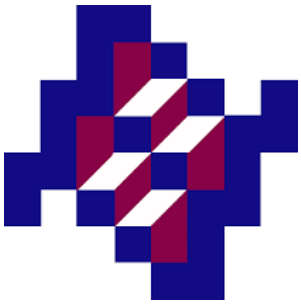

INSTITUTO NACIONAL DE SALUD PÚBLICA
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Asociación entre estrés psicosocial materno, ganancia excesiva de peso durante el embarazo y retención de peso posparto.

Tesis de titulación para obtener el grado de Doctora en Ciencias en Nutrición Poblacional

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Resumen

El presente estudio buscó explorar la asociación entre el estrés psicosocial materno (EPM), la ganancia excesiva de peso durante el embarazo (GEP) y la retención de peso al año posparto (RPP) en una cohorte de mujeres adultas con embarazo único de la Ciudad de México. La medición del peso de las mujeres en 5 momentos del estudio permitió identificar trayectorias de cambio de peso del segundo trimestre hasta el año posparto. Además, evaluamos el posible efecto modificador del estrés psicosocial materno sobre el patrón de asociación entre la GEP y RPP.

A partir de un análisis de trayectorias, se identificaron 6 tipos distintos cuya principal diferencia entre ellas se presenta en el comportamiento a partir del primer mes posparto. El 62.9% de las mujeres continuaron perdiendo peso después del mes posparto, mientras que el resto de las mujeres cambiaron la dirección de la trayectoria, pues comenzaron a ganar peso alrededor de los seis meses posparto. Además, la magnitud del incremento de peso del 2do al 3er trimestre del embarazo, la pérdida de peso después de la resolución del embarazo y el cambio de peso durante el posparto, fue diferente entre las trayectorias. En tres trayectorias en donde se presenta ganancia de peso alrededor de los seis meses posparto, se observó una mayor frecuencia de mujeres con sobrepeso u obesidad pre-gestacional. Por el contrario, en las otras tres trayectorias se encontraron una mayor frecuencia de mujeres con peso normal. En la trayectoria de cambio de peso que mostró una menor y continua pérdida de peso en el posparto, se encontraban mujeres significativamente más jóvenes que en el resto de las trayectorias.

Alrededor del 40% de las mujeres participantes del estudio retuvieron al menos 0.5 unidades de IMC al año posparto. La relación entre GEP y RPP no se vio modificada por el EPM. Debido a que observamos una relación compleja entre las variables (EPM, GEP y RPP) y características sociodemográficas de las mujeres, usamos un modelo de ecuaciones estructurales estratificado por historia reproductiva basado en los valores de criterio de información bayesiano más bajos, para evaluar dicha asociación. En las mujeres con hijos previos, aquellas con EPM moderado o alto tuvieron una mayor probabilidad de tener GEP, pero esta relación no influyó en la RPP, en comparación con mujeres con EPM bajo. Esta situación no se observó en las mujeres que fueron madres por primera vez; en este grupo, el EPM alto se asoció positivamente con una mayor

probabilidad de abandonar la lactancia materna antes de los seis meses posparto y, en consecuencia, presentaron mayor RPP.

Cápsula biográfica

Cinthya G. Muñoz Manrique obtuvo el grado de Licenciada en Nutrición y Ciencias de los Alimentos con excelencia académica por la Universidad Iberoamericana León en el 2008. En su último año de estudios superiores (2007-2008) realizó prácticas profesionales en el programa de internado rotatorio del Instituto Nacional de Perinatología bajo la dirección de la Dra. Otilia Perichart, con quien trabajó posteriormente como asistente de investigación en una cohorte de mujeres embarazadas y sus recién nacidos (2008-2012). Con dicho trabajo de investigación recibió el título de Maestra en Ciencias de la Salud, dentro del área de concentración en epidemiología clínica, por la Universidad Autónoma de México en el 2012. En su práctica privada en nutrición, Cinthya se ha especializado desde el 2009 en la atención previa, durante y posterior al embarazo de mujeres en edad reproductiva. En el 2013 logró certificarse como Asesora en Lactancia Materna por la Academia de Políticas y Prácticas en Lactancia de Estados Unidos. Impulsada por su interés en la salud de la mujer y la importancia de las políticas públicas sobre el binomio madre-hijo, realizó los estudios de doctorado en Ciencias en Nutrición Poblacional del Instituto Nacional de Salud Pública, en donde tuvo la fortuna de trabajar su tesis doctoral con datos de mujeres embarazadas de la Ciudad de México bajo la dirección de la Dra. Mara Téllez-Rojo.

Este trabajo está dedicado a Alonso, por quien siempre me esforzaré por ser un ejemplo de coraje, responsabilidad, determinación y compasión.

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AMAI	Mexican Association of Marketing Research and Public Opinion Index
BF	Breastfeeding
BIC	Bayesian Information Criterion
BMI	Body mass index
BMI-p	Pre-gestational body mass index
CRISYS	Crisis in Family Systems questionnaire
EPM	Estrés psicosocial materno
GA	Gestational age
GEP	Ganancia excesiva de peso durante el embarazo
GSEM	Generalized structural equation models
GWG	Gestational weight gain
HG-FL	High weight gain during pregnancy and fast weight loss postpartum
HG-HG	High weight gain during pregnancy and high gain postpartum
HG-MG	High weight gain during pregnancy and moderate gain postpartum
IMC	Índice de masa corporal
IMSS	Mexican Social Security Institute
LG-SL	Lower weight gain during pregnancy and slow loss postpartum
LM	Lactancia materna
LMP	Last menstrual period
MG-ML	Moderate weight gain during pregnancy and moderate loss postpartum
MG-SG	Moderate weight gain during pregnancy and slow gain postpartum
mo	Months
NCD	Chronic non-communicable disease
NLE	Negative life events
pp	Postpartum
PROGRESS	Programming Research in Obesity, Growth, Environmental, and Social Stress
PWC	Postpartum weight change
PW-p	Pre-gestational predicted weight
PWR	Postpartum weight retention
RMSE	Root Mean Squared Error
RPP	Retención de peso posparto
SES	Socioeconomic status
SRW-p	Pre-gestational self-reported weight

Capítulo 1

INTRODUCCIÓN

El incremento en las última décadas de la prevalencia de sobrepeso y obesidad en mujeres mexicanas en edad reproductiva (1,2), así como sus implicaciones en la salud a corto y largo plazo tanto para ellas como para las futuras generaciones, manifiesta su relevancia en identificar periodos de vulnerabilidad y comprender a detalle los factores relacionados con la ganancia de peso en esta población.

El embarazo y posparto son periodos sensibles para incrementar el índice de masa corporal (IMC) y la probabilidad de presentar sobrepeso y obesidad en años siguientes (3,4). Aproximadamente dos de tres mujeres no regresan a su peso previo al embarazo y alrededor del 15% de las mujeres retienen más de 5 kilos. Se dice que una mujer tiene retención de peso posparto (RPP) cuando existe una diferencia positiva entre el peso después de la resolución del embarazo y el peso previo a éste. Diversos estudios han observado una gran variabilidad en la RPP desde los 3 meses posparto hasta 15 años posteriores al embarazo (5). Reconociendo que existen mujeres con una RPP negativa (indicando una pérdida de peso) y otras que incluso aumentan de peso durante el posparto, aún no está claro cuánto tiempo es el ideal para que la mujer recupere su peso pregestacional ni el momento en el que sucede el incremento de peso no asociado al embarazo.

Es bien conocido que las mujeres con una ganancia de peso durante el embarazo por arriba del umbral esperado, son las que tienen mayor probabilidad de presentar retención de peso en cualquier momento después del parto (6). Además, se han identificado conductas de estilo de vida durante el posparto, como inactividad física, prácticas de sedentarismo, privación del sueño y consumo inadecuado de alimentos, que parecen influir en la RPP (7–9). Y aunque los resultados son inconsistentes (10), también se ha relacionado una corta duración de lactancia materna (LM) con menor probabilidad de recuperar el peso previo al embarazo. La relación de todos estos factores parece explicarse por su contribución en la pérdida o incremento de masa grasa durante el posparto.

En los últimos años se ha observado una asociación entre el estrés psicosocial y el incremento de peso o presencia de obesidad en mujeres no embarazadas (11). El estrés psicosocial es el resultado de la combinación de eventos negativos (estresores) de la vida, de la percepción al estrés y la respuesta establecida (ansiedad, depresión, entre otros) (12,13). La probabilidad de presentar mayor estrés psicosocial se incrementa en el embarazo y posparto, y ante situaciones cotidianas que involucran problemas financieros, violencia (robo, asalto), problemas interpersonales o la muerte inesperada de un familiar cercano, entre otros (12,13). Estas situaciones son frecuentes en mujeres de la Ciudad de México y se han asociado con mayores síntomas de depresión durante el curso de vida (14). La exposición al estrés psicosocial por un periodo de tiempo prolongado puede ocasionar desregulación del eje hipotalámico-pituitario-adrenal (HPA) y, como consecuencia, generar cambios biológicos y conductuales que resulten en el incremento o modificación de la masa grasa (15,16).

El incremento de la masa grasa, resultado de la ganancia excesiva de peso durante el embarazo, se puede exacerbar al existir mayor estrés psicosocial durante el embarazo, incrementando la probabilidad de presentar mayor RPP. Por lo anterior, el presente trabajo tuvo como objetivo 1) identificar y caracterizar las trayectorias de cambio de peso durante el embarazo y el primer año posparto, y 2) evaluar el posible efecto modificador de la asociación entre la ganancia excesiva de peso durante el embarazo y la retención de peso al año posparto debido al estrés psicosocial materno durante el embarazo en una cohorte de mujeres de la Ciudad de México.

