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The influence of sleep duration on postpartum weight change in black and Hispanic women

Sharon J. Herring[1,4], **Daohai Yu**[4], **Andrea Spaeth**[2], **Grace Pien**[5], **Niesha Darden**[2,4], **Valerie Riis**[6], **Veronica Bersani**[2,4], **Jessica Wallen**[2,4], **Adam Davey**[7], and **Gary D. Foster**[2,8,9]

1. Department of Medicine, Lewis Katz School of Medicine at Temple University, Philadelphia, PA

2. Center for Obesity Research and Education, College of Public Health, Temple University, Philadelphia, PA

3. Department of Obstetrics, Gynecology, and Reproductive Sciences, Lewis Katz School of Medicine at Temple University, Philadelphia, PA

4. Department of Clinical Sciences, Lewis Katz School of Medicine at Temple University, Philadelphia, PA

5. Department of Pulmonary and Critical Care Medicine, Johns Hopkins University, Baltimore, MD

6. Department of Obstetrics and Gynecology, University of Pennsylvania, Philadelphia, PA

7. College of Health Sciences, University of Delaware, Newark, DE

8. Weight Watchers International, New York, NY

9. Center for Weight and Eating Disorders, Perelman School of Medicine, University of Pennsylvania, Philadelphia, PA

Abstract

Objective: To examine associations of objectively-measured sleep duration with weight changes in black and Hispanic mothers over the first postpartum year.

Methods: Data were from 159 mothers (69% black, 32% Hispanic). We assessed nocturnal sleep duration using wrist actigraphy at 6 weeks and 5 months postpartum, examined as a continuous variable and in categories (<7 versus ≥7 hours/night, consistent with American Academy of Sleep Medicine recommendations). Body weights were abstracted from medical records in pregnancy

Address correspondence and reprint requests to: Sharon J. Herring, MD, MPH, Center for Obesity Research and Education, Temple University, 3223 N. Broad Street, Suite 175, Philadelphia, PA 19140, Phone: 215-707-2234, Fax: 215-707-6475, Sharon.Herring@temple.edu.

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and measured at 6 weeks, 5 months, and 12 months postpartum. Outcomes included early postpartum (6 weeks to 5 months) and late postpartum (5 to 12 months) weight changes.

Results: The majority of participants slept <7 hours/night at 6 weeks (75%) and 5 months (63%) postpartum. Early postpartum weight change did not differ by 6 week sleep duration category. By contrast, adjusted average late postpartum weight gain (SE) was 1.8 (0.7) kg higher in participants sleeping <7 hours at 5 months postpartum compared to those sleeping ≥7 hours (p=0.02). We did not detect statistically significant associations of continuous measures of sleep duration, nor measures of sleep quality, with postpartum weight changes.

Conclusions: Sleeping <7 hours/night was associated with late postpartum weight gain in minority mothers.

Keywords

maternal obesity; sleep disorders; African American; Hispanics; weight gain

Introduction

The postpartum period represents a critical opportunity for young, ethnic minority women to experience – or avoid – excess weight gain and incident cardiometabolic disease (1, 2), especially for the nearly three-quarters of black and Hispanic women who enter pregnancy already obese (3). These women may be particularly disadvantaged, as they are at highest risk for retaining weight at the end of the first postpartum year, and actually begin gaining weight after 4-6 weeks' postpartum (4-6). Excess weight accrued after childbirth may be particularly harmful, as its damaging effects cross generations; data suggest that even small increases in maternal body mass index (BMI) result in a host of new perinatal complications in subsequent pregnancies (e.g., preeclampsia, gestational diabetes, fetal overgrowth) (7). Understanding modifiable determinants of postpartum weight change is critical for the development of effective interventions to slow the trajectory of weight gain, particularly among those mothers at highest risk.

One potentially modifiable risk factor of increasing interest is sleep duration, as numerous epidemiologic studies have found an increased risk of new or persistent obesity and cardiometabolic disorders among adults and children with insufficient nocturnal sleep (8-10). Partial and complete sleep restriction alter levels of several hormones involved in the regulation of appetite, including increases in ghrelin and decreases in leptin, that predispose to elevated hunger and increased caloric intake (11). Curtailed sleep may lead to dietary disinhibition or present a greater opportunity to eat, particularly if the majority of time awake is spent in sedentary activities (e.g., television viewing), during which snacking is common (12). Other aspects of sleep, including the continuity or discontinuity of sleep and timing of sleep-wake cycles, may additionally promote obesity and disordered metabolism (13, 14). While the American Academy of Sleep Medicine (AASM) currently recommends that "adults aged 18 to 60 years should sleep 7 or more hours per night on a regular basis to promote optimal health and reduce the risk of adverse health outcomes" (15), most mothers report poor nocturnal sleep in the first year after childbirth (16). However, few studies have objectively evaluated postpartum sleep (17), and none to our knowledge have explored the relationship between objectively-assessed sleep parameters and postpartum weight change among a racially and ethnically diverse sample of mothers.

