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Body Mass Index is Associated With Appropriateness of Weight Gain But Not Leisure-Time Physical Activity During Pregnancy

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Abstract

BACKGROUND—Little is known about how leisure time physical activity (LTPA) influences gestational weight gain (GWG) among body mass index (BMI) categories. The purpose of this study was to examine the relationship between pregnancy LTPA and the proportion of normal, overweight, and obese women who meet GWG recommendations.

METHODS—Participants included 449 subcohort women from the Pregnancy Outcomes and Community Health (POUCH) Study. LTPA was collapsed into three categories [(None, <7.5 kcal/kg/wk (low), 7.5 kcal/kg/wk (recommended)]. GWG was categorized according to IOM recommendations (low, recommended or excess). Chi-square and logistic regression analyses were used to evaluate relationships among LTPA, BMI, and GWG.

RESULTS—Overweight women were more likely to have high GWG vs. normal weight women (OR=2.3, 95% C.I. 1.3, 4.0). Obese women were more likely to experience low GWG (OR=7.3, 95% C.I. 3.6, 15.1; vs. normal and overweight women) or excess GWG (OR=3.5, 95% C.I. 1.9, 6.5; vs. normal weight women). LTPA did not vary by pre-pregnancy BMI category ($p=0.55$) and was not related to GWG in any pre-pregnancy BMI category ($p=0.78$).

CONCLUSIONS—Regardless of pre-pregnancy BMI, LTPA did not affect a woman's GWG according to IOM recommendations. Results may be due to LTPA not differing among BMI categories.

Keywords

Health care; Guidelines and recommendations; Exercise

Background

Obesity has become a significant problem in the United States that affects much of the population, including women of childbearing age¹. Of all women giving birth in the United States in 2004–2005, it was estimated that one in five were obese². This is especially problematic since previous research has demonstrated that compared to normal weight women, obese pregnant women have an increased risk for pregnancy-related complications. In addition, the prevalence of maternal and offspring complications may be influenced by

the appropriateness of gestational weight gain (GWG)^{3, 4}, regardless of pre-pregnancy body size⁵⁻⁸.

It was previously believed that all women, regardless of pre-pregnancy body size, should gain the same amount of weight during pregnancy⁹. However, research has shown that GWG recommendations should be based on pre-pregnancy body size, since one general weight gain recommendation does not appear to benefit all women equally. As a result, the Institute of Medicine (IOM) currently recommends that GWG should vary by pre-pregnancy body mass index (BMI; see Table 1), with women classified as overweight or obese advised to gain less weight than normal weight women¹⁰.

The number of pregnant women in the US who gain in excess of IOM recommendations is significant. For example, Weisman et al. found that 51% of 103 pregnant women sampled gained weight in excess of the IOM recommended ranges, according to the 2009 IOM recommendations¹¹. A larger study (n=52,988) classified GWG according to the 1990 IOM recommendations and found that the prevalence of excess GWG varied according to pre-pregnancy BMI¹². The authors found that 40% of normal weight and 60% of overweight women experienced GWG in excess of recommendations. Obese women gained the least amount of weight, but since the 1990 IOM recommendations¹³ did not provide an upper limit for adequate GWG, commentary on the adequacy of GWG for the obese women in their sample was not possible. However, it was noted that 25% of obese women gained at least 35 pounds, which is significantly more than the 20-pound upper limit provided by the IOM's most recent recommendation for obese women.

Because of the high prevalence of excess weight gain during pregnancy, it is important to identify modifiable lifestyle behaviors that may help women achieve GWG within the recommended range. One such behavior is participation in leisure time physical activity (LTPA). LTPA during pregnancy may aid women in achieving GWG within IOM recommended ranges, since LTPA contributes to energy balance. Data available from observational studies suggest that women reporting participation in LTPA may be more likely to experience an attenuation of GWG within recommended ranges^{7, 11, 14}. Additionally, a recent meta-analysis investigated the effectiveness of LTPA interventions during pregnancy in modifying GWG and found that women participating in a LTPA intervention experienced less GWG¹⁵. After pooling the results, a statistically significant difference between intervention and control groups of 0.6 kg was found. Although the mean difference between intervention and control groups may not appear to be clinically significant, any reduction in GWG on a population level is relevant. Results of this meta-analysis are primarily generalizable to normal weight women, as eight of the 12 studies included in this meta-analysis reported an average pre-pregnancy BMI within the normal range.

