Sleep and Diet in Urban Pregnant African American Women

Journal of Health Disparities Research and Practice

Volume 13 | Issue 1 Article 7

2020

Sleep and Diet in Urban Pregnant African American Women

Erica C. Jansen , *University of Michigan*, janerica@umich.edu

Louise M. O'Brien , *University of Michigan*

Gwen L. Alexander , *Henry Ford Health System*

See next page for additional authors

Sleep and Diet in Urban Pregnant African American Women

Abstract

ABSTRACT

Objective: Sleep disturbances during pregnancy are associated with gestational diabetes and excessive weight gain. Diet could potentially play a role in these relationships, yet examinations of sleep and diet in African American pregnant populations are scarce.

Methods: The study population includes pregnant African American women from Detroit, MI (n=53). At the baseline study visit during late pregnancy, women were surveyed about typical bed and wake times, as well as usual food intake via a dietary screener. Sleep measures examined included time in bed and sleep midpoint (median of going to bed and wake time). Composite dietary measures included estimated fruit and vegetable (FV), dairy, and added sugar intake. Linear regression models were used to evaluate associations between sleep and dietary measures, adjusting for potential confounders.

Results: On average, women with shorter time in bed (<8 hours compared to>≥8 hours) had one cup/day higher intake of fruits and vegetables (95% CI 0.10 to 1.83), driven by the individual items tomato sauce, salsa, and fruit juice. Delayed sleep timing (a midpoint>2:45 AM compared to midpoint≤2:45 AM) was associated with 0.78 cup/day lower fruit and vegetable intake (95% CI -1.67 to 0.12), mostly driven by whole fruit and vegetables (e.g. string beans, peas, corn rather than salad or cooked dried beans). Later midpoint was also associated with lower dairy intake (0.41 fewer servings/day; 95% CI -0.78 to -0.04), particularly milk. Shorter time in bed was associated with higher pastry intake, and delayed sleep timing was associated with lower pastry intake.

Conclusions: Sleep characteristics were uniquely associated with diet in pregnant women.

Keywords

sleep duration, circadian, chronotype; midpoint; diet; fruits; vegetables; dairy; added sugar

Cover Page Footnote

We gratefully acknowledge the Mama Bear study team and all the women who participated. The study was funded by the National Institute of Child Health and Human Development grant 5R21HD085138 (PI-Kerver). Dr. Jansen reports postdoctoral support by the National Institutes of Health/National Heart, Lung, and Blood Institute grant T32HL110952 during the conduct of the study. The funders played no role in the present manuscript.

Authors

Erica C. Jansen, Louise M. O'Brien, Gwen L. Alexander, Gayle M. Shipp, Gwendolyn Norman, Kathryn Brogan-Hartlieb, Joseph C. Gardiner, and Jean M. Kerver

Journal of Health Disparities Research and Practice
Volume 12, Issue 1, pp. 125-135

School of Public Health
University of Nevada, Las Vegas

Sleep and Diet in Urban Pregnant African American Women

Erica C. Jansen, University of Michigan
Louise M. O'Brien, University of Michigan
Gwen L. Alexander, Henry Ford Health System
Gayle M. Shipp, Michigan State University
Gwendolyn S. Norman, Wayne State University
Kathryn Brogan-Hartlieb, Florida International University
Joseph C. Gardiner, Michigan State University
Jean M. Kerver, Michigan State University
Corresponding Author: Jean Kerver, Email: kerverje@msu.edu

ABSTRACT
Objective: Sleep disturbances during pregnancy are associated with gestational diabetes and excessive weight gain. Diet could potentially play a role in these relationships, yet examinations of sleep and diet in African American pregnant populations are scarce.
Methods: The study population includes pregnant African American women from Detroit, MI (n=53). At the baseline study visit during late pregnancy, women were surveyed about typical bed and wake times, as well as usual food intake via a dietary screener. Sleep measures examined included time in bed and sleep midpoint (median of going to bed and wake time). Composite dietary measures included estimated fruit and vegetable (FV), dairy, and added sugar intake. Linear regression models were used to evaluate associations between sleep and dietary measures, adjusting for potential confounders.
Results: On average, women with shorter time in bed (<8 hours compared to ≥8 hours) had one cup/day higher intake of fruits and vegetables (95% CI 0.10 to 1.83), driven by the individual items tomato sauce, salsa, and fruit juice. Delayed sleep timing (a midpoint>2:45 AM compared to midpoint≤2:45 AM) was associated with 0.78 cup/day lower fruit and vegetable intake (95% CI -1.67 to 0.12, P=0.09), mostly driven by whole fruit and vegetables (e.g. string beans, peas, corn rather than salad or cooked dried beans). Later midpoint was also associated with lower dairy intake (0.41 fewer servings/day; 95% CI -0.78 to -0.04, P=0.03), particularly milk. Shorter time in bed was associated with higher pastry intake, and delayed sleep timing was associated with lower pastry intake.
Conclusions: Sleep characteristics were uniquely associated with diet in pregnant women.

