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Original

Determinants of postpartum weight variation in a cohort of adult women: a hierarchical approach

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Abstract

Introduction: **Retention of the weight gained during pregnancy or the weight gain postpartum has been associated with increased prevalence of obesity in women of childbearing age.**

Objective: **To identify determinants of weight variation at 24 months postpartum in women from 2 towns in Bahia, Brazil.**

Methods: **Dynamic cohort data of 325 adult women were collected for 24 months postpartum. Weight variation at 24 months postpartum was considered a response variable. Socioeconomic, demographic, reproductive, related with childbirth variables and lifestyle conditions were considered exposure variables. A linear mixed-effects regression model with a hierarchical approach was used for data analysis.**

Results: **Suitable sanitary conditions in the household (2.175 kg; p = 0.001) and participation social programs for income transfer (1.300 kg; p = 0.018) contributed to weight gain in distal level of determinants, while at intermediate level, pre gestational overweight and surgical delivery had effects on postpartum weight, causing an average increase of 3.380 kg (p < 0.001) and loss of 2.451 kg (p < 0.001), respectively. At proximal level, a score point increase for breastfeeding yielded an average postpartum loss of 70 g (p = 0.002).**

Conclusion: **Our results indicate the need to promote weight control during and after pregnancy, encourage extended breastfeeding, and improve living conditions through intersectoral interventions.**

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Key words: *Postpartum weight. Risk factors. Hierarchical approach. Adult women. Cohort study.*

DETERMINANTES DE LA VARIACIÓN DEL PESO POSTPARTO EN UNA COHORTE DE MUJERES ADULTAS; UN ENFOQUE JERÁRQUICO

Resumen

Introducción: **La retención del aumento de peso durante el embarazo y el aumento de peso después del parto se ha asociado a una mayor prevalencia de la obesidad en las mujeres en edad fértil.**

Objetivo: **Identificar los factores determinantes de la variación del peso en los 24 meses posparto, en mujeres adultas en dos municipios de Bahía/Brasil.**

Métodos: **En una cohorte dinámica se incluyeron 325 mujeres, acompañadas durante 24 meses. La variación del peso a los 24 meses después del parto se consideró variable de respuesta y los factores socioeconómicos, demográficos, reproductivos, de la estilo de vida y factores relacionados con el niño, son las variables de exposición. En el análisis de datos se construyeron modelos de regresión lineal de efectos mixtos con un enfoque jerárquico para identificar los determinantes de la variación del peso posparto.**

Resultados: **Han contribuido al aumento de peso en el nivel distal, inadecuadas condiciones sanitarias de la vivienda (2,175 kg, p = 0,001) y la participación en los programas sociales de transferencia de ingresos (1.300 kg; p = 0,018). En el nivel intermedio, el exceso de peso antes del embarazo aumentó el peso después del parto en una media de 3,380 kg (p < 0,001), mientras que el parto por cesárea contribuyó a la pérdida de 2,451 kg (p < 0,001). A nivel proximal, el aumento de un punto en la puntuación de la lactancia materna contribuyo con la pérdida de 70 g (p = 0,002) en la media del peso posparto.**

Conclusiones: **Estos resultados indican a la necesidad de las acciones de salud dirigidas a controlar el peso durante el embarazo y después del parto incluyendo la promoción de la lactancia materna durante largos períodos y la mejora de las condiciones de vida, que implica acciones intersectoriales.**

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Palabras clave: *Peso posparto. Factores de riesgo. Enfoque jerárquico. Mujeres adultas cohorte del estudio.*

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Abbreviations

SACH: Sanitary Conditions in the Household.
SPIT: Social Programs of Income Transfer.
AIC: Akaike Information Criterion.
BF: Breastfeeding.
BMI: Body mass index.
CI: Confidence interval.

Introduction

Overweight and obesity are currently among the major global health problems. According to the World Health Organization (WHO), obesity prevalence has doubled from 1980 to 2008, affecting 10% of men and 14% of women worldwide. Higher prevalence of obesity was observed among women than among men in all regions included in the offices of the WHO, including those in Africa, Southeast Asia, and the Eastern Mediterranean.[1]

According on the WHO report of 2004, 19 factors were associated worldwide with increased mortality risk due to chronic disease. Obesity was among the top 5 factors, following hypertension, smoking, physical inactivity, and hyperglycemia, and it contributed to 4.8% of deaths.[2]

Based on data from national studies that have been conducted since the 1970s (National Survey of Household Expenditure [ENDEF]-1974/1975, Brazil National Survey on Health and Nutrition 1989 [PNSN] and Family Budget Survey [POF] 2008/2009), overweight and obesity have also been considered major health issues in Brazil. In POF data, the prevalence of overweight in the Brazilian population was estimated at 48.1%. A substantial increase in the prevalence of obesity was observed among men in the 34-year interval (1974/1975 to 2008/2009), increasing from 2.8% to 12.4%. However, during the same period, despite the great increase observed in the prevalence of obesity among men, there was still a higher prevalence of obesity in women, increasing from 8.0% to 16.9%.[3]

