2062
Yes	11.7	13.1	8.7	
No	88.3	86.9	91.3	
Gestational diabetes				0.4804
Yes	9.6	10.3	8.0	
No	90.4	89.7	92.0	
Pre-pregnancy BMI (kg/m^2)				0.0066
Underweight (<18.5)	3.6	3.3	4.3	
Normal weight (18.5–24.9)	42.4	37.2	53.4	
Overweight (25.0–29.9)	28.3	28.9	27.1	
Obese (≥30)	25.7	30.6	15.2	
Adequacy of gestational weight gain				0.0092
Inadequate	30.3	29.8	31.5	
Adequate	23.2	18.7	32.7	
Excessive	46.5	51.5	35.8	
Months of exercise during pregnancy				<0.0001
0	69.2	NA	0.0	
1–5	12.2		39.7	
6–9	18.6		60.3	

Table 1 continued

Characteristics	All women (%[b])	Did not exercise 3 times or more per week (%[a])	Exercised 3 times or more per week (%[a])	*p* value[b]
Patterns of exercise				<0.0001
None in either period	51.2	75.3	0	
Before but not during	16.8	24.7	0	
During but not before	3.8	0	10.3	
Both before and during	28.7	0	89.7	
Exercise index[c]				<0.0001
0	75.1	100.0	0	
≤19	9.5	0	38.4	
>19	15.3	0	61.6	

PRAMS Pregnancy Risk Assessment Monitoring System. *NA* not applicable

[a] Weighted percentages and unweighted sample sizes were presented

[b] *p* value was derived from the χ^2-test of independence between exercise during pregnancy and maternal characteristics

[c] Exercise index = (months of exercise) × (published MET score for the specified activity)

smoking during the last 3 months of their pregnancy. Almost 90 % of births occurred at a gestational age of 37 weeks or greater (range 16–42 weeks). Based on their prepregnancy BMI, 42.4 % of women were normal weight (BMI 18.5–24.9) prior to pregnancy, 28.3 % were overweight, 25.7 % were obese, and 3.6 % were underweight (BMI < 18.5). Less than a quarter (23.2 %) of women gained weight within the 2009 IOM recommendations, 46.5 % gained excessive weight, and 30.3 % gained inadequate weight during pregnancy (Table 1).

In South Carolina, 31.9 % of the women reported engaging in exercise or sports at least three times a week during pregnancy. Among the women who reported any exercise during pregnancy, a higher percentage of women reported exercising for 6–9 months (18.6 vs. 12.2 % for 1–5 months), nearly 90 % of them exercised both before and during pregnancy, and 61.6 % had EI score >19. The most frequently reported type of exercise was brisk walking (71.4 %), followed by general exercise (6.9 %), and aerobics and/or dancing (5.5 %) (not shown). Women who exercised at least 3 times a week during pregnancy were more educated, more likely to be married, more likely to be normal weight before pregnancy, and less likely to gain excessive weight during pregnancy compared to women who did not exercise 3 times per week during pregnancy (all $p < 0.05$) (Table 1).

As shown in Table 2, meeting the 2009 IOM recommendations on GWG was not significantly related to maternal age, race/ethnicity, education, marital status, parity, smoking status during pregnancy, preterm delivery, or gestational diabetes ($p > 0.05$). However, meeting the recommendations on GWG was marginally associated with gestational hypertension, with a higher proportion of hypertensive women gaining excessive weight during pregnancy ($p = 0.05$). Exercise during pregnancy was significantly associated with meeting IOM guidelines on GWG. Compared to women who did not exercise at least 3 times a week, a higher proportion of women who exercised gained adequate weight (32.7 vs. 18.7 %) and a lower proportion gained excessive weight during pregnancy (35.8 vs. 51.5 %) ($p < 0.05$). A much higher proportion of women who exercised for 6–9 months during pregnancy gained adequate weight during pregnancy than those who did not exercise 3 times a week (41.2 vs. 18.7 %). Finally, a higher proportion of women whose EI score was >19 gained adequate weight (40.6 vs. 18.7 %) and lower proportion gained excessive weight during pregnancy (26.0 vs. 51.5 %) than those whose score was 0 (Table 2).

