


ORIGINAL ARTICLE

Clinical Trials and Investigations

Effects of a lifestyle intervention on postpartum weight retention among women with elevated weight

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INTRODUCTION

Pregnancy and postpartum periods are critical life stages that may predispose women to develop obesity. Excessive gestational weight gain (GWG) is a known predictor of postpartum weight retention (1,2). Women who enter pregnancy with overweight or obesity are

Abstract

Objective: The effectiveness of a pregnancy and postpartum behavioral lifestyle intervention on postpartum weight retention was examined.

Methods: Pregnant women with overweight and obesity in South Carolina were recruited into a theory-based randomized controlled trial ($n = 112$ intervention, $n = 107$ standard care), which was designed to reduce gestational weight gain and postpartum weight retention.

Results: Participants (44% African American, 56% White) had a mean prepregnancy BMI of 32.3 kg/m^2 and were at 12.6 weeks' gestation at baseline. From prepregnancy to 6 months post partum, intervention participants retained less weight than standard care women (mean difference: -3.6 kg , 95% CI: -5.5 to -1.8). The intervention effect was maintained at 12 months post partum (mean difference: -2.4 kg , 95% CI: -4.3 to -0.5). Intervention women had 2.3 times higher odds of having no weight retention at 6 months post partum versus standard care women (95% CI: 1.2 to 4.4). Intervention participants also had lower odds of retaining $\geq 5\%$ of their prepregnancy weight after delivery (adjusted odds ratio: 0.3, 95% CI: 0.1 to 0.5 at 6 months; adjusted odds ratio: 0.3, 95% CI: 0.2 to 0.6 at 12 months).

Conclusion: This theory-based lifestyle intervention resulted in significantly less weight retention at 6 and 12 months after delivery among pregnant women with overweight and obesity.

two to three times more likely to exceed the Institute of Medicine's (IOM) GWG guidelines than women with normal weight (3) and are less likely to return to their prepregnancy weight (4). Postpartum weight retention or an increase in BMI between pregnancies is associated with an increased risk for many adverse pregnancy outcomes in a subsequent pregnancy (5). Excessive pregnancy-related weight gain and weight retention after delivery appear to contribute to the obesity epidemic among women (2,6–8). Given that the proportion of

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women entering pregnancy with overweight (BMI ≥ 25 kg/m²) or obesity (BMI ≥ 30 kg/m²) has been rising in the United States over the past three decades (9,10) and the trend of gaining excessive weight during pregnancy also appears to be rising over time (11–13), it is important to limit postpartum weight retention among at-risk women through reducing GWG and/or promoting postpartum weight loss.

The systematic review by Amorim et al. showed that lifestyle interventions based on diet and/or physical activity (PA) were effective at reducing postpartum weight retention (mean weight loss of 1.93 kg) among women of all BMI status (14). Another systematic review restricted to women with overweight or obesity found that a majority of lifestyle interventions targeting postpartum weight retention intervened only during the postpartum period (15). Few lifestyle interventions ($n = 7$) were conducted from pregnancy through the postpartum period (15,16). Four studies were conducted among women with overweight or obesity (17–20), and only two showed a significant improvement on postpartum weight retention (18,19). Because of insufficient evidence, the authors called for more research to identify effective lifestyle interventions that intervene during both the pregnancy and postpartum periods to reduce postpartum weight retention (15,16,21).

The purpose of this study was to examine the impact of a pregnancy and postpartum behavioral lifestyle intervention (vs. standard care) on postpartum weight retention during the first year after delivery among White and African American women with overweight or obesity. We hypothesized that women receiving the behavioral intervention would retain less weight during postpartum than women receiving standard care.

METHODS

The Health in Pregnancy and Postpartum (HIPPP) study was a randomized controlled trial conducted in South Carolina (ClinicalTrials.gov identifier NCT02260518). The Institutional Review Boards at participating institutes approved the study protocol. Participants provided written informed consent.

Participants

By design, we enrolled only White and African American women in order to examine race differences in outcomes; these two groups account for 95% of the South Carolina population (22). Potentially eligible women completed a brief screening form at obstetrician-gynecologists' offices or via the website between January 2015 and December 2018. This initial screening assessed the following eligibility criteria: 18 to 44 years of age, gestational age ≤ 16 weeks, self-identification as White or Black/African American, English-speaking, and prepregnancy BMI ≥ 25 kg/m² and weight ≤ 370 lb (maximum weight assessed by scale). Study staff called initially eligible women to assess additional exclusion criteria: multiple gestation, contraindications to aerobic exercise during pregnancy (23), hospitalization for a mental

Study Importance

What is already known?