Consequently, the focus of the scientific community has shifted to women. In particular, the reproductive phase in a woman's life has attracted attention because of its contribution to postpartum weight retention and/or gain, to increases in the prevalence of overweight/obesity.[4]

Several factors have been associated with postpartum weight retention and/or gain, including socioeconomic, demographic, and cultural factors, as well as reproduction, lifestyle, and child related factors.[5-9] However, despite progress in the understanding of these associations, some studies have reported contradictory results regarding certain factors such as lactation,[5,10,11] and insufficient results regarding physical activity and postpartum diet.[12] Moreover, analytical and methodological issues, including small samples, difficulty in obtaining pregestational and immediate postpartum weight records, and the need to control confounding and effect modifier variables[5,12] have encouraged new research in this area.

However, most of the studies that have investigated factors associated with postpartum weight retention have focused on the initial 12 months postpartum,[13] consequently, there is a dearth of information on the determinants of weight variation after this period. Moreover, we consider it important to understand the hierarchical organization of these factors, since it could help with the decision-making required for planning, managing, and executing actions directed at assessing and controlling postpartum obesity.

Therefore, this study aimed to identify factors associated with weight variation during the 24-month postpartum period of women living in 2 municipalities within the state of Bahia, Brazil, and to aid in the planning of programs and actions directed at the prevention and control of overweight and obesity.

Materials and methods

This study used another research project titled "*Amamentação e alimentação complementar no desmame-estado de nutrição e saúde nos dois primeiros anos de vida – um estudo de coorte*" as a data source; this project included women living in rural and urban areas of the Laje and Mutuípe municipalities in the southern region of Bahia, Brazil, which were 220 and 235 km from the state capital, respectively. These are predominantly agricultural towns; at the time of the study, the Human Development Index for Mutuípe and Laje was 0.657 and 0.654, respectively.[14]

Study population and selection criteria

From March 2005 to October 2006, cohort data were collected at the only 2 public hospitals of the participating municipalities. Participating women were followed up for 24 months postpartum; therefore, data collection was completed in October 2008.

Women were included in this study if they fulfilled the following criteria: lived in the area of the study; were ≥18 years old; had a gestational age ≥ 37 weeks; were not pregnant during the follow-up period; had given birth to children with a birth weight of ≥ 2,500 g; had not had multiple births; and did not report any chronic noncommunicable disease. We excluded women who had not raised their children themselves (n = 3), and those with only one weight measurement obtained during the follow-up period (n = 33). Therefore, of the 528 women initially recruited, 325 met the inclusion criteria.

Response variable

Postpartum weight variation (kg) was considered the response variable in this study. It was defined as the difference between the weight measured at the various postpartum phases of the study (6, 12, 18, and 24 months) and that obtained after childbirth in the maternity (baseline). In order to correct for the influence of weight variation during the time intervals between measurements, the weight difference calculated at each phase of the study was divided by the time interval between measurements, and subsequently by the number of days in the month (30.4 days). This monthly weight variation was then multiplied by the number of months of each postpartum phase of the study as follows:

Variation of postpartum weight for each postpartum phase = [(weight measured at each follow-up – baseline weight)/(date of weight measurement phase of the follow-up – date of the baseline weight)/30.4] × number of months of each follow-up phase.

Exposure variables

The reproductive, demographic, and socioeconomic factors associated with the child, as well as lifestyle factors and breastfeeding, were considered exposure variables, as presented in figure 1. They were categorized into distal, intermediate, and proximal-level determinants of postpartum weight variation.

Socioeconomic and demographic factors were considered distal determinants, and were characterized based on the following: participation in social programs for income transfer (SPIT) (yes, no), where participation was defined as families receiving financial support from government