Keywords: sleep duration, circadian, chronotype, midpoint, diet, fruits, vegetables, dairy, added sugar

INTRODUCTION

Disrupted sleep is a hallmark of pregnancy and has cardiometabolic implications for the pregnant person and developing fetus. For example, pregnant people with extremes in sleep duration (both shorter and longer) and lower sleep quality have a higher likelihood of gestational diabetes (Xu et al. 2018; Zhong et al. 2018) and may experience higher weight gain (Gay et al. 2017). Later sleep timing (which can be a marker of circadian misalignment) is also emerging as a potential independent risk factor for worse cardiometabolic outcomes during pregnancy (Facco et al. 2017).

As a potential mechanism linking sleep and metabolic health in adult populations, short and disrupted sleep has been associated with alterations of appetite and satiety hormones, poor dietary quality, higher total energy intake, and higher proportion of calories consumed from carbohydrates and/or fat (Chaput 2014). A few investigations of sleep and diet among pregnant women have been conducted, including studies from Singapore (Van Lee et al. 2017), Brazil (Gontijo et al. 2018), and the US. (Duke et al. 2017) Each study highlighted different aspects of sleep that may relate to lower-quality diet during pregnancy, including worse sleep quality, later chronotype, and short duration, respectively.

No studies to date have focused on urban African American women, a population especially at risk of experiencing poor sleep (Fuller-Rowell et al. 2016) and low dietary quality (Groth, Simpson, and Fernandez 2016). Thus, in an exploratory analysis, our aims were to evaluate whether shorter sleep duration and later sleep midpoints (median of bed and wake times) in late pregnancy were associated with less-healthy dietary intake among urban African American pregnant women.

METHODS

These data are from the baseline visit of a small randomized controlled trial focused on breastfeeding and postpartum weight management in African American women (R21HD085138). The institutional review boards at Michigan State University approved the research protocols and informed consent was obtained from all participants.

<u>Study Participants</u>

Pregnant African American women >18 years with intention to breastfeed were recruited from one large inner-city prenatal care clinic (Henry Ford Health System, Detroit, MI). Eligibility criteria included being an African American woman in mid-late pregnancy with intention to breastfeed. Recruitment occurred at the prenatal care visit that coincided with a glucose tolerance test. Within one week after study enrollment, participants completed interviewer-administered surveys.

<u>Sleep measures</u>

Sleep bed and wake times were assessed with two questions from the validated Pittsburgh Sleep Quality Index ("During the past month, what time have you usually gone to bed at night?" and "During the past month, what time have you usually gotten up in the morning?"). Using these data, two sleep variables regarding perceived sleep were calculated: time in bed (in hours) and midpoint of the sleep period (median of the bed and wake time, in decimal time). Time in bed and midpoint were each categorized dichotomously at the median.

Dietary Measures

Diet was measured with the Five Factor Screener developed by the NCI. (Thompson et al. 2007, 2008) These screener questions were used to estimate usual intake of fruit and vegetables (cups/day), dairy food (servings/day), and added sugars (teaspoons/day), according to the analytic steps detailed in the PhenX Toolkit. Although French fries were asked about in the questionnaire, intake of French fries was excluded from the fruits and vegetables composite score.

Covariates

The following variables from the phone interview were included as covariates: age, highest education attained, marital status, employment status, parity, the number of days spent walking>10 minutes, the amount of sedentary time on a typical weekday, and possible risk of depression (defined as a score<10 on the Edinburgh Postpartum Depression Scale), and pre-pregnancy BMI. Covariates were categorized as shown in Tables 1 and 2. Questions from the PhenX Healthy Food Environments were also examined to provide contextual information on neighborhood food access and quality.

Statistical Analyses:

Analyses were conducted with SAS version 9.4 (SAS Institute Inc, Cary, North Carolina). To examine associations between covariates and sleep, means ± SD of each dietary composite measure were stratified by categories of sleep duration and timing. For hypothesis testing, Kruskal Wallis tests were used, and P values<0.05 were considered as statistically significant. Due to the small sample size, associations with P values between 0.05 and <0.10 are also discussed.