While previous research indicates LTPA during pregnancy may attenuate GWG into recommended ranges, little is known about how this relationship might vary by pre-pregnancy BMI. Therefore, the purpose of this study was to examine the relationships among pre-pregnancy BMI, GWG appropriateness, and pregnancy LTPA.

Methods

Data for these analyses were obtained from the Pregnancy Outcomes and Community Health (POUCH) study¹⁶. The main purpose of the POUCH study was to investigate biological and social factors that affect the risk of preterm delivery. The Michigan State University Institutional Review Board approved all procedures for this study. Eligibility criteria for the POUCH Study included: 16th–27th week of pregnancy; maternal serum alpha-fetoprotein (MSAFP) screening; prenatal care at one of 52 clinics in 5 Michigan communities during September 8, 1998 through June 15, 2004; singleton pregnancy with no known chromosomal abnormality or birth defect; maternal age ≥ 15 years; no pre-pregnancy diabetes mellitus; and proficiency in English. Women who met the eligibility criteria and expressed interest in the study constituted the ‘sampling frame’ for a stratified random sample. Of the 3038 women sampled and recruited into the cohort, 3019 were followed (99%) through delivery.

Information obtained at enrollment included maternal age, parity, gravidity, race, education level, marital status, insurance status (Medicaid) and smoking or alcohol use during pregnancy. Date of delivery, maternal weight at delivery, and infant birth weight were abstracted from medical records. Gestational age at delivery was based on date of last menstrual period, except when this estimate differed from early ultrasound dating by more than two weeks, in which case the ultrasound estimate was used. Size for gestational age was classified as small (SGA), appropriate (AGA), or large (LGA) based on the method of Oken et al¹⁷.

In order to maximize resources when investigating the original study aims, a subcohort of 1371 was sampled for in-depth studies and contacted periodically in the postpartum period. In fall of 2007, subcohort mothers who did not decline further contact after delivery were sent a follow-up survey regarding LTPA during pregnancy and child health outcomes (n=1261). For this investigation, women who were unable to be contacted (n=299), had incomplete follow-up information about pregnancy LTPA (n=31), or delivered preterm (<37 weeks; n=335) were excluded. Aside from these exclusion criteria, women were removed from the current analyses if their pre-pregnancy BMI was ≥ 18.5 kg/m² (inadequate sample to investigate appropriateness of GWG among these women) or had unexplained high MSAFP levels at mid-pregnancy, because this latter group was over-sampled within the original study design (n=147). Finally, women with LTPA data not within three standard deviations of the mean were excluded as outliers (n=3). After these exclusions, 449 POUCH Study participants remained and were included in the analytic sample.

Leisure Time Physical Activity

Pregnancy LTPA (kcal/kg/week) was obtained from a POUCH follow-up survey (5.4 ± 1.4 years postpartum). Women were asked to recall physical activities performed most often during a typical week in their leisure time while pregnant. If LTPA was recalled, women reported type, average duration, and average frequency of up to two activities. Activities were quantified using MET intensities¹⁸. MET values were converted to energy expenditure (1 MET = 1kcal/kg/hr) and multiplied by reported duration and frequency, and then added together to calculate total LTPA energy expenditure (kcal/kg/wk). This method allowed us

to identify women who were sedentary, insufficiently active (<7.5 kcal/kg/wk, “low”), or met ACOG recommendations during pregnancy (≥ 7.5 kcal/kg/wk, “recommended”). Consequently, LTPA was collapsed into three categories for data analyses.

