Interpregnancy Weight Retention Patterning in Women Who Breastfed

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Abstract

This study compares weight change in lactating women with an 18-month interpregnancy interval with women who also breastfed but did not have an immediate subsequent pregnancy. Cases were women who breastfed an index infant for 6 months and subsequently became pregnant within 18 months (cases = 25), and the controls also breastfed an index infant for 6 months but had no ensuing pregnancy (controls = 20) within 18 months. The pattern of postpartum weight retention following the initial pregnancy was not statistically different in cases compared to the controls. However, following their ensuing subsequent pregnancy, cases were 1.3 kg heavier than their average weight after their baseline pregnancy (P = 0.02). The best predictor of this greater weight was their weight change during the interpregnancy interval (P = 0.03). Total weight gain during the gestational period of the subsequent pregnancy was not associated with the greater weight following the subsequent pregnancy. Likewise, estimates of the amount of energy as calories or physical activity levels were not significant predictors of this greater weight following the subsequent pregnancy. These findings suggest that monitoring of postpartum weight, even in breastfeeding women, is essential. These findings indicate that breastfeeding women begin the next postpartum interval weighing more than the amount observed in the initial postpartum period.


Key Words: weight retention pattern; lactation; pregnancy; obesity; postpartum weight

INTRODUCTION

The contribution of interpregnancy interval length on postpartum weight retention is largely unknown. Even more specifically, it is not known whether breastfeeding women with a relatively short interpregnancy interval have a different weight retention pattern than other breastfeeding women who did not have the shorter interpregnancy interval.

Although the interpregnancy interval has been examined for its contribution to risk of preterm labor [1], low birthweight [2-5], or other poor outcomes of the newborn [6,7], interpregnancy interval rarely has been considered for its impact on maternal status, including an association with postpartum weight retention pattern. In one of the few examples where maternal status was considered, Greene et al. [8] reported that weight gain in the first pregnancy was related to weight change between pregnancies among women, but the weight pattern during interpregnancy interval was not measured and the interpregnancy interval was quite wide, up to 6 years. Furthermore, breastfeeding characterization, which might affect the interpregnancy weight pattern, was identified only by whether women left the hospital breastfeeding or not.

The role of the interpregnancy interval upon weight retention is uncertain for women who breastfed. This is hardly surprising given inconsistent information about the role of lactation in postpartum weight retention in general. Some studies of lactation and weight retention reported a greater likelihood of weight loss with longer duration of lactation [9-11,14,15], with a diminution in the rate of loss as the postpartum period became more protracted. Other studies reported no difference between lactation practices and postpartum weight loss [12-15], or found that women who formula-fed rather than breastfed their infants had greater weight loss in the postpartum period [16-19]. In a longitudinal study, we demonstrated that women who breastfed their infants retained less weight over time compared to women who bottle fed their infants [21]. Thus interpretation of information about the interpregnancy
weight characteristics must be done while simultaneously considering the potential impact of type of infant feeding.

We hypothesized that breastfeeding women who experience a relatively brief interpregnancy interval are more likely to retain weight during that interpregnancy interval than other women who also breastfed but delay a subsequent conception for at least 24 months. We also hypothesized that postparturition weight after a subsequent pregnancy would be greater than the postparturition weight after an initial pregnancy if women had not returned to their baseline weight.

METHODS AND MATERIALS

Parent Population

Data for the 25 cases and 20 controls used in this substudy are from a parent population comprised of 115 women, aged 20–40 years and 0–1 parity. The women for the parent study were recruited for a study of bone mass and lactation in their third trimester of pregnancy from birthing education classes and obstetric practices located in the Ann Arbor, Michigan, area [21]. Women were eligible for the parent study if they intended to bottlefeed or breastfeed for at least 6 months. Women were not enrolled if they had any of the following: a history of endocrine, renal, liver, or chronic respiratory illness; complications of pregnancy including hypertension or gestational diabetes; complications at delivery including premature delivery (≤35 weeks); a hospitalization that exceeded 2 days; delivery of an infant small for gestational age (<2,500 g); or twins. The characteristics of this parent population are shown in Table 1.