To evaluate the primary study question, linear regression models were run with dietary measures as continuous dependent variables and dichotomous sleep measures as independent variables. In multivariable analysis, marital status, age, and education were included to account for potential confounding. These variables were selected based on prior knowledge and from associations noted in Table 1 (at P<0.2). Further adjustment for gestational age at baseline or for pre-pregnancy BMI (in sleep timing models) did not substantially alter the findings; thus, these variables were not retained in final models. Furthermore, to account for deviations from homoscedasticity and model misspecification, robust error variances were specified to estimate 95% confidence intervals (White, 1980). To more fully interpret the associations between sleep and the dietary composite scores, additional analyses were conducted with each individual food item from the dietary composite scores.

RESULTS

Of the 53 women eligible and enrolled in the randomized trial, all responded to the sleep questionnaire and answered at least one of the diet questions. The average age (SD) of women was 28.3 (6.4) years; the average gestation was 28.0 (3.5) weeks at enrollment. Women consumed an average (SD) of 2.8 (1.4) cups/day of fruits and vegetables, 1.1 (0.6) servings/day of dairy, and 13.2 (4.8) teaspoons/day of added sugar. Women at risk of depression had lower dairy intake and women classified as obese (prior to pregnancy) had higher consumption of added sugar (not shown). In addition, women with higher gestational age at the baseline visit had higher consumption of dairy (0.05 higher servings/week of gestation with 95% CI -0.01 to 0.10; P=0.08).

Regarding the neighborhood food environment, 15% of the sample disagreed with the statement that “the fresh fruits and vegetables in my neighborhood are of high quality”, 11%

disagreed with the statement that “a large selection of fresh fruits and vegetables is available in my neighborhood”, and 15% disagreed with the statement that “a large selection of low-fat products is available in my neighborhood” suggesting that over 80% of our sample did not feel food access to be a problem. Further, the access or quality of fruits, vegetables, and low-fat products in the neighborhood were not associated with components of dietary intake, except that less agreement with the statement “the fresh fruits and vegetables in my neighborhood are of high quality” was associated with lower added sugar intake (not shown).

Women reported spending on average 8.6 (2.1) hours in bed per night. The average bed time was 10:53 PM and average wake time was 7:29 AM; thus, the average sleep midpoint in decimal time was 3.2 (3:12 AM; SD=2.4). Age was inversely associated with time in bed (Table 1). Regarding midpoint, younger women (≤24 years) and older women (≥30 years) had later sleep midpoints compared to women aged 24 to <30 years.

Table 1. Maternal characteristics in relation to sleep in a sample of 53 African American pregnant women

Baseline characteristics	N	Time in bed, hours Mean ± SD	Sleep midpoint, decimal time Mean ± SD[1]
Age, years			
≤24	17	9.1 ± 2.3	3.5 ± 1.8
24 to <30	17	8.8 ± 2.1	2.0 ± 2.4
≥30	19	7.9 ± 1.8	4.0 ± 2.4
P value[2]		0.08	0.09
Estimated week of gestation			
23-25 weeks	14	8.9 ± 1.9	3.2 ± 2.9
26-28 weeks	18	8.9 ± 1.6	2.7 ± 2.0
30-37 weeks	18	8.0 ± 2.8	3.7 ± 2.8
P value		0.81	0.39
Attained education			
GED or less	20	8.8 ± 2.0	3.7 ± 2.1
Some higher education	23	8.9 ± 2.2	2.7 ± 2.4
Completed a college degree	10	7.4 ± 1.8	3.4 ± 2.6
P value		0.10	0.32
Marital status			
Never married	30	8.7 ± 2.3	3.1 ± 2.5
Living with a partner	14	8.6 ± 1.7	4.0 ± 2.2
Married	9	8.1 ± 1.9	2.3 ± 2.0
P value		0.48	0.17
Employment status			
Currently working	25	8.5 ± 2.0	3.2 ± 2.5
Not currently working	28	8.6 ± 2.2	3.2 ± 2.3
P value		0.45	0.85
Total number of pregnancies (including current)			
1 or 2	25	8.4 ± 2.2	3.1 ± 3.0

