Published in final edited form as:

Matern Child Health J. 2015 April ; 19(4): 840–849. doi:10.1007/s10995-014-1582-0.

Preventing excessive weight gain during pregnancy and promoting postpartum weight loss: A pilot lifestyle intervention for overweight and obese African American women

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Abstract

Objectives—To test the feasibility and acceptability of a theory-based lifestyle intervention designed to prevent excessive weight gain during pregnancy and promote weight loss in the early postpartum period in overweight and obese African American women.

Methods—Sixteen pregnant women (18 weeks gestation) were recruited from prenatal clinics in Columbia, South Carolina in 2011 and assigned to a lifestyle intervention program. The intervention, guided by formative research, consisted of an individual counseling session followed by 8 group sessions alternated with telephone counseling contacts that continued through 36 weeks of gestation. At 6–8 weeks postpartum, participants received a home visit and up to three counseling calls through week 12. Medical charts were reviewed for 38 contemporary controls who met the same inclusion criteria and attended the same prenatal clinics.

Results—Compared to controls, study participants gained less total weight, had a smaller weekly rate of weight gain across the 2nd and 3rd trimesters (0.89 vs. 0.96 lbs), and were less likely to exceed weight gain recommendations (56.3 vs. 65.8%). At 12 weeks postpartum, study participants retained 2.6 lbs from their prepregnancy weight, half of study participants were at their prepregnancy weight or lower, and only 35% retained 5 lbs. The intervention also demonstrated success in promoting physical activity and reducing caloric intake, and was well-received by participants.

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Conflicts of Interest: The authors declare that they have no conflict of interest.

Conclusions—The initial results were promising. The lessons learned can help inform future studies. The efficacy of our intervention will be tested in a large randomized controlled trial.

Keywords

Gestational weight gain; lifestyle intervention; pregnancy; obesity prevention and management; feasibility study

Introduction

The high prevalence of women who enter pregnancy overweight and obese is of increasing public health concern. African American women of childbearing age experience the highest rates of overweight and obesity in the United States; 78% report a body mass index (BMI) ≥ 30 kg/m² (1). Overweight and obese women are at increased risk for many pregnancy-related complications, including gestational diabetes, hypertensive disorders, cesarean sections and postoperative complications as compared to normal weight women (2).

Excessive gestational weight gain (GWG) is also a growing concern, with up to 50% of women gaining weight above the Institute of Medicine (IOM) guidelines during pregnancy (3). Overweight and obese women are almost twice as likely to experience excessive weight gain in pregnancy as normal weight women (4). Women who are African American or lower-income are also at increased risk for excessive GWG and postpartum weight retention (4–7).

Excessive GWG is associated with many adverse health outcomes for both mothers and children. For mothers, these risks include gestational diabetes, preeclampsia, cesarean delivery, postpartum weight retention and future overweight and obesity (4, 8, 9). For infants, the risks include low 5-minute Apgar scores, hypoglycemia, and macrosomia (10). Emerging evidence also suggests an association between excessive GWG and overweight and obesity in the offspring in early childhood through adolescence (11, 12). Therefore, reducing excessive GWG is one strategy to prevent the development of overweight and obesity in mothers and their children.

Interventions aimed at reducing GWG appear to be effective; however, the results have been modest and there is substantial heterogeneity in outcomes (13, 14). A recent review found that obese women who took part in a dietary and lifestyle intervention gained, on average, 2.2 fewer kg than control women (13). The 10 studies included in the review were rated as low to medium quality by the authors. The majority of these interventions were not grounded in behavioral theories and also largely focused on nutrition education, although physical activity has been shown to be both a safe and valuable component of a healthy pregnancy (15). Furthermore, physical activity during pregnancy may independently reduce the risk of excessive GWG (16, 17). There is a clear need to develop and test theoretically based interventions that emphasize physical activity participation as well as nutrition education.

An additional limitation is the paucity of intervention studies targeting African American women; the majority have focused exclusively on White women. Only five studies were

identified that included a sub-sample of African American women (18–22). While the majority of interventions reported a statistically significant reduction in GWG for those in the intervention group, no studies examined race differences in intervention effectiveness. Therefore, little is known about the effectiveness of GWG interventions in African Americans.

Finally, there are few intervention studies that have followed women through pregnancy into the postpartum period, and results have been mixed (23, 24). Additional interventions that follow women into the postpartum period are warranted. This is especially important given the contribution of postpartum weight retention to the development or continuation of overweight and obese status (4, 25, 26).

The purpose of this study was to test the feasibility and participant satisfaction of a theory-based nutrition and physical activity intervention designed to prevent excessive GWG and promote weight loss in the early postpartum period in overweight and obese African American women.

Methods/Design

Study Design

The study was implemented in two phases. In Phase 1, in-depth interviews were conducted with pregnant (n=25) and postpartum (n=8) African American women to learn the barriers and enablers of physical activity, healthy eating, and healthy weight gain during pregnancy and weight loss during postpartum, as well as preferred intervention channels and components. Phase 1 findings (27) were integrated with state-of-the-art behavioral strategies to develop and deliver an intervention (Phase 2) that was tailored to the unique circumstances of pregnant and postpartum African American women. This paper focuses on the study design, results, and lessons learned from Phase 2.