Substudy Cases and Controls

Enrollees in the parent study were evaluated in a longitudinal study design that included six measurements in the postpartum period at 0.5, 2, 4, 6, 12, and 18 months. The 25 women who subsequently became pregnant at any time during the 18-month follow-up period did not continue with the scheduled measurement intervals of the parent study. Instead, all these women were measured for the final time within 14 days of their subsequent delivery. These 25 breastfeeding women with a subsequent pregnancy were defined as “cases” in this substudy.

The 20 “controls” also breastfed but did not conceive during the 18-month follow-up period. These controls were frequency-matched with cases for timing of their measurements; 12 controls for this substudy were recalled for an additional measurement to correspond with the final measurement of those women who had become pregnant again. Thus, if a case was identified as having conceived again at 15 months following the birth of her reference child, she did not participate in the 18-month measurement, but would have been measured within 0.5 months of the subsequent delivery (or at 22 months following the birth of her reference child). To match a case, a “control” would have completed the regular program of measurements at 0.5, 2, 4, 6, 12, and 18 months, but also would have been recalled for an additional measurement at 24 months following the birth of her reference child. One case and one control reported using contraception.

Measures

Weight (in kilograms) was measured with a calibrated scale at each interview. Weight prior to baseline pregnancy was self-reported. There were two weight change variables used in the analysis. “Postpartum weight retention,” one of the outcome variables, was calculated by subtracting weight prior to the pregnancy of the reference infant from weight at each evaluation point during the postpartum period. The other outcome variable was “across pregnancy weight difference,” which is the difference between the weight of the cases 2 weeks after the birth of the reference infant and 2 weeks following the birth of the subsequent infant. Information about the baseline percent body fat were derived from measurement of body composition by dual x-ray densitometry within 14 days of the delivery of the reference child. Midarm muscle and fat area were computed from midarm circumferences and triceps skinfold according to the formulas of Gray et al. [22].

Participants were interviewed at each visit for information about infant feeding practices, menstruation status, diet, and physical activity. Women were described as fully breastfeeding if they nourished their infant in a manner so that no more than 1/3 of calories were provided from formula, juice, or alternative milk sources. Nutrient intake was assessed using the validated food frequency instrument to characterize usual food intake in 6-month time periods [23]. Physical activity was quantified using a modification of the Stanford Five-City instrument. The instrument charac-

| TABLE 1. Personal Characteristics of the 115 Postpartum Women of the Parent Population |
|---------------------------------------------|-----|-----|
| Characteristic                        | Mean (sd) | Range |
| Age (yr)                              | 29.3 (4.3) | 20, 40 |
| Height (cm)                           | 164.1 (5.6) | 152, 178 |
| Weight prior to pregnancy (kg)        | 59.7 (9.7) | 43, 93 |
| Weight gained (kg) first trimester    | 3.1 (2.9) | 7.7, 10.1 |
| second trimester                      | 6.4 (3.0) | -6.8, 13.5 |
| third trimester                       | 6.5 (2.9) | 4.4, 10.7 |
| total                                 | 16.2 (5.3) | 12.3, 35.9 |
| Weight gain during second pregnancy (kg)| 15.9 (4.2) | 11, 25 |
| Infants birth weight (kg)             | 3.5 (0.5)  | 2.4, 4.7  |
| Body mass index prior to pregnancy (kg/m²)| 22.2 (3.4) | 16.9, 33.8 |
| Parity: none                          | 61 53% |
| one                                   | 54 47% |
terizes the METs per week of moderate, hard, and very hard activity with one MET (metabolic equivalent time) being defined as the amount of energy consumed per minute of sitting at rest [24].