Table 3 presents the results from multinomial logistic regression models. First, exercise before pregnancy was not significantly associated with meeting the IOM guidelines for GWG. Women who exercised at least 3 times a week during pregnancy had a lower odds of gaining excessive weight during pregnancy [adjusted odds ratios (AOR) 0.43, 95 % CI 0.24–0.78) compared to women who did not. Compared to women who did not exercise at least 3 times a week during pregnancy, women who exercised both before and during pregnancy had lower odds of gaining excessive weight during pregnancy (AOR 0.43, 95 % CI 0.22–0.84). Women whose EI score was >19 had a 80 % lower odds of gaining excessive gestational weight (AOR 0.20, 95 % CI 0.08–0.49) than women who did not exercise during pregnancy. Finally, women who exercised at least 3 times a week for 6–9 months during pregnancy also had a decreased odds of excessive GWG (AOR 0.26, 95 % CI 0.12–0.56).

Table 2 Meeting the 2009 IOM gestational weight gain recommendations, South Carolina PRAMS, 2009

Characteristics	Adequacy of gestational weight gain (%)[a]			*p* value[b]
	Inadequate	Adequate	Excessive	
Total [% (n)[a]]	30.3 (290)	23.2 (404)	46.5 (162)	
Age (years)				0.1809
<20	34.0	20.5	45.5	
20–29	28.3	25.1	46.5	
30–34	24.8	16.1	59.1	
≥35	40.3	26.8	32.9	
Race				0.0909
Non-Hispanic white	24.9	26.2	48.9	
Non-Hispanic black	39.2	16.8	44.0	
Other	37.2	25.3	37.5	
Education (years)				0.0881
<12	34.0	28.1	37.9	
=12	37.7	18.1	44.2	
13–15	29.2	51.9	18.9	
≥16	20.6	29.1	50.2	
Marital status				0.9411
Yes	31.1	23.2	45.6	
No	29.5	23.2	47.4	
Parity				0.5123
None	26.3	22.3	51.4	
1	35	22.7	42.3	
≥2	31.9	25.9	42.2	
Smoked in the last 3 months of pregnancy				0.7874
Yes	27.1	27.3	45.6	
No	30.9	22.5	46.6	
Gestational age (weeks)				0.0916
<37	42.0	13.8	44.2	
≥37	29.0	24.3	46.7	
Hypertension				0.0524
Yes	25.4	12.7	61.9	
No	31.0	24.6	44.4	
Gestational Diabetes				0.4635
Yes	35.6	28.4	36.0	
No	29.8	22.7	47.6	
Pre-pregnancy BMI (kg/m^2)				0.0000
Underweight (<18.5)	28.2	22.5	49.3	
Normal (18.5–24.9)	30.7	34.2	35.2	
Overweight (25.0–29.9)	22.2	19.7	58.1	
Obese (≥30)	39.1	9.1	51.8	
Exercised during pregnancy				0.0092
No	29.8	18.7	51.5	
Yes	31.5	32.7	35.8	
Months of exercise during pregnancy				0.0097
0	29.8	18.7	51.5	
1–5	34.7	22.4	43.0	
6–9	30.0	41.2	28.9	
Patterns of exercise				0.1004
None in either period	31.0	19.0	50.0	
Before but not during	26.3	17.8	55.9	
During but not before	43.8	23.0	33.1	
Both before and during	30.0	33.8	36.1	
Exercise index				0.017
0	29.8	18.7	51.5	
≤19	31.8	19.0	49.2	
>19	33.4	40.6	26.0	

PRAMS Pregnancy Risk Assessment Monitoring System

[a] Weighted percentages and unweighted N were presented

[b] *p* value was derived from the χ^2-test of independence between gestational weight gain and maternal characteristics

When the analysis was restricted to full term births, our findings persisted. Exercise during pregnancy, exercise months, and EI remained significantly associated with GWG (Table 4).