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Capítulo 2

CAMBIO DE PESO DEL SEGUNDO TRIMESTRE DE EMBARAZO AL PRIMER AÑO POSPARTO

Artículo aprobado para enviar a publicación

Maternal weight change patterns from pregnancy to one year postpartum and their characteristics: A Group-Based Trajectory Model

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Abstract

Background: The childbearing years provide an opportunity to establish strategies that may improve woman´s and offspring health.

Objective: To identify trajectories of weight change during pregnancy and one year postpartum and characterized them according sociodemographic features, physical activity during and after pregnancy and breastfeeding practices in adult women from Mexico City.

Design: We conducted a secondary analysis of data from an ongoing pre-birth cohort that enrolled health adult women with singleton pregnancy from 2007-2011. We identified trajectories of weight change using measured weights at second and third trimester of pregnancy, as well at one, six and twelve months postpartum (pp), and applying group-based trajectory models. We then adjusted a multinomial regression model to characterize each type of trajectory.

Results: We identified six trajectories with mainly differences on weight change after one pp month. Almost two-thirds (n=515) of women continued to lose weight during the first year pp, and we further classified them as high gain/fast loss (10.6%), moderate gain/moderate loss (23.8%) and lower gain/slow loss (28.8%). Among the remaining (37.1%, n=304) of women, we observed weight gain around six month pp, and further classified these trajectories as high gain/moderate gain (20.6%), high gain/high gain (11.7%) and moderate gain/slow gain (4.4%). Pre-gestational body mass index (BMI-p) (kg/m2) [p<0.01] and age (y) [p=0.04] were associated with trajectory type. Trajectories of weight gain were also associated with women with more than 2 children's previous to current pregnancy, low socioeconomic status, non-working outside of the home or spent more than 2 hours in front of TV at pp.

Conclusions: Women may have different trajectories of weight change related with BMI-p and sociodemographic characteristics. Childbearing is a continuous process and the first year postpartum should be of particular attention on woman´s health.
Keywords: weight change, maternal, pregnancy, postpartum, trajectories

Introduction

Overweight and obesity rates have increased worldwide among all age groups and both are estimated to have slow and continuous increases in the coming years (1-2). In Mexico, according to the National Health and Nutrition Survey-2016, 73% of adult women are overweight or obese and the prevalence of the obesity had risen significantly in the last six years (3). Obesity during reproductive age is a metabolic risk factor for adverse perinatal outcomes (4) and development of chronic non-communicable disease (NCD) later in life (5).

Weight change during and after pregnancy are important predictors for obesity (6-7). Childbearing involves changes in body composition, physiology, and weight gain during pregnancy, including altered metabolism of glucose and lipids, as well as thyroid function (8). These changes can even persist after pregnancy and influence the development of overweight and obesity, and NCD later in life (7, 9-11).

Some weight gain is expected during pregnancy in order to promote an adequate fetal development and growth (12-13). Weight gain during pregnancy that is due to fetal components and body water is lost in the first weeks of postpartum, therefore the remaining gained weight corresponds to increases in maternal fat mass (12, -15). In some women fat mass is used as body storage to support breastfeeding (16). However, a higher fat mass accumulation during pregnancy may influence postpartum weight retention (17). Studies have shown that after delivery most women do not return to their pre-pregnancy weight and some even gain further weight (18-20). Even though it has been observed that some women do recover their pre-pregnancy weight and some gain further weight during the postpartum period, it is unclear whether the different weight trajectories among different women have specific health implications (17).

Most of the research looking at childbearing weight change has come out of the US and Western Europe (17-20). Studies conducted in Mexico and Latin America (21- 23) have observed weight change only at two time points rather than identifying the weight change trajectory and the characteristics associated with the type of trajectory (24-29). The aim of the present study was to identify trajectories of weight change during pregnancy and one

year postpartum and characterized them according sociodemographic features, physical activity during and after pregnancy and breastfeeding practices in adult women from Mexico City.

Material and Methods

Study Design, Settings and Participants

The present study is a secondary analysis from the ongoing Programming Research in Obesity, Growth, Environmental, and Social Stress (PROGRESS) pregnancy cohort conducted in Mexico City, aimed to study the effect of environmental exposures on infants' health and the potential effect modification by social stressors (30).

Between 2007 and 2011, research assistant invited pregnant women less than 20 weeks of gestation, who received prenatal care in family clinic from Mexican Social Security Institute (IMSS), to participate in the PROGRESS study. The study protocol was approved by the Institutional Review Boards from the National Institute of Public Health in Mexico, the Icahn School of Medicine at Mount Sinai and the Harvard T.H Chan School of Public Health.

After signing the informed consent, 956 adult women delivering a live singleton birth and planning to reside for more than two years in Mexico City were enrolled beginning in the 2nd trimester. Exclusion criteria were women with cardiovascular or renal disease, with use of steroids or antiepileptic drugs and habitual alcohol consumption. Participants were scheduled to visit our research facilities two times during pregnancy and three times along the first year postpartum. For the purpose of this analysis, we did not include women who delivered less than 37 weeks of gestation (n=120), who had a subsequent pregnancy less than one year (n=9) or women who did not return to follow up visits (n=8). The final sample for the analysis was composed by 819 pregnant women.

Weight changes during pregnancy and postpartum

During the second trimester of pregnancy, participants self-reported their usual weight six months before pregnancy (SRW-p). To account for potential recall bias we adjusted this value using a predicted weight estimated by imputation as follows (31). Briefly, maternal prepregnancy weight was predicted using a longitudinal model (linear mixed effect) with data from 6 months before pregnancy to the third trimester visit and sociodemographic variables. Predicted weight (PW-p) was compared with the prepregnancy weight available from clinic records. Performance of the model was tested using 10 fold cross validations

and a Root Mean Squared Error (RMSE) of 3.21 kg was considered as a measure of predictive accuracy. We calculated BMI-p with PW-p and classified women using WHO criteria (WHO, 2005): underweight (<18.5 kg/m2), normal weight (18.5, 24.9 kg/m2), overweight (25.0, 29.9 kg/m2) and obesity (≥ 30 kg/m2).

Trained personnel measured women's weight (without shoes and clothes) at the second and third trimester of pregnancy and height at baseline visit using a combined mechanical scale and stadiometer (Health-O-Meter; Scaleomatics INC, Cleveland, OG), measuring weight to the nearest 100g and height to the nearest 0.5 cm. Gestational age (GA) was defined according last menstrual period (LMP) and corroborated with Capurro test at born. In 33 cases that GA at born differed > 2 weeks with LMP, we re-calculated GA weeks during pregnancy considering Capurro test. Following IOM´s 2009 recommendations (13), we classified women´s gestational weight gain at 3rd trimester of pregnancy, considered BMI-p and length of pregnancy, into three categories: insufficient, adequate and excessive. After delivery, weight was assessed at one, six and twelve month's postpartum (pp).

Maternal Characteristics

Sociodemographic

A trained social worker applied a questionnaire at baseline visit to collect maternal information regarding age, years of schooling, marital status, reproductive history, and socioeconomic status (SES) using the Mexican Association of Marketing Research and Public Opinion Index (AMAI)13x6 battery based on family possessions, living condition and education. This instrument classifies the study population into six ordered categories from allocation tree considering 13 variables (32). Categories were re-classified into three categories based in the empirical data distribution: low (1, 2), medium (3) and high (4, 5, 6).

Physical Activity and Sedentary Behaviors

In each study visit, except at 12 months (mo) pp, participants reported average time spent on daily activities such as walking and watching television/reading. This information was categorized as inactive (<20 min/d), minimally active (20-60 min/d) and active (>60 min/d) for walking; and as non-sedentary (<120 min/d), less sedentary (120-180 min/d) and sedentary (>180 min/d) for watching television/reading (33).

Breastfeeding Practices

We collected information regarding breastfeeding practices at 1 and 6 mo pp. We coded as yes or not the women's response to the question “Do you currently breastfeed your baby?” and if the answer was yes, then, we asked “Do you currently feed your baby exclusively with breast milk (excluding any other liquid and solids food)? Type of BF was classified with the aforementioned answers in three categories (Non BF, No exclusive BF and Exclusive BF). Intensity of breastfeeding was defined as the times per day which women breastfeed the baby.

Statistical analysis

We first explored the maternal weight´s probability distribution at five moments in time: 2 during pregnancy and 3 after; weeks lapsed were counted since LMP: baseline visit at 18 ±1.36 weeks (2nd trimester of pregnancy), 31.76 ± 1.38 weeks (3th trimester of pregnancy), 43.73 ± 1.32 weeks (1mo pp), 65.67 ± 1.32 weeks (6 mo pp) and 92.01 ± 1.52 weeks (12 mo pp). We transformed weeks into the log scale to deal with the uneven time lapses between measurements. As part of the exploratory analysis, we also studied the behavior of maternal variables and evaluated for potential selection bias comparing maternal characteristics between women included and excluded from the analysis.

We constructed the possible weight trajectories (from second trimester of pregnancy to one year postpartum) as well as assessed their shape. Based on the information of 819 women, Group-Based Trajectory Models (34) were used to identify groups following similar weight change trajectories. We considered a model with time points varying among women, normal distribution for the response and trajectory shapes that followed a cubic polynomial. Two to six types of trajectories were evaluated. The optimum number of types of trajectories was chosen using the lower Bayesian Information Criterion (BIC), probabilities of membership (>90%) and odds of correct classification (>5).

Additionally, we adjusted a multinomial regression model in women with complete data (n=306) to characterize each type of trajectory depending on sociodemographic characteristics, breastfeeding practices and physical activity/sedentary behavior during pregnancy and postpartum. Because a higher pre-gestational BMI in women could be consequence of older age and/or higher number of children, we tested first and second interactions between BMI-p (kg/m^2), age (y) and number of children before current pregnancy.

Analyses were carried out with STATA 12.0 software (StataCorp LP) and $\alpha < 0.05$ was considered statistically significant.