Participants

Pregnant women were recruited from five prenatal clinics in Columbia, South Carolina from February to July 2011 and received a lifestyle intervention program. Inclusion criteria were being 18 weeks of gestation at enrollment, African American, and having a prepregnancy BMI between 25.0 and 40.0 kg/m². Women were excluded for the following reasons: multiple gestations, uncontrolled hypertension, type 1 diabetes, uncontrolled or untreated thyroid disease, hospitalized for a mental health or substance-abuse disorder in the past 6 months, persistent bleeding past the first trimester, and physical disabilities that prevented exercise. Written physician approval to participate was also required, using a form adapted from the Physical Activity Readiness Medical Examination (PARmed-X) for Pregnancy (28).

Due to limitations in funding, contemporary controls provided comparison data for study participants. Staff at the hospital's Medical Records Division selected all women who met the same inclusion criteria (race, age, and prepregnancy BMI) as the study participants and delivered a singleton live birth between August 1 and November 15, 2011. These women also attended the same prenatal care clinics and delivered in the same hospital as the study

participants. There were 38 women who met our inclusion criteria and their medical records were abstracted for weight measurements (all prenatal care visits and delivery room), pregnancy outcomes, and basic demographic information. The study protocol was approved by the Institutional Review Boards at both the hospital and the university.

Behavioral intervention

Intervention channels shown to be effective in general populations and in pregnant and postpartum women include: telephone-based counseling (29–31), in-person counseling conducted in conjunction with routine obstetric visits (4, 32), home-delivered interventions (33), group-based sessions (34) and print- or internet-delivered interventions (31, 35). Our Phase 1 formative research revealed a strong preference for a group-based intervention with openness to telephone calls to supplement these sessions. Thus, our lifestyle intervention consisted of an individual counseling session followed by 8 group sessions alternated with telephone counseling contacts that continued through 36 weeks of gestation. At 6–8 weeks postpartum, participants received a home visit and up to three counseling calls to promote postpartum weight loss through week 12. All intervention materials were delivered by a registered dietitian with an MSPH in health promotion. All group sessions were co-led by an African American research staff member with an MPH in health promotion.

Intervention components - pregnancy

Consistent with social cognitive theory (36), participants learned how to use behavioral skills and knowledge; self-regulate (set goals, self-monitor, problem solve, and use reinforcement); employ stimulus control strategies to promote healthier choices; seek out social support; increase self-efficacy; identify high-risk situations and how to cope with them; and prepare for and cope with setbacks (37). Participants received the 2009 Institute of Medicine (IOM) recommendations for healthy weight gain (38) and a weight gain chart. Frequent self-monitoring of physical activity, diet, and weight was strongly encouraged and achieved through the use of pedometers, scales (provided to participants), and simple dietary logs.

The initial face-to-face session provided personalized feedback regarding recommended gestational weight gain based on prepregnancy BMI, a graph to plot weight gain through 40 weeks gestation with upper and lower recommended limits, dietary intake based on three 24-hour dietary recalls (discussed below), physical activity level based on the SenseWear dietary armband (discussed below), and initial goals for physical activity and diet (participant selected). General nutrition information for pregnant women (using individualized MyPyramid for Moms Daily Food Plan) and basic exercise information and recommendations for pregnant women was also provided.

Each of the 90-minute group sessions included general didactic content, discussion and application of a behavioral strategy (e.g., self-monitoring), skill training in diet and/or physical activity (e.g., label reading, exercise options with baby), and a group activity (e.g., game, planning a meal). An attendance incentive was provided, and each session included a healthy food demonstration and tasting.

Each telephone call assessed participant health and safety and progress toward the physical activity and dietary goals. Each call also included problem solving regarding overcoming barriers to meeting goals, reinforcement of content discussed in group, and setting new physical activity and dietary goals.

Intervention components - postpartum

Because the life circumstances, medical issues, and dietary needs of women change during postpartum, we resumed contact with women at 6 to 8 weeks postpartum. Through the face-to-face home visit and counseling telephone calls, similar in structure to that described for the pregnancy period, the intervention focused on setting goals for gradually resuming physical activity and exercise options that could be done with a baby. The participant learned her nutritional needs during postpartum (personalized MyPyramid for Moms Daily Food Plan), including how these needs are affected by breastfeeding. Strategies for weight reduction were discussed.

Intervention goals

Consistent with guidelines for pregnant women (39, 40), intervention goals were to engage in 30 minutes of moderate intensity physical activity (e.g., brisk walking) on 5 or more days per week and to eat a diet high in fruits, vegetables, and whole grains and low in saturated and trans fats, while also balancing caloric intake to match but not exceed dietary needs for pregnancy and lactation. MyPyramid for Moms were used to help women select a balanced diet that incorporated the higher needs for some vitamins and minerals (40). Pregnancy weight gain goals were consistent with the 2009 IOM recommendations (15–25 lbs for overweight and 11–20 lbs for obese women) (38). During the postpartum period, participants were encouraged to set short-term goals of losing approximately 1–3 lbs/week. They also received feedback regarding achieving a healthy BMI.

Key measurements

To evaluate the effects of the lifestyle intervention, study participants were measured at three time points: baseline (18 weeks gestation), 32 weeks gestation, and 12 weeks postpartum, in addition to abstraction from medical records.

