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Nutrition and Exercise Prevent Excess Weight Gain in Overweight Pregnant Women

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Abstract

Purpose—To determine the effect of a Nutrition and Exercise Lifestyle Intervention Program (NELIP) for overweight (OW) and obese (OB) pregnant women on pregnancy weight gain, birth weight, and maternal weight retention at 2 months postpartum.

Methods—This is a single-arm intervention matched by prepregnant body mass index, age, and parity to a historical cohort (4:1). Women with a prepregnancy body mass index of ≥25.0 $kg \cdot m^{-2}$ (N = 65) participated in a NELIP starting at 16–20 wk of pregnancy, continuing until delivery. NELIP consisted of an individualized nutrition plan with total energy intake of approximately 2000 $kcal \cdot d^{-1}$ (8360 $kJ \cdot d^{-1}$) and 40%–55% of total energy intake from carbohydrate. Exercise consisted of a walking program (30% HR reserve), three to four times per week, using a pedometer to count steps. Matched historical cohort (MC; N = 260) was from a large local perinatal database.

Results—Weight gained by women on the NELIP was 6.8 ± 4.1 kg (0.38 ± 0.2 $kg \cdot wk^{-1}$), with a total pregnancy weight gain of 12.0 ± 5.7 kg. Excessive weight gain occurred before NELIP began at 16 wk of gestation. Eighty percent of the women did not exceed recommended pregnancy

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weight gain on NELIP. Weight retention at 2 months postpartum was 2.2 ± 5.6 kg with no difference between the OW and the OB women on NELIP. Mean birth weight was not different between NELIP (3.59 ± 0.5 kg) and MC (3.56 ± 0.6 kg, $P > 0.05$).

Conclusions—NELIP reduces the risk of excessive pregnancy weight gain with minimal weight retention at 2 months postpartum in OW and OB women. This intervention may assist OW and OB women in successful weight control after childbirth.

Keywords

INTERVENTION; HEALTHY LIFESTYLE; OBESE; GESTATION

Overweight (body mass index [BMI] ≥25.0 to 29.9 kg·m^{-2}) (41) and obesity (BMI ≥30.0 kg·m^{-2}) (41) have been identified as major public health issues because the prevalence of obesity has been increasing worldwide at an alarming rate (13). Excess weight gain during gestation and failure to lose that weight after pregnancy are identifiable predictors of long-term obesity, cardiovascular disease, and type 2 diabetes (13,34). Over-weight (OW) mothers experiencing weight retention also start their next pregnancy with a higher early rate of weight gain (29). Excessive weight gain during pregnancy places women at higher risk for pregnancy-induced hypertension (32) and gestational diabetes mellitus (5).

Total weight gain recommended for OW pregnant women is 7–11.5 kg (20), with a suggested weight gain in the first trimester of 0.91 kg (18). For obese (OB) women, the total weight gain during pregnancy recommended is at least 6 kg (20), with no upper limit of gain. Many researchers use 11.5 kg as the upper limit in assessing excessive weight gain for OB pregnant women because this is the same upper recommendation for OW women (6,12,36).

Maternal weight gain and prepregnancy BMI have been positively correlated with birth weight (19). Maternal obesity is an independent risk factor for macrosomic infants (birth weight >4.0 kg) (4), perhaps imparting more risk for large babies than for glucose intolerance (19). Large babies are at greater risk for obesity later in life, together with related comorbidities, such as type 2 diabetes (30). Statistics shows that children of OB mothers are twice as likely to be large for gestational age at birth and that large for gestational age babies are more likely to be OB preschoolers (19). The direct influence of the fetal environment on lifelong health and the risk of chronic disease (8,30) cannot be ignored because it has been suggested that many intrauterine influences can be transmitted to the next generation nongenetically, and thus many of these modifiable undesired effects may be reversed and prevented (22).