Results

A total of 819 women were included in the analysis. Women were 27 ± 5.4 years old and with 11.8 ± 2.8 years of schooling at enrolled time to the cohort. Most of them had ≥ 1 children before current pregnancy (62.7%), reported living with a partner (81.21%) and were classified as low SES (51.77%). Mean BMI-p was 26.7 ± 4.34 kg/m2. Prevalence of underweight, normal weight, overweight and obesity were 1.2 %, 42.7 %. 38.5 % and 17.6 %, respectively. Out of the women included, 86.6% (n=701), 74.7% (n=612), 67.8% (n=555) and 52.9% (n=434) returned to the visit at 3th trimester of pregnancy, 1 mo pp, 6 mo pp and 12 mo pp, respectively. Compared with women with weight data in all visits (n=306), these women were similar in age, parity, education, marital status and SES, and although the former had higher BMI-p, there were not differences in proportion of women with overweight or obesity prior to pregnancy.

We identified six distinct trajectories of overall weight change from the second trimester of pregnancy to twelve months postpartum, each of these with two time intervals (**Figure 1**). The first interval corresponds to weight change during pregnancy and the first month postpartum. The second interval correspond to weight change after the first month postpartum. As expected, all trajectories showed weight gain during pregnancy and substantial weight loss in the first month postpartum; however, they differed in the magnitude of such weight change.

In the second interval, additional to the differences in magnitude of weight change, two distinct groups could be observed. In the first group women continued to lose weight, while in the other, women gained weight. Trajectory 1 corresponds to a high weight gain during pregnancy and fast weight loss postpartum (HG-FL); trajectory 2 corresponds to a moderate weight gain during pregnancy and moderate loss postpartum (MG-ML); trajectory 3 correspond to lower weight gain during pregnancy and slow loss postpartum (LG-SL). In the second group, trajectory 4 corresponds to a high weight gain during pregnancy and moderate gain postpartum (HG-MG); trajectory 5 corresponds to a high weight gain during pregnancy and high gain postpartum (HG-HG); trajectory 6 correspond to a moderate weight gain during pregnancy and slow gain postpartum (MG-SG). Most women were classified in trajectory LG-SL (28.8%), followed by trajectories MG-ML (23.8%), HG-MG (20.6%), HG-HG (11.7%), HG-FL (10.6%) and MG-SG (4.4%).

BMI-p was significantly different between trajectories ($p<0.01$). On average, BMI-p of women in HG-FL and MG-ML corresponded to normal weight, LG-SL and HG-HG to

overweight, HG-MG and MG-SG to obesity. Concerning women in HG-FL and MG-ML, none of them had obesity prior to pregnancy, while in MG-SG all of them did.

Table 1 shows the different features that characterized each trajectory. Along with a lower BMI-p (21.01 ± 1.53 kg/m2), women in HG-FL were the youngest (24.4 ± 4.6 y), with only one women with more than 2 children prior to the current pregnancy (n= 1, 3.8%) and a higher proportion of women with more than 9 years of schooling (n= 23, 88.5%). Women in MG-ML were those with the highest SES (n= 27, 31.8%) and who reported working outside of the home (n= 65, 76.5%). Women in MG-SG were those with the highest BMI-p (36.41 ± 3.81 kg/m2) and with the lowest proportions of both low SES (n= 6, 37.5%) and working outside of the home (n= 7, 43.8%). Compared with women in HG-FL, trajectories HG-HG and HG-MG showed a greater proportion of women with more than 2 children previous to the current pregnancy [β=1.99 (95% CI: -0.15, 4.13); p=0.06] [β=1.99 (95% CI: -0.30, 4.28); p=0.08], respectively. Also in HG-HG were the oldest women [β=0.16 (95% CI: 0.05, 0.26); p<0.001]. Because a higher BMI-p may have resulted from older age and higher parity, we tested whether the interaction between these variables characterized the women in each trajectory, but it was not significant (p>0.30).

Almost one in three women (28%) had an excessive gestational weight gain at 3rd trimester of pregnancy. This proportion was similar for both analytical samples (n=819 vs n=306) (p>0.50). Women in HG-HG and HG-FL were those with the highest and lowest prevalence accelerated gestational weight gain, respectively (54.6 % vs. 7.7 %).

Physical activity and sedentary behavior during postpartum were associated with type of trajectory (p<0.20). A higher proportion of women classified with more than 20 minutes of walking per day at one and six-month pp in trajectories HG-FL (n=21, 80.8%) and HG-MG (n=37, 93.1%), respectively. In addition, HG-MG type showed a greater proportion of women who spent more than 2 hours in front of TV at one (n=59, 81.9%) and six (n=57, 86.4%) months of postpartum.

One third of women breastfed exclusively at 1month pp and only 1.92% continued at 6 months pp. Most of the women (~ 60%) reported No exclusive-BF in both study visits. The median intensity of BF was 8 times/day (interquartile range (IQR) = 3) on the first month and 7 times/day (IQR= 5) at 6 months. Trajectories were not different according to BF practices (p>0.30). However, women in MG-ML were those with less prevalence of Non-BF (n=3, 4.2%) and higher prevalence (n=9, 39.1%) of Exclusive-BF at one month. In contrast, a higher prevalence of non-BF was observed in MG-SG [β=1.34 (95% CI: -1.34, 4.02); P=0.32] and HG-HG [β=1.12 (95% CI: -0.55, 2.79); P=0.189]. Furthermore, out of all

nursing women (either exclusively or mixed), those in trajectories MG-ML and HG-HG reported BF their baby more frequently at one month (median 9 [iqr = 3] times/day and 8.5 [iqr = 3.5] times/day, respectively).

Discussion

We identified six types of weight change trajectories from second trimester of pregnancy to 12 mo after delivery among Mexican adult women. As expected, all groups increased weight during pregnancy followed by a substantial lost at 1st mo postpartum, however, the rate of change of weight varied according to 6 trajectories. The main difference in the trajectories was the change seen after six months pp. Patterns of weight change were characterized mainly by BMI-p and maternal age. Higher number of children before current pregnancy, low and high SES, less than 9 years of schooling and spending more than 2 hours in front of TV during postpartum were also related with type of trajectory.

Sixty percent of the women showed an ideal and expected pattern of weight change, where, on average, they gained the recommended weight during pregnancy, returned to their second trimester weight´s and continued to lose during first postpartum year. A similar pattern was observed by Leonard et al in the ~ 60% of their study population among young and adult women from USA (35). There is consistent evidence that women with pre-gestational obesity are less likely to have these patterns (17, 35), although most of the studies have focused on the weight change at just two time points and have shown a wide variability in weight gained during pregnancy and postpartum weight change (17). About a third of women did not return to their pre-pregnancy weight and even gained weight by the first year postpartum. These women are at high risk to develop adverse outcomes in subsequent pregnancies, as well as obesity and NCD related to metabolic syndrome both in them and in their offspring (35, 36).

Other studies have described that weight change during childbearing is strongly related with BMI and BMI-p (35, 37-38). Very few of them have identified trajectories of weight change during childbearing. They have been identified around 3 trajectories corresponding to normal weight, overweight and obesity exclusively (35, 37). Identification of our trajectories showed that even among the same category of BMI-p, there might be different patterns. Unexpectedly, the group of women with the highest BMI-p (kg/m2) did not correspond to the HG-HG trajectory. This may be the result of the influence of sociodemographic factors, among others, on the adherence to the recommendation of weight gain during pregnancy (13, 38-40). Although our findings are consistent with other

studies suggesting that pregnancy at older ages are associated with high gestational weight gain (13), we found a higher frequency of women with more than 2 children in the trajectories with the most accelerated gestational weight gain at 3T of pregnancy. In addition, higher SES and working outside of the home may be related with behaviors that promote a healthy weight gain pattern during pregnancy and postpartum in women with pre-gestational overweight (39). In non-pregnant population, lower educational level used as indicator of SES has been associated with obesity in adult women (41-42). On contrary, we did not observe higher proportion of women with less than 10 years of schooling in those trajectories with pre-gestational overweight or obesity. However, it should be noted that our classification of high SES is explained in a high percentage by the education of the partner or the head of the family and do not correspond to the highest level of population (32).

In addition to BMI-p, the role of gestational weight gain (GWG) on postpartum weight change has been previously established in other countries (17). Our findings in Mexico are consistent with previous results. Types of trajectories with a continuous weight loss during first postpartum year were those with lower proportion of excessive GWG. However, this did not happen for women with pre-pregnancy obesity, who despite having gained less weight during pregnancy, began to gain weight during the postpartum year. This could be the result, in part, of lack and early cessation of breastfeeding in the first six months (43-44), as we observed a trend of non-breastfeeding in these women, although not significant.

Other features may contribute to postpartum weight change, in line with our findings, sedentary behavior during postpartum life has been associated with postpartum weight retention regardless of BMI-p (25, 27). We did not observe strong variability in physical activity among different trajectories but this could have been because in this population most of the women have shown an inactive lifestyle during pregnancy and postpartum. This may be as a result of possible socio-cultural beliefs in the first's years of a child's life (45-46). Additionally, women with pre-gestational obesity and weight gained during postpartum reported higher breastfeeding intensity during the first month but abandoned by six months. One of the reasons for the early discontinuation of breastfeeding may be due to problems associated with an inadequate technique (47). However, such problems could be overcome with an effective and early breastfeeding counseling (48). Therefore, an effort must be made to implement and monitor strategies, programs and policies that

encourage and strengthen the mothers' social support for breastfeeding, especially on women with obesity.

One of the strengths of this study is that we measured and analyzed weight prospectively from pregnancy to one year postpartum. To date, most of the weight change 'studies women during childbearing years have evaluated only weight change during pregnancy or up to the early stages of the postpartum period, limiting their ability to identify the time that occurs change (17). In addition, identification of more than three trajectories allowed us to describe other features than BMI-p related with weight change. Although socio-demographic characteristics are non-modifiable factors, should be considered as possible variables related with healthy behaviors.