Discussion and Conclusions

Although there is a significant amount of literature available on the prevalence of and risk associated with high gestational weight gain, the empirical evidence concerning the impact of exercise on gestational weight gain is limited. In this assessment of population-based data from a survey of women who had a live birth in South Carolina, we found that women who exercised at least 3 times a week during pregnancy had a lower odds of gaining excessive weight during pregnancy. Similarly, women who exercised both

Table 3 Associations between Exercise before or during Pregnancy and Adequacy of Gestational Weight Gain (GWG), South Carolina PRAMS, 2009

	Inadequate GWG[a]		Excessive GWG[a]	
	Crude OR (95 % CI)	Adjusted OR[b] (95 % CI)	Crude OR (95 % CI)	Adjusted OR[b] (95 % CI)
Exercised before pregnancy				
No	1.00	1.00	1.00	1.00
Yes	0.63 (0.34–1.15)	0.71 (0.37–1.36)	0.62 (0.35–1.07)	0.62 (0.35–1.12)
Exercised during pregnancy				
No	1.00	1.00	1.00	1.00
Yes	0.60 (0.33–1.12)	0.80 (0.42–1.52)	0.40 (0.22–0.71)	0.43 (0.24–0.78)
Patterns of exercise				
None in either period	1.00	1.00	1.00	1.00
Before but not during	0.91 (0.38–2.20)	0.92 (0.37–2.30)	1.20 (0.55–2.63)	1.10 (0.48–2.50)
During but not before	1.17 (0.25–5.46)	1.78 (0.28–11.2)	0.55 (0.12–2.61)	0.58 (0.11–3.10)
Both before and during	0.55 (0.28–1.08)	0.70 (0.34–1.44)	0.41 (0.21–0.77)	0.43 (0.22–0.84)
Exercise index during pregnancy				
0	1.00	1.00	1.00	1.00
≤19	1.05 (0.34–3.28)	1.36 (0.40–4.59)	0.94 (0.33–2.70)	1.00 (0.36–2.84)
>19	0.52 (0.24–1.13)	0.62 (0.26–1.46)	0.23 (0.10–0.53)	0.20 (0.08–0.49)
Months of exercise during pregnancy				
0	1.00	1.00	1.00	1.00
1–5	0.97 (0.38–2.52)	1.32 (0.49–3.59)	0.70 (0.29–1.71)	0.78 (0.33–1.84)
6–9	0.46 (0.22–0.94)	0.60 (0.28–1.31)	0.26 (0.12–0.52)	0.26 (0.12–0.56)

GWG gestational weight gain, *OR* odds ratios, *CI* confidence interval

[a] Multinomial logistic regression model and the reference outcome is adequate weight gain

[b] Adjusted for maternal age, race, marital status, education, parity, smoking during pregnancy, continuous body mass index, hypertension, gestational diabetes, and gestational age

before and during pregnancy, women who exercised at higher intensity, and women who exercised 6–9 months during pregnancy were less likely to gain weight above the recommendation. However, a reduction in the risk for excessive gestational weight gain was not observed among women who only exercised before pregnancy. This result suggests that to prevent excessive gestational weight gain, exercise during pregnancy is more important than exercise before pregnancy and the dose of exercise matters.

These results are consistent with existing studies showing that exercise during pregnancy is beneficial in preventing excessive gestational weight gain [22, 23, 38]. This study is unique in several ways. We used the data from the latest PRAMS survey, which interviewed a population-based sample and is weighted to represent births in South Carolina. By including a racial diverse population (over 30 % are African American women), our study adds to the existing literature which focuses primarily on educated Caucasian women [22, 23]. Second, we were able to assess the joint effect of exercise before pregnancy and during pregnancy in relationship to the risk of inadequate or excessive gestational weight gain during pregnancy. Only one previous study estimated physical activity level before pregnancy and found that it was marginally associated with the rate of weight gain in the third trimester [39]. Lastly, our results examined both the dose and intensity of exercise during pregnancy on gestational weight gain and found the protective effects of physical activity during pregnancy on gestational weight gain to be consistent across measures.

This study has several limitations. First, the South Carolina PRAMS data only included pregnant women who were residents of South Carolina and had a live birth in the state. Previous studies show that compared to residents in other parts of the country, residents from the South are disproportionately more rural and financially-disadvantaged [40]. Southerners also often consume more processed high-fat, high-sodium, or fried foods, more sugary and carbonated beverages, and fewer fruits and non-starchy vegetables [41]. Consequently, they may be more likely to be obese, which limits the generalizability of these results to other areas of the US. A second and related point is that we lacked data on dietary intake, an important risk factor for gestational weight gain. Previous studies considering this factor [22, 24, 26] have found total energy intake [22, 26], consumption of dairy and fried foods [22], and self-perception of eating much more food during pregnancy than before [24] to be significantly associated with increased odds of excessive gestational weight gain. Thus, our findings may be an overestimate of the true association due to uncontrolled confounding. It is possible that women who are more physically active also eat a healthier diet. Another limitation of the PRAMS data is that the questions were answered, on average, 3.7 months (range 2.5–7.9) after delivery, so there may be differential measurement errors in exercise history recall. However, we