- Pregnancy and postpartum periods are critical life stages that may predispose women to develop obesity. Women who enter pregnancy with overweight or obesity are more likely to exceed the Institute of Medicine's gestational weight gain guidelines than women with normal weight and are less likely to return to their prepregnancy weight.
- A majority of lifestyle interventions targeting postpartum weight retention among women with overweight or obesity intervened only during the postpartum period.

What does this study add?

- In a diverse sample of pregnant women with overweight and obesity, a combined pregnancy and postpartum behavioral lifestyle intervention was effective at reducing postpartum weight retention within 1 year after delivery. The intervention effect was larger than the average effect in published trials that intervened during pregnancy alone or during both the pregnancy and postpartum periods.
- The intervention also increased the percentages of women who returned to prepregnancy weight and reduced the percentage having major weight retention at 6 months after delivery.

How might these results change the direction of research?

- Future trials are needed to disentangle whether prenatal intervention alone, postpartum intervention alone, or the combination of both is most effective in reducing postpartum weight retention.

health or substance abuse disorder in the past 6 months, physical disability that prevents exercise, doctor's advice not to exercise during pregnancy, and current or previous eating disorder. Intervention-related exclusions included inconsistent phone access and unwillingness to be randomized or take part in weekly phone calls. Participants were withdrawn from the study if they had a miscarriage, stillbirth, or discovery of multiple gestation after randomization.

Randomization

Those who completed baseline measurement activities before 18 weeks of gestation were randomly assigned within delivery hospital sites and by racial group. With each stratum, for every four

participants, two were randomized to the behavioral lifestyle group and two to the standard care group (allocation ratio: 1:1). A randomization list was generated by the statistician.

Behavioral lifestyle intervention

Overview

From early pregnancy until 6 months post partum, intervention women received two in-depth counseling sessions, brief telephone counseling, behavioral podcasts, and social media support that targeted weight self-monitoring, increased PA, and healthier dietary practices. Intervention components, guided by the Social Cognitive Theory (24), were described in detail elsewhere (25).

Pregnancy intervention

The in-depth pregnancy counseling session (≤ 18 weeks gestation) included printed reports and feedback regarding the participant's dietary intake and PA (based on dietary recalls and objective PA assessment), a personalized weight gain tracking graph, guidance on following GWG goals consistent with the 2009 IOM recommendations (11), and guidance on PA (26,27) and dietary recommendations during pregnancy (26,28,29). Participants set an initial PA and diet goal and received a binder of study handouts (referenced during pregnancy calls 1 to 10), a pedometer, and a bathroom scale.

After this session, participants received 10 weekly counseling calls that incorporated discussion of a behavioral strategy and/or a diet/PA topic and 10 accompanying podcasts. Participants then received shorter weekly or biweekly counseling calls throughout their pregnancy. All calls included plotting the participant's weight, assessing for changes in health status, discussing progress toward PA and healthy eating goals, problem-solving regarding barriers to reaching goals, and setting new behavioral goals.

Postpartum intervention

After delivery, the interventionist called participants weekly for very brief check-in calls that included no discussion of weight, diet, or PA. The in-depth counseling session took place 6 to 8 weeks post partum and focused on setting goals for gradually resuming PA, meeting nutritional needs (including during breastfeeding), the benefits of breastfeeding for weight reduction, calorie targets for weight loss, and strategies for losing 1 to 3 pounds/week. Participants received a 6-month personalized weight-loss tracking graph that included the upper and lower bounds of recommended weight loss over time.

After this session and through 6 months after delivery, participants received biweekly counseling calls focused on postpartum weight loss. The structure of the calls was the same as the brief pregnancy counseling calls. Beginning at 4 weeks after delivery, participants received their

first of 16 weekly podcasts that followed the 16 core Diabetes Prevention Program sessions and focused on gradual weight loss (30). When necessary, the content was tailored for postpartum women.

From pregnancy through 6 months post partum, participants were encouraged to join a private Facebook group to reinforce intervention contents, while allowing participants to support each other.

Standard care

Participants were encouraged to attend prenatal care with their providers. To enhance retention and keep participants engaged, this group received six monthly mailings each in pregnancy and at postpartum. They also received 10 weekly podcasts during pregnancy and 16 weekly podcasts after delivery (all publicly available) focused on a healthy pregnancy, fetal and infant development, and parenting. The podcasts were matched for duration and frequency to the intervention group. Neither mailings nor podcasts discussed weight, PA, or diet.

Measures

All participants were assessed at baseline (≤ 18 weeks' gestation; 90% at research office), 32 weeks' gestation (82% at research office), 6 months post partum (54% at research office, 42% at participant home), and 12 months post partum (47% at research office, 42% at participant home). Participants were assessed during each visit for new symptoms, conditions, or adverse events, and if present, the study medical monitor determined safety of continued participation and relevance to the study.