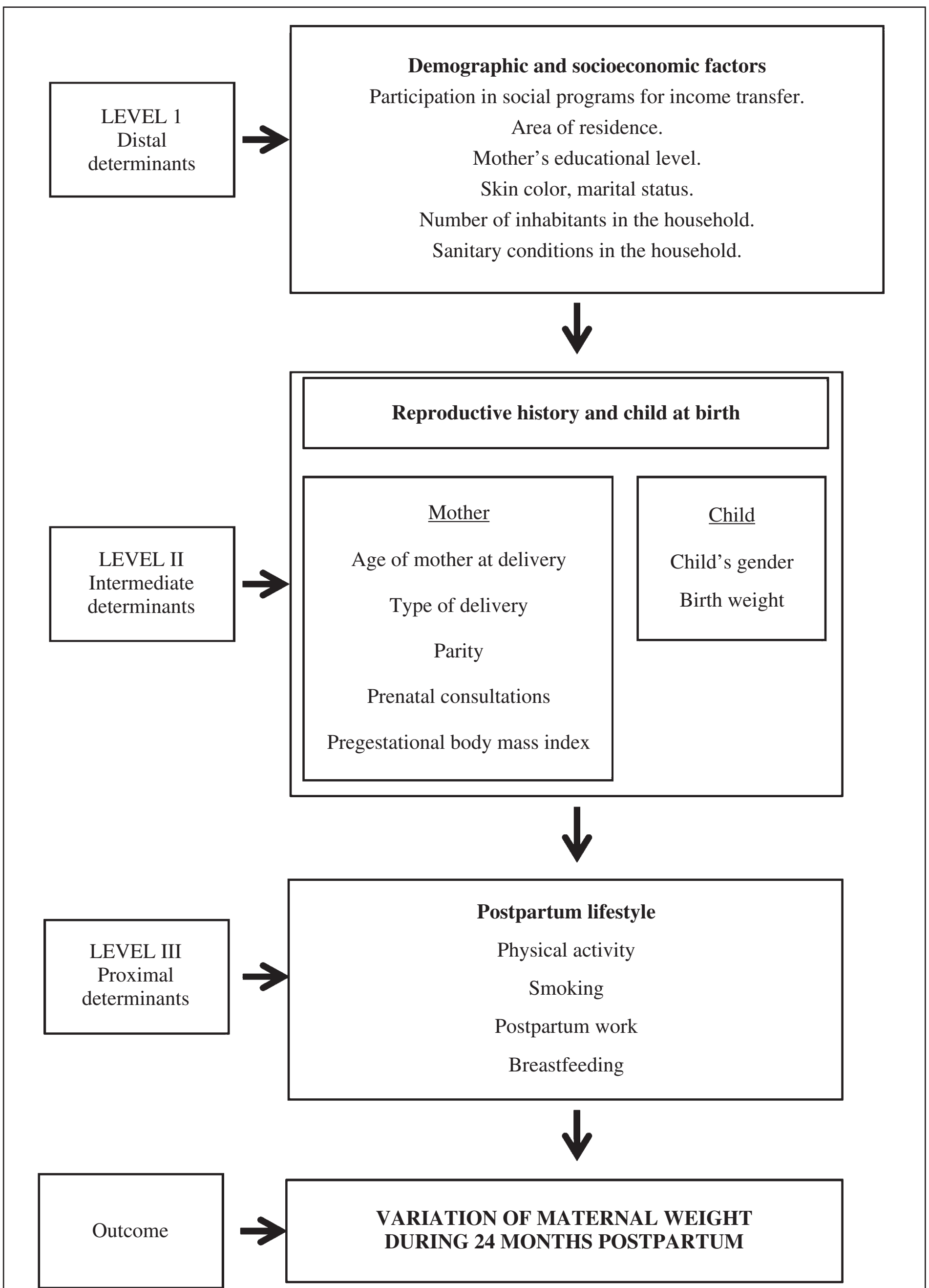

Fig. 1.—Conceptual and hierarchical structure to analyze determinants of variation of postpartum weight. Mutuípe/Laje 2005-2008.

programs, such as "*Bolsa Família*", for more or equal 12 months days, and no participation was defined as families never receiving such benefits or receiving them for less than 12 months; area of residence (rural, urban); skin color/ethnicity, which was self-reported, and the 6 possible responses were categorized as (white/clear, brown, and dark); marital status (living with a partner, single); the mother's education level (illiterate/incomplete elementary school, complete elementary school/incomplete high school, complete high school/undergraduate); gender of the head of the family (male, female); number of household inhabitants (≤ 4, > 4); and sanitary conditions in the household (SACH) (suitable, semi-suitable, unsuitable).

The SACH index was based on the following variables: sanitary drainage, garbage disposal, water supply source, presence of faucets, kitchen and bathroom wall type, and the number of people per room in the household, as adapted from Oliveira et al.[15] The most favorable situations received 4 points and the least favorable received 0 points. The overall points for each family were grouped into tertiles, and the families were classified as having an unsuitable (≤ 15 points), semi-suitable (16-24 points), or suitable (≥ 25 points) SACH index.

Variables relating to the mother's reproductive history and the child at birth were considered intermediate-level determinants and were characterized based on the age of the mother at delivery (< 24 years, ≥ 24 years); type of delivery (natural, surgical); parity (primiparous, 2-3 children, ≥ 4 children); prenatal consultations (< 6, ≥ 6); child's gender (male, female); child's birth weight (2,500-2,999 g, 3,000-3,500 g, > 3500 g); pregestational body mass index (BMI)[4] = (pregestational weight/height^2), categorized as not overweight (< 25.0 kg/m^2) and overweight (≥ 25 kg/m^2) and mother's height (< 1.59 m, ≥ 1.59 m).