Gestational Weight Gain

Pre-pregnancy weight and height were obtained by self-report at study enrollment. To obtain GWG, pre-pregnancy weight was subtracted from weight at delivery. Maternal BMI was calculated using pre-pregnancy height and weight. Adequacy of GWG was evaluated based on BMI-specific 2009 IOM recommendations¹⁰. For each participant, GWG was categorized as low, recommended or excess.

Statistical Analyses

LTPA was modeled as a categorical variable and compared across pre-pregnancy BMI categories with a Chi square test. Polytomous logistic regression was used to evaluate main effects and interactions between LTPA category and pre-pregnancy BMI, with appropriateness of GWG as the outcome. Odds ratios (OR) and 95% confidence intervals were calculated by using no LTPA and normal pre-pregnancy BMI as referent categories.

A conceptual model was constructed to evaluate potentially important covariates. Criteria for covariate inclusion in the analytic models were as follows: 1) does not function as a mediator or collider; 2) biologic rationale for potential confounding based on previous literature; and 3) a statistically significant association with appropriateness of GWG, or alters other main effect estimates by more than 10 percent in the current dataset. Models will be run unadjusted and adjusted for potential confounding variables. An alpha level of $P = 0.05$ was considered statistically significant.

Results

Table 2 summarizes maternal characteristics of the POUCH Study subcohort women who met the eligibility criteria for these analyses, and compares those who were and were not followed-up. Overall, women who were unable to be contacted were younger and had fewer years of education at the time of initial enrollment. Additionally, a higher percentage of the non-follow-up sample was of non-white ethnicity/race, insured by Medicaid, and obese according to pre-pregnancy BMI. Among the analytic sample, average ($\pm$ SD) age of the mother at enrollment was 26.7 ± 5.4 years, gestational age at delivery was 39.6 ± 1.2 weeks, and 59% of the participants were nulliparous. Our study sample was also diverse with 42% non-White. In this sample (which excluded underweight women), 45% had a normal pre-pregnancy BMI, while 23% and 32% were classified as overweight and obese, respectively.

Almost half the participants (47%) reported no LTPA during pregnancy, 21% reported “low” pregnancy LTPA (<7.5 kcal/kg/week), and 32% reported “recommended” pregnancy LTPA (≥ 7.5 kcal/kg/week). We found that self-report of no LTPA during pregnancy was more common in overweight (52%) and obese women (53%) than in normal weight women (41%), but Chi square tests did not reach statistical significance (χ^2 for overweight= 4.92, $p = 0.55$, $\phi = 0.07$; Figure 1).

The appropriateness of GWG was significantly different among pre-pregnancy BMI categories. Women with pre-pregnancy obesity were more likely to experience either low GWG (OR= 7.3, 95% C.I. 3.6, 15.1; compared to normal and overweight women) or excess GWG (OR= 3.5, 95% C.I. 1.9, 6.5; compared to normal weight women). Overweight women were more likely to experience excess GWG (OR= 2.3, 95% C.I. 1.3, 4.0 compared to normal weight women; Table 3).

In the total sample, LTPA in pregnancy was not significantly related to the appropriateness of GWG. Odds ratios ranged from 0.47–0.92 but all 95% confidence intervals included 1.0 (Table 3). More than half of the women in each LTPA category gained weight in excess of recommendations. This finding is graphically presented in Figure 2, which shows that after stratifying the total sample by pregnancy LTPA category, the distribution of the appropriateness of GWG was similar among different LTPA categories. The interaction between LTPA and pre-pregnancy BMI in relation to the appropriateness of GWG was not significant ($p = 0.78$).

Evaluation for potential confounding revealed that parity, Medicaid status, smoking, and gestational age at delivery were significantly related to the appropriateness of GWG in the total sample ($p < 0.05$). However, after entering these four variables into the regression model with pregnancy LTPA and pre-pregnancy BMI, parity was the only covariate that remained statistically significant ($p = .003$; nulliparous women were more likely to experience excess GWG). Therefore, we retained parity in the final adjusted regression model. After adjusting the regression model for parity, changes in OR's were small, and not significantly different from the unadjusted model (Table 3).