Gestational weight gain (GWG) was our primary outcome. Data for calculating GWG for both study participants and control women came from medical records abstraction. GWG was assessed in three ways. First, total GWG was calculated as the delivery room weight minus prepregnancy weight. Second, considering that total GWG varies by gestational age at delivery, the ratio of actual weight gain to expected weight gain for each gestational week based on the 2009 IOM guideline was used to determine the proportion of women meeting IOM guidelines (inadequate, adequate, or excessive) (38). Details on how to derive this measure are available in other published studies (41). Third, the weekly rate of weight gain in the 2nd and 3rd trimesters (14 weeks of gestation until delivery) was calculated.

In addition to GWG measures, we assessed several secondary outcomes, which were only available for study participants. Postpartum weight retention was calculated as 12-week postpartum weight minus prepregnancy weight in lbs.

Physical activity (PA) was assessed using SenseWear Armband (BodyMedia Inc. Pittsburgh, PA). The Armband has been validated for use in free-living non-pregnant (42) and pregnant (43) participants. We distributed Armbands at all three measurement visits. Participants were instructed to wear the Armband for seven consecutive days (24 hours/day), and to only remove it for showers/baths, water activities, and monitor cleaning. The number of steps/day, daily minutes spent in moderate- to vigorous-intensity PA (MVPA; MET ≥ 3), and total energy expenditure were used. Protocol compliance was high. The majority of our participants provided armband data (80–93% across visits) with an average wear time of 23 hours/day and six days with >20 hours/day.

Dietary intake—Three telephone-administered 24-hour recall interviews were conducted on non-consecutive, randomly selected days (two weekdays, one weekend) after each measurement visit by experienced registered dietitians, using the Nutrition Data System for Research software (NDSR, Version 2008). Data from participants with at least 2 completed and reliable recalls were used in our analysis.

Program satisfaction—Participants were asked to share, via structured and open-ended questions, what they liked most/least about the intervention, recommendations for intervention modification, perceived usefulness of the intervention in preventing excessive weight gain and promoting postpartum weight loss, and factors that helped and hindered behavior change at 32 weeks of gestation and 12 weeks postpartum.

Statistical analyses

Continuous variables are shown as means $\pm$ standard deviations and categorical variables as numbers and percentages. For total GWG and total energy expenditure, the means and standard errors adjusted for prepregnancy BMI. For all diet intake variables, except the percentages of calories from fat and saturated fat, we adjusted for total energy intake at the respective measurement visit. To compare group differences, two-sided Fisher's exact tests were used for categorical variables and independent sample t-tests were used for continuous variables. We also used paired t-tests for within-subject comparisons of PA and dietary intake variables measured at the three time points. Because this was a small pilot study, results focus on the direction and magnitude of observed differences. All analyses were performed with SAS (SAS Institute Inc., Cary, NC, USA).

Results

Study sample

We recruited 16 overweight or obese African American women into our behavioral intervention program at 13.2 ± 2.5 weeks of gestation (range: 9–17 weeks). They were 25.6 ± 4.2 years with a mean prepregnancy BMI of 28.6 ± 3.5 kg/m². Over 56% attended some college, 81.3% were not married, and 56.3% were employed during pregnancy. Our contemporary controls were very similar to our intervention except that a higher proportion of control women had education levels at or less than high school (71.1%) and prepregnancy weight was higher among control women (Table 1).

Effect on gestational weight gain and postpartum weight retention

As shown in Table 2, compared to contemporary controls, study participants gained less total weight on average and were less likely to exceed GWG recommendations. Study participants also had a smaller weekly rate of weight gain in the 2nd and 3rd trimesters. In the group that exceeded IOM recommendations, total GWG was 33.1 lbs in study participants versus 36.9 lbs in contemporary controls, after adjusting for prepregnancy BMI. These differences, however, were not statistically significant.

At 12 weeks postpartum, study participants retained 2.6 lbs from their prepregnancy weight. Half of the study participants were at their prepregnancy weight or lower, and 35% of participants retained at least 5 lbs postpartum.

As shown in Table 3, adverse maternal and birth outcomes were similar for study participants and contemporary controls. No significant differences were found in infants' birth weight, gestational ages, fetal growth, apgar scores, c-section delivery, NICU admission, and diagnosis of gestational diabetes. Interestingly, offspring born to study participants had longer birth length (49.2 cm) than contemporary controls (47.1 cm) ($p=0.0006$).

PA, diet, and birth outcomes (Table 4)

Steps per day in study participants were similar at baseline (6,599) and 32 weeks of gestation (6,219), suggesting less decline in PA than is typically seen in pregnancy (44, 45). Steps per day increased to 7,773 at postpartum ($p=0.06$, baseline vs. 12 wk postpartum). Similarly, total minutes spent in MVPA were 48.6 minutes at baseline, 40 minutes at 32 weeks of gestation, and 59.0 minutes at 12 weeks postpartum ($p=0.04$, baseline vs. 12 wk postpartum). Total daily energy expenditure was 2,325 kcal/day at baseline, and increased significantly at 32 wks gestation ($p=0.03$, baseline vs. 32 wk) and at postpartum ($p=0.008$, baseline vs. 12 wk postpartum).