3 or more	28	8.7 ± 2.0	3.3 ± 1.7
P value		0.84	0.84
Depression[3]			
Score<10	43	8.7 ± 1.9	3.1 ± 2.4
Score 10 or more	10	8.1 ± 2.7	3.6 ± 2.0
P value		0.54	0.54
Number of days walking>10 min			
≤4 days	21	8.0 ± 2.3	3.0 ± 2.1
>4 days	23	8.7 ± 2.0	3.4 ± 2.6
P value		0.40	0.24
Time spent sitting on a weekday			
≤240 minutes	25	8.6 ± 2.2	3.6 ± 2.5
>240 minutes	20	8.3 ± 2.0	2.9 ± 2.4
P value		0.52	0.58
Pre-pregnancy BMI, self-report			
Not obese	27	8.6 ± 2.4	3.7 ± 2.0
Obese (BMI≥30)	26	8.6 ± 1.8	2.7 ± 2.6
P value		0.95	0.07

[1] Sleep midpoint refers to median between bed time and wake time, and is reported in decimal time (e.g. 3:30 AM= 3.5)

[2]P values from Kruskal Wallis test

[3]From the Edinburgh Depression Scale, a score or 10 or more indicates possible risk of depression

After accounting for age, education, and marital status, women reporting <8 hours in bed reported approximately 1 cup/day (0.80 cups) higher intake of fruits and vegetables (95% CI 0.10 to 1.83; P=0.03; Figure 1). Additional analyses revealed that the fruit/vegetable food sources with the strongest positive associations were fruit juice (P=0.08), tomato sauce (P=0.03), and salsa (P=0.03) (Table 2).

Women with a sleep midpoint later than 2:45 AM had 0.78 cup/day lower adjusted intake of fruits and vegetable (95% CI -1.67 to 0.12; P=0.09) and 0.41 adjusted servings/day less dairy (95% CI -0.78 to -0.04; P=0.03) than women with a sleep midpoint 2:45 AM or earlier. The fruit/vegetable food sources with the strongest positive associations with sleep were foods from the "fruit" and "other vegetables" (e.g. string beans, peas, corn) categories (Table 2); while the dairy food that had the strongest association was milk (Table 3).

There were no associations between sleep characteristics and overall intake of added sugar (Table 4). Nonetheless, additional analyses revealed that time in bed and sleep midpoint were each associated with consumption of pastries; women with shorter time in bed had higher intake of pastries (0.4 servings/day with 95% CI 0.08 to 0.65; P=0.01), while women with later sleep midpoints had lower intake of pastries (-0.3 servings/day with 95% CI -0.6 to -0.01; P=0.01).

Fid 1. Bivariate associations between sleep and intake of fruits/vegetables, dairy, and added sugar in a sample of 53 African American pregnant women