Variables relating to the mother's lifestyle were considered proximal determinants and were characterized based on postpartum physical activity (yes, no); postpartum smoking status (yes, no); postpartum work (yes, not); and duration and intensity breastfeeding (continuous).

The breastfeeding variable was assessed using a score adapted from Baker et al.[16] and Olhlin & Rossner[17] constructed from the sum of points assigned according to the type and duration of breastfeeding as follows: each month of exclusive and predominant breastfeeding was awarded 2.0 points; complementary breastfeeding was awarded 1.5 points, and mixed breastfeeding was awarded 1.0 point. Following 12 months postpartum, 0.5 points per awarded 2.0 points; complementary breastfeeding was awarded 1.5 points, and mixed breastfeeding was awarded 1.0 point. Following 12 months postpartum, 0.5 points per month were awarded to any type of breastfeeding until the child reached 24 months of age. Breastfeeding was implemented as a continuous variable in the model.

Categorical variables were assigned codes, with (0) assigned to reference categories and (1) to risk categories. Variables falling into more than 2 categories were treated as dummy variables Breastfeeding and variation of weight at 24 months postpartum were considered variables that varied in time.

Data collection

Data were collected by properly trained healthcare professionals and nutritionists using standard techniques. Pregestational weight measurements were collected from pregnancy follow-up cards, and they indicated measurements obtained during the mother's initial prenatal visit prior to 13 weeks of gestation. In the absence of such records, pregestational weight measurements were self-reported. Information on type of delivery and hydration during labor were obtained from hospital records.

The mother's weight and height were measured at the maternity after delivery, and subsequently, measurements were obtained at 6, 12, 18, and 24 months postpartum at the healthcare facility. If the mother failed to appear for a scheduled meeting, measurements were carried out by the team at home.

Weight was measured using a microelectronic scale (Filizola, model E-150/3P) with a 150-kg capacity and height was measured using a portable stadiometer (Leicester Height Measure); weight and height were measured to the nearest 0.100 g and 0.1 cm, respectively., The child's birth weight was measured in the delivery room by maternity healthcare professionals using a Filizola digital scale with 50-kg capacity and 10-g precision. Duplicate readings for each measurement were obtained using standard techniques.[18]

Demographic and socioeconomic factors were assessed during the initial postpartum month at the mother's home. Breastfeeding data were also collected at home during the first postpartum month, after which data were collected monthly at the healthcare facility for 6 months, and then every 6 months until the end of follow-up. During each interview, continuous collection of data on breastfeeding and the child's diet was achieved using semi-quantitative food frequency questionnaires and 24-h diet recall. Breastfeeding was classified based on WHO criteria[19] as exclusive, when maternal milk was the only food source offered to the child; predominant, when breast milk was the only dairy food source, but water, tea, and juice were also offered to the child; and partial, when breast milk was combined with other types of milk, and possibly other foods. When breast milk was the only dairy source but was combined with other foods, it was considered complementary breastfeeding.[20]

Lifestyle data were collected at the end of the study.

Statistical analysis

The Kolmogorov-Smirnov test and q-plots were used to evaluate the linearity and normality of the response and exposure variables, when continuous. The paired *t*-test was used in exploratory analysis to compare the average weight variations between different postpartum phases of the study.

Table I
Socioeconomic, demographic, parity, and anthropometric status characteristics of the study participants followed in this study and the losses at 24 months. Mutuípe/Laje (2005-2007)

Variables	*Follow-up (282)*		*Loses (43)*		*p-value*[1]
	n	*%*	*n*	*%*	
Area of residence					
Rural	201	71.3	28	65.1	0.582
Urban	81	28.7	15	34.9	
Mother's age at delivery (years)					
< 24	136	48.2	29	67.4	0.019
≥ 24	146	51.8	14	32.6	
Mother's education level					
Elementary grade incomplete	109	38.7	18	41.9	
Complete elementary	123	43.6	20	46.5	0.610
High school/college	50	17.7	5	11.6	
Marital Status					
Single	66	23.4	10	23.3	0.355
Married	216	76.6	33	76.7	
Parity					
One child	118	41.8	20	46.5	0.564
Two or more children	164	58.2	23	53.2	
Anthropometric pregestational status					
Not overweight	219	81.4	29	90.6	0.177
Overweight	50	18.6	03	9.4	

[1]Chi-square test.