Thus, in this study of black and Hispanic women over the first postpartum year, our primary purpose was to examine the impact of objectively-measured sleep duration via wrist actigraphy at 6 weeks and 5 months postpartum on weight changes from 6 weeks to 5 months and 5 months to 12 months after childbirth, respectively. We additionally examined associations of actigraphy-measured sleep timing and continuity on postpartum weight changes.

Methods

Study design and participants

Study subjects were participants in a longitudinal cohort study of maternal cardiometabolic risk factors, sleep, and offspring health over the first year after childbirth (grant 2012065 from the Doris Duke Charitable Foundation). Designed to identify modifiable and non-modifiable contributors of one-year postpartum weight gains in ethnic minority socioeconomically disadvantaged mothers, cohort participants were recruited between 2012 and 2013 in late pregnancy or at delivery from Temple University Hospital, an urban academic medical center in Philadelphia that serves predominately black and Hispanic, Medicaid-insured patients. At 6 weeks and 5 months postpartum (baseline and second study visits, respectively), trained research staff administered a questionnaire assessing demographics, medical history and lifestyle behaviors, obtained maternal anthropometric measures, and provided participants with a wrist actigraph to wear over the subsequent week. At 12 months postpartum (final study visit), staff again administered the questionnaire and obtained anthropometric measures.

Eligibility criteria included age ≥16 years, <1 month postpartum at recruitment, fluency in English, and plans to stay in Philadelphia for the first postpartum year. Women were excluded if they delivered multiples (e.g., twins, triplets), had pre-existing cardiometabolic disease (e.g., cardiovascular disease, diabetes mellitus, hypertension), or carried a diagnosis of obstructive sleep apnea. We recruited 540 women (85% of those approached), of whom 251 subsequently became ineligible for cohort enrollment because of stillbirth/infant death (n=4), relocation outside of Philadelphia (n=14), or failure to attend baseline assessments (n=233), leaving 289 enrolled mothers. All women provided written informed consent, and the institutional review board of Temple University approved the protocol.

Because the primary aim of this investigation was to examine the association between objectively-measured sleep duration and weight change over the first postpartum year, only participants who had complete measured sleep and weight data at all pre-specified time points were included, yielding a final analytic sample of 159 women. Participants excluded from analyses were more likely to be married (36% vs. 12%) and feed their infants some breastmilk (61% vs. 44%) compared to those who were included in analyses. Average weights (at 6 weeks, 5 months, and 12 months postpartum) and prevalence of early pregnancy obesity (36% vs. 39%) were not significantly different between the two groups.

Postpartum sleep duration, continuity, and timing

Sleep duration was assessed using an actigraph wristwatch (AW-2, Philips Respironics) that participants were asked to wear on their non-dominant wrists continuously for seven days and nights at 6 weeks and 5 months postpartum. Actigraphs use highly sensitive accelerometers to measure gross motor activity, analyzed to identify sleep periods (18). Wrist actigraphy has been compared to polysomnography (PSG) – considered the gold standard for measuring sleep, demonstrating high accuracy (87%) and sensitivity (97%) for detecting nighttime sleep, but low specificity (33%) for detecting wakefulness (19). However, actigraphy is preferable for measuring nocturnal sleep duration because it is unobtrusive, records for multiple nights at a lower cost than PSG, and it eliminates participant burden or laboratory effects. The actigraph device had an event marker that could be pressed to indicate specific times; participants were asked to press this marker when they got in and out of bed at night. Participants were also asked to keep a daily sleep log (adapted from our prior research) (20), recording their nighttime sleep onset time, morning wake time, and any periods of device removal. An actigraphy recording was considered successful if there was a minimum of 3, 24-hour periods recorded and if there was no off-wrist time within these periods noted in sleep log records.

Actigraphy data were analyzed by two trained research staff with the use of Actiware Software version 6.0.0 (Phillips Respironics). We first used the manufacturer default setting of 10 minutes immobile for determination of nocturnal sleep onset and end times, followed by verification or manual adjustment of the sleep period by trained staff after review of each participant's event marker data. Sleep logs aided scoring when participants forgot to push event markers. Large discrepancies in sleep onset/end times were brought to biweekly meetings for adjudication. For each 30-second epoch, a medium sensitivity threshold (40 activity counts/minute) was used to calculate sleep/wake variables within the interval between sleep onset time and sleep end time (21).

For this analysis, we were most concerned with average nocturnal sleep duration at 6 weeks and 5 months postpartum, calculated as the time between sleep onset and end times, minus the time classified as awake using the medium sensitivity threshold (preset by the manufacturer), averaged over the number of days with scored data. We additionally used actigraphy to calculate average nocturnal sleep timing and continuity measures at each time period, including: wake after sleep onset (WASO, defined as minutes spent awake between sleep onset and end time); sleep efficiency (the percentage of time spent asleep during the sleep period); and sleep midpoint (the clock time that represents the midpoint between sleep onset and end time). Participants were categorized as having normal sleep timing if the average midpoint of sleep was between 1AM and 5AM or late sleep timing if the midpoint was >5AM, which is past the 50^{th} percentile of sleep midpoint times in the general population (22).