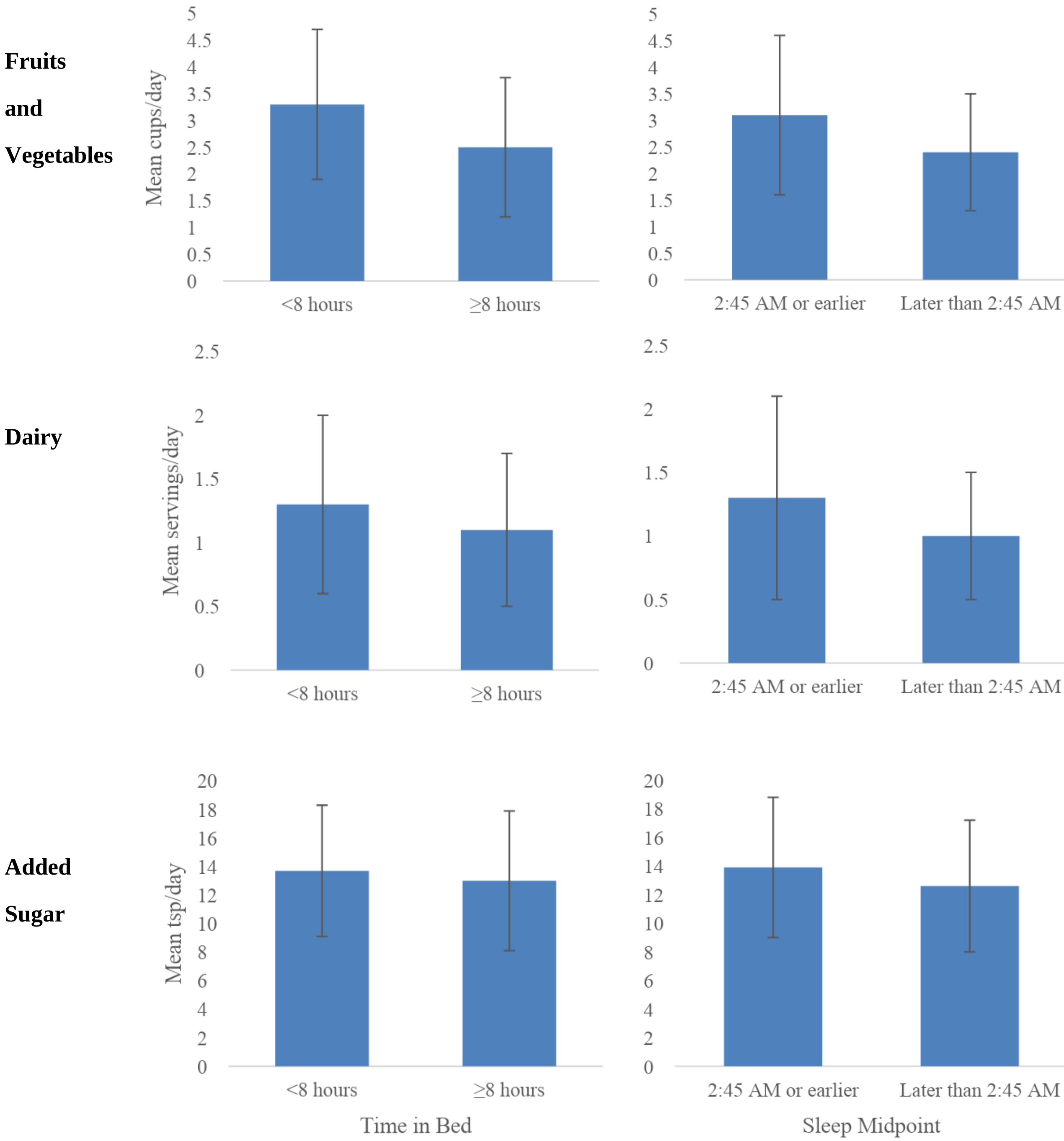

Table 2. Sleep in relation to intake of fruits/vegetables, added sugar, and dairy in a sample of 53 African American pregnant women

		Fruits and Vegetables		Added Sugar		Dairy	
Sleep characteristics	N	Means ± SD, cups/day	Adjusted Difference[1] (95% CI)	Means ± SD, tsp/day	Adjusted Difference[1] (95% CI)	Means ± SD, servings/day	Adjusted Difference[1] (95% CI)
Time in bed							
<8 hours	27	3.3 ± 1.4	0.96 (0.10, 1.83)	13.7 ± 4.6	1.57 (-1.25, 4.38)	1.3 ± 0.7	0.29 (-0.11, 0.71)
≥8 hours	26	2.5 ± 1.3	Reference	13.0 ± 4.9	Reference	1.1 ± 0.6	Reference
P value[2]			0.03		0.27		0.15
Sleep midpoint							
≤2:45 AM	26	3.1 ± 1.5	Reference	13.9 ± 4.9	Reference	1.3 ± 0.8	Reference
> 2:45 AM	27	2.4 ± 1.1	-0.78 (-1.67, 0.12)	12.6 ± 4.6	-1.50 (-4.26, 1.26)	1.0 ± 0.5	-0.41 (-0.78, -0.04)
P value			0.09		0.28		0.03

[1] From linear regression models with dietary measure as the outcome and sleep measure as the predictor (each sleep measure in a separate model), adjusted for age, education, and marital status. In each model, robust standard errors were applied to mitigate effects of heteroscedasticity and model misspecification.

Table 3. Sleep in relation to intake of foods from the fruits and vegetables screener in a sample of 53 African American pregnant women

		Fruits and vegetables intake Means ± SD, in servings per day							
Sleep characteristics	N	Fruit	Fruit Juice	Salad	White potatoes	Legumes	Other vegetables	Tomato Sauce	Salsa
Time in bed									
<8 hours	27	1.2 ± 0.7	1.1 ± 1.2	0.5 ± 0.6	0.3 ± 0.7	0.1 ± 0.1	0.6 ± 0.5	0.2 ± 0.2	0.06 ± 0.06
≥8 hours	26	0.8 ± 0.8	0.7 ± 1.0	0.4 ± 0.5	0.2 ± 0.2	0.1 ± 0.2	0.6 ± 0.9	0.1 ± 0.1	0.02 ± 0.04
P value[1]		0.46	0.08	0.53	0.25	0.39	0.78	0.03	0.03
Sleep midpoint									
≤2:45 AM	26	1.2 ± 1.0	0.9 ± 1.1	0.5 ± 0.7	0.3 ± 0.6	0.1 ± 0.1	0.8 ± 1.0	0.2 ± 0.1	0.04 ± 0.05
> 2:45 AM	27	0.6 ± 0.4	0.8 ± 1.0	0.3 ± 0.4	0.1 ± 0.1	0.1 ± 0.2	0.4 ± 0.3	0.2 ± 0.2	0.04 ± 0.06
P value[1]		0.02	0.43	0.39	0.15	0.96	0.03	0.82	0.69