Pregnancy-related obesity can lead to a lifetime of unhealthy weight for the mother and her family. These concerns are reflected in the recent opinion statement from the American College of Obstetricians and Gynecologists on obesity during pregnancy, which recommends aggressive preventative management in all OW and OB women before conception, during pregnancy, and after delivery (3). This strong opinion reinforces the idea that a practical solution for obesity prevention in both mother and offspring may lie with the study of evidence-based interventions that are viable in the real world but conducted with scientific rigor (26) to promote long-term participation and effective knowledge translation. Unfortunately, there are very few studies reporting success in the prevention of excessive weight gain because of an intervention program specifically designed for OW or OB pregnant women.

The purpose of the present study was to investigate the effects of a combined Nutrition and Exercise Lifestyle Intervention Program (NELIP) on pregnancy weight gain, birth weight, and weight retention early postpartum in OW and OB women. We defined excessive gestational weight gain on NELIP as >10.6 kg because we subtracted 0.91 kg (the recommended weight gain for first trimester) from the maximum total weight gain recommended (11.5 kg) for OW and OB women, which coincides with our intervention time frame during pregnancy. It was hypothesized that NELIP would prevent excessive pregnancy weight gain (≤10.6 kg) and minimize weight retention at 2 months postpartum. To determine whether OW women respond differently or similarly to OB women placed on the same intervention (NELIP), participants with a prepregnancy BMI of ≥25.0 to 29.9 $kg{\cdot}m^{-2}$ (OW) were compared with those women with a prepregnancy BMI of ≥30.0 $kg{\cdot}m^{-2}$ (OB). For comparative purposes, to form a matched historical cohort (MC) group, we collected hospital and birth record information at random from a large local perinatal database of women screened for chronic disease and delivering singleton births, who matched our intervention women by prepregnant BMI, maternal age, and parity during this same time frame.

RESEARCH METHODS AND PROCEDURES

Intervention—Recruited Participants

Seventy-five women with a prepregnancy BMI between 25.0 and 29.9 $kg{\cdot}m^{-2}$ (OW) and a BMI ≥30 $kg{\cdot}m^{-2}$ (OB), between 16 and 20 wk of gestation, were recruited for the intervention through physician and midwife referrals, posters, and advertisements in newspapers in London, Ontario, Canada. Before being enrolled in the study, women were medically prescreened (PARmed-X for Pregnancy) (28) by their health care provider. Women with a multiple gestation, chronic disease, or other contraindications to exercise were excluded (28). Ethics approval was obtained from the Human Research Ethics Board for Health Sciences at The University of Western Ontario, and written informed consent was obtained from participants.

At 16–20 wk of gestation, each volunteer participated in a peak exercise test on a treadmill to volitional fatigue to assess peak aerobic capacity, as detailed elsewhere (28). The results of the peak exercise test were used to prescribe the appropriate intensity (30% HR reserve) of each individual's walking program (11,28).

Intervention—NELIP

Individualized nutrition intervention program—A baseline assessment of each woman's usual food intake occurred at 16–20 wk of gestation before the start of the program. A consecutive 3-d food intake record, which included one weekend day, was collected (15). The food records were analyzed for nutritional content and caloric intake using the ESHA Food Processor SQL (version 9.8; Canadian Nutrient File database).

Each woman met with the study dietitian for nutrition assessment and counseling, and an individualized nutrition intervention plan was developed from the baseline food intake assessment, participant preferences, and the NELIP Meal Plan. The NELIP Meal Plan is an eating guide (adapted from the medical nutrition therapy given to women whose conditions were diagnosed as gestational diabetes mellitus) (17,37) with practical educational tools specifically developed to promote healthy eating during pregnancy. On a weekly basis, each participant completed a 1-d food diary record form (15). These data were used to examine dietary compliance and to give individualized feedback to each woman as needed.

To prevent excessive gestational weight gain, the specific goals of the nutrition program were as follows: 1) to individualize the total energy intake to approximately 2000 $kcal \cdot d^{-1}$ (8360 $kJ \cdot d^{-1}$) while taking into account the usual energy intake as indicated by each dietary assessment (including 3-d food intake records) with a restriction of not more than 33% total energy intake; 2) to individualize the total carbohydrate intake to 40%–55% of total energy intake while distributing carbohydrate intake throughout the day with three balanced meals and three to four snacks per day, emphasizing complex carbohydrates and low-glycemic index foods; 3) to individualize the total fat intake to 30% of total energy intake (substituting monounsaturated fatty acids for saturated and trans-fatty acids), with the remaining 20%–30% of energy dedicated to protein intake; and 4) to meet micronutrient and fluid needs recommended during pregnancy (21).