A hierarchical approach in a mixed-effects linear regression model was used to examine the association between risk factors and weight variation at 24 months postpartum. This technique is appropriate for longitudinal and unbalanced data because it incorporates fixed and time-variant variables, allowing assessment of the weight variation rate during the follow-up period.[21]

Implementation of the hierarchical approach aimed at examining the hierarchy between the exposure variables was based not only on statistical analysis but also on the consistency of the conceptual epidemiological model, which previously defined the inclusion of variables in the model.[22]

Bivariate analysis was initially conducted to select single variables in the model that could explain the variation in postpartum weight ($p < 0.20$) and to integrate the multivariate models at each hierarchical level.[23] While conducting multivariate analysis, distal-level determinants were included in the first phase. After progressive (backward) elimination, significant distal-level variables ($p < 0.05$) were retained in the analysis and included in the block adjustment of the second hierarchical-level exposure variables. The same procedure was followed for the third hierarchical level, integrating the proximal-level variables.

The Akaike information criterion was used to identify the best fit for the selection of the mixed-effects model.[24] Exploratory and descriptive analyses were conducted using SPSS version 17.0 for Windows, and modeling was performed using the Statistical Analysis System version 9.0.

Ethical aspect

Women who participated in the study were required to sign a consent form. Illiterate participants provided consent using their fingerprints. The study was approved by the *Maternity Climério de Oliveira* Research Ethics Committee of the Federal University of Bahia (Opinion No. 74/2005).

Results

Of the 325 participating women, 282 continued in the study for the entire 24-month period, with the percentage of loss estimated at 13.2% (n = 43) by the end of follow-up. The losses were caused by difficulties reaching the study sites during the rainy season, women failing to visit the healthcare centers for their scheduled meetings or having left the city for a long period of time, exclusion of outliers, or participants moving away to another city.

Comparison of the distribution of variables between the group of women that completed the study and the loss group (table I) indicated that, except for age (p = 0.019), all variables exhibited a homogeneous distribution ($p \geq 0.05$).