Trained and blinded research staff assessed weight and height in duplicate to the nearest 0.1 kg or 0.1 cm with a calibrated Seca scale and stadiometer. The participant wore lightweight clothing without shoes. Weight retention was computed as the difference between self-reported prepregnancy weight at screening to weight measured at the 6- and 12-month postpartum study visits. Self-reported prepregnancy weight was highly correlated with clinic prepregnancy weight measured within a year prior to this pregnancy in our study (31). To examine the robustness of our results, we also calculated weight retention from weight measured at baseline to postpartum and weight loss from delivery (abstracted from medical records) to postpartum. When delivery room weight was not available ($n = 56$), weight at the last prenatal visit (mean 4.8 days earlier than delivery date) was used. Furthermore, categorical weight retention outcomes the proportions with no postpartum weight retention (≤ 0.9 kg) (32,33) and the proportions retaining $\geq 5\%$ postpartum weight relative to prepregnancy or baseline weights were calculated.

Statistical analyses

The study's target sample size was 400 participants (200 women/group, 200 White and 200 African American) to detect a 2.0-kg difference in HIPP trial's primary outcome (total GWG) between

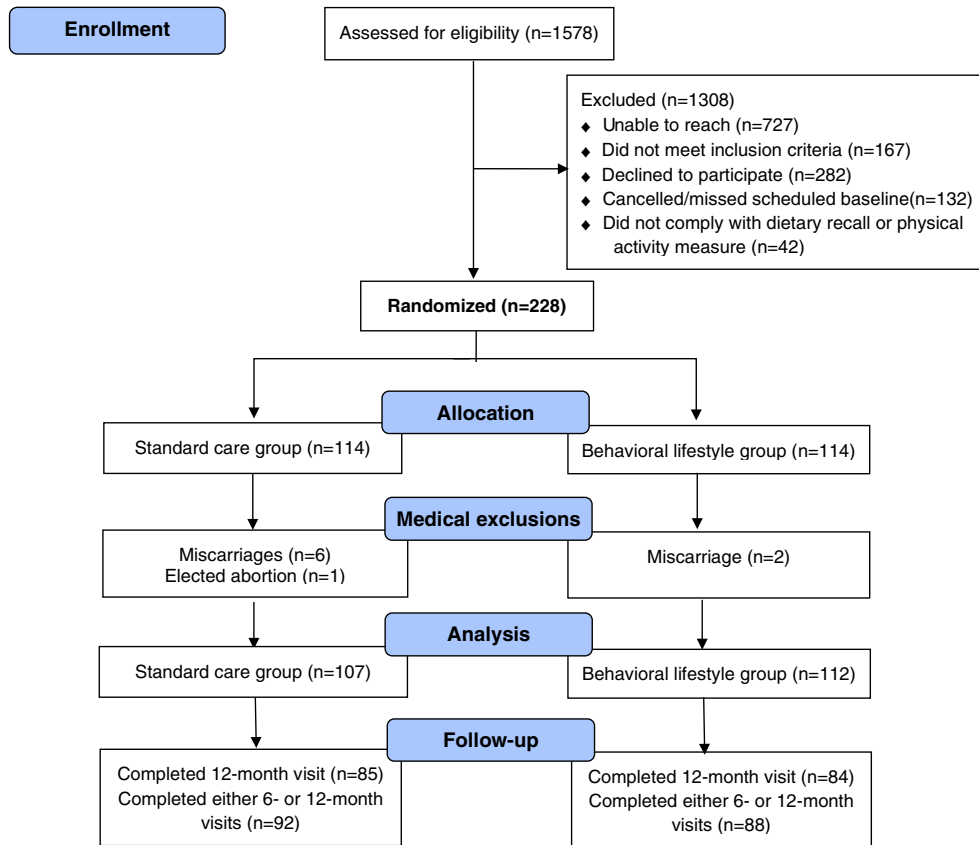


FIGURE 1 Consolidated Standards of Reporting Trials (CONSORT) diagram [Color figure can be viewed at wileyonlinelibrary.com]

intervention and standard care participants, corresponding to a small effect size of 0.28, assuming a two-sided type I error rate of 0.05 and 80% power.

For continuous weight retention outcomes, repeated-measures linear mixed-effects models were used under an intent-to-treat principle. Participants with missing data at one or more follow-up times were retained, and all available time points were used for full information maximum likelihood (FIML) estimation. The time effect had five levels (prepregnancy, baseline, delivery, 6 and 12 months post partum). In addition to the time variable, each model also included an intervention group variable, all time \times group interaction terms, and other covariates. Models were estimated using PROC MIXED in SAS 9.4 (SAS Institute, Cary, North Carolina).