Individualized exercise program—Once the peak exercise test was complete, women were familiarized with the controlled walking program by a kinesiologist, using their target HR (30% peak HR reserve) (11). We used this mild walking program to facilitate compliance (11). At the first exercise session, each woman wore a portable HR monitor (Polar Pacer, Polar Electro Oy, Kempele, Finland), and HR was monitored throughout the workout to confirm the appropriate exercise intensity. The first week consisted of 25 min of walking per session, three to four times per week. Each subsequent week thereafter, the exercise time increased by 2 min, until a maximum of 40 min was reached. Forty minutes of exercise was maintained until delivery (three to four times a week). The HR during exercise and the duration of each exercise session were recorded in exercise logs. In addition, each subject wore a pedometer (Digi-walker2; Accusplit, Inc., San Jose, CA) and recorded steps walked (7 d at the start of NELIP) and during at least one exercise session per week until delivery. Pedometers were placed in a horizontal plane, facing laterally in line with the side seams on the waist band.

Measurements—Body weight was rounded to the nearest 0.1 kg (Health o meter®, Bridgeview, IL). Body weight recorded at the time of the peak exercise test was considered the preprogram weight. In addition, self-reported prepregnancy weight and height were used to calculate prepregnancy BMI ($kg \cdot m^{-2}$). Ethnicity was also self-reported. Women were weighed in the laboratory on a weekly basis.

Within 6–18 h after delivery, newborn birth weight, length, and complications during delivery were recorded. At 2 months postpartum, the women returned to the laboratory to be weighed.

MC (control)—Retrospectively, we examined medical and birth records from a large local perinatal database from women who delivered singleton births in our region during the same period. Those women who had chronic diseases or any medical impairment to exercise as recorded on their medical charts were not considered. Once reviewed, we directly matched medical charts at random to our intervention cohort by prepregnancy BMI, maternal age, and parity, obtaining data from four matched controls per intervention participant. We also recorded prepregnancy body mass, birth weight, and gestational age at delivery for previous singleton pregnancies for those controls who were multiparous. By subtracting the prepregnancy weight of the previous pregnancy from the next, we were able to calculate weight retention between pregnancies.

Study design and statistical analyses—Our study design was based on Olsen et al. (31), who recruited 50 OW women, with a 90% power to detect a 50% reduction from the observed 71% in a historical control group ($n = 91$) who gained excessive weight during pregnancy, with a 5% false-positive rate using a two-sided test of significance. We therefore defined a successful intervention program with no excessive gestational weight gain to be ≥65% of the participants.

The Student *t*-test and the Mann–Whitney nonparametric statistical comparison of means were performed comparing the MC with the NELIP group and the OW women compared with the OB women on continuous variables. The χ^2 test (conditional logistic regression) was performed on the percentage of babies born weighing between 4.0 and 4.5 kg, greater than 4.5 kg, and less than 2.5 kg, respectively, comparing the NELIP women with the MC. Significance was accepted at $P < 0.05$, and all results are presented as mean ± SD. All statistics were analyzed using SPSS (version 14.0 for Windows; SPSS, Inc., Chicago, IL, 2005).