Table 4 Associations between exercise before or during pregnancy and IOM gestational weight gain recommendations among South Carolina women who delivered a full term baby, 2009

	Inadequate GWG[a]		Excessive GWG[a]	
	Crude OR (95 % CI)	Adjusted OR[b] (95 % CI)	Crude OR (95 % CI)	Adjusted OR[b] (95 % CI)
Exercised before pregnancy				
No	1.00	1.00	1.00	1.00
Yes	0.55 (0.29–1.06)	0.61 (0.30–1.25)	0.55 (0.30–1.00)	0.57 (0.31–1.08)
Exercised during pregnancy				
No	1.00	1.00	1.00	1.00
Yes	0.55 (0.28–1.07)	0.69 (0.33–1.42)	0.36 (0.19–0.66)	0.39 (0.21–0.75)
Patterns of exercise				
None in either period	1.00	1.00	1.00	1.00
Before but not during	0.84 (0.32–2.21)	0.86 (0.31–2.38)	1.10 (0.47–2.58)	1.02 (0.42–2.47)
During but not before	1.20 (0.25–5.67)	1.66 (0.24–11.47)	0.46 (0.09–2.47)	0.45 (0.08–2.70)
Both before and during	0.48 (0.23–0.99)	0.58 (0.26–1.29)	0.36 (0.18–0.71)	0.39 (0.19–0.80)
Exercise index during pregnancy				
0	1.00	1.00	1.00	1.00
≤19	0.94 (0.28–3.14)	1.13 (0.28–4.58)	0.85 (0.28–2.55)	0.95 (0.31–2.88)
>19	0.48 (0.21–1.10)	0.52 (0.20–1.38)	0.21 (0.08–0.50)	0.18 (0.07–0.47)
Months of exercise during pregnancy				
0	1.00	1.00	1.00	1.00
1–5	0.77 (0.27–2.15)	0.96 (0.30–3.09)	0.62 (0.24–1.57)	0.72 (0.29–1.75)
6–9	0.47 (0.22–0.99)	0.58 (0.25–1.35)	0.23 (0.11–0.49)	0.24 (0.10–0.54)

GWG gestational weight gain, *OR* odds ratios, *CI* confidence interval

[a] Multinomial logistic regression model and the reference outcome is adequate weight gain

[b] Adjusted for maternal age, race, marital status, education, parity, smoking during pregnancy, continuous body mass index, hypertension, and gestational diabetes

did not find that exercise participation during pregnancy and gestational weight gain varied by the timing of response to the survey, and adjusting for this variable did not change our results (not shown). Furthermore, the validated 32-item Pregnancy Physical Activity Questionnaire [42] or another objective measurement of physical activity was not available in PRAMS because of cost and interview length concerns in large, population-based studies. Future studies are needed to develop a short questionnaire to assess physical activity during pregnancy with reasonable validity and reliability. Future studies should also consider assessing household/caregiving and occupation related activities in addition to exercises/sports because these activities make up the majority of total activity for pregnant women [43], and are not included in most published studies [21–24]. Although two studies of Hispanic women examined the relationship between these types of physical activity with gestational weight gain, they found no association [25, 26]. In spite of this potential misclassification, the significant findings from our study indicate the robustness of the inverse association between exercise participation and excessive gestational weight gain. Finally, the PRAMS survey asked about the number of months of exercise. We were not able to group the women into trimesters because the question did not ask the women about their exercise patterns in regards to exactly when they started and ended their exercise during pregnancy. This lack of information did not allow us to clearly define exercise patterns by trimester as in previous research studies [25, 44–46].

Exercise among healthy pregnant women should be encouraged because of its known health benefits for both mothers and children and its additional benefit of helping women gain weight within the recommendation. In spite of the exercise recommendation for healthy pregnant women, only 1 out of 3 pregnant women in South Carolina reported that they exercised or played sports at least three times a week during pregnancy, which is lower than the 42 % estimated in a 1988 national survey of US women that used the same instrument as our study [35]. Health care professionals may use known risk factors to identify women who do not exercise during pregnancy. Our study and others have found that women with low education [16, 47–49], who are single [16, 46–50], and overweight or obese before pregnancy [47, 50, 51] were most likely to discontinue exercise during pregnancy.