Each linear mixed model produced estimates of weight change over specific intervals within each group as well as the difference in the changes between the two groups. LSMESTIMATE statements were used to specify all intervals of interest for each continuous outcome. For weight retention, the intervals of interest were from prepregnancy/baseline/delivery to 6 and 12 months post partum, respectively. For each estimate of within-group change or between-group differences in change, the corresponding 95% CI and *t* test *p* value were computed. To examine the heterogeneity of intervention effects, we conducted subgroup analyses (Black vs. White; overweight vs. obese) by including two-way and three-way interaction terms between treatment, weight category, and race/ethnicity.

The Akaike Information Criterion (AIC) statistics were used to determine whether the interaction terms should be included. The log likelihood-ratio test of significance suggested that the model with obesity \times group had a better fit than the model without interaction term.

Multiple logistic regression models were used to examine the effect of intervention on categorical weight outcomes. Adjusted odds ratios (AOR) and the 95% CI for the treatment were presented. Finally, we examined whether postpartum intervention dose and meeting the 2009 IOM guidelines in GWG (11) were related to postpartum weight retention outcomes.

RESULTS

The HIPP trial randomized 228 eligible participants. After randomization, nine participants were withdrawn because of medical reasons, resulting in 219 women (107 standard care and 112 intervention) in the trial. A total of 174 participants (91% or 85% of standard care, 83% or 74% of intervention) completed the 6-month postpartum visit, and 169 participants (85% or 79% of standard care, 84% or 75% of intervention) completed the 12-month visit (mean follow-up time = 18.8 months) (Figure 1). We did not use weight from women who were pregnant before 6 or 12 months after delivery (five standard care, four intervention) in weight outcome analyses.

TABLE 1 HIPP study participants' baseline characteristics

	Total (n = 219)	Behavioral intervention (n = 112)	Standard care (n = 107)
Maternal age, %			
18–24	16.0	12.5	19.6
25–29	28.3	27.7	29.0
30–34	37.4	39.3	35.5
≥35	18.3	20.5	15.9
Race, %			
White	55.7	58.0	53.3
Black/African American	44.3	42.0	46.7
Married, %	67.1	75.0	58.9
Education, %			
≤12th grade or high school graduate	40.6	40.2	41.1
College 1–3 years or more	59.4	59.8	58.9
Employed full-time during pregnancy, %	61.2	61.6	60.8
Family income, %			
<\$35,000	29.4	23.4	35.5
\$35,000–\$49,999	13.8	15.3	12.2
\$50,000–\$74,999	19.3	18.0	20.6
≥\$75,000	37.6	43.2	31.8
Medicaid recipient, %	30.6	29.5	31.8
Primiparous, %	42.9	43.8	42.1
Obese before pregnancy (BMI ≥ 30), %	51.6	50.0	53.3
Maternal age (y), mean ± SD	29.7 ± 5.0	30.4 ± 5.1	29.1 ± 4.8
Prepregnancy BMI (kg/m ²), mean ± SD	32.3 ± 5.9	31.9 ± 5.9	32.8 ± 6.1
Baseline gestational age (wk), mean ± SD	12.6 ± 2.3	12.6 ± 2.3	12.6 ± 2.3
Gestational age at delivery (wk), mean ± SD	38.9 ± 1.4	39.1 ± 1.5	38.8 ± 1.4
Prepregnancy weight (kg), mean ± SD	87.0 ± 17.9	85.7 ± 17.5	88.5 ± 18.3
Baseline weight (kg), mean ± SD	89.5 ± 18.4	88.0 ± 18.5	91.0 ± 18.2
Weight at delivery (kg), mean ± SD	99.7 ± 17.1	98.6 ± 17.9	100.9 ± 16.2
Total gestational weight gain (kg), mean ± SD	12.7 (7.6)	12.9 ± 6.9	12.6 (8.3)

Abbreviation: HIPP, Health in Pregnancy and Postpartum study.

Participant characteristics were similar across randomized groups at baseline (Table 1). They averaged 29.7 years, were racially diverse (55.7% White, 44.3% African American), and had a mean prepregnancy BMI of 32.3 kg/m² and a mean of 12.6 weeks gestation at baseline. Over half of the participants had obesity before pregnancy.

Continuous weight retention outcomes

Table 2 presents change in weight from prepregnancy, baseline, or delivery time to 6 and 12 months post partum. A significant intervention group × time interaction was observed ($p < 0.001$). From prepregnancy to 6 months post partum, the adjusted mean weight retained among intervention participants was 1.5 kg (95% CI: 0.1–2.8),

which was lower than weight retained among the standard care participants (5.1 kg, 95% CI: 3.8–6.4), representing a between-group difference of 3.6 kg less weight (95% CI: –5.5 to –1.8 kg) in intervention participants. The intervention effect was maintained at 12 months post partum, in which the between-group difference was 2.4 kg less weight in the intervention group (95% CI: –4.3 to –0.5).