Total caloric intake declined across time. Intake for other components of diet was similar across the three time points except vegetable intake, which declined somewhat from baseline to postpartum. In general, participants ate a lower fiber diet, with very few servings of whole grains, and regularly consumed sweetened beverages. No within-subject comparisons were statistically significant at the 0.05 level.

Acceptability of the intervention

During pregnancy, participants attended an average of 3.8 group sessions plus 1.3 makeup sessions, thus receiving 64% of the group session content. They received 43% of the attempted phone contacts. Fifty percent of postpartum intervention home visits and 40% of postpartum phone calls were completed. Retention at 32 weeks gestation (94%) and 12 weeks postpartum (88%) was high. As shown in Table 5, participants rated the program positively (3.8/4.0), and all reported they would recommend it to a friend. Participants rated the following aspects as being particularly helpful (mean score 2.4 out of 3 as the possible points): nutrition and exercise information received in one-on-one session, setting eating goals, reading food labels, regular weighing, money saving tips for food purchasing, and

group sessions. Most (~90%) described the number of group sessions and phone calls as “about right.”

Discussion

This paper described the development of a theory-based behavioral lifestyle intervention aimed at preventing excessive weight gain during pregnancy and promoting weight loss after delivery. The intervention was pilot tested in a small group of overweight and obese African American women. In spite of the limited resources available in this feasibility study, we found that study participants gained 2.4 fewer pounds than contemporary controls, the effect in a magnitude similar to findings from a meta-analysis in this area (46). The total GWG in the sub-group of study participants who exceeded IOM recommendations was 4.4 lbs lower than those in the contemporary control group. This finding suggests we were able to attenuate the degree of excessive gestational weight gain. In terms of postpartum weight retention, half of our study participants were able to return to prepregnancy weight or lower and the mean net weight retention was 2.6 lbs at 12 weeks postpartum. Because most studies of overweight/obese women have been conducted in countries where total weight gain among controls was less than in our sample of controls, it is difficult to compare our findings with the larger literature in this population (47–50). Furthermore, our intervention also showed initial evidence in maintaining physical activity, reducing caloric intake, and being well-received by participants. There were no major differences in maternal or birth outcomes between our study participants and control women. In some outcomes such as birth length, preterm births, and gestational diabetes, study participants appeared to have better outcomes than the contemporary controls.

Through this feasibility study, we also had learnings that can help inform future studies. We used a group format based on the expressed preference by our study population, but attendance at group sessions was not ideal. On the one hand, less-than-ideal attendance might be related to only being able to offer one time slot for the group session due to resource constraints (i.e., weekday, 5:30 pm). On the other hand, this finding indicates that these high-risk pregnant women have many barriers to attending classes and adopting healthier lifestyles during pregnancy. We also believe that having no contact with participants from 36 weeks gestation to 6–8 weeks postpartum was problematic in terms of maintaining rapport and contact. The feasibility study underscored the importance of offering participants novel, alternate, and more flexible intervention channels such as social media or technology to enhance engagement for this population.

Although the intervention showed promising results in reducing gestational weight gain, we had expected to see larger differences relative to the contemporary controls. However, the fact that the magnitude of our results were comparable to a recent meta-analysis (46) is promising given we targeted a higher-risk and less-studied population (i.e., overweight and obese African American women). Having greater study resources to more intensively target participants not meeting weight goals and greater flexibility regarding class times and intervention channels might lead to improved outcomes. Furthermore, our study is limited by its small sample and use of contemporary controls as comparison group. Finally, some might question the high intensity of this behavioral intervention and its feasibility for

dissemination. However, previous studies using low intensity approaches such as brochures or mailings or a very limited number of counseling sessions or phone calls were not successful in reducing GWG for overweight/obese women (48, 51). A more intensive intervention approach, such as more frequent contacts and greater emphasis on both physical activity and nutrition, consistent with our intervention approach, has been recommended for overweight and obese women (51). If a more intensive intervention is effective, then future research is needed to examine the minimally effective dose and how the intervention can be integrated into prenatal or community-based care.

In spite of these limitations, this study has multiple strengths. First, we have designed a theory-based study which was tailored to the unique barriers and facilitators for this high-risk population. Second, we were able to successfully recruit and retain participants from busy clinical practices. Third, our intervention was designed to fully target both physical activity and nutrition components, while the extant literature relies predominantly on nutrition education. Fourth, we used objectively measured physical activity and 24-hour dietary recalls, both which are rarely seen in published studies in this area. Lastly, by intervening in both prenatal and postpartum periods, we are able to see a longer-term impact on weight retention after pregnancy.

Conclusions

In response to major gaps and limitations in the field, we have designed and pilot tested a theory-based behavioral lifestyle intervention program which was tailored for overweight or obese African American women. This population has not been well studied in the existing literature. Our initial results were promising and our follow-up and measurement retention rates were high. The lessons learned can inform future studies. The efficacy of our intervention will be tested in a large randomized controlled trial.