RESULTS

Prepregnant—NELIP participants

Of the 75 women recruited to the NELIP group, 10 dropped out of the program because of lack of time and other family commitments (13% dropout rate). Age and physical characteristics before the current pregnancy for the 65 remaining women are shown in Table 1. Because they were matched, no difference existed between the perinatal database controls (MC; $N = 260$) and the NELIP cohort ($N = 65$; Table 1). Fifteen percent of the women in the OB group were OB class III before pregnancy (BMI ≥40.0 kg·m^{-2}) (41). For the total population of OW and OB NELIP women, 62% had previous pregnancies, most of whom retained an average of 10.3 ± 10.9 kg between pregnancies. When the two NELIP groups were compared, 55% of the OW women and 68% of the OB women had at least one previous pregnancy. Of those multiparous women in the OW group, 94% retained weight from previous pregnancies, which was on average 8.0 ± 6.6 kg. In the OB group, 76% retained weight from a previous pregnancy, which was on average 12.0 ± 13.2 kg. Sixtyeight percent of both NELIP groups reported an unstable body weight, trying various unsuccessful methods of weight loss in the year before the index pregnancy (data not shown). The multiparous NELIP women retained an excessive amount of weight from a previous pregnancy compared with the MC women (Table 1).

In the NELIP OW women, ethnic diversity was represented by 26% of total participants; 63% of whom were Aboriginal (First Nations, Metis, or Inuit) and 37% were of Middle Eastern, Hispanic, Asian, or African descent. In the NELIP OB group of women, 38% were of diverse ethnic backgrounds; 54% of whom were Aboriginal descent and 46% were of Hispanic, East Indian, or Asian descent. Ethnicity was not available from the medical records of the MC.

Pregnant—NELIP participants

Table 2 presents the characteristics of the women during the NELIP. The amount of weight gained during pregnancy before NELIP was similar in the OW and OB groups (4.3 ± 2.7 and 3.8 ± 3.2 kg, respectively, $P = 0.5$), although higher than the recommended 0.91-kg weight gain for the first trimester (36). Eighty percent of NELIP participants did not gain greater than 10.6 kg during the intervention. Mean weight gained on NELIP was 6.8 ± 4.1 kg for the entire group, with no difference between the OW and the OB women (7.8 ± 3.8 vs 5.9 ± 4.3 kg, respectively, $P = 0.06$). Weekly weight gain on NELIP was 0.38 ± 0.23 $kg \cdot wk^{-1}$ for all and 0.43 ± 0.21 kg for the OW group and 0.33 ± 0.24 $kg \cdot wk^{-1}$ for the OB group ($P = 0.06$). This compares favorably with the recommended weekly weight gain of 0.3 to 0.4 kg during the second and third trimesters for OW and OB women (18).

NELIP participants decreased their mean daily total energy intake from 2228.0 ± 474.6 to 1900.2 ± 343 kcal, and daily carbohydrate intake dropped from 318.5 ± 155.1 to 259.1 ± 93.9 g while increasing the percent of daily energy from protein from 16.9% ± 2.4% to 18.4% ± 2.3% ($P < 0.05$; Table 3). On NELIP, the OW women reported caloric intakes of 2031.9 ± 401.6 $kcal \cdot d^{-1}$, whereas the OB women reported an average daily total of 1802.9 ± 246.5 $kcal \cdot d^{-1}$ ($P = 0.06$). The nutrition profiles for each group while on NELIP were congruent with the overall goals of the nutrition program.

In our population of OW and OB women, average daily step counts from pedometer readings before the intervention program was approximately 5677.6 ± 1738.0 steps, with no difference between OW and OB groups (data not shown). For all NELIP women, the step counts at 25 min (initial exercise session) were, on average, 2861 ± 287.7 steps, which then increased to 4406.9 ± 461.0 steps at 40 min per session, with no difference between the groups (OW = 4460.3 ± 355.8 steps and OB = 4344.5 ± 564.1 steps, $P = 0.46$). When mean daily steps were added to the steps taken at the end of the program (40 min of structured walking), the women were taking more than 10,000 steps. Frequency of walking was 2.84 ± 0.87 times per week, with no difference between groups (OW = 2.98 ± 0.91 times per week and OB = 2.62 ± 0.88 times per week, $P = 0.31$).