Health care professionals should counsel pregnant women about the recommended weight gain during pregnancy so as to avoid excessive or inadequate weight gain. If pregnant women are gaining above the recommended weekly rate, health care professionals should further provide them with information about staying active and healthy eating during pregnancy. Because brisk walking is the most commonly reported exercise for pregnant women and is relatively safe, brisk walking should be encouraged among all pregnant women [16, 22, 44]. Although weight

may be a sensitive topic for most individuals, health care providers should be trained on how to sensitively discuss it with pregnant women.

In brief, this study found that exercise during pregnancy is associated with lower odds of gaining excessive weight during pregnancy. Women who exercised both before and during pregnancy were less likely to gain excessive weight than women who did not. These findings provide encouraging news that promoting exercise during pregnancy can help women achieve their recommended gestational weight gain and experience better maternal and fetal outcomes.

Acknowledgments Funding for the South Carolina Pregnancy Risk Assessment Monitoring System Program is provided by the Center for Disease Control and Prevention, Atlanta, GA (grant no. 5UR6 DP000502-02). We thank Michael Smith and other staff members of South Carolina Department of Health and Environmental Control (DHEC) for providing us with the data for this study. The authors received no outside funding for this work.

Conflict of interest None

References

1. Stotland, N. E., Hopkins, L. M., & Caughey, A. B. (2004). Gestational weight gain, macrosomia, and risk of cesarean birth in nondiabetic nulliparas. *Obstetrics and Gynecology, 104*, 671–677. doi:10.1097/01.AOG.0000139515.97799.f6.
2. Weiss, J. L., Malone, F. D., Emig, D., et al. (2004). Obesity, obstetric complications and cesarean delivery rate—a population-based screening study. *American Journal of Obstetrics and Gynecology, 190*, 1091–1097.
3. Rosenberg, T. J., Garbers, S., Lipkind, H., et al. (2005). Maternal obesity and diabetes as risk factors for adverse pregnancy outcomes: Differences among 4 racial/ethnic groups. *American Journal of Public Health, 95*, 1545–1551.
4. Siega-Riz, A. M., Herring, A. H., Carrier, K., et al. (2010). Sociodemographic, perinatal, behavioral, and psychosocial predictors of weight retention at 3 and 12 months Postpartum. *Obesity (Silver Spring), 18*, 1996–2003.
5. Mamun, A. A., Kinarivala, M., O'Callaghan, M. J., et al. (2010). Associations of excess weight gain during pregnancy with long-term maternal overweight and obesity: Evidence from 21 y postpartum follow-up. *American Journal of Clinical Nutrition, 91*, 1336–1341.
6. Bodnar, L. M., Siega-Riz, A. M., Simhan, H. N., et al. (2010). Severe obesity, gestational weight gain, and adverse birth outcomes. *American Journal of Clinical Nutrition, 91*, 1642–1648.
7. Wise, L. A., Palmer, J. R., Heffner, L. J., et al. (2010). Prepregnancy body size, gestational weight gain, and risk of preterm birth in African-American women. *Epidemiology, 21*, 243–252. doi:10.1097/EDE.0b013e3181cb61a9.
8. Sewell, M. F., Huston-Presley, L., Super, D. M., et al. (2006). Increased neonatal fat mass, not lean body mass, is associated with maternal obesity. *American Journal of Obstetrics and Gynecology, 195*, 1100–1103.
9. Oken, E., Rifas-Shiman, S. L., Field, A. E., et al. (2008). Maternal gestational weight gain and offspring weight in adolescence. *Obstetrics and Gynecology, 112*, 999–1006.
10. Oken, E., Taveras, E. M., Kleinman, K. P., et al. (2007). Gestational weight gain and child adiposity at age 3 years. *American Journal of Obstetrics and Gynceology, 196*(322), e1–e8.