Conclusions

Our purpose was to examine how pregnancy LTPA might influence the appropriateness of GWG, according to the 2009 IOM recommendations, among a sample of normal weight, overweight, and obese women. We found that the appropriateness of GWG differed among pre-pregnancy BMI categories. Obese and overweight women were significantly more likely to gain weight in excess of recommended ranges as compared to normal weight women and obese women were significantly more likely to experience weight gain below recommendations compared to normal and overweight women. Although significant differences in the appropriateness of GWG were found by pre-pregnancy BMI, LTPA in pregnancy did not affect the appropriateness of GWG in any of the BMI categories.

Among women of all BMI categories, we found that 53% of women in our sample reported participating in any LTPA while pregnant, which is similar to what has been found in nationally representative data²⁴. In general, BMI and LTPA have been found to be inversely associated in non-pregnant populations^{19–23}. Although many studies have examined prevalence and patterns of pre-pregnancy and pregnancy LTPA^{24–27}, most have not investigated differences in pregnancy LTPA among pre-pregnancy BMI categories. In our sample, LTPA was not significantly related to pre-pregnancy BMI. This null result may be due to insufficient statistical power to detect a small difference in LTPA (12 percentage points) among BMI groups, when less than one-third of our sample reported meeting ACOG

pregnancy LTPA recommendations. It is also feasible that, in our sample, pregnancy LTPA was truly not associated with pre-pregnancy BMI. Evidence gathered from previous research investigating the association between pre-pregnancy BMI and pregnancy LTPA is mixed^{25, 28, 29}. For example, daily step counts have been found to be lower in obese versus normal weight pregnant women²⁸, but studies that corroborate this finding are lacking. In a sample of nulliparous women, Hegaard et al. evaluated LTPA during pregnancy via questionnaire. Clear inverse associations were found between pre-pregnancy BMI and pre-pregnancy LTPA. However, similar to our results, differences in pregnancy LTPA among pre-pregnancy BMI categories were not significant. The authors' only significant finding related to BMI and pregnancy LTPA was that continuation of moderate-to-heavy LTPA from pre-pregnancy into the first trimester was more common among women with a normal pre-pregnancy BMI, compared to those in the other BMI categories²⁵. In another recent study, McParlin et al. assessed physical activity levels of overweight and obese pregnant British women with accelerometry. On average, moderate-to-vigorous physical activity was 35 minutes per day, and was achieved by more than 60% of the sample²⁹. Although not directly comparable, this estimate is similar to the 57% of pregnant women in the United States who report engaging in any moderate-to-vigorous activity²⁴. Results of these studies indicate that in contrast to the nonpregnant population, pregnancy LTPA may not differ among pregnant women of different prepartum body sizes.

Approximately 58% of the women in our analyses experienced GWG in excess of the upper limit of BMI specific recommended ranges. The appropriateness of GWG in this sample, according to the 2009 IOM recommendations, was similar to that shown in previous reports^{11, 30, 31}. Interestingly, the obese women in our sample were most likely to experience both low and excess GWG compared to normal weight women. In contrast, overweight women did not differ from normal weight women in their propensity to be low weight gainers during pregnancy. Physical activity interventions in pregnancy to prevent excess GWG have typically been designed for women who are obese according to pre-pregnancy BMI. Therefore, our high percentage of low GWG in obese women could be related to medical advice they received, since recent research has shown favorable pregnancy outcomes have been associated with restricted weight gain³². Additionally, Bish et al. found that women who were advised to lose weight by their health care providers were nine times more likely to report trying to lose weight during pregnancy³³. The authors also found obesity (and not other BMI classifications) to be independently associated with trying to lose weight, suggesting that obese women may be more likely to be told to maintain or lose weight than overweight women. We do not have information regarding weight gain advice received during prenatal care for the women in our sample so further inference is speculative. However, it is critical that health care providers educate their pregnant patients (regardless of pre-pregnancy BMI) about appropriate GWG and behavioral strategies (such as balancing energy intake with expenditure) that may help women achieve GWG within their pre-pregnancy BMI recommended range. Furthermore, our results on pre-pregnancy body size and appropriateness of GWG indicate that future intervention studies should also include overweight women, particularly since adverse outcomes have been associated with excessive GWG, regardless of pre-pregnancy BMI⁵⁻⁸.