This study has some limitations. Our research team was not able to measure pre-pregnancy weight which could have influenced on the trajectories followed at second trimester of pregnancy. To overcome this limitation, we used information from the medical records and created a prediction model which allowed us to classify women according to their BMI-p, thus decreasing error associated with weight underreporting and misclassification bias. Missing data at subsequent visits is another limitation. We used statistical techniques that used the available information in every participant to estimate the types of trajectories in this population. We adjusted multinomial models in those who had completed and incomplete data, observing only difference on BMI-p (kg/m2), assuming that trajectories identified and characterized are relevant to the current nutritional profile in Mexico and Worldwide.

We recommend that other studies replicate our findings to validate the reproducibility of these 6 trajectories in Mexico and to explore how these trajectories are related to the risk of overweight and obesity in later stage. Efforts be directed to establish timely pre-conception and inter-pregnancy interventions that are effective in women with overweight or obesity to influence on the cycle of obesity and NCD.

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Tables

TABLE 1								
Characteristics of women according type of trajectory.								
	All Women n=306	1 (HG-FL) n=26	2 (MG-SL) n=74	3 (LG-SL) n=85	4 (HG-MG) n=72	5 (HG-HG) n=33	6 (MG-SG) n=16	p[c]
Age, yr.	27.46 (5.52)[a]	24.26 (4.62)[a]	27.57 (5.21)[a]	27.82 (5.73)[a]	27.62 (5.17)[a]	28.54 (6.16)[a]	28.06 (6.18)[a]	0.04
Schooling, yr.	12 (4)[b]	12 (1)[b]	12 (4)[b]	12 (4)[b]	12 (4.5)[b]	12 (3)[b]	12 (5.5)[b]	0.9
< 10	81 (26.5%)	3 (11.5%)	26 (35.1%)	20 (23.5%)	19 (26.4%)	9 (27.3%)	4 (25%)	0.24
≥ 10	225 (73.5%)	23 (88.5%)	48 (64.9%)	65 (76.5%)	53 (73.6%)	24 (72.7%)	12 (75%)	
Children previous current pregnancy	2 (2)[b]	2 (2)[b]	2 (2)[b]	1 (2)[b]	2 (2)[b]	2 (2)[b]	1.5 (2)[b]	0.3
0	114 (37.3%)	11 (42.3%)	28 (37.8%)	37 (43.5%)	24 (33.3%)	9 (27.3%)	5 (31.2%)	0.35
1-2	149 (48.7%)	14 (53.9%)	37 (50%)	40 (47.1%)	32 (44.5%)	18 (54.6%)	8 (50%)	
≥ 3	43 (14.0%)	1 (3.8%)	9 (12.2%)	8 (9.4%)	16 (22.2%)	6 (18.1%)	3 (18.8%)	
Living with partner								
No	57 (18.6%)	5 (19.2%)	15 (20.3%)	17 (20%)	11 (15.3%)	5 (15.5%)	4 (25%)	0.91
Yes	249 (81.4%)	21 (80.8%)	59 (79.7%)	68 (80%)	61 (84.7%)	28 (84.5%)	12 (75%)	
Working outside of the home								
Yes	206 (67.3%)	18 (69.2%)	44 (59.5%)	65 (76.5%)	51 (70.8%)	21 (63.6%)	7 (43.8%)	0.08
No	100 (32.7%)	8 (30.8%)	30 (40.5%)	20 (25.5%)	21 (29.2%)	12 (36.4%)	9 (56.2%)	
Socioeconomic status								
Low	166 (54.3%)	18 (69.2%)	41 (55.4%)	41 (48.2%)	39 (54.2%)	21 (63.6%)	6 (37.5%)	0.3
Medium	66 (21.6%)	2 (7.7%)	16 (21.6%)	17 (20.0%)	18 (25.0%)	7 (21.2%)	6 (37.5%)	
High	74 (24.2%)	6 (23.1%)	17 (23.0%)	27 (31.8%)	15 (20.8%)	5 (15.2%)	4 (25.0%)	
Anthropometric								
Height, mts	1.55 (0.05)[a]	1.51 (0.04)[a]	1.53 (0.05)[a]	1.54 (0.05)[a]	1.56 (0.05)[a]	1.58 (0.05)[a]	1.58 (0.04)[a]	<0.01
Predicted pre-pregnancy weight, kg	64.21 (11.29)[a]	48.02 (3.08)[a]	54.91 (3.38)[a]	62.10 (4.63)[a]	69.68 (3.64)[a]	78.29 (4.91)[a]	91.04 (5.88)[a]	<0.01
BMI-p, kg/m^2	26.67 (4.34)[a]	21.01 (1.53)[a]	23.40 (2.46)[a]	25.93 (2.46)[a]	28.65 (2.10)[a]	31.33 (2.50)[a]	36.41 (3.81)[a]	<0.01
BMI-p category								
Low weight	2 (0.7%)	2 (7.7%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	<0.01

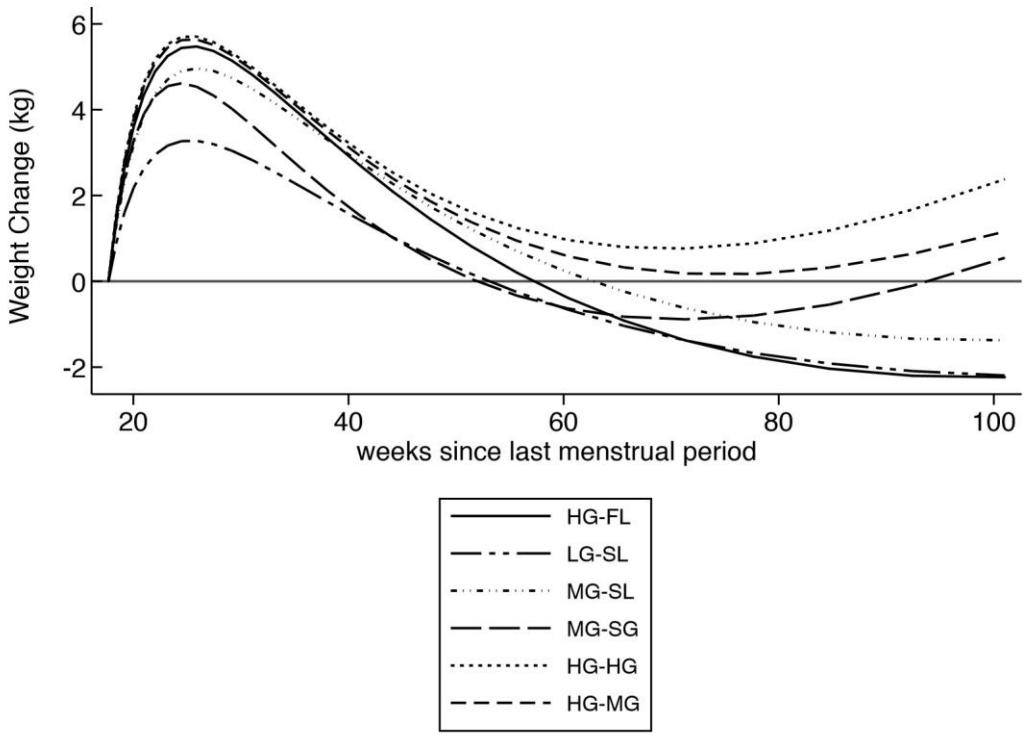
Normal weight	114 (37.3%)	24 (92.3%)	58 (78.4%)	27 (31.8%)	4 (5.6%)	1 (3%)	0 (0%)	
Overweight	132 (43.1%)	0 (0%)	16 (21.6%)	54 (63.5%)	54 (75%)	8 (24.3%)	0 (0%)	
Obesity	58 (18.9%)	0 (0%)	0 (0%)	4 (4.7%)	14 (19.4%)	24 (72.7%)	16 (100%)	
Walking at 2nd trimester of pregnancy								
< 20 min/d	41 (13.4%)	1 (3.9%)	12 (16.2%)	14 (16.5%)	6 (8.3%)	5 (15.1%)	3 (18.7%)	
20-60 min/d	146 (47.7%)	13 (50%)	32 (43.3%)	42 (49.4%)	35 (48.6%)	18 (54.6%)	6 (37.5%)	0.58
> 60 min/d	119 (38.9%)	12 (46.1%)	30 (40.5%)	29 (34.1%)	31 (43.1%)	10 (30.3%)	7 (43.8%)	
Watched TV or reading books at 2nd trimester of pregnancy								
< 60 min/d	80 (26.1%)	6 (23.1%)	20 (27.1%)	29 (34.2%)	13 (18.1%)	10 (30.3%)	2 (12.5%)	
60-180 min/d	187 (61.1%)	18 (69.2%)	45 (60.8%)	45 (52.9%)	47 (65.3%)	21 (63.6%)	11 (68.7%)	0.39
> 180 min/d	39 (12.8%)	2 (7.7%)	9 (27.1%)	11 (12.9%)	12 (16.6%)	2 (6.1%)	3 (18.8%)	

[a] Mean (standard deviation).
[b] Median (interquartile range).
[c] Crude multinomial logistic regression.
BMI-p, Pre-gestational Body Mass Index; HG-FL, high weight gain during pregnancy and fast weight loss postpartum; HG-HG, high weight gain during pregnancy and high gain postpartum; HG-MG, high weight gain during pregnancy and moderate gain postpartum; LG-SL, lower gain during pregnancy and moderate loss postpartum; MG-SG, moderate weight gain during pregnancy and slow gain postpartum; MG-ML, moderate weight gain during pregnancy and moderate loss postpartum.