Postpartum weight change

At 6 weeks, 5 months, and 12 months postpartum, maternal body weights in kilograms were measured in light clothing, without shoes, using a calibrated SECA digital scale at our research facility or at participants' homes by trained research staff. In the rare case when research weights were missing (n=7 [4%] at 6 weeks, n=10 [6%] at 5 months, and n=7 [4%] at 12 months), we included electronic health record (EHR) weights abstracted from physician visits ±14 days of a study assessment, given the strong concordance between maternal EHR weights and research weights (23). We focused our analyses on two non-overlapping, measured weight change outcome variables over the first postpartum year: early postpartum weight change and late postpartum weight change. We subtracted 5-month postpartum weight from 6-week postpartum weight to calculate early postpartum weight change. Late postpartum weight change was defined at 12-month postpartum weight minus 5-month postpartum weight.

Covariates

Sociodemographic variables.—We collected information on sociodemographics including maternal race/ethnicity, age, education, parity, marital status, and eligibility to receive benefits from the Special Supplemental Nutrition Program for Women, Infants, and Children (income proxy), all reported by the participants at 6 weeks postpartum.

Perinatal variables.—We calculated early pregnancy BMI using participants' first measured prenatal weight and height, both abstracted from medical records. Similar to other studies among childbearing women, we chose to use participants' first trimester weight as the proxy for maternal pregravid weight because measured pre-pregnancy weight is infrequently available and self-reported weight varies by BMI and sociodemographic factors (24, 25). One hundred fourteen (72%) participants had a first trimester weight available for analysis; we created a regression model (described in a prior publication) for the remaining women to predict first trimester prenatal weight (26). Initial BMI categories were underweight ($<18.5 kg/m^2$), healthy weight ($18.5-24.9 kg/m^2$), overweight ($25-29.9 kg/m^2$), or obesity ($\geq 30 kg/m^2$). However, preliminary findings revealed similar postpartum mean weight changes for underweight, healthy weight and overweight early pregnancy BMI categories, and thus, we collapsed these three BMI groups into one (women without early pregnancy obesity, $<30 kg/m^2$), and compared them to women with obesity ($\geq 30 kg/m^2$) for this analysis.

We additionally calculated mothers' total gestational weight gain, defined as delivery weight (abstracted from prenatal records, mean 0.7 weeks before delivery) minus first trimester weight. Because gestational weight gain was non-normally distributed, we log-transformed and standardized its distribution before entry into regression models. We also created categories of gestational weight gain (excessive vs. adequate/inadequate) based on each woman's early pregnancy BMI using 2009 Institute of Medicine (IOM) gestational weight gain guidelines (25).

Psychosocial and additional behavioral variables.—Physical activity was assessed using questions adapted from the 2001 Behavioral Risk Factor Surveillance System survey (27). We asked participants to recall overall frequency and duration of time spent in activities of light intensity (e.g., walking), moderate intensity (e.g., vacuuming), and vigorous intensity (e.g., running) in a usual week over the past month at 6 weeks and 5 months postpartum. Because so few women engaged in moderate and/or vigorous activity at either time point (<10%), only data for walking were analyzed. Mothers were categorized into 3 groups using cut-points adapted from Bentley *et al* (28): 1) not walking at least 10 minutes at a time in a usual week; 2) walking between 10 and 60 minutes; or 3) walking >60 minutes. The walking measure has moderate reliability across gender and race (kappa coefficient=0.4), and fair validity compared to physical activity logs (kappa coefficient=0.2) (29). We also queried participants about time spent watching television and using the computer at each visit, quantified as average hours per day.

Data classifying mothers' eating behaviors were collected at 6 weeks and 5 months postpartum using the 51-item Three-Factor Eating Questionnaire which measures dietary restraint, disinhibition, and subjective feelings of hunger (30). Higher scores represent higher levels of the eating behavior studied. The instrument has demonstrated reliability (alphas range from 0.80 to 0.93) and criterion validity (31).

At 6 weeks and 5 months postpartum, participants additionally reported cigarette smoking habits, employment status, and infant milk feeding, the latter categorized as exclusive breastfeeding, breastfeeding/formula mix, or formula only. Symptoms of postpartum depression were evaluated at each visit with the 10-item Edinburgh Postnatal Depression Scale (32), a widely used self-report screening measure. We used a cut-point of ≥9 to define depressive symptoms, validated in a large sample of low-income, urban women (33).

Statistical analyses

We built independent linear regression main effects models to evaluate relationships of sleep duration, examined as a continuous variable and in categories, with each postpartum weight change variable, first by starting with the full model of exposures and covariates at the corresponding time point (e.g., 6 weeks or 5 months postpartum), and then iteratively eliminating the least significant predictor ($p \geq 0.05$) followed by adding back a potentially significant variable ($p < 0.25$), one at a time. While we initially divided mean actigraphy-measured sleep duration into five categories, the small numbers of participants in some sleep groups, and the similar mean postpartum weight changes among those mothers with <5, 5 to <6, and 6 to <7 hours compared to those with 7 to <8 and ≥8 hours of nightly sleep at each time point, led us to collapse our sleep duration variable into two groups: <7 versus ≥7 hours/night. For example, adjusted associations between 5 month postpartum sleep duration categories and late postpartum weight changes (kg) included: <5 hours (n=11, β [SE] = 1.4 [1.4]); 5 to <6 hours (n=37, β [SE] = 0.8 [1.0]); 6 to <7 hours (n=52, β [SE] = 2.4 [0.9]); 7 to <8 hours (n=47, referent); and ≥8 hours (n=12, β [SE] = −0.5 [1.4]). The binary cut-point is consistent with AASM recommendations for adequate versus short sleep duration and prior data linking <7 hours of nightly sleep to obesity (10, 15). Post-hoc multiple comparison adjustments were made via the Tukey-Kramer method in the multiple linear regression setting. We explored effect modification by including biologically plausible interaction terms into the models. We used the same modeling strategy to additionally assess individual relationships of sleep quality measures with postpartum weight changes at each time point. SAS version 9.4 (SAS Institute, Carey, NC) was utilized to carry out all analyses.