Part of the difficulty in comparing results across studies investigating the association between pregnancy LTPA and GWG is due to the inconsistency in methods used to assess pregnancy physical activity. Most studies have relied on self-report measures, often collected in the postpartum period. The subjectivity of questionnaires and other self-report measures might result in misclassification, which could explain weak associations observed between LTPA and outcome measures (specifically GWG) in previous investigations^{14, 34–36} and the non-significant association found in our sample. Furthermore, in this study, pregnancy LTPA was recalled 5.4 years postpartum, on average, which may have resulted in recall bias. However, previous research suggests women's ability to recall factors related to pregnancy (including GWG) is very good, even 30 years postpartum³⁷. More relevant to our investigation was Bauer et al.'s recent evaluation of women's ability to recall pregnancy physical activity in the postpartum period. Physical activity was originally measured at 20 and 32 weeks gestation via physical activity diary and was recalled at six years postpartum using a Modifiable Activity Questionnaire. Women's recall ability was good ($r=0.57$; 20 weeks) to excellent ($r=0.85$; 32 weeks) for physical activity performed during pregnancy³⁸. These correlation coefficients are higher than what has been reported in previous research using non-pregnant populations^{39, 40}. This finding suggests that awareness and memory of behaviors during pregnancy might be heightened compared to a non-pregnant state. As a result, it appears that recalled pregnancy LTPA estimates in the postpartum period are at least equally and possibly more valid than recalled LTPA in non-pregnant populations.

Aside from the self-reported nature of our LTPA data and duration of recall, there are other limitations of this study that are worth mentioning. We were not able to capture variation in LTPA by trimester or total daily energy expenditure. It is possible that LTPA participation varied across trimesters, which might influence the relationships examined in the present study. Additionally, neither energy intake nor other nutritional data were collected, and pre-pregnancy weight was self-reported at enrollment (16–27 weeks gestation). Like any self-reported measure there is potential for this estimate to be biased; though previous research has validated the use of self-reported pre-pregnancy weight and found it to be an acceptable proxy for measured weight^{41–43}. The distribution of pregnancy LTPA in our sample resulted in low statistical power to evaluate interactions. Although the percentage of women meeting recommendations in our sample was similar to estimates published previously²⁴, samples including a greater range of LTPA, with more women meeting and exceeding recommendations, are likely necessary to properly investigate the relationships among GWG, LTPA, and pre-pregnancy BMI.

Study strengths included our large racially and economically diverse sample, consideration of covariates and the use of measured weight at delivery to calculate GWG. We are also one of the first groups to evaluate pregnancy LTPA participation specific to pre-pregnancy BMI and each of these two variable's independent and joint associations with the appropriateness of GWG. Prevalence data pertaining to the appropriateness of GWG and pregnancy LTPA were not dissimilar from previous reports and expected significant associations were found between covariates (parity, gestational age, and smoking) and GWG. Although LTPA did not significantly influence the appropriateness of GWG in our sample, our overall study results were consistent with previous studies. Prospective studies should incorporate more

objective LTPA measurement tools (such as accelerometry) and include an assessment of energy intake. Additionally, large and diverse samples (with respect to physical activity volume, intensity, and mode) are necessary to further explore the relationships among pre-pregnancy BMI, physical activity, and gestational weight gain.

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*Legend categories are leisure-time physical activity and are categorized as [(None, <7.5 kcal/kg/wk (low), and ≥ 7.5 kcal/kg/wk (recommended))]
Pre-pregnancy BMI was categorized according to the WHO cutpoints

Figure 1.
Leisure-time physical activity participation by pre-pregnancy BMI.