Figures

FIGURE 1

Kilograms of weight change from second trimester of pregnancy to one year postpartum according type of trajectory. In order to compare graphically, trajectories were out of phase with respect to the average weight of the second trimester of pregnancy, starting at 0 kg (indicating without change). The key indicates type of trajectories named as HG-FL (solid), LG-SL (long dash-short dash), MG-SL (short dash-dot-dot), MG-SG (long dash), HG-HG (very short dash) and HG-MG (dash). HG-FL, high weight gain during pregnancy and fast weight loss postpartum; HG-HG, high weight gain during pregnancy and high gain postpartum; HG-MG, high weight gain during pregnancy and moderate gain postpartum; LG-SL, lower gain during pregnancy and moderate loss postpartum; MG-SG, moderate weight gain during pregnancy and slow gain postpartum; MG-ML, moderate weight gain during pregnancy and moderate loss postpartum.



Capítulo 3

EFECTO MODIFICADOR DEL ESTRÉS PSICOSOCIAL MATERNO SOBRE LA ASOCIACIÓN ENTRE GANANCIA EXCESIVA DE PESO DURANTE EL EMBARAZO Y RETENCIÓN DE PESO AL AÑO POSPARTO

Artículo aprobado para enviar a publicación

Maternal psychosocial stress influences differentially on excessive gestational weight gain and one year postpartum weight retention according reproductive history

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Abstract

Background: Weight change during and after pregnancy influences the development of obesity and non-communicable diseases later in life. In non-pregnant population, psychosocial stress has been associated with weight gain; however, the influence of maternal psychosocial stress during pregnancy on postpartum weight retention (PWR) is not yet understood.

Objective: To assess association of maternal psychosocial stress and excessive gestational weight gain (GWG) on postpartum weight retention one year after delivery. We also investigated if this association was modified for parity status.

Methods: Data from adult Mexican women with singleton pregnancies (n=994), participants of an ongoing prospective birth cohort were analyzed. We used a negative life events (NLE, 0-11 possible events) score at early pregnancy resulting from Crisis in Family Systems questionnaire to evaluate maternal psychosocial stress. Excessive GWG at third trimester of pregnancy was classified following IOM recommendations. The difference between body mass index one year after delivery (BMI_{post}) and pre-pregnancy BMI (BMI_{pre}) was used to define PWR. We used generalized structural equation models to evaluate the pattern association between psychosocial stress and excessive GWG on PWR.

Results: Mean (SD) pre-pregnancy BMI and PWR were 26.39 (4.08) kg/m^2 and 0.38 (1.73) kg/m^2, respectively. Among multiparous women, those with NLE ≥ 4 had higher probability of excessive GWG (p=0.011) than those with NLE <2, but this association did not influence on PWR (p=0.432). In nulliparous women, excessive GWG was associated with higher PWR (0.78 kg/m^2, p=0.041), compared to women with adequate GWG. Nulliparous women with NLE ≥ 2 had higher probability of breastfeeding cessation before six months postpartum,

which associated with 0.85 kg/m^2 higher PWR (p=0.014), compared with nulliparous women with NLE < 2.

Conclusions: Maternal psychosocial stress differentially influences GWG and one year PWR, depending on the women's reproductive history. The effect of psychosocial stress on PWR may be influenced by health behaviors such as breastfeeding. The need to develop prenatal and postnatal interventions tailored to the particular needs of women is highlighted.

Introduction

Weight gained during pregnancy may be retained after delivery increasing the probability to develop maternal obesity (1,2) and non-communicable diseases (NCD) later in life, which is among the top causes of mortality in adult women in Mexico and worldwide (3,4). Women who increased body mass index (BMI) after pregnancy are also in risk of developing perinatal complications in subsequent pregnancies regardless of BMI category (5,6). Postpartum weight change (PWC) has been evaluated from one month postpartum to fifteen years after delivery; however, it has shown to be highly variable among women even at the same measurement point (7), having both women with postpartum weight retention (PWR) and those with weight loss, in relation to their weight before pregnancy. Several studies have identified a link between gestational weight gain (GWG) above the recommendations and weight retention from three months after pregnancy onwards (7,8). Furthermore, several postpartum lifestyle factors, including sleep deprivation, physical inactivity, sedentary behavior, and inadequate breastfeeding practices, have been related with weight retention after pregnancy due to the gain of fat mass (9–11). These factors may be more prevalent depending on sociodemographic characteristics such as age, lower education or socioeconomic status, parity and ethnicity, which are also associated with weight retention after pregnancy (9, 12,13).

On the other hand, studies on non-pregnant population have suggested that psychosocial stress is associated with obesity (14,15) due to its potential effect on fat mass accumulation caused by dysregulation of the hypothalamus-pituitary-adrenal (HPA) axis and elevated cortisol concentrations (16). During pregnancy, only few studies have documented such association, suggesting a relationship between maternal anxiety and PWR (17,18). However, whether this association is mediated by GWG or results from a combined effect of both, is still not clear.

Therefore, in this study we aimed to assess if maternal psychosocial stress has a modifying effect on the association between excessive gestational weight gain and one year postpartum weight retention, taking into consideration sociodemographic characteristics, sedentary and breastfeeding practices. We also assessed if this association differs for parity status.

Methods

Study design and participants

We conducted a secondary analysis of pregnant women who participated in a Programing Research in Obesity, Growth, Environmental, and Social Stress (PROGRESS) cohort study. Briefly, PROGRESS is an ongoing closed prospective pregnancy cohort started in 2007 and enrolled 1054 women until 2011 who delivered live singleton birth. The general aim of the original study was to evaluate the effect of environmental exposure on infants´ health and the potential effect modification by social stressors (19). The study protocol was approved by the Research, Ethics and Biosafety committees from the National Institute of Public Health in Mexico and the Internal Review Board of the Icahn School of Medicine at Mount Sinai and the Harvard T.H. Chan School of Public Health. All women were informed about objectives and procedures of the study and signed the informed consent.

Research assistant invited women beneficiaries of 4 family clinics from Mexican Social Security Institute (IMSS) to participate in the study (19). Inclusion criteria were pregnancies with less than 20 weeks of gestation and women planning to reside in Mexico City at least for the next two years. Women were not included if they had cardiovascular or renal disease, were using steroids or antiepileptic drugs, or regular alcohol intake. Participants were followed up at third trimester of pregnancy and several times along postpartum.

Postpartum weight retention (PWR) one year after delivery

PWR was defined as the difference between BMI (kg/m^2) at one year postpartum (BMI_{post}) and pre-pregnancy BMI (BMI_{pre}) (kg/m^2). Both, pre and post BMIs were calculated with height measured at baseline visit (18±1.36 weeks of gestation) using a combined mechanical stadiometer-scale (Health-O-Meter; Scaleomatics INC, Cleveland, OG). BMI_{pre} was estimated using a longitudinal approach (mixed-effects linear model) adjusted with weight data from 6 months before pregnancy collected from clinical records; height, weight and socio-demographics characteristics measured at 2^{nd} trimester and weight measured at 3rd trimester of pregnancy. Performance of the model was tested using 10-fold cross validation and a Root Mean Square Error (RSE) of 3.21 kg was considered as a measure of predictive accuracy. Once BMI_{pre} was calculated, we classified women into four categories: underweight (<18.5 kg/m^2), normal weight (18.5- 24.9 kg/m^2), overweight (25.0- 29.9 kg/m^2) and obesity (≥ 30.0 kg/m^2).

BMI_{post} was calculated with weight measured at one year after delivery, without shoes and minimum of clothes, using the combined stadiometer-scale (Health-O-Meter; Scaleomatics INC, Cleveland, OG). All weight and height measurements were performed by trained personnel.

Excessive gestational weight gain (GWG)

We categorized participants´ GWG in the 3rd trimester of pregnancy (range 27-38 weeks) into insufficient, adequate and excessive, following the recommendations of the USA's Institute of Medicine (20). In order to classify each woman into these three categories of GWG, we adjusted their GWG with gestational age and the recommended rate of weight gain for each category of BMI_{pre}.

Gestational age (GA) at 3rd trimester was calculated from last menstrual period (LMP) and corroborated with Capurro test at birth. In the 33 cases where Capurro test differed > 2 weeks from LMP, we re-calculated GA considering Capurro test only.

To calculate the recommended rate of weight gain, we subtracted 13 weeks (corresponding to the first trimester) from the calculated GA at 3rd trimester. The resulting value was multiplied by the recommend lower and upper rate of weight gain for each BMI_{pre} category. We added 0.5 kg and 2.0 kg to the lower and upper limits, respectively, to calculate the suggested total range. We then compared this range with the GWG of each woman in the third trimester of pregnancy. GWG was computed by subtracting the measured weight at 3rd trimester from the predicted pre-pregnancy weight. We defined insufficient GWG when woman´s GWG was below the lower limit, adequate when within range and excessive when above the upper limit.

Maternal psychosocial stress

To measure maternal psychological stress, we used a negative life events (NLE) scale resulting from Crisis in Family Systems questionnaire (CRISYS) (21). This questionnaire was selected based on the maternal psychosocial stress model of Lazarus and Folkman (22) to assess stressful events and women's perception of them. This instrument has a linguistic validation for Spanish speaking population (23). Trained psychologists applied face to face CRISYS questionnaire to participants during third trimester of pregnancy. Participants were asked if any of the 64 stressing life events related to 11 domains (financial, legal, career, relationships, medical pertaining to respondent and to others, safety in the community and at home, other home issues, difficulty with authority, and discrimination) had occurred in the past six months. For each possible occurred event, women rated it as positive, negative or neutral experience. We added the number of domains in which each woman reported at least 1 negative life event to get a NLE score count from 0 to 11 (total number of domains). According to findings from research which suggested (24) than diversity of domains increase vulnerability and from our exploratory analysis results, we classified women into three categories: low psychosocial stress (NLE score 0-1), moderate psychosocial stress (NLE score 2-3) and high psychosocial stress (NLE score ≥ 4).