Compared with standard care participants, intervention participants on average retained 3.5 kg less weight (95% CI: –5.3 to –1.6) from baseline to 6 months post partum and 2.2 kg less weight (95% CI: –4.1 to –0.3) at 12 months post partum. From delivery room to both 6 and 12 months post partum, intervention participants on average retained 3.9 kg less weight (95% CI: –5.8 to –2.1) at 6 months post partum and 2.7 kg less weight (95% CI: –4.6 to –0.8) at 12 months post partum. The mean adjusted weights at each time point, by intervention group, are also presented in Figure 2.

TABLE 2 Changes in weight from prepregnancy, baseline, and delivery room weights to 6 and 12 months post partum in the behavioral intervention vs. standard care groups

Outcomes	Least squares mean (95% CI) ^b			Between-group <i>p</i> value
	Behavioral intervention	Standard care	Between-group difference ^a	
Weight change from prepregnancy weight to postpartum weight, kg				
6 months post partum	1.5 (0.1, 2.8)	5.1 (3.8, 6.4)	-3.6 (-5.5, -1.8)	0.0001
12 months post partum	1.6 (0.3, 2.9)	3.9 (2.6, 5.3)	-2.4 (-4.3, -0.5)	0.0154
Weight change from baseline weight to postpartum weight, kg				
6 months post partum	-0.8 (-2.2, 0.5)	2.6 (1.3, 3.9)	-3.5 (-5.3, -1.6)	0.0003
12 months post partum	-0.7 (-2.1, 0.6)	1.5 (0.1, 2.8)	-2.2 (-4.1, -0.3)	0.0254
Weight change from delivery room weight to postpartum, kg				
6 months post partum	-11.4 (-12.7, -10.1)	-7.4 (-8.7, -6.1)	-3.9 (-5.8, -2.1)	<0.0001
12 months post partum	-11.3 (-12.6, -9.9)	-8.6 (-9.9, -7.2)	-2.7 (-4.6, -0.8)	0.0060

^aBetween-group difference: weight change in behavioral intervention group minus weight change in standard care group.

^bResults were derived from linear mixed models with repeated measurements and the model adjusted for race/ethnicity, marital status, education, full-time employment, Medicaid insurance, parity, prepregnancy obesity, age (continuous), and gestational age at baseline. The *p* value for group × time was <0.0001. Numbers in bold were statistically significant at the 0.05 level.

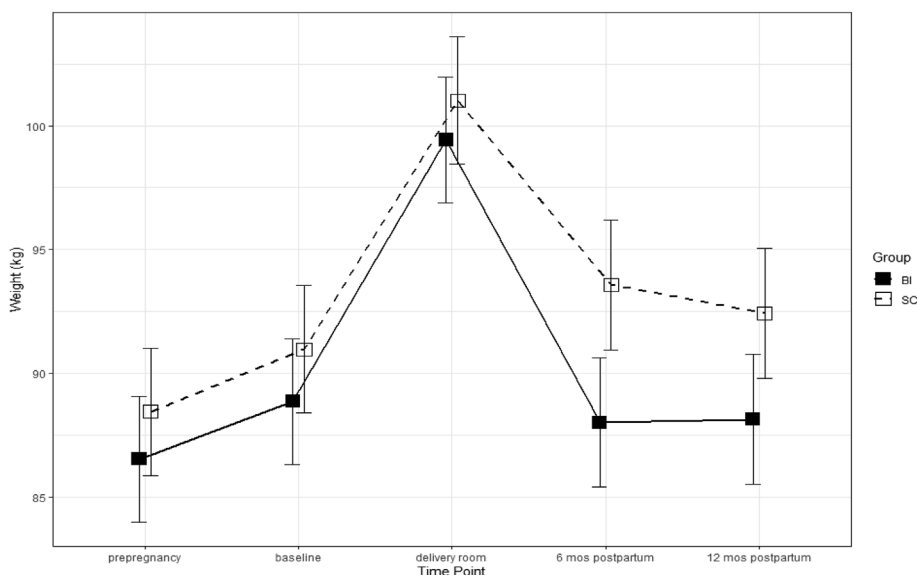


FIGURE 2 Mean adjusted weights and the 95% CI by time points for participants assigned into behavioral intervention (BI) vs. standard care (SC) groups

Subgroup analyses

Intervention effects for weight retention were not significantly different by race ($p = 0.73$) but differed by prepregnancy BMI categories (p for group × time × BMI = 0.03). Compared with standard care participants, intervention participants on average retained 4.1 kg less weight (95% CI: -6.7 to -1.5) among women with overweight and 3.3 kg less weight (95% CI: -5.8 to -0.7) among women with obesity from prepregnancy to 6 months after delivery (Table 3). The between-group differences in weight retention relative to baseline weight were similar among intervention participants with overweight or obesity. The between-group difference was only significant at 12 months among women with overweight relative prepregnancy weight

(-2.9 kg, 95% CI: -5.5 to -0.3). With regard to weight loss from delivery to postpartum, intervention effects were observed among women with obesity (6 months: -5.9 kg, 95% CI: -8.5 to -3.4; 12 months: -4.6 kg, 95% CI: -7.3 to -2.0). The mean adjusted weights at each time point, by intervention group and BMI categories, are presented in Supporting Information Figure S1.