[1] From linear regression models with each food item as the outcome and sleep measure as the predictor (separate models), adjusted for age, education, and marital status. In each model, robust standard errors were applied to mitigate effects of heteroscedasticity and model misspecification.

Table 4. Sleep in relation to intake of foods in the dairy screener in a sample of 53 African American pregnant women

		Dairy Means ± SD, in servings per day	
Sleep characteristics	N	Milk	Cheese
Time in bed			
<8 hours	27	0.5 ± 0.5	0.8 ± 0.7
≥8 hours	26	0.4 ± 0.6	0.5 ± 0.6
P value[1]		0.25	0.30
Sleep midpoint			
≤2:45 AM	26	0.6 ± 0.7	0.6 ± 0.6
> 2:45 AM	27	0.3 ± 0.3	0.5 ± 0.5
P value[1]		0.05	0.66

[1] From linear regression models with each food item as the outcome and sleep measure as the predictor (separate models), adjusted for age, education, and marital status. In each model, robust standard errors were applied to mitigate effects of heteroscedasticity and model misspecification.

Table 5. Sleep in relation to intake of foods in the added sugar screener in a sample of 53 African American pregnant women

		Foods with Added Sugar, Means ± SD, in servings per day			
Sleep characteristics	N	Soda	Flavored Fruit Drinks	Pastries	Cookies
Time in bed					
<8 hours	27	0.2 ± 0.2	0.2 ± 0.3	0.4 ± 0.5	0.2 ± 0.2
≥8 hours	26	0.2 ± 0.3	0.2 ± 0.3	0.1 ± 0.2	0.2 ± 0.2
P value[1]		0.68	0.29	0.01	0.87
Sleep midpoint					
≤2:45 AM	26	0.2 ± 0.3	0.2 ± 0.4	0.3 ± 0.5	0.2 ± 0.2
> 2:45 AM	27	0.2 ± 0.3	0.1 ± 0.2	0.1 ± 0.2	0.1 ± 0.2
P value[1]		0.67	0.23	0.04	0.52

[1] From linear regression models with each food item as the outcome and sleep measure as the predictor (separate models), adjusted for age, education, and marital status. In each model, robust standard errors were applied to mitigate effects of heteroscedasticity and model misspecification.

DISCUSSION

In this exploratory analysis of urban African American pregnant women, there were independent associations between self-reported time in bed and sleep midpoint in relation to diet, indicating that circadian-related relationships between appetite and food intake may be different from those of sleep duration.

A shorter amount of time spent in bed was associated with higher intake of fruits and vegetables, an association that was opposite to some previous findings. (Duke et al. 2017) Nevertheless, the fact that the association between time in bed and fruit and vegetable consumption was driven by tomato sauce, salsa, and fruit juice may indicate that the women were consuming more pizza, spaghetti and tortilla chips, or other unhealthy foods that are typically consumed with tomato sauce and salsa. Another explanation is that the amount of time spent in bed may not correspond well to the amount of time spent asleep, especially during pregnancy when sleep difficulties are quite common (Bei, Coo, and Trinder 2015). Instead, it is possible that a longer time in bed could be a marker of worse sleep quality, insomnia symptoms, or poor mental health. The finding that women with shorter time in bed also had higher consumption of pastries was in the expected direction, as other studies have reported associations between shorter sleep duration and higher refined carbohydrate intake (Haghighatdoost et al. 2012; Dashti et al. 2015), albeit in non-pregnant populations.

Pregnant women with later sleep timing had lower whole fruit and vegetable consumption. These findings are also in line with those from Brazil (Gontijo et al. 2018) and Singapore (Van Lee et al. 2017), where later sleep timing was related to lower fruit consumption and to lower adherence to a fruit and vegetable pattern, respectively. The associations may be attributed to bidirectional relationships. On one hand, delayed sleep timing may disrupt appetite hormones (Kim, Jeong, and Hong 2015) and mood (Sharkey, Pearlstein, and Carskadon 2013), which in turn could affect food choice. On the other hand, the antioxidants and nutrients present in fruits and vegetables, as well as dairy, may support healthy onset of sleep (St-Onge, Mikic, and Pietrolungo 2016).