Socio-demographic characteristics

At baseline visit, a trained social worker applied a questionnaire on sociodemographic information. Family socioeconomic status (SES) was scored from 1 to 6 using the Mexican Association of Marketing Research and Public Opinion Index (AMAI) 13x6 battery based on family possessions, living condition and education attainment of the head of household (25). Lower scores represent families with lower SES, while families with the higher scores, and represent families with higher SES.

We constructed categories of age (18-24 y, 25-34 y, ≥ 35 y), years of schooling (≤ 6 y, 7-11 y, ≥12 y), marital status (partner, non partner) and parity (nulliparity, multiparity) based on our exploratory analysis results and scientific evidence.

Sedentarism patterns during pregnancy and postpartum

We constructed sedentary patterns from the participants' reported daily average time spent watching television/reading at four moments: two during pregnancy (initial visit and 3rd trimester) and two postpartum (follow-up visits at 1 and 6 months). This information was categorized as non-sedentary (<120 min/d), less sedentary (120-180 min/d) and sedentary (>180 min/d) (26). For pattern construction, we only used data from those women with at least one measurement during pregnancy and one during postpartum. We identified 68 different patterns which were merged into four final categories according to their similarity; for example, the first category included patterns in which a non-sedentary type was predominant. The four final categories were: mostly non-sedentarism, mostly low sedentarism, mostly sedentarism and up-down sedentarism. This latter category included cases that shifted between categories along measurements.

Breastfeeding practices

We used the data of breastfeeding practices collected at 6 months postpartum, since duration of breastfeeding has been associated with PWR (27). We classified as non-breastfeeding (non-BF) women who answered that they were not breastfeeding their babies at the time. On the other hand, women who responded they were non-exclusive breastfeeding at the time were classified as breastfeeding women (BF). We did not include women who reported exclusive breastfeeding since in a complementary analysis, we found this group to have different demographic characteristics than the rest of the sample.

Data analysis

PWR showed an approximate normal distribution as evaluated with the Kolmogorov-Smirnov test. We assessed simple patterns of association between PWR and categories of GWG,

categories of maternal psychosocial stress, as well as with other maternal variables, using generalized linear regression models and distributional graphs. To evaluate the modifying effect of maternal psychosocial stress, we fitted these models including interaction term (category of GWG*category of psychosocial stress) and stratifying according to maternal psychosocial stress categories.

Due to complex pattern among variables, we decided to use generalized structural equation models (GSEM) (28) to asses direct and indirect associations as determined by the causal diagram path (**figure 1**) based on previous evidence and exploratory analysis results. We fitted GSEM considering PWR (kg/m^2) as endogenous variable; BMI_{pre} (normal weight, overweight, obesity), GWG (insufficient, adequate, excessive), maternal psychosocial stress (low, moderate, high), non-breastfeeding (yes, no), and sedentary pattern (mostly non-sedentarism, mostly low sedentarism, mostly sedentarism, up-down sedentarism) as endogenous/exogenous variables; and age (18-24 y, 25-34 y, ≥ 35 y), SES (SES^2), years of schooling (≤ 6 y, 7-11 y, ≥12 y), marital status (partner, non partner), nulliparity (yes, no), and working away from home (yes, no) as exogenous variables.

Since primary results showed a correlation pattern between nulliparity and multiple exogenous variables, besides the possible biological effect of having a child for the first time, we stratified GSEM by nulliparity and multiparity (≥ 1 children before current pregnancy). Then, final models were fitted using a stepwise estimation method, although confirming that these were biologically plausible. We evaluated goodness of fit of each model using the available options for GSEM and final models were selected as those having the lower Bayesian Information Criterion (BIC).

We performed all analyses using STATA software (StataCorp LP) 12.0 and 14.0.

Results

Participants' characteristics

Figure 2 shows the flow chart of enrolled participants as well as those with weight data at 12 months postpartum. Of the 994 women included in the analysis, mean (sd) age was 27.1 (5.5) years and 113 (11.4%) of them were 35 years or older at inclusion. Most women had pre-pregnancy normal weight (41.9%, n=379), ≥ 1 children before current pregnancy (61.8%, n=614), partner (81.7%, n=812), 12 years or less of schooling (68.9%, n=685) and were working away from home (68.8%, n=684). According to SES score, 73.7% (n=733) of them were classified in category 3 or less. Compared with these women, those with weight data at 12 months postpartum were similar on proportion of nulliparity, category of BMI_{pre}, age, years of schooling, living with partner, SES score and proportion of working away from home ($p>0.05$).

Proportion of women classified with low, moderate and high maternal psychosocial stress was 22.9% (n=187), 39.6% (n=344) and 37.5% (n=307), respectively. Nulliparity [β= -0.37; CI 95% (-0.74, -0.00); p=0.05] and having a partner [β= -0.71; CI 95% (-1.24, -0.19); p<0.01] were associated with lower probability of being categorized with high maternal psychosocial stress. Regarding gestational weight gained at third trimester of pregnancy, 26.3% (n=191), 44.9% (n=326) and 28.8% (n=209) of the women were classified with insufficient, adequate and excessive, respectively. Women with overweight or obesity previous to pregnancy were more likely to exceed GWG recommendation, compared with women with normal weight (p<0.01).

Participants' characteristics before, during and after pregnancy by parity status and psychosocial stress level are presented in Table 1.

Postpartum weight retention one year after delivery

Mean (SD) of PWR was 0.32 (1.73) kg/m^2. Most women (n=200, 44.0%) retained above 0.5 units of BMI at one year postpartum. On the contrary, one third of women (n=140) lost more than 0.5 units. PWR was significantly higher in nulliparous women compared to multiparous women (0.57 (SD: 1.78) vs 0.16 (SD: 1.68), respectively; p<0.05). Among nulliparous women, excessive GWG (vs adequate), no BF at 6 months postpartum, not working away from home, and mostly low sedentarism and up-down sedentarism (vs mostly non sedentarism) were associated with higher PWR (p<0.05) (**Table 2**). Of these variables, only no BF was associated with PWR, with a lower coefficient magnitude among multiparous women (p<0.05). Conversely, insufficient GWG (vs adequate) was associated with lower PWR on both nulliparous and multiparous women (**Table 2**).

Association pattern among maternal characteristics before, during and after pregnancy and PWR in both nulliparous and multiparous women are shown in Figure 1A and 1B.

Association between psychosocial stress and excessive gestational weight gain on PWR

We found neither an interaction between maternal psychosocial stress and excessive GWG (data no shown) nor a modifying effect of psychosocial stress on the association between GWG and PWR (**Table 2**). Among multiparous women, we observed an association between higher psychosocial stress and excessive GWG but it was not related with PWR (**Table 2**, **Table 3**).

We did observe an indirect association between maternal psychosocial stress and PWR through the path of no BF at 6 months postpartum among nulliparous women but not among multiparous women (**Table 3)**. Compared with women with low psychosocial stress, women

with moderate or high psychosocial stress showed a significantly higher probability of no breastfeeding at 6 months postpartum.

Discussion

To our knowledge, this is the first study that assesses the association between excessive gestational weight gain (GWG) and one year postpartum weight retention (PWR) that takes into account the role of maternal psychosocial stress. Our findings differ from our hypothesis regarding the modifying effect of maternal psychosocial stress, where we expected that women with higher psychosocial stress would show a higher positive association between excessive GWG and PWR. They also differ from other studies that have shown a relationship between psychosocial stress and PWR; however, these are not directly comparable with our study since both their instrument and time of stress measure differ from ours (18,29).

The lack of a modifying effect of psychosocial stress on the association between excessive GWG and one year PWR. First, we chose negative life events (NLE) to define psychosocial stress, since we considered this measure would reflect the women's chronic exposition to stressful events, and therefore reflect a possible modification on signaling modulators of adipogenesis related to the activation of the HPA axis. However, we did not measure stress biomarkers to analyze the degree of adaptive response to stressors, thus among some women such adaptive response may differ from negative perception (30, 31), which we were not able to identify. Although cortisol concentrations during pregnancy have been used as a stress biomarker, the use of this biomarker has several limitations, including inconsistencies related with the sample used (saliva, hair, blood) and time of collection; these may influence the association of cortisol to negative outcomes (32–34). Furthermore, most perinatal research that includes cortisol measurement comes from studies that have assessed offspring's health but not the mother (35, 36).

The time when psychosocial stress was evaluated may be another consideration; this variable was collected at third trimester of pregnancy because we were looking for chronic exposition to stress and to avoid reverse causality. Pregnancy and postpartum are themselves stressful events particularly in first-time mothers (37,38), which may have influenced the lack of association in both excessive GWG and one year PWR, since the adaptive responses to stress during pregnancy may be similar among nulliparous women. The possible influence of postpartum psychosocial stress on maternal PWR requires further study.

In addition, among multiparous women who begin their pregnancy with higher stress, the physiological increase of placental-derived corticotropin releasing hormone (CRH) during the

third trimester (39) may further contribute to the association between stress and excessive GWG (32). However, their accumulated stress during pregnancy would not necessarily be related with PWR, since these women have already had experience with dealing with postnatal stressful events (40).

Our results are consistent with findings by Pedersen et al (41) showing an association between psychosocial stress during pregnancy and PWR. Our data further suggests that among nulliparous women, the positive association between psychosocial stress and PWR may be mediated by health behaviors, since women with higher psychosocial stress during pregnancy were those who had ceased to breastfeed before six months postpartum (42). In this regard, similar studies across different populations have showed than women who reported having more stressing events during pregnancy had higher probability of early termination of any type of breastfeeding (43, 44).