11. Institute of Medicine Committee to Reexamine IOM Pregnancy Weight Guidelines. (2009). *Weight gain during pregnancy: Reexamining the guidelines*. Washington, DC: Institute of Medicine and National Research Council of the National Academies.
12. Olson, C. M. (2008). Achieving a healthy weight gain during pregnancy. *Annual Review of Nutrition, 28*, 411–423.
13. US Department of Health and Human Services. (2010) *Healthy People 2020*. http://www.healthypeople.gov/2020/default.aspx. Accessed May 26 2011.
14. American College of Obstetricians and Gynecologists. (2002). Exercise during pregnancy and the postpartum period. ACOG Committee opinion 267. *Obstetrics and Gynecology, 99*, 171–173.
15. Sorensen, T. K., Williams, M. A., Lee, I. M., et al. (2003). Recreational physical activity during pregnancy and risk of preeclampsia. *Hypertension, 41*, 1273–1280.
16. Ning, Y., Williams, M. A., Dempsey, J. C., et al. (2003). Correlates of recreational physical activity in early pregnancy. *Journal of Maternal-Fetal and Neonatal Medicine, 13*, 385–393.
17. Martin, C. L., & Brunner Huber, L. R. (2010). Physical activity and hypertensive complications during pregnancy: Findings from 2004 to 2006 North Carolina Pregnancy Risk Assessment Monitoring System. *Birth, 37*, 202–210.
18. Lee, I. M., Djousse, L., Sesso, H. D., et al. (2010). Physical activity and weight gain prevention. *JAMA, 303*, 1173–1179.
19. Mekary, R. A., Feskanich, D., Malspeis, S., et al. (2009). Physical activity patterns and prevention of weight gain in premenopausal women. *International Journal of Obesity(London), 33*, 1039–1047.
20. Donnelly, J. E., Blair, S. N., Jakicic, J. M., et al. (2009). American College of Sports Medicine Position Stand. Appropriate physical activity intervention strategies for weight loss and prevention of weight regain for adults. *Medicine and Science in Sports and Exercise, 41*, 459–471.
21. Kraschnewski, J. L., Chuang, C. H., Downs, D. S., et al. (2013). Association of prenatal physical activity and gestational weight gain: Results from the first baby study. *Womens Health Issues, 23*, e233–e238.
22. Stuebe, A. M., Oken, E., & Gillman, M. W. (2009). Associations of diet and physical activity during pregnancy with risk for excessive gestational weight gain. *American Journal of Obstetrics and Gynecology, 201*(58), e1–e8.
23. Haakstad, L. A. H., Voldner, N., Henriksen, T., et al. (2007). Physical activity level and weight gain in a cohort of pregnant Norwegian women. *Acta Obstetricia et Gynecologica Scandinavica, 86*, 559–564.
24. Olson, C. M., & Strawderman, M. S. (2003). Modifiable behavioral factors in a biopsychosocial model predict inadequate and excessive gestational weight gain. *Journal of the American Dietetic Association, 103*, 48–54.
25. Chasan-Taber, L., Silveira, M., Lynch, K. E., et al. (2014). Physical activity and gestational weight gain in Hispanic women. *Obesity (Silver Spring), 22*, 909–918.
26. Chasan-Taber, L., Schmidt, M. D., Pekow, P., et al. (2008). Predictors of excessive and inadequate gestational weight gain in Hispanic women. *Obesity (Silver Spring), 16*, 1657–1666.
27. Flegal, K. M., Carroll, M. D., Kit, B. K., et al. (2012). Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999–2010. *JAMA, 307*, 491–497.
28. Olson, C. M. (2008). Achieving a healthy weight gain during pregnancy. *Annual Review of Nutrition, 28*, 411–423.
29. Parker, J. D., & Abrams, B. (1993). Differences in postpartum weight retention between black and white mothers. *Obstetrics and Gynecology, 81*, 768–774.
30. Salihu, H. M., Lynch, O., Alio, A. P., et al. (2008). Obesity subtypes and risk of spontaneous versus medically indicated preterm births in singletons and twins. *American Journal of Epidemiology, 168*, 13–20.