Acknowledgments

This study was funded by the Eunice Kennedy Shriver National Institute of Child Health and Human Development R21 HD061885 (Principal Investigators: Jihong Liu, Sc.D, Sara Wilcox, PhD). Our appreciation goes to Drs. Anthony Gregg, Paul Browne, and Lisa Spiryda for serving as medical directors for this study at different stages and for contributing their valuable knowledge to the study design and recruitment of participants from the clinics. We also thank Ms. Alicia Albergottie, Ms. Diona Blocker, and Ms. Myah Griffin for their assistance in recruitments and data collection and Ms. Ellen Wingard and Ms. Donna Strong for delivering the lifestyle intervention programs to the study participants. Further, we thank all women and all prenatal clinics for participation in the study and their assistance with data collection.

References

1. Flegal KM, Carroll MD, Ogden CL, et al. Prevalence and trends in obesity among US adults, 1999–2008. *JAMA*. 2010; 303(3):235–41. [PubMed: 20071471]
2. Galtier-Dereure F, Boegner C, Bringer J. Obesity and pregnancy: complications and cost. *Am J Clin Nutr*. 2000; 71(5 Suppl):1242S–8S. [PubMed: 10799397]
3. Institute of Medicine. Influence of Pregnancy Weight on Maternal and Child Health: Workshop Report; Washington D.C. 2007.
4. Olson CM. Achieving a healthy weight gain during pregnancy. *Annu Rev Nutr*. 2008; 28:411–23. [PubMed: 18422452]

5. Olson CM, Strawderman MS. Modifiable behavioral factors in a biopsychosocial model predict inadequate and excessive gestational weight gain. *J Am Diet Assoc.* 2003; 103(1):48–54. [PubMed: 12525793]
6. Parker JD, Abrams B. Differences in postpartum weight retention between black and white mothers. *Obstet Gynecol.* 1993; 81(5 Pt 1):768–74. [PubMed: 8469470]
7. Smith DE, Lewis CE, Caveny JL, et al. Longitudinal changes in adiposity associated with pregnancy. The CARDIA Study. Coronary Artery Risk Development in Young Adults Study. *JAMA.* 1994; 271(22):1747–51. [PubMed: 8196117]
8. Hedderson MM, Gunderson EP, Ferrara A. Gestational weight gain and risk of gestational diabetes mellitus. *Obstet Gynecol.* 2010; 115:597–604. [PubMed: 20177292]
9. Nehring I, Schmoll S, Beyerlein A, et al. Gestational weight gain and long-term postpartum weight retention: a meta-analysis. *Am J Clin Nutr.* 2011; 94(5):1225–31. [PubMed: 21918221]
10. Stotland NE, Cheng YW, Hopkins LM, et al. Gestational weight gain and adverse neonatal outcome among term infants. *Obstet Gynecol.* 2006; 108(3 Pt 1):635–43. [PubMed: 16946225]
11. Deierlein AL, Siega-Riz AM, Herring AH, et al. Gestational weight gain and predicted changes in offspring anthropometrics between early infancy and 3 years. *Pediatr Obes.* 2012; 7:134–42. [PubMed: 22434753]
12. Oken E, Rifas-Shiman SL, Field AE, et al. Maternal gestational weight gain and offspring weight in adolescence. *Obstet Gynecol.* 2008; 112(5):999–1006. [PubMed: 18978098]
13. Oteng-Ntim E, Varma R, Croker H, et al. Lifestyle interventions for overweight and obese pregnant women to improve pregnancy outcome: systematic review and meta-analysis. *BMC Med.* 2012; 10:47. [PubMed: 22574949]
14. Gardner B, Wardle J, Poston L, et al. Changing diet and physical activity to reduce gestational weight gain: a meta-analysis. *Obes Rev.* 2011; 12(7):e602–20. [PubMed: 21521451]
15. Ferraro ZM, Gaudet L, Adamo KB. The Potential Impact of Physical Activity During Pregnancy on Maternal and Neonatal Outcomes. *Obstet Gynecol Surv.* 2012; 67(2):99–110. [PubMed: 22325300]
16. Streuling I, Beyerlein A, Rosenfeld E, et al. Physical activity and gestational weight gain: a meta-analysis of intervention trials. *BJOG.* 2011; 118(3):278–84. [PubMed: 21134106]
17. Harris ST, Liu J, Wilcox S, et al. Exercise During Pregnancy and its Association with Gestational Weight Gain. *Matern Child Health J.* 2014 (ePub ahead of print).
18. Polley BA, Wing RR, Sims CJ. Randomized controlled trial to prevent excessive weight gain in pregnant women. *Int J Obes Relat Metab Disord.* 2002; 26(11):1494–502. [PubMed: 12439652]
19. Artal R, Catanzaro RB, Gavard JA, et al. A lifestyle intervention of weight-gain restriction: diet and exercise in obese women with gestational diabetes mellitus. *Applied Physiology, Nutrition, and Metabolism.* 2007; 32:596–601.
20. Thornton YS. Preventing excessive weight gain during pregnancy through dietary and lifestyle counseling: a randomized controlled trial. *Obstet Gynecol.* 2009; 114(1):173. [PubMed: 19546789]
21. Shirazian T, Monteith S, Friedman F, et al. Lifestyle modification program decreases pregnancy weight gain in obese women. *Am J Perinatol.* 2010; 27(5):411–4. [PubMed: 20013602]
22. Asbee SM, Jenkins TR, Butler JR, et al. Preventing excessive weight gain during pregnancy through dietary and lifestyle counseling: a randomized controlled trial. *Obstet Gynecol.* 2009; 113(2):305–11. [PubMed: 19155899]
23. Althuisen E, van der Wijden CL, van Mechelen W, et al. The effect of a counselling intervention on weight changes during and after pregnancy: a randomised trial. *BJOG.* 2013; 120(1):92–9. [PubMed: 23121074]
24. Huang TT, Yeh CY, Tsai YC. A diet and physical activity intervention for preventing weight retention among Taiwanese childbearing women: a randomised controlled trial. *Midwifery.* 2011; 27(2):257–64. [PubMed: 19775782]
25. Siega-Riz AM, Evenson KR, Dole N. Pregnancy-related weight gain--a link to obesity? *Nutr Rev.* 2004; 62(7 Pt 2):S105–11. [PubMed: 15387475]