Results

Demographics and weight change

Mean postpartum weeks at baseline was 6.0±1.9; mean postpartum months was 4.6±0.5 and 12.1±0.7 at the second and final study visits, respectively. Participant characteristics are presented in Table 1. Mean postpartum weight change from 6 weeks to 5 months was 1.0±4.3kg; mean weight change from 5 months to 12 months was −0.9±5.0kg. When stratified by early pregnancy BMI, there was a clear difference in weight change over the first postpartum year between participants with obesity compared to those without obesity (Figure 1), with the former experiencing a mean weight gain, and the latter experiencing mean weight loss.

Sleep duration, continuity, and timing

On average, participants wore the actigraph wristwatch for 6 nights (range 3 to 13), with the majority (>70%) wearing the device for 6 or 7 nights at each time period. Mean sleep durations were 6.4±1.0 and 6.6±1.1 hours/night at 6 weeks and 5 months postpartum, respectively. Short sleep duration was common; 75% of the sample slept <7 hours at 6 weeks postpartum and 63% at 5 months postpartum. Less than 1% of participants had nightly sleep durations of ≥9 hours at either time point. Average WASO decreased from 6 weeks (101.4 minutes) to 5 months (78.5 minutes) postpartum, while mean sleep efficiency modestly increased between time points (74% at 6 weeks, 78% at 5 months). In all, 38% and 32% of participants had late sleep timing (midpoint of sleep was >5AM) at 6 weeks and 5 months postpartum, respectively. Psychosocial and behavioral variables collected at 6 weeks and 5 months after childbirth were analyzed by category of sleep duration at each time point (Table 2). No statistically significant differences were found.

Associations between sleep and postpartum weight change

Table 3 shows the results of the multivariable linear regression analyses with sleep duration as a categorical variable. Early postpartum weight change did not differ by 6 week sleep duration category (p=0.76). By contrast, adjusted average late postpartum weight gain (SE) was 1.8 (0.7) kg higher in participants sleeping <7 hours at 5 months postpartum compared to those sleeping ≥7 hours (p=0.02). Additional predictors of early and/or late postpartum weight change on multivariable analyses (Table 3) were early pregnancy BMI (both early and late), gestational weight gain (early and late), parity (late only), ethnicity (late only), and smoking status (late only).

There was neither a significant linear association between sleep duration at 6 weeks postpartum and early postpartum weight change (adjusted β [SE] = 0.3 [0.3], p=0.30), nor between sleep duration at 5 months postpartum and late postpartum weight change (adjusted β [SE] = −0.5 [0.3], p=0.14). Adding a quadratic term of sleep duration into models was also not statistically significant (data not shown).

We next investigated whether the effect of sleep duration on postpartum weight change varied according to early pregnancy BMI, gestational weight gain, parity, smoking status, and ethnicity. Multiplicative interaction terms were significant only for early pregnancy BMI and categorical sleep duration (p=0.04), such that participants with obesity who slept <7 hours/night at 5 months postpartum had greater late postpartum weight gains (adjusted mean [SE] = 2.6 [0.8] kg) than longer sleepers with obesity (adjusted mean [SE] = −1.1 [1.0] kg) or women without obesity (adjusted means [SE] = −1.5 [0.7] kg and −1.9 [0.8] kg for nonobese women sleeping <7 hours/night and ≥7 hours/night, respectively; Figure 2). There was a trend toward an interaction between continuous sleep duration at 5 months postpartum and BMI category (adjusted β [SE] = −1.5 [0.8], p=0.058 for continuous sleep duration*early pregnancy obesity).

No significant associations were found between sleep timing or continuity (WASO, sleep efficiency, sleep midpoint) and postpartum weight change at either time point (Table 4).

Discussion

In this prospective cohort study using objective measures of sleep to explore the relationship between sleep duration and weight change over the first postpartum year, we found that black and Hispanic women who slept <7 hours/night at 5 months postpartum were more likely to gain weight between 5 and 12 months after childbirth, even after adjustment for important covariates, namely early pregnancy BMI category, gestational weight gain, cigarette smoking, ethnicity, and parity. Findings are consistent with those of Siega Riz, Gunderson, and Taveras that showed independent associations between self-reported short sleep duration categories at 3 or 6 months postpartum and weight retention (34-36); however, to our knowledge, the current study is the first to address the question using objective measures of sleep and weight. We did not detect statistically significant associations of continuous measures of sleep duration with postpartum weight changes.