Birth outcome

Infant birth weight and gestational age at delivery did not differ between the NELIP and the MC groups (Table 4). The percentage of babies born weighing between 4.0 and 4.5 kg to the

NELIP women was not different from the MC (15.4% vs 15.6%, respectively, $P = 1.0$). However, when stratified by BMI, 3.2% of the OW NELIP women had babies weighing between 4.0 and 4.5 kg compared with 18% of the OW MC ($P = 0.048$). Twenty-six percent of the OB NELIP women had babies weighing between 4.0 and 4.5 kg compared with 13.3% in the OB MC ($P = 0.071$). The percentage of NELIP babies born weighing more than 4.5 kg was not different between the NELIP women (3.1%) compared with the MC (3.9%, $P = 1.0$), regardless of BMI. No babies born to the NELIP women weighed less than 2.5 kg, whereas 3.5% of the babies born to the MC (OW = 4.0% and OB = 2.9%) were in this weight category. The rate of cesarean delivery was 7% for the MC group and 4.6% for the NELIP women. No other complications were reported in the NELIP women.

Postpartum

NELIP women at 2 months postpartum (Table 5) retained a mean of 2.2 ± 5.6 kg (range = −12.7 to 13.6 kg), with no difference between the OW group (3.0 ± 5.3 kg, range = −5.9 to 13.6 kg) and the OB group (1.5 ± 6.0 kg, range = −12.7 to 11.8 kg; $P = 0.27$). Fifty-three percent of the NELIP women were within 2 kg of prepregnancy body mass at 2 months after delivery.

DISCUSSION

To our knowledge, NELIP is the first study that quantified an individualized walking program in combination with nutritional control specifically designed for preventing excessive pregnancy weight gain and postpartum weight retention in OW and OB women. Our 80% success rate in preventing excessive weight gain in this convenience sample, many of whom had difficulty with weight loss programs in the year before the current pregnancy, is important because many of the multiparous women (84%) had experienced excessive weight retention (10.3 kg) from previous pregnancies. In addition, before our program, our cohort had already experienced excessive weight gain (4.5 kg), which is substantially more than the guideline of 0.91 kg for OW women in the first trimester (18,36). However, while on NELIP, subsequent weight gain was within the recommended guidelines of 0.3 to 0.4 $kg \cdot wk^{-1}$ for OW women in the second and third trimesters (18), with our cohort gaining an average of 0.38 $kg \cdot wk^{-1}$.

Total weight gain recommended for pregnant women with a BMI of >27.0 $kg \cdot m^{-2}$ is 7.0–11.5 kg (20), although these standards are currently under review (7). NELIP resulted in a mean weight gain of 6.8 kg, with a mean total pregnancy gain of 12.0 kg, which included the amount of weight gained before entry into the NELIP. Because NELIP women gained excessive weight before our program, an intervention of this type would be of increased benefit if started earlier in pregnancy. However, during the first trimester, many women experience nausea, vomit, and/or extreme fatigue. Because of these pregnancy-induced maladies, initiating lifestyle changes in nutrition and exercise during the first trimester may not be effective in this cohort of women. In addition, all of our women were medically prescreened for contra-indications to exercise before entering the program by their family physician or midwife, which delayed the initiation of NELIP. Thus, the most practical time to start our program occurred between 16 and 20 wk of gestation, which still ensured an intervention of at least 18 wk in duration. If recruitment tactics permit, it may be beneficial for other health care centers to begin a lifestyle program earlier, such as during 12–14 wk of gestation, after medical prescreening has occurred.

Step counts for sedentary individuals are <5000 daily steps, and 5000–7499 daily steps are classified as "low active" (38). Our population was in the sedentary to low active range before NELIP. By the end of the program, women were taking more than 10,000 steps, bringing them into the "active" category (38). We found from a previous study that many pregnant women use walking as the primary mode of recreational activity (27). Initiating a mild walking program during pregnancy, especially with OW and OB women, combined with nutritional control may promote healthy lifestyle changes.

Because there is a strong association between pregnancy weight gain and postpartum weight retention (33), it is imperative that excessive gestational weight gain be prevented. Reducing weight retention after delivery may also help to sever the link between excessive pregnancy weight gain and risk for further obesity. Our cohort retained a mean of only 2.2 kg at 2 months postpartum. After the initial weight loss that occurs after delivery, by 6 wk postpartum, one in six women will retain at least 5 kg from prepregnancy (33). This period (approximately 8 wk) is when many women have their first medical examination after delivery and may be a critical time for the assessment of weight retention, providing an opportunity for health care providers to reinforce healthy lifestyle changes in the early postpartum period.