Regarding GWG, similar to previous studies (45, 46), we found that women with pre-pregnancy overweight or obesity, both nulliparous and multiparous, had a higher probability of having excessive GWG. However, this excessive GWG was only associated with one year PWR among nulliparous women. This could be explained given that there was a higher proportion of pre-pregnancy overweight and obesity among multiparous women. Since we considered women with adequate GWG at third trimester of pregnancy as reference group, recommendations of GWG may be not adequate for women with pre-pregnancy overweight or obesity to decrease their risk of PWR, since these recommendations are based on the relationship of maternal gestational weight with newborn's weight (47–49).

The role of parity on postpartum weight retention (PWR) is unclear. Some studies suggest multiparous women are more likely to retain weight after pregnancy, while others argue the same for nulliparous women (50). What seems to be consistent, as we observe in our study, is that multiparous women have higher pre-pregnancy BMI (50) while women with higher BMI are more likely to have excessive GWG. Therefore, pre-pregnancy obesity may explain the relationship with PWR through excessive GWG, not parity. However, most studies include parity as co-variable or confounder variable which does not allow to evaluate the indirect association between parity and PWR or the modifying effect by parity (50).

Our findings of weight change variability at one year postpartum are consistent with observational studies (50–52). Few women returned to their pre-pregnancy weight, most women retained weight and even some women lost weight. PWR has been studied in different populations, however, there is inconsistency on the time after delivery when the

measurements are carried out, some studies with measures at 3 months postpartum while others as far as fifteen years later (53). Therefore there is a lack of definition of the time when women are expected to return to their pre-pregnancy weight. To our knowledge, in Mexico there are very few studies than have reported postpartum weight retention, and most of them have evaluated weight between three and six months postpartum (54, 55). This may be a short time because there are some women who continue to lose weight after six months postpartum. Conversely, considering measurement after one year (late postpartum weight retention) may be related not only to weight gained during pregnancy, but also to weight gained after six months postpartum, which would be secondary to pre-pregnancy diet and lifestyle behavior.

Our study had some limitations to be noted. We were not able to measure pre-pregnancy weight. Therefore, bias associated with predicted pre-pregnancy weight may be correlated with GWG and weight retention at one year postpartum because predicted pre-pregnancy weight was used to calculate both of them. However, using predicted weight allow us to overcome self-report bias (56). In addition, loss to follow up is another limitation in our study. However, the pre-pregnancy characteristics of women with weight measure at one year postpartum were similar to those without data.

Prospective data collection is a main strength of our study, since it allowed us to use structural equation models, which led to the construction of causal diagrams, assess direct and indirect associations of sociodemographic characteristics, as well as the mediation role of GWG and some postpartum behaviors, on one PWR. Another strength of our study is that we considered the change in BMI as indicator of PWR rather than absolute weight, since an increase in the former may better reflect health risk than the latter.

Conclusions

Our prospective study shows that a complex relationship exists between higher maternal psychosocial stress, excessive gestational weight gain and higher one year PWR. These relationships are different between nulliparous and multiparous women. Our results suggests that the effect of psychosocial stress on gestational weight gain and postpartum weight retention is influenced by health behaviors including, but not limited to, breastfeeding. Further studies are needed to confirm our findings, which also highlight the importance of developing prenatal and postnatal interventions tailored to the particular needs of women.

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Table 1. Participants' characteristics before, during and after pregnancy by parity status and psychosocial stress level.

	Nulliparous			Multiparous		
	Low stress (n=83)	**Mid stress (n=120)**	**High stress (n=109)**	**Low stress (n=104)**	**Mid stress (n=204)**	**High stress (n=198)**
Age						
18-24 y	37 (44.6%)	66 (55.0%)	56 (51.4%)	28 (26.9%)	48 (23.5%)	50 (25.3%)
25-34 y	41 (49.4%)	44 (36.7%)	46 (42.2%)	61 (58.6%)	126 (61.8%)	123 (62.1%)
35 y	5 (6.0%)	10 (8.3%)	7 (6.4%)	15 (14.5%)	30 (14.7%)	25 (12.6%)
School						
≤ 6 y	0 (0%)	1 (0.8%)	0 (0%)	9 (8.6%)	6 (2.9%)	9 (4.6%)
7-11 y	56 (67.5%)	70 (58.4%)	64 (58.7%)	76 (73.1%)	153 (75.0%)	145 (73.2%)
≥ 12 y	27 (32.5%)	49 (40.8%)	45 (41.3%)	19 (18.3%)	45 (22.1%)	44 (22.2%)
Partner	65 (78.3%)	66 (55.0%)	65 (59.6%)	100 (96.2%)	190 (93.1%)	176 (88.9%)
Working away from home	64 (77.1%)	90 (75.0%)	81 (74.3%)	57 (54.8%)	132 (64.7%)	139 (70.2%)
SES, median (iqr)	2 (2)	3 (2)	2 (1)	3 (2)	2 (1)	2 (2)
BMI_{pre}, kg/m^2	25.8 ± 4.0	25.5 ± 3.8	26.1 ± 3.9	27.3 ± 3.8	26.5 ± 4.6	26.8 ± 3.9
Normal weight	39 (48.7%)	55 (47.8%)	44 (41.5%)	34 (33.3%)	89 (45.0%)	70 (36.5%)
Overweight	28 (35.0%)	43 (37.4%)	47 (44.3%)	49 (48.1%)	64 (32.3%)	84 (43.7%)
Obesity	13 (16.3%)	17 (14.8%)	15 (14.2%)	19 (18.6%)	45 (22.7%)	38 (19.8%)
Adequate GWG at 3T	35 (48.6%)	40 (40.8%)	44 (46.3%)	49 (53.3%)	48 (44.5%)	70 (40.2%)
Excessive GWG at 3T	22 (30.5%)	42 (42.9%)	29 (30.5%)	16 (17.4%)	44 (24.2%)	54 (31.0%)
Delivery < 37 weeks	11 (13.7%)	14 (14.8%)	7 (6.6%)	7 (6.9%)	21 (10.6%)	21 (10.9%)
Newborn weight/ age, z score	-0.6 ± 0.9	-0.5 ± 0.9	-0.5 ± 0.9	-0.4 ± 1.1	-0.6 ± 1.0	-0.5 ± 0.9
Non-BF at 6 months pp	10 (23.8%)	29 (48.3%)	29 (43.9%)	12 (21.8%)	33 (25.4%)	39 (30.5%)
Sedentarism pattern during pregnancy and postpartum						
Mostly non sedentarism	4 (6.0%)	17 (16.8%)	10 (11.2%)	14 (17.9%)	15 (9.5%)	26 (15.9%)
Mostly low sedentarism	40 (59.7%)	46 (45.5%)	48 (53.9%)	43 (55.1%)	88 (55.7%)	81 (49.7%)
Mostly sedentarism	9 (13.4%)	23 (22.8%)	19 (21.4%)	13 (16.7%)	36 (22.8%)	40 (25.5%)
Up-down sedentarism	14 (20.9%)	15 (14.8%)	12 (13.5%)	8 (10.26%)	19 (12.0%)	16 (9.8%)

SES: Socioeconomic Status; IQR: interquartile range; GWG: gestational weight gain; BF: breastfeeding

Table 2. Coefficients estimates modeling direct association between maternal characteristics and one year PWR (kg/m^2).

	Nulliparous		**Multiparous**	
	β (SE), CI 95%	**p value**[1]	**β (SE), CI 95%**	**p value**[1]
Direct association on one year PWR (kg/m^2)				
Non-Breastfeeding				
No	0.85 (0.35); 0.17, 1.53	0.014	0.55 (0.26); 0.04, 1.06	0.033
Yes	reference		reference	
Gestational weight gain at 3rd trimester of pregnancy				
Insufficient	-1.27 (0.43); -2.12, -0.41	0.004	-0.77 (0.27); -1.29, -0.25	0.004
Adequate	reference		reference	
Excessive	0.78 (0.38); 0.03, 1.53	0.041	0.21 (0.27); -0.32, 0.75	0.432
Years of schooling				
≤ 6 y	NSA		reference	
7-12 y	NSA		-0.68 (0.60); -1.86, 0.49	0.255
> 12 y	NSA		-1.23 (0.63); -2.47, 0.01	0.052
Working away from home				
Yes	-0.77 (0.36): -1.48, -0.06	0.034	NSA	
No	reference		reference	
Sedentarism pattern during pregnancy and postpartum				
Mostly non-sedentarism	reference		NSA	
Mostly low sedentarism	0.97 (0.46); 0.70, 1.86	0.035	NSA	
Mostly sedentarism	0.28 (0.59); -0.88, 1.45	0.631	NSA	
Up-down sedentarism	1.42 (0.61); 0.22, 2.61	0.020	NSA	

PWR: Postpartum Weight Retention; NSA: No significant association.
[1]Generalized Structural Equation Modeling.

Table 3. Coefficients estimates modeling indirect association between maternal characteristics and one year PWR (kg/m^2) through no breastfeeding, inadequate GWG and sedentary pattern paths.

	Nulliparous		**Multiparous**	
	β (SE), CI 95%	**p value**[1]	**β (SE), CI 95%**	**p value**
No BF[2]				
Having a partner				
Yes	NSA		-0.88 (0.43); -1.72, -0.04	0.039
No	NSA		reference	
Psychosocial stress				
Low	reference		NSA	
Moderate	1.09 (0.44); 0.22, 1.97	0.014	NSA	
High	0.91 (0.43): 0.06, 1.78	0.036	NSA	
Insufficient GWG[3]				
Age				
18-24 y	reference		reference	
≥ 35 y	1.22 (0.51); 0.20, 2.23	0.018	0.45 (0.29); -0.11, 1.01	0.115
Excessive GWG[3]				
Category of BMI_{pre}				
Normal weight	reference		NSA	
Overweight	1.24 (0.31); 0.65, 1.85	< 0.001	1.38 (0.29); 0.80, 1.96	< 0.001
Obesity	2.02 (0.41); 1.22, 2.83	< 0.001	2.07 (0.32); 1.45, 2.71	< 0.001
Maternal psychosocial stress				
Low	reference		reference	
Moderate	0.60 (0.35); -0.08, 1.29	0.084	0.53 (0.34); -0.13, 1.19	0.118
High	-0.07 (0.36); -0.78, 0.64	0.837	0.84 (0.33); 0.18, 1.49	0.011
Up-down sedentarism[4]				
Having a partner				
Yes	-0.79 (0.33); -1.43, -0.14	0.017	NSA	
No	reference		NSA	
Mostly sedentarism[4]				
Years of schooling				

≤ 6 y	reference		NSA
> 12 y	-0.68 (0.33); -1.33, -0.04	0.039	NSA

Non-BF: no breastfeeding at 6 months postpartum; GWG: gestational weight gain; NSA: No significant association.
[1]Generalized Structural Equation Modeling.
[2]Compared to Non-Exclusive Breastfeeding at 6 months postpartum.
[3]Compared to adequate GWG at 3rd trimester of pregnancy.
[4]Compared to Mostly non-sedentarism.