In this sample of urban African American pregnant women, who represent an underserved population, there are several insights regarding sleep and diet. First, there was wide variability in sleep patterns, particularly in the timing which ranged from 5 PM to 8 AM for typical bed times and 11 PM to 1 PM for wake times. These patterns could be reflective of many other things going on in the study participants' lives, including work schedules and family obligations. They also likely indicate potential mental health concerns, as irregular sleep timing is common in individuals with depression and anxiety (Charrier, Olliac, Roubertoux, & Tordjman, 2017); indeed 19% of the sample screened high for depressive symptoms. Regarding diet, overall fruit and vegetable intake was fairly low, which could be due to multiple socioeconomic factors such as lack of access to fresh grocery items. Incidentally, we also found that women with higher depression scores had worse diet quality, an association that should be explored in greater depth in future analyses.

Strengths of this study include the novelty of the research question and study population. These results may be generalizable to other African American pregnant women from urban areas, a population that is historically under-represented in research. The main limitation is the small study size, which reduced power to detect associations. Second, both sleep and dietary information was self-reported, as is accepted practice in community-based rather than laboratory-based data collection. However, self-reported information can be subject to measurement error and recall bias.

Thus, findings have to be interpreted as associations between perceived sleep and self-reported diet. Another limitation was the narrow scope of the sleep and diet questions, which had to do with high perceived participant burden. A more comprehensive examination of sleep would have included other aspects of sleep quality and sleep disorders. No data were collected about timing of meals, which may have relevance with regard to sleep timing. There were also no data on the number of children within the households, which could act as an unmeasured confounder. Finally, the cross-sectional nature of this study precluded establishing the temporal sequence of sleep and diet.

CONCLUSION

In conclusion, in a small study among pregnant African American women, there was clear evidence of associations between particular aspects of sleep and diet. Future research should examine the independent contributions of sleep duration and sleep timing on dietary components other than those assessed in the present study. Given the implications of both sleep and diet for new mothers and their babies, whether the improvement of sleep health in pregnant people could also improve diet, or vice versa, deserves further study.

ACKNOWLEDGEMENTS

We gratefully acknowledge the Mama Bear study team and all the women who participated.

The study was funded by the National Institute of Child Health and Human Development grant 5R21HD085138 (PI- Kerver). Dr. Jansen reports postdoctoral support by the National Institutes of Health/National Heart, Lung, and Blood Institute grant T32HL110952 during the conduct of the study. The funders played no role in the present manuscript.

DECLARATION OF INTEREST: The authors have no conflicts of interest to disclose.

REFERENCES

Bei, Bei, Soledad Coo, and John Trinder. 2015. “Sleep and Mood during Pregnancy and the Postpartum Period.” *Sleep Medicine Clinics*. doi:10.1016/j.jsmc.2014.11.011.

Chaput, Jean-Philippe. 2014. “Sleep Patterns, Diet Quality and Energy Balance.” *Physiology & Behavior* 134: 86–91. doi:10.1016/j.physbeh.2013.09.006.

Dashti, Hassan S., Jack L. Follis, Caren E. Smith, Toshiko Tanaka, Brian E. Cade, Daniel J. Gottlieb, Adela Hruby, et al. 2015. “Habitual Sleep Duration Is Associated with BMI and Macronutrient Intake and May Be Modified by CLOCK Genetic Variants.” *American Journal of Clinical Nutrition* 101 (1): 135–43. doi:10.3945/ajcn.114.095026.

Duke, C. H., J. A. Williamson, K. R. Snook, K. C. Finch, and K. L. Sullivan. 2017. “Association Between Fruit and Vegetable Consumption and Sleep Quantity in Pregnant Women.” *Maternal and Child Health Journal* 21 (5): 966–73. doi:10.1007/s10995-016-2247-y.

Facco, F L, W A Grobman, K J Reid, C B Parker, S M Hunter, R M Silver, R C Basner, et al. 2017. “Objectively Measured Short Sleep Duration and Later Sleep Midpoint in Pregnancy Are Associated with a Higher Risk of Gestational Diabetes.” *Am J Obstet Gynecol* 217 (4): 447.e1-447.e13. doi:10.1016/j.ajog.2017.05.066.