Few studies have examined the effectiveness of an intervention designed to prevent excessive weight gain during pregnancy, and the reported success rates have been low (2,31). To date, only three successful intervention programs for OW or OB pregnant women have been reported. The first was a case–control intervention of OB women using extra midwife visits, motivational behavior change objectives, and access to aqua aerobic classes once or twice per week and showed an average weight gain of 8.7 kg with only 36% of the women gaining the original objective of <7 kg (9). Another study reported dietary intake in a small randomized controlled trial using 10 h of dietary counseling as an intervention, which succeeded in restricting gestational weight gain to 6.6 ± 5.5 kg in OB women; however, activity levels, advice on exercise during pregnancy, and intervention for exercise were lacking (39). The inclusion of mild to moderate exercise is an important part of an intervention during pregnancy because dietary control alone may potentially reduce not only fat mass but also fat-free mass. Because pregnant women with a high BMI are at risk for gestational diabetes, decreasing muscle mass and lack of physical activity may lead to problems with glucose uptake due to insulin resistance. In addition, the frequency of exercise classes is also important because sessions of only one to two times per week will not give aerobic benefit to the participants (28). Thus, it is imperative to investigate the effects of lifestyle change using a specific intervention incorporating a combination of dietary control and exercise (three to four times per week) during pregnancy on maternal body weight gain in OW and OB pregnant women.

The third study examined OB participants whose conditions were diagnosed with gestational diabetes (not yet on insulin) who self-selected into a diet-alone group (medical nutrition therapy, with caloric needs of 20 kcal·kg^{-1} and 40%–45% of total energy from carbohydrates) or a diet plus exercise group (60% maximum aerobic capacity, once per week in the laboratory, and six times per week unsupervised, using walking or semirecumbent cycling) (4). Using exercise logs, the exercising group reported an average of 153 ± 91.4 min·wk^{-1} of exercise time. Weight gain per week was lower in the diet and exercise group (0.1 ± 0.4 kg) than in the diet-alone group (0.3 ± 0.4 kg) (4). No control group was used in this intervention study.

Our dietary intervention was similar (4) in that a controlled carbohydrate intake and a modification of the medical nutrition therapy program given to women with gestational diabetes (17,37) were used. Placing OW and OB pregnant women on a specific nutritional program such as this, with portion control and smaller meals more often, which included specific combinations of carbohydrate and protein, partnered with the mild walking program, also prevented excessive weight gain in our cohort of OW and OB women who did not have gestational diabetes.

Birth weight is directly associated with BMI later in life (8), with a slightly higher BMI in individuals born small (<2.5 kg) but a larger prevalence of overweight and obesity in those born large (>4.0 kg) (8). The birth weight of infants from our OW and OB women did not differ from the 50th percentile for birth weight and length (24) and were along the zero *z*-line for BMI at birth for both males and females (40). Although the percentage of babies born weighing between 4.0 and 4.5 kg were not different from the MC, when stratified by BMI, our NELIP decreased the incidence of babies born in this weight range to OW women compared with the MC and others who reported an incidence of 12% (14). However, 26.5% of the OB NELIP women had babies weighing between 4.0 and 4.5 kg compared with 13.3% in the OB MC. Others have reported the incidence of large babies to be from 17% to 31% in OB women (25). Although our cohort of OB women were within the percent range of having large babies found in the literature, it is surprising that this incidence was so high. It may be that our program assisted in decreasing birth weight from more than 4.5 kg into the range between 4.0 and 4.5 kg, which would have increased the numbers in that category, although not statistically significant.

Babies born <2.5 kg are also at risk for obesity later in life, perhaps related to a period of catch-up growth and associated risk for central or truncal obesity, which increases cardiovascular risk later in life (30). None of our NELIP women gave birth to babies in this category, whereas the prevalence in the MC was 3.5%. When high prepregnancy BMI is combined with excessive gestational weight gain (>0.79 kg·wk^{-1}), the prevalence of giving birth to a small baby is as high as 9% (12). Combining important lifestyle changes such as optimal nutrition and mild exercise for OW and OB women is likely to result in healthy fetal growth and development.