31. Shulman, H.B., Gilbert, B.C., Lansky, A. (2006). The Pregnancy Risk Assessment Monitoring System (PRAMS): Current Methods and Evaluation of 2001 Response Rates. 2006. *Public Health Report.* Association of Schools of Public Health: Atlanta. pp 74–83.
32. Centers for Disease Control and Prevention. (2004). Birth Edit Specifications for the 2003 Proposed Revision of the U.S. Standard Certificate of Birth. http://www.cdc.gov/nchs/data/dvs/birth_edit_specifications.pdf. Accessed December 3 2012.
33. Bodnar, L. M., Siega-Riz, A. M., Arab, L., et al. (2004). Predictors of pregnancy and postpartum haemoglobin concentrations in low-income women. *Public Health Nutrition, 7*, 701–711.
34. Bodnar, L. M., Siega-Riz, A. M., Simhan, H. N., et al. (2010). Severe obesity, gestational weight gain, and adverse birth outcomes. *American Journal of Clinical Nutrition, 91*, 1642–1648.
35. Zhang, J., & Savitz, D. A. (1996). Exercise during pregnancy among US women. *Annals of Epidemiology, 6*, 53–59.
36. Liu, J., Laditka, J. N., Mayer-Davis, E. J., et al. (2008). Does physical activity during pregnancy reduce the risk of gestational diabetes among previously inactive women? *Birth, 35*, 188–195.
37. Ainsworth, B. E., Haskell, W. L., Whitt, M. C., et al. (2000). Compendium of physical activities: An update of activity codes and MET intensities. *Medicine and Science in Sports and Exercise, 32*, S498–S504.
38. Clapp, J. F, 3rd, & Little, K. D. (1995). Effect of recreational exercise on pregnancy weight gain and subcutaneous fat deposition. *Medicine and Science in Sports and Exercise, 27*, 170–177.
39. Löf, M., Hilakivi-Clarke, L., Sandin, S., et al. (2008). Effects of pre-pregnancy physical activity and maternal BMI on gestational weight gain and birth weight. *Acta Obstetricia et Gynecologica Scandinavica, 87*, 524–530.
40. Probst, J. C., Bellinger, J. D., Walsemann, K. M., et al. (2011). Higher risk of death in rural blacks and whites than urbanites is related to lower incomes, education, and health coverage. *Health Affairs (Millwood), 30*, 1872–1879.
41. Bovell-Benjamin, A., Dawkins, N., Pace, R., et al. (2010). Dietary consumption practices and cancer risk in African Americans in the rural South. *Journal of Health Care for the Poor and Underserved, 21*, 57–75.
42. Chasan-Taber, L., Schmidt, M. D., Roberts, D. E., et al. (2004). Development and validation of a pregnancy physical activity questionnaire. *Medicine and Science in Sports and Exercise, 36*, 1750–1760.
43. Chasan-Taber, L., Schmidt, M. D., Pekow, P., et al. (2007). Correlates of physical activity in pregnancy among Latina women. *Maternal and Child Health Journal, 11*, 353–363.
44. Evenson, K. R., & Wen, F. (2010). National trends in self-reported physical activity and sedentary behaviors among pregnant women: NHANES 1999–2006. *Preventive Medicine, 50*, 123–128.
45. Laraia, B., Messer, L., Evenson, K., et al. (2007). Neighborhood factors associated with physical activity and adequacy of weight gain during pregnancy. *Journal of Urban Health, 84*, 793–806.
46. Schmidt, M. D., Pekow, P., Freedson, P. S., et al. (2006). Physical activity patterns during pregnancy in a diverse population of women. *Journal of Women's Health, 15*, 909–918.
47. Fell, D., Joseph, K., Armson, B., et al. (2009). The impact of pregnancy on physical activity level. *Maternal and Child Health Journal, 13*, 597–603.
48. Hinton, P. S., & Olson, C. M. (2001). Predictors of pregnancy-associated change in physical activity in a rural white population. *Maternal and Child Health Journal, 5*, 7–14.
49. Petersen, A. M., Leet, T. L., & Brownson, R. C. (2005). Correlates of physical activity among pregnant women in the United States. *Medicine and Science in Sports and Exercise, 37*, 1748–1753.
50. Pereira, M. A., Rifas-Shiman, S. L., Kleinman, K. P., et al. (2007). Predictors of change in physical activity during and after pregnancy: Project viva. *American Journal of Preventive Medicine, 32*, 312–319.
51. Mottola, M. F., & Campbell, M. K. (2003). Activity patterns during pregnancy. *Canadian Journal of Applied Physiology, 28*, 642–653.