26. Hernandez DC. Gestational weight gain as a predictor of longitudinal body mass index transitions among socioeconomically disadvantaged women. *J Womens Health (Larchmt)*. 2012; 21(10): 1082–90. [PubMed: 22694763]
27. Goodrich K, Cregger M, Wilcox S, et al. A qualitative study of factors affecting pregnancy weight gain in African American women. *Matern Child Health J*. 2013; 17(3):432–40. [PubMed: 22527762]
28. Canadian Society for Exercise Physiology. [Accessed December 27 2012] PARmed-X for Pregnancy: Physical Activity Readiness Medical Examination. 2002. <http://www.csep.ca/cmfiles/publications/parq/parmed-xpreg.pdf>
29. Goode AD, Reeves MM, Eakin EG. Telephone-delivered interventions for physical activity and dietary behavior change: an updated systematic review. *Am J Prev Med*. 2012; 42(1):81–8. [PubMed: 22176852]
30. Dennis CL, Hodnett E, Kenton L, et al. Effect of peer support on prevention of postnatal depression among high risk women: multisite randomised controlled trial. *BMJ*. 2009; 338:a3064. [PubMed: 19147637]
31. Bullock L, Everett KD, Mullen PD, et al. Baby BEEP: A randomized controlled trial of nurses' individualized social support for poor rural pregnant smokers. *Matern Child Health J*. 2009; 13(3): 395–406. [PubMed: 18496746]
32. Ferreira-Borges C. Effectiveness of a brief counseling and behavioral intervention for smoking cessation in pregnant women. *Prev Med*. 2005; 41(1):295–302. [PubMed: 15917025]
33. Leis JA, Mendelson T, Tandon SD, et al. A systematic review of home-based interventions to prevent and treat postpartum depression. *Arch Womens Ment Health*. 2009; 12(1):3–13. [PubMed: 19137448]
34. Cheung NW, Smith BJ, Henriksen H, et al. A group-based healthy lifestyle program for women with previous gestational diabetes. *Diabetes Res Clin Pract*. 2007; 77(2):333–4. [PubMed: 17161488]
35. Marcus BH, Lewis BA, Williams DM, et al. A comparison of Internet and print-based physical activity interventions. *Arch Intern Med*. 2007; 167(9):944–9. [PubMed: 17502536]
36. Bandura, A. Social foundations of thought and action: a social cognitive theory. Englewood Cliffs, NJ: Prentice-Hall; 1986.
37. Marcus BH, King TK, Clark MM, et al. Theories and techniques for promoting physical activity behaviours. *Sports Med*. 1996; 22(5):321–31. [PubMed: 8923649]
38. Institute of Medicine Committee to Reexamine IOM Pregnancy Weight Guidelines. Weight Gain During Pregnancy: Reexamining the Guidelines. Washington D.C: Institute of Medicine and National Research Council of the National Academies; 2009.
39. ACOG Committee opinion. Number 267. 2002: exercise during pregnancy and the postpartum period. *Obstet Gynecol*. Jan; 2002 99(1):171–3. [PubMed: 11777528]
40. Kaiser L, Allen LH. Position of the American Dietetic Association: nutrition and lifestyle for a healthy pregnancy outcome. *J Am Diet Assoc*. 2008; 108(3):553–61. [PubMed: 18401922]
41. Bodnar LM, Siega-Riz AM, Simhan HN, et al. Severe obesity, gestational weight gain, and adverse birth outcomes. *Am J Clin Nutr*. 2010; 91(6):1642–8. [PubMed: 20357043]
42. Johannsen DL, Calabro MA, Stewart J, et al. Accuracy of armband monitors for measuring daily energy expenditure in healthy adults. *Med Sci Sports Exerc*. 2010; 42(11):2134–40. [PubMed: 20386334]
43. Smith KM, Lanningham-Foster LM, Welk GJ, et al. Validity of the SenseWear(R) Armband to predict energy expenditure in pregnant women. *Medicine and Science in Sports and Exercise*. 2012; 44(10):2001–8. [PubMed: 22617395]
44. Pereira MA, Rifas-Shiman SL, Kleinman KP, et al. Predictors of change in physical activity during and after pregnancy: Project Viva. *Am J Prev Med*. 2007; 32(4):312–9. [PubMed: 17383562]
45. Borodulin KM, Evenson KR, Wen F, et al. Physical activity patterns during pregnancy. *Med Sci Sports Exerc*. 2008; 40(11):1901–8. [PubMed: 18845974]
46. Thangaratinam S, Rogozinska E, Jolly K, et al. Interventions to reduce or prevent obesity in pregnant women: a systematic review. *Health Technol Assess*. 2012; 16(31):iii–iv. 1–191. [PubMed: 22814301]