Categorical weight retention outcomes

Compared with standard care participants, intervention participants had 2.3 times (95% CI: 1.2-4.4) higher odds of having no weight retention at 6 months post partum from their prepregnancy weight, and the

TABLE 3 Interactive effects of behavioral intervention and prepregnancy BMI on changes in weight from prepregnancy, baseline, and delivery room weights to 6 and 12 months post partum

Outcomes	Least squares mean (95% CI) ^b		Between-group difference ^a	Between-group <i>p</i> value
	Behavioral intervention	Standard care		
<i>Participants with overweight before pregnancy</i>				
Weight change from prepregnancy weight to postpartum weight, kg				
6 months post partum	1.9 (0.1, 3.7)	5.9 (4.1, 7.8)	-4.1 (-6.7, -1.5)	0.002
12 months post partum	1.9 (0.1, 3.7)	4.8 (2.9, 6.7)	-2.9 (-5.5, -0.3)	0.031
Weight change from baseline weight to postpartum weight, kg				
6 months post partum	-0.4 (-2.2, 1.4)	2.8 (1.0, 4.7)	-3.2 (-5.8, -0.6)	0.0149
12 months post partum	-0.3 (-2.1, 1.5)	1.7 (-0.2, 3.6)	-2.0 (-4.7, 0.6)	0.1322
Weight change from delivery room weight to postpartum weight, kg				
6 months post partum	-12.0 (-13.8, -10.2)	-10.5 (-12.3, -8.6)	-1.6 (-4.2, 1.0)	0.2327
12 months post partum	-11.9 (-13.8, -10.2)	-11.6 (-13.5, -9.7)	-0.4 (-3.0, 2.3)	0.7766
<i>Participants with obesity before pregnancy</i>				
Weight change from prepregnancy weight to postpartum weight, kg				
6 months post partum	1.1 (-0.8, 2.9)	4.4 (2.6, 6.1)	-3.3 (-5.8, -0.7)	0.0119
12 months post partum	1.3 (-0.6, 3.2)	3.2 (1.4, 5.0)	-1.9 (-4.6, 0.7)	0.1469
Weight change from baseline weight to postpartum weight, kg				
6 months post partum	-1.3 (-3.2, 0.5)	2.4 (0.6, 4.2)	-3.7 (-6.3, -1.2)	0.0044
12 months post partum	-1.1 (-3.0, 0.8)	1.3 (-0.5, 3.1)	-2.4 (-5.0, 0.2)	0.0759
Weight change from delivery room weight to postpartum, kg				
6 months post partum	-10.8 (-12.6, -8.9)	-4.8 (-6.6, -3.0)	-5.9 (-8.5, -3.4)	<0.0001
12 months post partum	-10.6 (-12.5, -8.7)	-5.9 (-7.8, -4.1)	-4.6 (-7.3, -2.0)	0.0006

^aBetween-group difference: weight change in behavioral intervention group minus weight change in standard care group.

^bResults were derived from linear mixed models with repeated measurements and the model was adjusted for race/ethnicity, marital status, education, full-time employment, Medicaid insurance, parity, prepregnancy obesity, age (continuous), and gestational age at baseline. The *p* values for interaction term group × time × BMI category was 0.03. Numbers in bold were statistically significant at the 0.05 level.

intervention effect was larger when using baseline weight (AOR: 3.5, 95% CI: 1.8-6.8). However, at 12 months post partum, the advantage of intervention participants having no weight retention was no longer significant. Intervention participants had lower odds of retaining ≥5% of their prepregnancy weight after delivery (AOR: 0.3, 95% CI: 0.1-0.5 at 6 months; AOR: 0.3, 95% CI: 0.2-0.6 at 12 months) (Table 4).