Women were categorized at each evaluation according to whether menstruation had returned since parturition (0 = menstruation had not returned, 1 = menstruation returned). Menstruation was defined as two consecutive bleeding episodes lasting more than a single day and occurring within a 45-day period of time. One-time covariates assessed at the birth of the referenced infant were education (0 = #16 yr, 1 = >16 yr), parity (0, 1), type of delivery (0 = vaginal, 1 = cesarean), season of delivery (winter, spring, summer with fall as the referent season), marital status (0 = married, 1 = other), age in years, and smoking prior to or during pregnancy (0 = no, 1 = yes).

Both the parent study and this substudy were approved by the Institutional Review Board at the University of Michigan.

**Statistical Analyses**

To assess the comparability of the controls with the cases, characteristics such as weight and bone density as well as lifestyle practices were compared using Fisher's exact tests for categorical variables and t-tests for continuous variables. In addition, paired t-tests were used to assess the change in weight between the baseline postparturition measure and the subsequent postpartum measure among the cases. Simple linear regression analysis was used to describe any factors that might explain the weight changes between the beginning of the initial or baseline postpartum period and the subsequent gestational period.

The comparison of weight retention patterns for the cases and the controls was evaluated by longitudinal analysis using a nonparametric mixed model that does not assume a specific functional form for the weight retention curves. Random intercept and random slope, plus measurement error, were used to model the correlation and the variability in the repeated measurements (see Appendix).

### RESULTS

Table 2 describes the proportion of cases and controls who were fully breastfeeding, partially breastfeeding, or bottlefeeding at each measurement time point for cases and controls following the birth of the reference infant. There was no statistically detectable differences between cases and controls as to their lactation practice (P > 0.7) with both...
groups having progressed from intense breast feeding to limited breast feeding after the 6-month examination.

Table 3 contrasts selected characteristics of the cases and controls. There were no significant differences between the two groups for age or any measure of body composition following the reference pregnancy. The primary difference between the two groups was that women who were cases were more likely to have been nulliparous at the time of the reference birth, whereas controls were more likely to have had a single previous pregnancy.

The average weight loss in the postpartum period was 4.7 (±4.3) kg for cases and 4.4 (±3.0) kg for controls, which are not significantly different. Figure 1 presents a plot of each women’s retained weight (kg) by months since parturition as well as the average weight retention curves with 95% confidence intervals for the cases and controls. There was
Previously, we reported that the pattern of postpartum weight retention differed among lactating and nonlactating women; furthermore, the degree of weight retention was influenced by weight gain during pregnancy, age, and marital status [20]. Lactating women exhibited greater rates of weight loss than bottlefeeding women. Furthermore, they were more likely to return to their prepregnancy weight at an earlier date. Thus we chose to limit this report only to those women (both cases and controls) who had engaged in relatively long-term lactation. The effect is to remove the role of lactation peak in predicting the weight retention pattern of women who conceived within 18 months as opposed to not conceiving within 18 months.

We speculated that there was no difference in weight retention pattern between cases and controls because the subsequent pregnancy usually occurred more than 8 months following parturition. As shown in Figure 1, the major weight loss period occurred during the first 8–10 months following parturition. In this study, the women averaged 15.4 months between the delivery of the reference child and conception of the subsequent child. By 15 months postpartum, the rate of weight loss had, on average, plateaued.

Although the cases with a brief interpregnancy interval lost weight in the first 8–10 months of the postpartum period, they nonetheless weighed, on average, 1.3 kg more after the subsequent pregnancy as compared to the reference pregnancy. Our previous study [20], as well as others [12,13,16,25–28], found weight gain during pregnancy to be positively associated with postpartum weight retention. We found that the amount of weight change over the interpregnancy interval, not the weight gain during the subsequent pregnancy, predicted this weight difference. In this study, estimates of energy intake or physical activity were not important factors to explain the weight differential between the baseline postpartum weight and the subsequent postpartum weight.

Since subsequent pregnancy is a natural part of the reproductive cycle for women of childbearing age, these women may provide insight into the role of reproduction on the development of obesity while controlling for the effect of breastfeeding. If women have not achieved their pregnancy weight prior to the subsequent pregnancy, women may increase their likelihood of continued weight accumulation.