47. Bogaerts AF, Devlieger R, Nuyts E, et al. Effects of lifestyle intervention in obese pregnant women on gestational weight gain and mental health: a randomized controlled trial. *Int J Obes (Lond)*. 2013; 37(6):814–21. [PubMed: 23032404]
48. Guelinckx I, Devlieger R, Mullie P, et al. Effect of lifestyle intervention on dietary habits, physical activity, and gestational weight gain in obese pregnant women: a randomized controlled trial. *The American Journal of Clinical Nutrition*. 2010; 91:373–80. [PubMed: 19955397]
49. Nascimento SL, Surita FG, Parpinelli MA, et al. The effect of an antenatal physical exercise programme on maternal/perinatal outcomes and quality of life in overweight and obese pregnant women: a randomised clinical trial. *BJOG*. 2011; 118(12):1455–63. [PubMed: 21895947]
50. Vinter CA, Jensen DM, Ovesen P, et al. The LiP (Lifestyle in Pregnancy) study: a randomized controlled trial of lifestyle intervention in 360 obese pregnant women. *Diabetes Care*. 2011; 34(12):2502–7. [PubMed: 21972411]
51. Phelan S, Phipps MG, Abrams B, et al. Randomized trial of a behavioral intervention to prevent excessive gestational weight gain: the Fit for Delivery Study. *Am J Clin Nutr*. 2011; 93(4):772–9. [PubMed: 21310836]

Table 1

Baseline characteristics of the study sample

Baseline Characteristics	Intervention N = 16	Contemporary control N = 38	P value [*]
Age, years, mean (SD)	25.1 (4.2)	27.4 (4.9)	0.10
Age category, %			0.23
20.0–24.9 years	56.3	36.8	
25.0–40.0 years	43.7	63.2	
Prepregnancy BMI, kg/m ² , mean (SD)	28.6 (3.5)	29.8 (3.1)	0.59
Prepregnancy BMI category, %			0.12
Overweight (25.0–29.9 kg/m ²)	81.3	57.9	
Obese (30.0–40.0 kg/m ²)	18.7	42.1	
Education, %			0.07
high school	43.7	71.1	
Some college or higher	56.3	28.9	
Marital status, %			0.51
Married	18.7	31.6	
Never married/not married	81.3	68.4	
Employment during pregnancy, %			0.71
Yes	56.3	55.3	
No	43.7	36.8	
Missing	0	7.9	

Abbreviations: BMI = body mass index, SD = standard deviation.

^{*} P-values were based on 2-sided Fisher's exact tests for categorical variables and independent sample t-tests for continuous variables.

Table 2

Gestational weight gain (GWG) and postpartum weight retention in the intervention versus contemporary control group

Characteristics	Intervention	Contemporary control	P value [*]
Gestational weight gain	N = 16	N = 38	
Total GWG, lbs, mean (SE)	24.9 (13.3)	26.2 (17.6)	0.23
BMI-adjusted total GWG, lbs, mean (SE)	24.1 (4.1)	26.5 (2.7)	0.63
Meeting IOM guidelines, %			0.07
Below recommendations	12.5	7.9	
Met recommendations	31.2	28.9	
Exceeded recommendations	56.3	63.2	
BMI-adjusted total GWG by meeting IOM guideline categories, lbs, mean (SE)			
Below recommendations	3.1 (3.7)	3.3 (1.5)	0.97
Met recommendations	18.2 (1.6)	18.6 (2.2)	0.89
Exceeded recommendations	31.6 (3.7)	36.9 (2.2)	0.24
Weekly rate of weight gain in the 2 nd and 3 rd trimesters, lbs, mean (SD)	0.89 (0.51)	0.96 (0.68)	0.24
Postpartum weight retention, sample size	n = 14	No data	
Weight retention – 4 months postpartum			
Net weight retention, lbs, mean (SD)	2.6 (12.6)	No data	
Subjects at or below prepregnancy weight, %	50.0	No data	
Weight retaining ≥ 5 lbs, %	35.7	No data	

Abbreviations: BMI=body mass index, lbs=pounds, SE = standard error, IOM = Institute of Medicine, SD = standard deviation.

* P-values were based on 2-sided Fisher's exact tests for categorical variables and independent sample t-tests for continuous variables.

Table 3

Pregnancy and birth-related outcomes in the intervention versus contemporary control group

Outcomes	Intervention N = 16	Contemporary control N = 38	P value *
Infant sex, %			0.77
Female	43.7	50.0	
Male	56.3	50.0	
Birth weight, grams, mean (SD)	3,199 (433)	3,167 (506)	0.53
Fetal growth, %			0.85
Large-for-gestational age (>90 th pctl)	6.3	5.3	
Small-for-gestational age (<10 th pctl)	18.8	13.2	
Appropriate-for-gestational age (10–90 th pctl)	75.0	81.6	
Birth length, cm, mean (SD)	49.2 (2.2)	47.1 (5.4)	0.0006
Gestational age at delivery, weeks, mean (SD)	38.4 (0.89)	38.2 (1.56)	0.63
Preterm birth, %	0	10.5	0.31
Apgar score at 1 min, mean (SD)	7.6 (1.5) **	7.7 (1.3)	0.42
Apgar score at 5 min, mean (SD)	8.7 (0.7) **	8.9 (0.3)	0.20
C-section delivery, %	25.0	31.6	0.75
NICU admission, %	6.3	7.9	1.00
Gestational diabetes diagnosis, %	0	7.9	0.85

Abbreviations: SD = standard deviation, pctl = percentile, CM = centimeter, min = minute(s), NICU = neonatal intensive care units.