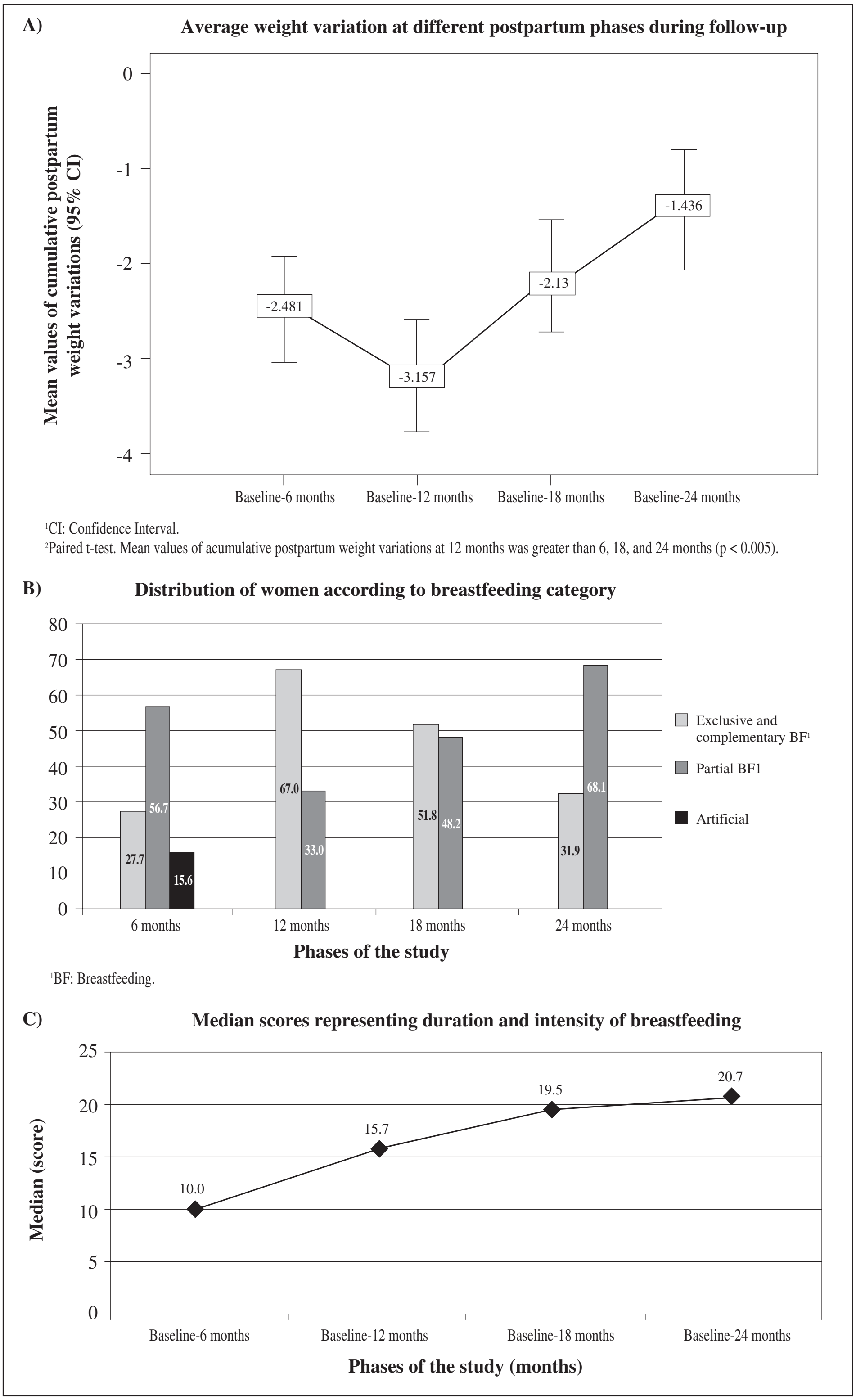

Fig. 2.—Behavioral changes in postpartum weight and breastfeeding, during the 24-month postpartum period. Mutuípe-Laje 2005-2008.

Considering all postpartum evaluations, the average weight loss by the end of follow-up was 2.268 kg (SD 4.873 kg), ranging from -16.3 kg to + 16.4 kg.

The variation pattern of postpartum weight and breastfeeding during follow-up is presented in figure 2A. There was a higher average weight loss at the 12-month interval (3.157 kg; 95% confidence interval CI: -2.574 to -3.740) and a lower average weight loss at 24 months postpartum (1.436 kg; 95% CI: -0.807 to -2.064) than that observed at other intervals of the study as compared to the baseline weight (fig. 2A).

At 24 months postpartum, 26.2% of the women had lost > 5 kg, 13.1% had gained > 5 kg, and 60.6% had either gained or lost ≤ 5 kg (data not shown).

As illustrated in figure 2B, 31.9% of the women were still breastfeeding their children at 24 months postpartum. The median scores representing breastfeeding duration and intensity from the first month following childbirth to 6, 12, 18, and 24 months postpartum are depicted in figure 2C.

Sample characterization and bivariate analysis of the association between postpartum weight variation and exposure variables according to hierarchical level are presented in table II. Therefore, area of residence, health conditions in the household, SPIT, skin color, mother's education level, parity, prenatal consultations, type of delivery, anthropometric pregestational status, birth weight, work postpartum, and breastfeeding variables were included in the multivariate analysis, yielding a p-value < 0.20.

The final mixed-effect multivariate regression analysis model (table III) indicated that unsuitable SACH and SPIT participation contributed to an average postpartum weight increase of 2.175 kg (p = 0.001) and 1.301 kg (p = 0.018), respectively. Surgical delivery and pregestational overweight had an intermediate effect on weight variation, contributing to a loss of 2.451 kg (p < 0.001) and a gain of 3.380 kg (p < 0.001), respectively. Among the proximal-level determinants, breastfeeding was associated with weight variation during the 24 months postpartum, where for each breastfeeding score point increase, an average postpartum weight loss of 70 g (p = 0.002) was observed.

Discussion

The hierarchical approach used in the identification of factors associated with postpartum weight variation indicated that SACH and SPIT participation are distal determinants, type of delivery and anthropometric pregestational status are intermediate determinants, and that breastfeeding is a proximal-level determinant of postpartum weight variation.

This study shows that women of low socioeconomic status, defined by unsuitable SACH and SPIT participation, have a greater predisposition to weight gain following delivery. This is consistent with results reported by Kac et al.[6] and Shrewsbury et al.[25], which suggested postpartum weight retention as a possible explanation for this observation.

The mother's income and education level are socioeconomic factors that have been associated with postpartum weight retention or variation in several studies.[8,26] In this study, we noted that although the mother's education level was associated with postpartum weight variation according to bivariate analysis, this association was not sustained, following adjustments, in the final model. Consequently, an unfavorable SACH index and SPIT participation could be better indicators of unsuitable socioeconomic factors for women, since having access to SPIT implies that the woman and her family suffer from high social and economic vulnerability.[27]

Thus, a possible explanation for postpartum weight gain among women of low socioeconomic level is insufficient access to the information and financial resources that are required for a healthy lifestyle, including access to low-energy density foods, being in shape, and social and family support needed to care for the child, which allows the woman to take better care of her body.

In the 24 months of follow-up, our results showed that intermediate-level determinants such as surgical delivery contributed to the average loss of 2.451 kg compared to natural delivery, and that pregestational overweight contributed to an average increase of 3.380 kg as compared to women who did not present pregestational excess weight.