There are limitations to these data that must be considered. Subtle differences in weight retention patterns between cases and controls might be difficult to observe because of the sample size; however, the use of longitudinal data analysis techniques should optimize the identification of important patterns. With samples the size of those in this study, we have the power to detect moderate to large differences by not small differences of less than one-four standard deviation. Measurement of diet and physical activity are notoriously difficult to assess, and measurement error may account for the lack of statistical significance in associating these variables with weight retention patterns. Our study participants were white nonsmokers with higher

### Table 4. Physical Activity and Caloric Intake Characteristics of Cases and Controls in Interval Between Baseline and Subsequent Pregnancy

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Cases (METS)</th>
<th>Controls (METS)</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.5 month</td>
<td>201.2 ± 45.2</td>
<td>205.7 ± 42.9</td>
<td>0.74</td>
</tr>
<tr>
<td>2 months</td>
<td>290.6 ± 24.1</td>
<td>301.9 ± 21.1</td>
<td>0.10</td>
</tr>
<tr>
<td>4 months</td>
<td>292.4 ± 18.4</td>
<td>300.9 ± 18.6</td>
<td>0.13</td>
</tr>
<tr>
<td>6 months</td>
<td>293.1 ± 18.0</td>
<td>304.4 ± 20.8</td>
<td>0.06</td>
</tr>
<tr>
<td>12 months</td>
<td>299.1 ± 19.0</td>
<td>302.7 ± 14.6</td>
<td>0.50</td>
</tr>
<tr>
<td>18 months</td>
<td>297.9 ± 19.4</td>
<td>304.8 ± 30.1</td>
<td>0.47</td>
</tr>
</tbody>
</table>

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is a natural cubic spline in (t) treating f(t) as a random effect. The estimator \( \hat{t} \) is estimated via maximizing the REML log-likelihood function of the parameter vector in the variance components model \( \sigma^2 \).

In summary, these data suggest that there is no evidence that women with an interpregnancy interval <18 months have a different weight retention pattern than other women who delay a subsequent conception >24 months. Further, there was a greater subsequent postpartum weight after the ensuing subsequent pregnancy that was associated with amount of weight loss in the interpregnancy interval. This higher weight, then, would represent a higher threshold level from which future weight patterns in subsequent pregnancies would develop.

**APPENDIX**

The following nonparametric mixed models were used to model the weight retention patterns for cases and controls:

\[ Y_{ij} = f(t_{ij}) + Z_{ij}b_i + e_{ij} \]

where \( Y_{ij} \) is the retained weight for subject \( i \) at time \( t_{ij} \), \( f(t) \) is a smooth function with continuous second derivatives. \( Z_{ij} = (1, t_{ij})' \), \( b_i \) is a bivariate normal variable representing random intercept and slope, \( e_{ij} \) is the measurement error independent of \( b_i \). The curve \( f(t) \) is estimated via maximizing the following penalized log-likelihood (26)

\[
\begin{align*}
L_p(f, \theta; Y) &= \sum_{i=1}^{m} l_i(f, \theta; Y_i) - \frac{\lambda}{2} \int_{T_1}^{T_2} (f''(t))^2 dt,
\end{align*}
\]

where \( l_i(f, \theta; Y_i) \) is the log-likelihood contributed by \( Y_i = (Y_{i1}, \ldots, Y_{im})' \), data from subject \( i \), \( \lambda > 0 \) is the smoothing parameter, \( (T_1, T_2) \) is an interval covering time \( t_{ij} \), and \( \theta \) is the parameter vector in the variance components \( b_i \) and \( e_{ij} \). The smoothing parameter \( \lambda \) and the parameter vector \( \theta \) are estimated via maximizing the REML log-likelihood function (27) treating \( f(t) \) as a random effect. The estimator \( \hat{t} \) is a natural cubic spline in \( (T_1, T_2) \) with knots \( t_{ij} \).

**REFERENCES**