The present study examined sleep duration as both a continuous and categorical variable. This approach was taken because many previous studies of sleep across the life course have used sleep as a continuous variable, revealing negative linear associations with weight gain and/or BMI. However, studies have also shown that the association between sleep and body weight is nonlinear (e.g., U-shaped or J-shaped), and there may be weight differences by sleep duration category (8-10). This later finding has been particularly apparent in studies linking self-reported short sleep duration with postpartum weight change (34-36), and may be the etiology of the non-significant associations in our study between continuous measures of sleep duration and weight change. Our relatively small number of subjects at extremes of sleep duration also contributed to our inability to fully explore the shape of the relationship between sleep duration and postpartum weight gain.

We found a particular risk of short sleep duration on late postpartum weight change among women with obesity. Previous studies, however, have been inconsistent regarding an interaction between BMI and postpartum sleep duration (34-36). Whether this is due to our large sample of racial/ethnic minorities is unclear and merits additional study. We also did not find that sleep duration at 6 weeks postpartum impacted weight change from 6 weeks to 5 months after birth; however, our analyses did not include daytime napping, and thus, we may have incorrectly categorized mothers as short sleepers in the early postpartum period when napping is common (17). Because naps may differ from overnight sleep in length and amount of deep sleep and rapid eye movement sleep (37), scoring algorithms validated for nighttime sleep estimation may not be equivalent for naps (38). More studies are needed to ensure that actigraphy can reliably detect napping (versus non-wear time or periods of quiet rest) to better investigate the association between early postpartum sleep duration and weight change immediately after childbirth.

In addition to sleep duration, the timing and continuity of sleep may be independent risk factors for obesity and poor cardiometabolic health (13, 14). However, data linking sleep quality variables with adiposity have largely been mixed, with studies relying on different approaches and/or cut points to define sleep measures (39, 40). In this study, we did not detect statistically significant associations of WASO, sleep midpoint, or sleep efficiency with postpartum weight changes. While Sharkey and colleagues found that women with 16-week postpartum weight retention had later sleep offset times and lower sleep efficiencies than those without postpartum weight retention (41), their study was limited by its small sample (n=21), inclusion only of women with a history of major depression or bipolar disorder, and predominance of Caucasian mothers. Adequately powered studies in diverse samples are needed to further investigate associations of sleep quality with postpartum weight gain.

We found that postpartum weight change was also positively associated with early pregnancy BMI, Hispanic ethnicity, and primiparity in our analyses, and negatively linked to smoking and gestational weight gain. These data are consistent with findings from similar samples of ethnic minority women (1, 4, 6, 42). For example, in a study of 450 women with overweight and obesity (nearly half self-identifying as black race), Ostbye *et al.* found that weight gain external to the index pregnancy began as early as 6 weeks postpartum, and lower gestational weight gains were not protective from additional weight accumulation postpartum (4). Among 427 predominately black and Hispanic mothers, Gould Rothberg *et al.* found that ongoing tobacco smoking significantly reduced postpartum weight retention (1). Additionally, several studies have found that the prevalence of high weight gains/weight retention ranged from 40%–60% among low-income Hispanic women (42, 43). Thus, any intervention designed to encourage postpartum weight loss should target mothers at highest risk for weight gain (e.g., those women who are primiparous, with early pregnancy obesity, and Hispanic ethnicity).

Strengths of our study include objective assessments of weight and sleep measured at multiple time points, a relatively large sample of socioeconomically disadvantaged black and Hispanic women followed over 12 months, and detailed information on a number of potential sociodemographic and behavioral covariates. We did not collect objective measures of physical activity and diet, which is a limitation. There is also the possibility of selection bias because the analyses only included women with available data on measured postpartum weight and sleep. However, few baseline variables were different among those included versus not, and it is unlikely that predictors of postpartum weight change would be different. While we may have included women with undiagnosed obstructive sleep apnea in this sample, adding frequent snoring to our models did not change the results (data not shown). And despite that some studies suggest sleeping >9 hours/night is also a risk factor for weight gain (10), the small number of women with sleep durations in this range precluded our ability to examine the relationship between long sleep duration and postpartum weight change. Finally, findings may not be generalizable to non-Hispanic whites or non-English speaking women.

In summary, objectively-measured nighttime sleep durations <7 hours were associated with late postpartum weight gains among black and Hispanic women. Because weight gains over the first postpartum year are associated with an adverse cardiometabolic profile (e.g., higher blood pressure, greater insulin resistance, lower adiponectin, and higher LDL cholesterol levels), emerging as early as 12 months after childbirth (2), strategies to promote postpartum weight loss are critical to the design of interventions to improve maternal health outcomes. Further research is needed to determine whether extending nocturnal sleep duration offers a useful approach for slowing the trajectory of postpartum weight gain, particularly among black and Hispanic mothers who enter pregnancy with obesity.

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What is already known about this subject?