Fuller-Rowell, Thomas E., David S. Curtis, Mona El-Sheikh, David H. Chae, Jennifer Morozink

Boylan, and Carol D. Ryff. 2016. "Racial Disparities in Sleep: The Role of Neighborhood Disadvantage." *Sleep Medicine* 27–28: 1–8. doi:10.1016/j.sleep.2016.10.008.

Gay, Caryl L., Sarah E. Richoux, Kathleen R. Beebe, and Kathryn A. Lee. 2017. "Sleep Disruption and Duration in Late Pregnancy Is Associated with Excess Gestational Weight Gain among Overweight and Obese Women." *Birth* 44 (2): 173–80. doi:10.1111/birt.12277.

Gontijo, Cristiana Araújo, Bruna Borges Macedo Cabral, Laura Cristina Tibiletti Balieiro, Gabriela Pereira Teixeira, Walid Makin Fahmy, Yara Cristina de Paiva Maia, and Cibele Aparecida Crispim. 2018. "Time-Related Eating Patterns and Chronotype Are Associated with Diet Quality in Pregnant Women." *Chronobiology International*, September, 1–10. doi:10.1080/07420528.2018.1518328.

Groth, Susan W., Alison H. Simpson, and I. Diana Fernandez. 2016. "The Dietary Choices of Women Who Are Low-Income, Pregnant, and African American." *Journal of Midwifery and Women's Health* 61 (5): 606–12. doi:10.1111/jmwh.12463.

Haghighatdoost, Fahimeh, Golgis Karimi, Ahmad Esmaillzadeh, and Leila Azadbakht. 2012. "Sleep Deprivation Is Associated with Lower Diet Quality Indices and Higher Rate of General and Central Obesity among Young Female Students in Iran." *Nutrition* 28 (11–12): 1146–50. doi:10.1016/j.nut.2012.04.015.

Kim, Tae Won, Jong-Hyun Jeong, and Seung-Chul Hong. 2015. "The Impact of Sleep and Circadian Disturbance on Hormones and Metabolism." *International Journal of Endocrinology* 2015: 1–9. doi:10.1155/2015/591729.

Lee, Linde Van, Ai Ru Chia, See Ling Loy, Marjorelee Colega, Elaine K.H. Tham, Shirong Cai, Fabian Yap, et al. 2017. "Sleep and Dietary Patterns in Pregnancy: Findings from the Gusto Cohort." *International Journal of Environmental Research and Public Health* 14 (11). doi:10.3390/ijerph14111409.

Sharkey, Katherine M., Teri B. Pearlstein, and Mary A. Carskadon. 2013. "Circadian Phase Shifts and Mood across the Perinatal Period in Women with a History of Major Depressive Disorder: A Preliminary Communication." *Journal of Affective Disorders* 150 (3): 1103–8. doi:10.1016/j.jad.2013.04.046.

St-Onge, Marie-Pierre, Anja Mikic, and Cara E Pietrolungo. 2016. "Effects of Diet on Sleep Quality." *Advances in Nutrition* 7 (5): 938–49. doi:10.3945/an.116.012336.

Thompson, Frances E., Douglas Midthune, Amy F. Subar, Victor Kipnis, Lisa L. Kahle, and Arthur Schatzkin. 2007. "Development and Evaluation of a Short Instrument to Estimate Usual Dietary Intake of Percentage Energy from Fat." *Journal of the American Dietetic Association* 107 (5): 760–67. doi:10.1016/j.jada.2007.02.006.

Thompson, Frances E, Douglas Midthune, Geoffrey C Williams, Amy L Yaroch, Thomas G Hurley, Ken Resnicow, James R Hebert, et al. 2008. "Evaluation of a Short Dietary Assessment Instrument for Percentage Energy from Fat in an Intervention Study." *The Journal of Nutrition* 138 (1): 193S–199S. doi:10.1093/jn/138.1.193S.

Xu, Ya-Hui, Le Shi, Yan-Ping Bao, Si-Jing Chen, Jie Shi, Rui-Ling Zhang, and Lin Lu. 2018. "Association between Sleep Duration during Pregnancy and Gestational Diabetes Mellitus: A Meta-Analysis." *Sleep Medicine* 52 (December): 67–74. doi:10.1016/j.sleep.2018.07.021.

Zhong, Chunrong, Renjuan Chen, Xuezhen Zhou, Shangzhi Xu, Qian Li, Wenli Cui, Weiye Wang, et al. 2018. "Poor Sleep during Early Pregnancy Increases Subsequent Risk of Gestational Diabetes Mellitus." *Sleep Medicine* 46 (June): 20–25. doi:10.1016/j.sleep.2018.02.014.