Intervention delivery, GWG, and postpartum weight retention

Among intervention women, 81.2% received an in-depth postpartum counseling session with a mean of 8.4 phone calls after delivery. Receiving the in-depth postpartum counseling session reduced the odds of retaining ≥5% of their baseline weight at 6 months (crude OR: 0.1, 95% CI: 0.02-0.80) and 12 months postpartum (crude OR: 0.1, 95% CI: 0.02-0.70). Receiving this in-depth postpartum counseling session was also, on average, associated with 4.9 kg less weight from delivery room to 6 months postpartum (*p* = 0.06) and 5.2 kg less at 12 months (*p* = 0.09) compared with not receiving this session. Each postpartum phone counseling call was associated with lower odds of retaining ≥5% of their baseline weight at 6 and 12 months after delivery (crude OR: 0.89, 95% CI: 0.79-1.02; *p* = 0.09) (results not shown).

Participants who gained excessive weight during pregnancy were less likely to achieve no weight retention at 6 months post partum (AOR: 0.4), whereas they had higher odds of ≥5% weight retention at 6 months (AOR: 3.3) and at 12 months post partum (AOR: 2.9) (Supporting Information Table S1).

Adverse events

Supporting Information Table S2 presents 24 adverse events happened during pregnancy and 18 adverse events during the postpartum period. The adverse events did not significantly differ by intervention group. Most of the adverse events were mild and moderate in severity. All adverse events except one were deemed unrelated to the intervention. The one exception was unknown as to whether it was related to the intervention.

DISCUSSION

We found that a combined pregnancy and postpartum behavioral lifestyle intervention among women with overweight or obesity significantly reduced postpartum weight retention outcomes at 6 and 12

TABLE 4 Categorical weight retention outcomes in the behavioral intervention vs. standard care group at 6 months and 12 months post partum

Outcomes	Predicted percentage (95% CI) ^a		Intervention effect
	Behavioral intervention	Standard care	AOR (95% CI) ^a
Percentage with no weight retention^b			
From prepregnancy to 6 months post partum	49.9 (36.7, 63.1)	30.3 (20.4, 42.4)	2.3 (1.2, 4.4)
From baseline to 6 months post partum	67.3 (53.9, 78.3)	36.9 (25.9, 49.3)	3.5 (1.8, 6.8)
From prepregnancy to 12 months post partum	46.4 (33.1, 60.2)	33.7 (22.6, 47.1)	1.7 (0.9, 3.4)
From baseline to 12 months post partum	58.7 (45.2, 71.1)	51.9 (39.1, 64.6)	1.3 (0.7, 2.5)
Percentage who retained ≥5% of weight			
From prepregnancy to 6 months post partum	25.8 (16.1, 38.6)	56.3 (43.8, 68.1)	0.3 (0.1, 0.5)
From baseline to 6 months post partum	19.1 (10.9, 31.3)	33.3 (22.5, 46.2)	0.5 (0.2, 1.0)
From prepregnancy to 12 months post partum	23.7 (14.3, 36.6)	49.5 (36.4, 62.6)	0.3 (0.2, 0.6)
From baseline to 12 months post partum	18.2 (9.9, 30.9)	30.7 (19.4, 45.0)	0.5 (0.2, 1.2)

^aPredicted percentages, adjusted odds ratios (AOR), and their 95% CI were adjusted for race/ethnicity, marital status, education, full-time employment, Medicaid insurance, parity, prepregnancy obesity, age (continuous), and gestational age at baseline. The sample sizes were 171 for 6-month outcomes and 161 for 12-month outcomes. Numbers in bold were statistically significant at the 0.05 level.

^bNo weight retention means weight retention from prepregnancy weight or baseline weight to the postpartum weights at 6 months or 12 months post partum were ≤0.9 kg.

months after delivery. The intervention also significantly increased the percentages of women who returned to their prepregnancy weight and reduced the percentage having major weight retention after delivery (≥5%) at 6 months after delivery. The intervention effects were similar among women with overweight or obesity, although the intervention effects on postpartum weight loss from delivery to postpartum were stronger among women with obesity. The HIPP trial also confirmed that GWG was associated with postpartum weight retention (34).

The theory-based HIPP trial was designed to reduce GWG (primary outcome) and postpartum weight retention (secondary outcome). The HIPP trial's intervention content included a combined approach of diet, PA, and weight self-monitoring. The type of contact included both face-to-face and telephone-based counseling sessions, which were supplemented by innovative podcasts and Facebook support. The intervention duration ran from early pregnancy to 6 months after delivery, with a mean duration of 12 months. This study added to the small number of lifestyle interventions that intervened during both pregnancy and postpartum periods among pregnant women with overweight or obesity (17–19,35).