Evidence suggests that women who are overweight or obese before pregnancy have an increased chance of undergoing a surgical or cesarean delivery compared to those with a lower BMI.[4,28] In this study, we considered surgical delivery requests to be not mainly based on overweight or obesity, but also other obstetrical risks, as 31.2% of the women underwent a cesarean section, 73.3% of whom had either appropriate pregestational weight or lower than average pregestational weight for their height.

Pregestational BMI ≥ 25 kg/m^2 was a strong predictor of postpartum weight variation in this study, contributing to an average postpartum weight gain of 3.380 kg (p < 0.001) during the 24 months of follow-up. Our results indicated that while 18.6% of the women were overweight at the onset of their pregnancy, the prevalence of overweight was 33% by the end of the follow-up. This is equivalent to a 1.8-fold increase in prevalence during the 2-year postpartum period, i.e., 14.8% of the women did not return to their pre-pregnancy weight, and some even gained weight during the postpartum period. The weight variation pattern demonstrated that there was a gradual reduction in weight loss rate over time after the 12-month postpartum period. This can contribute to the increase in the predominance of obesity observed among women of childbearing age.[29,30]

We can explain a negative association between breastfeeding and postpartum weight gain observed at the proximal determinant level in this study by the influence of breastfeeding duration and intensity, considering that 31.9% of the participating women were still breastfeeding at 24 months postpartum. Therefore, according to the definition of breastfeeding used in this study, our results indicate that the larger the amount of milk produced and the longer the breastfeeding duration, greater the additional maternal energy expenditure and consequently, the postpartum weight loss. Similar observations were reported by Ohlin and Rossner[17] between 2.5 and 6 months' post-

Table II
Characterization of the study population and bivariate analysis of the association between weight variation during the 24 months postpartum and dital, intermediate, and proximal determinants. Mutuípe/Laje (2005-2008) (N = 282)

Variables	*n*	*%*	*Estimate*	*EP*	*p-value*
Distal determinants					
Area of residence					
Rural[1]	201	71.3	1		
Urban	81	28.7	-1.234	0.597	0.039
Participation in SPIT2					
> 12 months	109	38.8	1.400	0.554	0.016
≤ 12 months and did not participate[1]	172	61.2	1		
Gender of the head of the family					
Male[1]	238	84.4	1		
Female	44	15.6	0.031	0.749	0.478
Marital status					
Single[1]	66	23.4	1		
Living with a partner	216	76.6	0.207	0.642	0.747
Mother's education level					
Illiterate/elementary incomplete	50	17.7	2.293	0.769	0.003
Elementary complete/high school incomplete	109	38.7	1.601	0.755	0.342
High school complete/undergraduate[1]	123	43.6	1		
SACH 3					
Suitable	86	30.5	0.0714	0.640	0.265
Semi-suitable	103	36.5	2.273	0.670	< 0.001
Suitable[1]	93	33.0	1		
Skin color (self-reported)					
Clear[1]	140	49.6	1		
Brown	60	21.3	0.909	0.701	0.195
Dark	82	29.1	1.214	0.631	0.055
No. of residents per household					
1-4[1]	120	42.6	1		
> 4	162	57.4	-0.340	0.550	0.537
Intermediate determinants:					
Parity (No. of children)					
Primiparous[1]	118	41.8	1		
2-3	126	44.7	1.082	0.576	0.609
≥ 4	38	13.5	2.430	0.841	0.004
Mother's age at delivery (years)					
< 24[1]	136	48.2	1		
≥ 24	146	51.8	-0.148	0.544	0.781
Prenatal (No. of consultations)					
< 6	149	52.8	0.858	0.542	0.114
≥ 6[1]	133	47.2	1		
Gestational age (weeks)					
≥ 38	183	69.1	-0.364	0.5698	0.523
< 38[1]	82	30.9	1		
Type of delivery					
Natural[1]	194	68.8	1		
Surgical	88	31.2	-1.547	0.579	0.008
Pre- pregnancy BMI[4]					
Not overweight[1]	219	81.4	1		
Overweight	50	18.6	3.137	0.678	< 0.001
Physiological serum during delivery (mL)					
≤ 500	108	38.0	0.466	0.637	0.465
> 500	76	27.0	0.051	0.698	0.941
No[1]	98	34.8	1		

Table II (continuation) Characterization of the study population and bivariate analysis of the association between weight variation during the 24 months postpartum and dital, intermediate, and proximal determinants. Mutuípe/Laje (2005-2008) (N = 282)					
Variables	*n*	*%*	*Estimate*	*EP*	*p-value*
Birth weight (g)					
2,500-2,999	89	31.6	1.244	0.639	0.052
3,000-3,500[1]	117	41.5	1		
> 3,500	76	27.0	0.583	0.669	0.384
Child's gender					
Male[1]	151	53.5	1		
Female	131	46.5	-0.186	0.545	0.732
Proximal Determinants:					
Smoked postpartum					
Yes[1]	20	7.4	1		
No	261	92.6	1.030	1.059	0.331
Postpartum physical activity					
Yes[1]	42	14.8	1		
No	240	85.2	0.618	0.762	0.417
Postpartum work					
Yes[1]	225	79.8	1		
No	57	20.2	-0.965	0.675	**0.153**
BF[5] duration and intensity					
Score (continues)	-	-	-0.066	0.228	**0.004**

[1]Reference categories; [2]Social programs for income transfer; [3]Sanitary conditions in the household; [4]Body mass index; [5]Breastfeeding.