Figure 2.
Gestational weight gain by leisure-time physical activity.

Table 1

Institute of Medicine gestational weight gain recommendations (2009).

Pre-Pregnancy BMI category (kg/m ²)	Recommended gestational weight gain (lbs)
<18.5 (Underweight)	28–40
18.5–24.9 (Normal weight)	25–35
25.0–29.9 (Overweight)	15–25
>30.0 (Obese)	11–20

Table 2

Maternal characteristics for the POUCH study analytic sample

	<u>Analytic Sample (N=449)</u>		<u>Non-followup Term Sample (N=587)</u>		<u>p-value</u>
	N	(%)	N	(%)	
Maternal Age (years)					0.001
< 20	58	(12.9)	127	(21.6)	
20–29	265	(59.0)	324	(55.2)	
30	126	(28.1)	136	(23.2)	
Maternal Education (years)					<.0001
<12	77	(17.2)	163	(27.8)	
12	118	(26.3)	178	(30.3)	
> 12	254	(56.6)	246	(41.9)	
Race/Ethnicity					<.0001
White	257	(57.2)	238	(40.5)	
African American	164	(36.5)	305	(52.0)	
Others	28	(6.2)	44	(7.5)	
Gestational Age at enrollment					0.4664
<20 weeks	71	(15.8)	86	(14.7)	
20–24 weeks	323	(71.9)	414	(70.5)	
25–27 weeks	55	(12.3)	87	(14.8)	
Medicaid Insurance					<.0001
No	227	(50.6)	213	(36.3)	
Yes	222	(49.4)	373	(63.7)	
Parity					0.8328
None	186	(41.4)	247	(42.1)	
At least one	263	(58.6)	340	(57.9)	
Smoking					0.6418
Never	328	(73.1)	416	(70.9)	
Stopped before enrollment	44	(9.8)	53	(9.0)	
< ½ pack per day at enrollment	54	(12.0)	86	(14.7)	
½ pack per day at enrollment	23	(5.1)	32	(5.5)	

	Analytic Sample (N=449)		Non-followup Term Sample (N=587)		p-value
	N	(%)	N	(%)	
Pre-pregnancy BMI					<.0001
Normal	203	(45.2)	255	(47.2)	
High	105	(23.4)	131	(24.3)	
Obese	141	(31.4)	154	(28.5)	
Leisure Time Physical Activity					0.9555
None	212	(47.2)			
Low	96	(21.4)			
Recommended	141	(31.4)			
Gestational Weight Gain					0.9555
Low	76	(16.9)	81	(15.9)	
Recommended	111	(24.7)	114	(22.3)	
Excess	262	(58.4)	316	(61.8)	

Table 3
Associations among gestational weight gain, pre-pregnancy BMI and leisure time physical activity

	G estational Weight Gain					
	Recommended (ref)		Low		Excess	
	N	N	OR (95% C. I.)	aOR* (95% C. I.)	OR (95% C. I.)	aOR (95% C. I.)
Pre-pregnancy BMI						
Normal	72	26	1	1	1	1
Overweight	23	5	0.58 (0.20, 1.68)	0.62 (0.21, 1.81)	2.32 (1.33, 4.03)	2.92 (1.63, 5.20)
Obese	17	44	7.33 (3.56, 15.11)	7.76 (3.73, 16.18)	3.51 (1.90, 6.48)	4.24 (2.25, 7.99)
LTPA						
None	47	40	1	1	1	1
Low	30	12	0.47 (0.21, 1.04)	0.47 (0.21, 1.03)	0.68 (0.39, 1.18)	0.65 (0.37, 1.14)
Recommended	34	12	0.83 (0.42, 1.62)	0.82 (0.42, 1.61)	0.92 (0.55, 1.55)	0.84 (0.49, 1.43)

* Odds Ratio adjusted for Parity; Leisure Time Physical Activity (LTPA), Body mass index (BMI)