- The most important known predictors of new or persistent obesity after childbirth are a high pregravid body mass index, primiparity, excessive gestational weight gain, and being nonwhite race/ethnicity; however, modifiable behaviors that contribute to postpartum weight gain have not been well studied, particularly among groups at highest risk.
- One potentially modifiable risk factor of increasing interest is sleep duration, as numerous epidemiologic studies have found an increased risk of new or persistent obesity and cardiometabolic disorders among adults and children with sleep durations less than 7 hours per night.
- Data support an association between self-reported short sleep duration and higher postpartum weight; however, no data evaluating this relationship using objective measures of sleep duration and body weight exist.
- The continuity or discontinuity of sleep and timing of sleep-wake cycles may additionally promote obesity and disordered metabolism, yet little is known about associations of sleep quality variables with postpartum weight changes.

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What does your study add?

- Our study is the first to find an association between short sleep duration, categorized as <7 hours/night, and postpartum weight gain using objective measures of both sleep and body weight.
- We did not detect statistically significant associations of continuously measured sleep duration, nor measures of sleep quality, with postpartum weight changes.

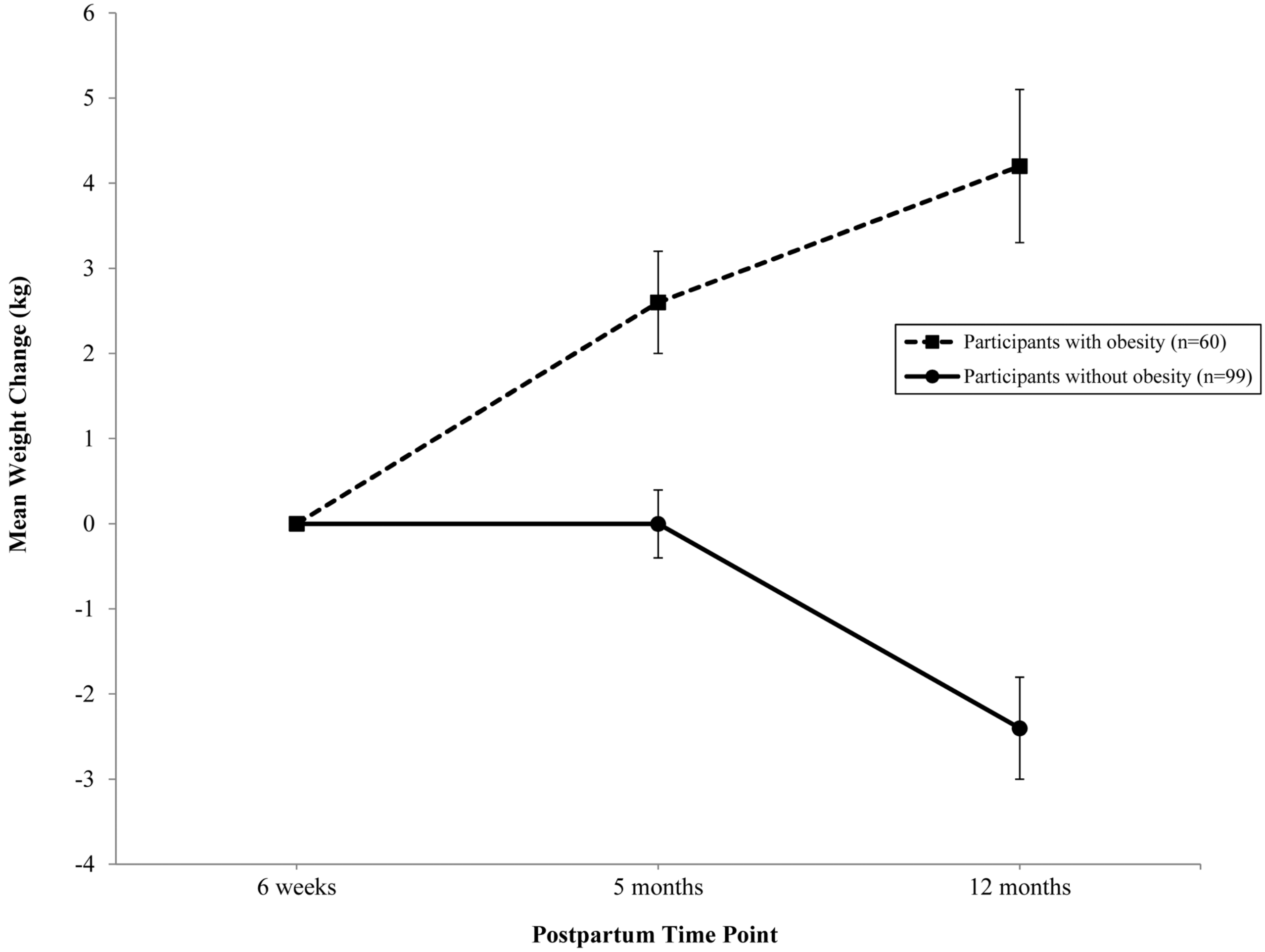

Figure 1:
Early and late postpartum mean (SE) weight trajectories stratified by early pregnancy BMI[a]
[a]0.001 between participants with and without obesity at each time point.