* P-values for categorical variables were based on chi-square tests of independence or Fisher's exact test if there were small cells. P-values for continuous variables were based on independent sample t-tests.

**
N=15

Table 4

Physical activity and dietary intake among intervention participants

Outcomes	Early Pregnancy (<20 wks)	Pregnancy (32 wks)	Postpartum (12 wks)
Physical activity	n=15	n=13	n=11
Steps/day, mean (SD)	6,599 (2,266)	6,219 (2,407)	7,773 (2,470)
Total minutes in moderate-vigorous physical activity, mean (SD) [§]	48.6 (28.3)	40.0 (22.9)	59.0 (25.3)
Total energy expenditure, kcals, mean (SE) * ^{§¶}	2,325 (58.4)	2,462 (62.8)	2,524 (68.1)
Dietary intake	n=16	n=14	n=14
Total caloric intake, kcals/day, mean (SD)	1,925 (176)	1,797 (189)	1,641 (189)
% of calories from total fat, mean (SD)	34.4 (7.3)	34.8 (7.6)	34.3 (5.7)
% of calories from saturated fat, mean (SD)	11.1 (3.7)	11.1 (2.2)	11.4 (2.7)
Total dietary fiber, grams/day, mean (SE) **	11.9 (0.8)	12.0 (0.9)	11.4 (0.9)
Total fruit, servings/day, mean (SE) **	2.5 (0.6)	1.9 (0.7)	1.7 (0.7)
Total vegetables, servings/day, mean (SE) **	2.5 (0.3)	2.0 (0.3)	1.8 (0.3)
Dairy, servings/day, mean (SE) **	1.2 (0.2)	1.2 (0.2)	1.4 (0.2)
Whole grains, servings/day, mean (SE) **	0.7 (0.2)	0.7 (0.2)	0.4 (0.2)
Lean meat, servings/day, mean (SE) **	1.9 (0.5)	2.7 (0.5)	2.1 (0.5)
Sweetened beverages, servings/day, mean (SE) **	1.7 (0.3)	1.3 (0.3)	1.7 (0.3)

Abbreviations: SE = standard error, SD = standard deviation.

* Adjusted for prepregnancy body mass index.

** Adjusted for total caloric intake.

[§] P<0.05 based on paired t-tests to make within-subject comparisons between baseline and 12-week postpartum measurements (n=11).[¶] P<0.05 based on paired t-tests to make within-subject comparisons between baseline and 32-week measurements (n=13).

Table 5

Participant satisfaction with the intervention, mean (SD) or % (n)

Items	32-wk gestation n = 13	12-wk postpartum n = 14
Overall program rating (1=poor, 4=excellent)	3.8 (0.4)	3.8 (0.4)
Recommend to friend, % (n) yes	100% (13)	100% (14)
Helpfulness of programmatic content or format [*] (1=none, 2=some, 3=a lot)		
Nutrition content from one-on-one session	2.6 (0.7)	2.8 (0.5)
Exercise content from one-on-one session	2.6 (0.5)	2.8 (0.5)
Keeping a healthy eating log	1.9 (0.3)	1.6 (0.5)
Keeping an exercise log	2.0 (0.7)	1.8 (0.6)
Wearing a pedometer	2.2 (0.6)	1.9 (0.8)
Setting eating goals	2.4 (0.7)	2.2 (0.5)
Setting exercise goals	2.0 (0.7)	2.2 (0.4)
Meal planning	2.3 (0.7)	2.1 (0.7)
Problem solving strategies	2.1 (0.7)	1.9 (0.5)
Stress management skills	2.1 (0.7)	2.2 (0.6)
Time management skills	1.9 (0.6)	2.2 (0.6)
Reading food labels	2.5 (0.7)	2.1 (0.5)
Regular weighing	2.6 (0.5)	2.3 (0.6)
Recipes from class	1.7 (0.6)	2.0 (0.7)
Asking for support/help for healthy eating	1.8 (0.7)	1.7 (0.5)
Asking for support/help for exercise	1.6 (0.7)	1.9 (0.7)
Money saving tips for food purchasing	2.4 (0.5)	2.4 (0.6)
Group sessions	2.7 (0.5)	NA
Phone calls	2.2 (0.6)	2.4 (0.5)
Number of group sessions was, % (n)		
Too few	8.3% (1)	
About right	91.7 (11)	
Too many	0% (0)	NA
Number of phone calls was, % (n)		
Too few	0% (0)	0% (0)
About right	92.3% (12)	90.9% (10)
Too many	7.7% (1)	9.1% (1)

^{*} Helpfulness of programmatic content was only rated by those who reported the activity (range: 8–13).