We recognized that there are limitations to our study design. This was not a randomized controlled trial. Because of the overwhelming evidence that excessive weight gain and weight retention in this vulnerable group of women links the metabolic influence of the mother to the fetal environment, the best solution for obesity prevention for a mother and her offspring may begin with the study of evidence-based interventions. Individuals who volunteer for a research study may be more health conscious than the general population, which also includes a control group. Because our MC group only included medical records, we screened for chronic diseases and contraindications to walking (bed rest) before they were matched to the intervention group. All women in our region have the same access to health care providers and programs offered in our community. Comparison control groups from the literature are small because many women are disappointed at being randomized into a control group (39), women are given the opportunity to self-select (4), or women are not given a choice when specific clinics receive the intervention (23). Regardless, we have chosen to match our cohort to historical controls by prepregnancy BMI, age, and parity. These are important factors that may influence birth outcome and postpartum weight retention (10). This method has been used in other intervention type studies (9,10,16). Matching on these factors and using four controls per intervention participant with a rigorous indication of rate of success (≥65%) strengthen the results of our intervention.

Other limitations include self-reported prepregnancy height and body mass, which tend to be slightly different from when directly measured; however, these approaches have been used in the literature (1). It was unfortunate that we had no ethnicity information from our MC as others have reported that Aboriginal women (16), Hispanic, and other ethnicities (35) are at increased risk for excessive weight gain and large or small babies at delivery. All of the women in our study had access to identical health care information and delivered in the same city during the same time frame. Another limitation may have been related to underreporting of food intake and overreporting of pedometer steps or frequency of exercise.

In conclusion, our hypotheses were confirmed, in that, our NELIP prevented excessive weight gain and promoted minimal weight retention at 2 months postpartum in OW and OB pregnant women. Despite challenges related to the initiation of the NELIP, this is a unique program offering a practical option for weight management in pregnant women at risk for excessive weight gain.

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TABLE 1

Characteristics of OW and OB NELIP women before the index pregnancy compared with the MC.

Groups	Height (cm)	Age (yr)	Prepregnancy Mass (kg)	Prepregnancy BMI (kg·m^{-2})	Previous Pregnancy (%)	Weight Retention[a] (kg)
NELIP (all), N = 65	165.9 ± 6.6	32.4 ± 4.0	88.3 ± 17.7	32.1 ± 6.2	62	10.3 ± 10.9*
OW, n = 31	166.2 ± 6.9	31.8 ± 3.6	75.8 ± 6.7	27.4 ± 1.6	55	8.0 ± 6.6*
OB, n = 34	165.6 ± 6.5	32.8 ± 4.3	99.8 ± 16.8	36.4 ± 5.6	68	12.0 ± 13.2*
MC (all), N = 260	164.0 ± 6.8	31.9 ± 3.5	85.5 ± 16.1	33.4 ± 6.3	62	4.2 ± 7.9
OW, n = 124	164.6 ± 6.3	32.1 ± 3.2	74.3 ± 7.4	27.4 ± 1.7	55	4.4 ± 7.4
OB, n = 136	163.5 ± 6.9	31.8 ± 3.6	96.8 ± 14.2	36.2 ± 4.8	68	4.0 ± 8.6

NELIP started at 16–20 wk of pregnancy. Values are presented as mean ± SD.

[a] Weight retention is the self-reported weight retained because of a previous pregnancy for the NELIP cohort. Weight retained for the MC was obtained from medical records of last two consecutive pregnancies.

* Different from MC, $P < 0.05$.

TABLE 2

Physical characteristics at the start and during NELIP for OW and OB pregnant women.