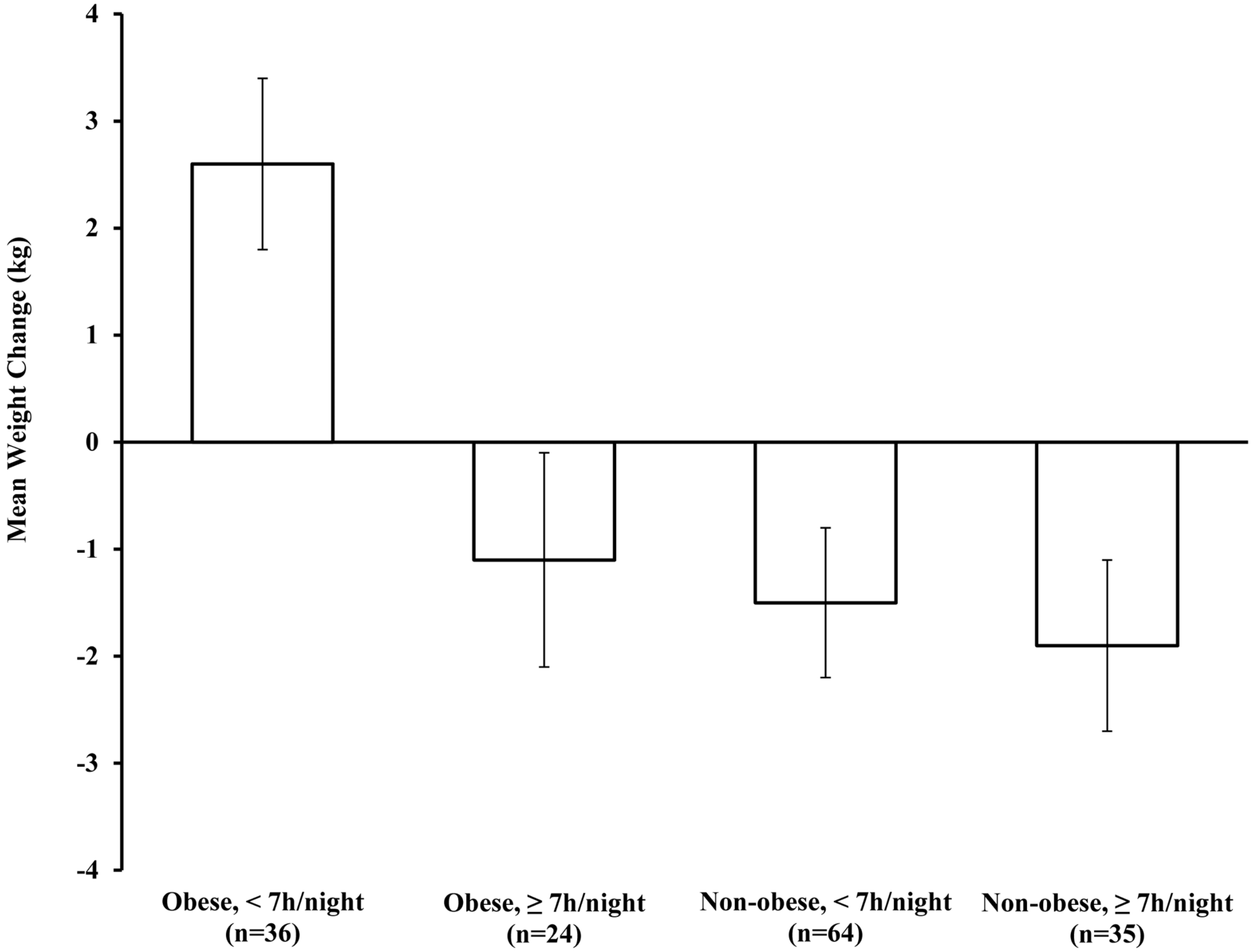

Figure 2:

Adjusted late postpartum mean weight change (SE) according to objectively-measured sleep duration and obesity status[a]

[a]Based on linear regression model for late postpartum weight change including interaction terms for early pregnancy BMI, gestational weight gain, parity, smoking status, and ethnicity with sleep duration. $p<0.01$ between participants with obesity sleeping <7 hours/night and all other groups, while all other pairwise comparisons were not statistically significant.

Table 1:

Sample characteristics and perinatal variables (n=159)[a]

	Mean ± SD or % (n)[b]
Age (years)	24.8 ± 6.0
Race	
Black	69% (110)
Other (Caucasian, American Indian)	31% (49)
Ethnicity	
Hispanic	32% (51)
Non-Hispanic	68% (108)
Education	
High school graduate or less	75% (119)
Some college or more	25% (40)
Parity	
Primiparous	38% (57)
Multiparous	62% (92)
Marital status	
Married or living as married	25% (38)
Single, separated or divorced	75% (112)
WIC eligible (at or below 185 percent of the U.S. Poverty Income Guidelines)	100% (159)
Early pregnancy BMI (kg/m^2)	
<30 (non-obese)	62% (99)
≥30 (obese)	38% (60)
Gestational weight gain (IOM guidelines)	
Excessive	42% (66)
Adequate/inadequate	58% (93)

SD = Standard Deviation; WIC = Special Supplemental Nutrition Program for Women, Infants, and Children; BMI = Body Mass Index; IOM = Institute of Medicine.