Table III Final mixed-effect multivariate regression analysis from determinant factors of postpartum weight variation. Mutuípe/Laje (2005-2008)				
Determinants	*Estimate*	*Standard error*	*p-value*	*AIC[8]*
Model I				5,285.1
Distal determinants				
SACH[1]				
Suitable[2]	1			
Semi-suitable	0.579	0.6415	0.367	
Unsuitable	2.175	0.6691	0.001	
Participation in SPIT[3]				
Yes (≥ 12 months)	1.301	0.5478	0.018	
No (< 12 months)/did not participate	1			
Model II[4]				4,999.1
Intermediante determinants[5]				
Type of delivery				
Natural[2]	1			
Surgical	-2.451	0.6843	< 0.001	
Pre-pregnancy BMI				
Not overweight	1			
Overweight	3.380	0.6627	< 0.001	
Model III[6]				4,995.4
Proximal determinants[5]				
Breastfeeding duration and intensity (score)[7]	-0.070	0.0227	0.002	

[1]Sanitary conditions in the household; [2]Reference categories; [3]Social programs of income transfer; [4]Model II adjusted by the variables of Model I; [5]Adjustment variable: physiological saline during delivery (mL); [6]Model III adjusted by the variables of Models I and II; [7]Treated as continuous; [8]Akaike information criterion.

partum follow-up, Dewey et al.[31] between 6 and 12 months, Kac et al.[10] at 9 months, Baker et al.[16] at 6 and 18 months, and Amorim et al.[32] at 6, 12, and 15 months postpartum. According to Amorim et al.[32] this emphasizes the high long-term significance of lactation.

A multicenter study involving women from 6 countries (Brazil, Ghana, India, Norway, Oman, and USA) was conducted by Onyango et al.[33] In that study, the women were also followed up for 24 months postpartum; however, no association was reported between breastfeeding duration and intensity, and postpartum weight variation. These contradictory results and from other studies suggest that it is difficult to prevent postpartum overweight through lactation only,[34] as it is also important to consider socioeconomic, demographic, cultural, and reproductive factors and those related to lifestyle conditions. However, the fact that many women were still breastfeeding for 24 months after childbirth made a difference in this study and might partly explain the association observed between breastfeeding and postpartum weight loss. We also emphasize that using postpartum weight variation as a response variable in this study allowed the identification of women who had not lost all of their pregnancy weight as well as those that gained weight postpartum. This demonstrated the contribution of this phase in life in increasing the incidence of overweight or obesity and should encourage future studies to investigate the distinction between factors that influence weight gain due to pregnancy and labor and those that do so independently of reproduction.

This study has several strong points, such as the lower percentage of losses and longer postpartum follow-up period (24 months) than that of most other studies,[34] as well as the use of a hierarchical approach. This approach allowed model adjustment at each level by predetermined theoretical relationships between predictors of postpartum weight variation.[22] Moreover, the use of a mixed regression analysis model allowed the incorporation of weight changes over time.[21]

The limitations of this study include: (i) using weight measurements obtained immediately after delivery as the baseline, since the consensus is that 10–14 days are required for uterine involution and elimination of water retention.[5,36] However, considering the model's adjustment for the quantity of intravenously of saline during the delivery, we believe that we partly reduced the effect of that limitation; (ii) the use of self-reported pregestational weight infers the possibility of underestimation or overestimation.[35] However, it is important to note that studies have validated the use of self-reporting in population surveys.[35-36]

Finally, we believe that the results of this study may contribute to the proper planning of action concerning women's healthcare at the intermediate and proximal-level determinants directed at weight control before and during pregnancy as well as during the postpartum period, avoiding the reverse effect, since obese mothers are more likely to have delayed lactogenesis and reduced lactation.[37] Such actions could include encouraging exclusive breastfeeding during the first 6 months of the child's life, and complementary breastfeeding until the child is at least 24 months old. Improvement of living conditions, which involves intersectoral actions, is also fundamental to the control of postpartum weight at the distal-level determinants. Further studies that examine the role of the family and social support in childcare as well as food intake and energy expenditure in the postpartum period are required.

Conflict of interest declaration

The authors declare no conflicts of interest.

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