Groups	Body Mass (kg) at the Start of NELIP	Weight Gain (kg) before NELIP	Weight Gain (kg) on NELIP	Total Weight Gained (kg)	Weekly Weight Gain on NELIP (kg)
All, $N = 65$	92.4 ± 17.4	4.0 ± 3.0	6.8 ± 4.1	12.0 ± 5.7	0.38 ± 0.23
OW, $n = 31$	80.1 ± 7.4	4.3 ± 2.7	7.8 ± 3.8	13.1 ± 4.5	0.43 ± 0.21
OB, $n = 34$	103.6 ± 16.4	3.8 ± 3.2	5.9 ± 4.3	11.0 ± 6.5	0.33 ± 0.24

NELIP started at 16–20 wk of pregnancy. Values are presented as mean ± SD.

TABLE 3

Average daily dietary intake profiles (3-d food intake records) of the OW and OB women before participating in NELIP and the average daily dietary intake profiles during NELIP (weekly 24-h records).

Groups	Total Energy Intake (kcal·d^{-1})	Total CHO Intake (g·d^{-1})	Percent Energy from CHO	Percent Energy from Fat	Percent Energy from Protein
Before NELIP					
All	2228.0 ± 474.6	318.5 ± 155.1	57.1 ± 25.5	32.1 ± 4.8	16.9 ± 2.4
OW	2366.4 ± 523.6	372.0 ± 213.7	63.0 ± 37.1	32.5 ± 5.5	16.7 ± 2.3
OB	2115.7 ± 413.6	275.1 ± 62.4	52.2 ± 7.7	31.8 ± 4.3	17.1 ± 2.5
During NELIP					
All	1900.2 ± 343.0[a]	259.1 ± 93.9[a]	54.5 ± 13.8	31.7 ± 3.4	18.4 ± 2.3[a]
OW	2031.9 ± 401.6	292.9 ± 128.4	57.0 ± 20.1	32.1 ± 3.4	17.8 ± 1.7
OB	1802.9 ± 246.5[a]	231.6 ± 38.5[a]	52.0 ± 3.9	31.5 ± 3.5	18.8 ± 2.6[a]

One kilocalorie equals 4.18 kJ. Values are presented as mean ± SD.

[a]Different from values before NELIP.

CHO, carbohydrates.

TABLE 4

Birth outcome for those women who participated in NELIP compared with MC.

Groups	Birth Weight (kg)	Gestational Age at Birth (wk)	Babies 4.0–4.5 kg (%)	Babies 9 4.5 kg (%)	Babies G 2.5 kg (%)
NELIP (all), $N = 65$	3.590 ± 0.5	39.3 ± 1.4	15.4	3.1	0
OW, $n = 31$	3.538 ± 0.4	39.6 ± 1.1	3.2*	3.2	0
OB, $n = 34$	3.648 ± 0.6	39.0 ± 1.8	26.5	2.9	0
MC, $N = 260$	3.564 ± 0.6	39.0 ± 2.0	15.6	3.9	3.5
OW, $n = 124$	3.576 ± 0.6	39.0 ± 1.4	18.0	3.1	4.0
OB, $n = 136$	3.552 ± 0.6	39.1 ± 2.2	13.3	4.7	2.9

NELIP started at 16–20 wk of pregnancy. Values are presented as mean ± SD.

*Different from MC, $P = 0.048$.

TABLE 5

Body mass, BMI, and weight retained at 2 months postpartum for OW and OB women who participated in NELIP.

Group NELIP	Body Mass (kg)	Weight Retained (kg)	BMI ($kg \cdot m^{-2}$)	Change in BMI ($kg \cdot m^{-2}$)
All	89.8 ± 16.8	2.2 ± 5.6	32.8 ± 6.0	0.8 ± 2.1
OW	78.7 ± 8.3*	3.0 ± 5.3	28.6 ± 2.6*	1.1 ± 1.9
OB	100.2 ± 16.0	1.5 ± 6.0	36.7 ± 5.6	0.6 ± 2.2

Values are presented as mean ± SD. Weight retained for the women who participated in NELIP was calculated by subtracting 2 month postpartum from prepregnancy body mass for each participant. Change in BMI for the women who participated in NELIP is 2 months postpartum minus prepregnancy.

*Different from OB, $P < 0.05$.