[a]Measured at baseline (6 weeks postpartum) except where noted.

[b]The sample sizes indicate that some women did not have complete data for all the variables.

Table 2:

Psychosocial and behavioral variables at 6 weeks and 5 months postpartum by category of sleep duration (<7 hours/night vs. ≥7 hours/night) at each time point[a]

	6 weeks postpartum		5 months postpartum	
	<7 hours *n=120*	≥7 hours *n=39*	<7 hours *n=100*	≥7 hours *n=59*
Cigarette smoking habit				
Current smoker	27% (31)	24% (9)	31% (24)	30% (15)
Non-smoker	73% (82)	76% (28)	69% (54)	70% (35)
Breastfeeding status				
Exclusively breastfeeding	12% (14)	19% (7)	5% (4)	6% (3)
Breastmilk/Formula mix	43% (48)	35% (13)	45% (35)	26% (13)
Formula only	45% (51)	46% (17)	50% (39)	68% (34)
Employment				
Working	27% (31)	24% (9)	41% (32)	32% (16)
Not working or on maternity leave	73% (82)	76% (28)	59% (46)	68% (34)
Depressive symptoms				
No (<9 EPDS score)	78% (86)	86% (32)	91% (71)	90% (45)
Yes (≥9 EPDS score)	22% (24)	14% (5)	9% (7)	10% (5)
Low-intensity activity (walking)				
None to <10 minutes/week	46% (51)	64% (23)	32% (24)	50% (25)
10-60 minutes/week	10% (11)	11% (4)	11% (8)	8% (4)
≥60 minutes/week	44% (48)	25% (9)	57% (43)	42% (21)
TV (hours/day)[b,c]	4.2 ± 2.8	4.4 ± 3.0	3.1 ± 2.4	3.7 ± 2.5
Computer use (hours/day)[b,c]	3.9 ± 3.2	4.1 ± 3.8	3.7 ± 2.9	4.1 ± 3.1
Eating behavior[b,c]				
Disinhibition	3.8 ± 2.2	3.5 ± 2.3	4.5 ± 3.0	4.8 ± 3.1
Cognitive Restraint	3.7 ± 3.1	2.6 ± 2.3	4.5 ± 4.0	4.1 ± 3.7
Hunger	3.8 ± 2.5	3.7 ± 2.5	4.2 ± 3.4	4.9 ± 3.3

EPDS = Edinburgh Postnatal Depression Scale. Data are presented as mean ± standard deviation or % (n).

[a]The sample sizes indicate that some women did not have complete data for all the variables.

[b,c]n=113 and 37 at 6 weeks postpartum, respectively; n=78 and 50 at 5 months postpartum, respectively.

Table 3:

Coefficient estimates modeling sleep duration category with early (6 weeks to 5 months) and late (5 to 12 months) postpartum weight changes (kg)

	Early postpartum weight change		Late postpartum weight change	
	β ± SE	*p*-value	β ± SE	*p*-value
Sleep (hours/night)[a]		0.76		0.02
<7 hours	0.2 ± 0.7		1.8 ± 0.7	
≥7 hours	Reference		Reference	
Early pregnancy body mass index		0.006		<0.001
Obese	1.9 ± 0.7		2.8 ± 0.8	
Non-Obese	Reference		Reference	
Gestational weight gain (kg^{log10})	−2.8 ± 1.0	0.008	−3.8 ± 1.2	0.002
Ethnicity	-			0.009
Hispanic			2.0 ± 0.8	
Non-Hispanic			Reference	
Parity	-			0.02
Primiparous			1.8 ± 0.8	
Multiparous			Reference	
Cigarette smoking habit[a]	-			0.08
Current smoker			−1.4 ± 0.8	
Non-smoker			Reference	

[a]These variables were measured at 6 weeks postpartum for associations with early postpartum weight change and at 5 months postpartum for associations with late postpartum weight change.

Table 4:

Associations of sleep continuity or timing with early (6 weeks to 5 months) and late (5 to 12 months) postpartum weight changes (kg)[a]

	Early postpartum weight change[b]		Late postpartum weight change[c]	
	β ± SE	***p*-value**	**β ± SE**	***p*-value**
Sleep midpoint		0.08		0.74
>5am	−1.1 ± 0.6		−0.3 ± 0.8	
≤5am	Reference		Reference	
WASO (minutes)	0.01 ± 0.01	0.14	−0.005 ± 0.01	0.70
Sleep efficiency (%)	−0.003 ± 0.04	0.94	0.02 ± 0.1	0.74

WASO = wake after sleep onset

[a]Sleep variables were measured at 6 weeks postpartum for associations with early postpartum weight change and at 5 months postpartum for associations with late postpartum weight change.

[b]Each sleep variable was analyzed in separate multivariable regression models, adjusted for gestational weight gain and early pregnancy body mass index.

[c]Each sleep variable was analyzed in separate multivariable regression models, adjusted for gestational weight gain, early pregnancy body mass index, ethnicity, parity, and 5 month postpartum smoking habit.