Previous studies that evaluated the effectiveness of lifestyle interventions in pregnant and/or postpartum women with overweight or obesity for managing postpartum weight retention mainly examined continuous measures of postpartum weight retention (15). The HIPP trial became one of three trials (19,33) that showed favorable intervention effects on both continuous and categorical weight retention outcomes. For example, the behavioral intervention in the HIPP trial was effective in reducing 6-month postpartum weight retention by −3.6 kg from prepregnancy weight relative to the standard care group. At 6 months after delivery, half of the participants in the intervention group returned to their prepregnancy weight (compared with

30.3% in standard care), and only a quarter of women in the intervention group had ≥5% weight retention from their prepregnancy weight (compared with 56.3% in standard care). Our intervention effect was larger than the average effect (−1.6 kg, 95% CI: −2.5 to −0.7) reported in a recent meta-analysis of seven clinical trials from LIFE-Moms ($N = 1,150$) (19). Our favorable outcomes are likely attributable to the intervention spanning both the pregnancy and postpartum periods. Previous trials including the LIFE-Moms trials found that women randomized to the combined pregnancy and postpartum intervention had the least postpartum weight retention and those trials that intervened only during pregnancy were less likely to find intervention effects (15,19). These cumulative findings including ours indicate the best intervention timing for managing postpartum weight should start in pregnancy. The combined pregnancy and postpartum intervention will reduce GWG and promote healthy weight-related behaviors during pregnancy, while continuing to help after delivery, resulting in high effectiveness on postpartum weight outcomes.

As reported earlier, contrary to our study hypotheses, the behavioral intervention in the HIPP trial did not result in significant reduction in total GWG relative to the standard care group (31). However, we found that the intervention effect in GWG was moderated by race/ethnicity and prepregnancy BMI. Only African American participants with overweight benefited from the intervention (31). Even though the behavioral intervention in the HIPP trial was only effective in one subgroup for GWG, the results in this paper show that the behavioral intervention was effective at reducing postpartum weight retention overall. These findings suggest the importance of extending lifestyle intervention to the postpartum period.

The strengths of this study include the randomized, blinded design; use of theory-based and evidence-based intervention strategies delivered via multiple channels; inclusion of a diverse population;

and inclusion of measured weights through 12 months after delivery. In addition, an acceptable proportion (79%) of randomized participants completed the 12-month postpartum study visit. By including a 6-month maintenance period without active intervention (7 to 12 months post partum), the HIPP study also has the advantage of assessing weight maintenance 6 months postintervention because pregnancy and post partum represents critical life stages for weight change for women.

The HIPP trial also has several limitations. First, our findings may not be generalizable to women with normal weight, women from different racial/ethnic backgrounds, or women whose first prenatal care visit is later than 16 weeks. Similar to other lifestyle intervention programs (36), a low proportion of women who were initially eligible were randomized (37). This indicates the challenges of recruiting pregnant women in early pregnancy (such as pregnancy-related discomfort, fatigue, or nausea) or the disinterest in enrolling into an intervention, which involves long follow-up and needs time commitment, etc. (37) Third, the characteristics of those who completed postpartum visits differed from those noncompleters. Those who remained in our study had higher socioeconomic status. Yet they were not different by intervention group, prepregnancy BMI, and total GWG (Supporting Information Table S3). Finally, the HIPP trial may be underpowered to detect some differences, particularly in subgroups of participants.

CONCLUSION

Compared with standard care, a behavioral lifestyle intervention initiated in pregnancy and focused on healthy eating, increased PA, and weight self-monitoring resulted in significantly less weight retention at 6 and 12 months after delivery in a large sample of women from South Carolina with overweight and obesity. The HIPP trial showed the intervention starting in pregnancy was effective at reducing postpartum weight retention among these at-risk population. Findings from this study and earlier studies suggested that continuing intervention during drngpostpartum may positively benefit postpartum weight retention. Future trials are needed to disentangle whether prenatal intervention alone, postpartum intervention alone, or the combination of both is most effective in reducing postpartum weight retention. Future interventions should consider integrating intervention content into existing prenatal visits or community programs in which participants are already receiving care or services to reduce participant burden. Future studies are needed to understand factors (e.g., healthy eating and PA, built environments) contributing to successful outcomes in postpartum weight retention.○

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CONFLICT OF INTEREST

The authors declared no conflict of interest.

AUTHOR CONTRIBUTIONS

JL wrote the original draft; JL, SW, and GT-M conceptualized the study; JL, SW, EW, and GT-M conducted the research; JL and BH analyzed the data; and all authors reviewed, edited, and approved the final paper.

CLINICAL TRIAL REGISTRATION

ClinicalTrials.gov identifier NCT02260518.

DATA AVAILABILITY STATEMENT

The deidentified participant data that underlie the results reported in the article, including data dictionaries and study protocol, will be shared with the researchers who provide a methodological sound proposal beginning at 9 months and ending 36 months following article publication. Proposals should be directed to jliu@mailbox.sc.edu.

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SUPPORTING INFORMATION

Additional supporting information may be found in the online version of the article at the publisher's website.

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