Figure 1. Association pattern among maternal characteristics and one year PWR on multiparous women (**A**) and nulliparous women (**B**).

Generalized structural equation models were used to construct causal diagrams; all exogenous variables were treated as categorical, not continuous. Continuous lines indicate a significant association, while dotted lines indicate tendencies without statistical significance. Among multiparous women (A) working away from home was associated with high psychosocial stress, compared with low psychosocial stress. Additionally, in these women, insufficient GWG, but not excessive GWG, was associated with PWR. Women between 25-34 years old tended to have more pre-pregnancy overweight or obesity than those younger than 25. In both nulliparous and multiparous women, being older than 34 was associated with pre-pregnancy overweight or obesity.

GWG = gestational weight gain; BF = breastfeeding; PWR = postpartum weight retention

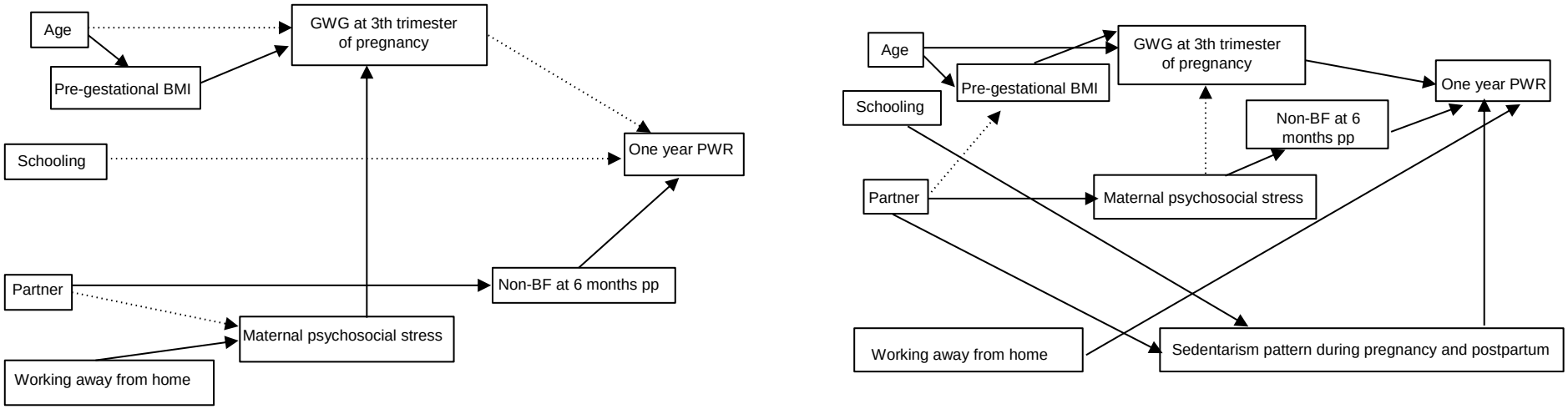
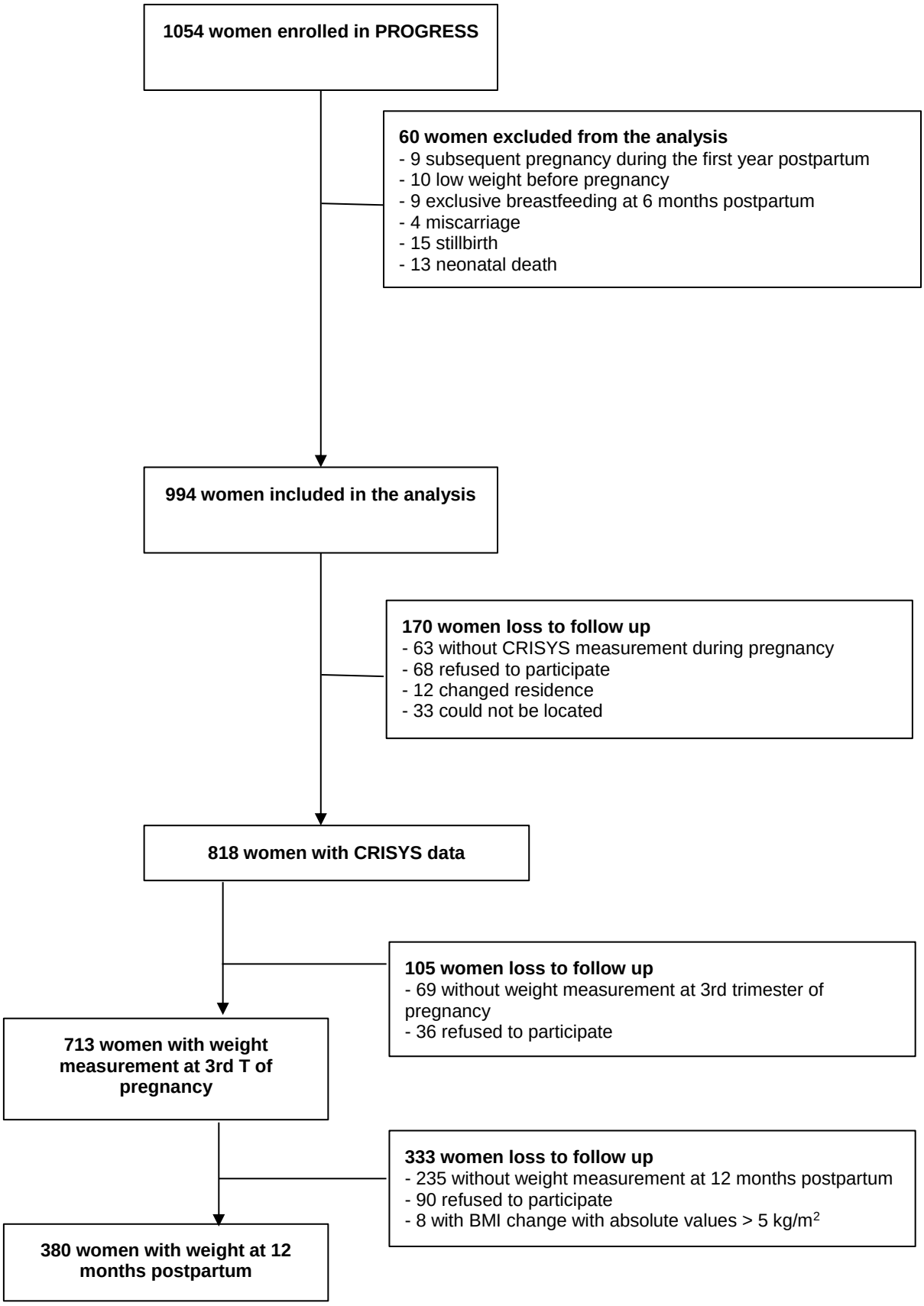


Figure 2. Flow chart of selection and loss to follow up of study participants.



Capítulo 4

CONCLUSIONES

Los resultados de la presente investigación son consistentes con la evidencia científica en relación al incremento de la probabilidad de perpetuar la mala nutrición durante el embarazo y posparto en mujeres mexicanas con sobrepeso u obesidad pre-gestacional. Además, su contribución es novedosa al estudio de la RPP, debido a que se identifica cómo el peso puede deberse no solo a la retención sino a una ganancia, hace una diferencia de las variables asociadas con la RPP de acuerdo a la historia reproductiva, sugiere una posible relación causal en las variables de estudio e incluye la dimensión psicológica en la relación entre la GEP y RPP.

Resaltamos la necesidad de otros estudios que confirmen los resultados derivados de la presente investigación. Además, considerar la evaluación de conductas de alimentación y estilo de vida, como es la privación de sueño y actividad física, durante y después del embarazo, sobre la RPP. Esto con el fin de diferenciar si estas conductas explican la relación del EPM con la GEP o tienen un efecto independiente durante el posparto que atenúa la relación entre la GEP y RPP, en mujeres multíparas. También sugerimos se re-evalúen las recomendaciones de ganancia de peso durante el embarazo en mujeres mexicanas, que además de considerar el crecimiento adecuado del bebé, impacten en la recuperación del peso pre-gestacional en los primeros 6 meses posparto.

La presente investigación tiene implicaciones importantes de salud para las mujeres mexicanas en edad reproductiva. En primer lugar, revela la importancia de individualizar las intervenciones prenatales de salud y nutrición de acuerdo a la historia reproductiva de la mujer. Además, se necesitan soluciones complejas para problemas complejos, por lo que las intervenciones o estrategias deben considerar múltiples componentes que no solo abarquen la etapa de embarazo, sino también previo y posterior a éste. En dicho sentido, se hace un llamado especial para ofrecer una atención de salud continua a la mujer desde la etapa prenatal hasta el primer año posparto. Por último, se sugiere evaluar el impacto de la atención temprana durante el embarazo y redes de apoyo durante el posparto sobre la RPP tanto en mujeres que serán madres por primera vez o aquellas que comienzan su embarazo con sobrepeso u obesidad.