Nighttime Sleep Duration and Sleep Behaviors among Toddlers from Low-Income Families: Associations with Obesogenic Behaviors and Obesity and the Role of Parenting

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Abstract

Background: Shortened sleep duration is associated with poor health and obesity among young children. Little is known about relationships among nighttime sleep duration, sleep behaviors, and obesogenic behaviors/obesity among toddlers. This study characterizes sleep behaviors/duration and examines relationships with obesogenic behaviors/obesity among toddlers from low-income families.

Methods: Mothers of toddlers (age 12–32 months) were recruited from urban/suburban sites serving low-income families. Mothers provided demographic information and completed the Brief Infant Sleep Questionnaire (BISQ); a 6-item Toddler Sleep Behavior Scale was derived (TSBS-BISQ, higher score reflects more recommended behaviors). Toddler weight/length were measured; obesity defined as ≥95th percentile weight-for-length. Measures of obesogenic behaviors: physical activity [accelerometry, minutes/day in Moderate-to-Vigorous Physical Activity (MVPA)] and diet quality [24-hour recall, Healthy Eating Index 2005 (HEI-2005)]. Bivariate and adjusted multivariable models examined associations between nighttime sleep behaviors/duration and obesogenic behaviors/obesity.

Results: Sample included 240 toddlers (mean age = 20.2 months), 55% male, 69% black, 59% urban. Toddlers spent 55.4 minutes/day in MVPA, mean HEI-2005 score was 55.4, 13% were obese. Mean sleep duration was 9.1 hours, with 35% endorsing 5–6 recommended sleep behaviors (TSBS-BISQ). In multivariable models, MVPA was positively related to sleep duration; obese toddlers had a shorter nighttime sleep duration than healthy weight toddlers [odds ratio = 0.69, *p* = 0.014]. Nighttime sleep duration was associated with high TSBS-BISQ scores, F = 6.1, *p* = 0.003.

Conclusions: Toddlers with a shorter nighttime sleep duration are at higher risk for obesity and inactivity. Interventions to promote healthy sleep behaviors among toddlers from low-income families may improve nighttime sleep duration and reduce obesogenic behaviors/obesity.

Introduction

Short sleep duration in early childhood is a risk factor for obesity.[1,2] Children from low-income families are at risk for insufficient sleep[3] and obesity,[4] yet sleep–obesity associations are understudied. Sleep patterns established in toddlerhood (age 12–36 months) are maintained into childhood.[5] Parents play an important role in young children's bedtime routines.[4] Children from low-income families are at risk for irregular bedtime routines and short sleep duration.[6] Characterizing sleep behaviors among toddlers from low-income families, with a focus on modifiable correlates, fills a gap in the sleep-obesity association among toddlers and provides guidelines on obesity prevention trials.

Obesogenic factors, including low physical activity and poor diet, put toddlers at increased risk of obesity. The interplay of these factors, in combination with poor sleep behaviors (late bedtime, multiple night awakenings, etc.) resulting in

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short sleep duration, may increase the risk for obesity. Interrelationships between obesogenic behaviors and sleep duration have been explored among school-aged children with mixed results. One study found that school-aged children achieving adequate sleep (>9 hours) participated in higher intensity physical activity compared with children sleeping <9 hours,[7] with other studies finding no association between sleep duration and physical activity.[8,9] Studies examining relationships between sleep duration and diet among school-aged children consistently demonstrated that shorter sleep duration was associated with poor diet quality.[10–12] With limited research available on sleep in toddlerhood, little is known about associations among toddler sleep duration, sleep behaviors, and obesogenic behaviors and obesity.

The social ecological model provides a theoretical framework for examining how diet and physical activity, in the context of family demographics, are associated with child sleep behaviors and sleep duration.[13–15] Sleep and body weight share a constellation of contributing factors within the child, family, environment, and community.[14–17] The present study relies on the social ecological model to generate hypotheses regarding factors associated with shorter nighttime sleep duration and sleep behaviors, and to provide a framework for dynamic and bidirectional relationships between children's sleep behaviors and parental behaviors,[18] among very young children who are highly dependent on parents for structure and basic needs.

The purpose of this study is to examine how nighttime sleep duration and sleep behaviors relate to obesogenic behaviors and obesity among ethnically and geographically diverse toddlers from low-income families. We also characterize toddlers at highest risk for shorter nighttime sleep durations and poor sleep behaviors by examining demographic factors associated with sleep duration and sleep behaviors, based on proximal systems within the social ecological model. We focus on nighttime sleep duration because many of the sleep behaviors examined are specific to nighttime sleep (not daytime napping). Focusing on the mechanisms associated with parents' role in implementing healthy sleep behaviors can identify modifiable parent behavior for future intervention studies.[19,20] We hypothesize that (1) obesogenic health behaviors (low physical activity and poor diet quality) and obesity are associated with a shorter nighttime sleep duration and poor sleep behaviors, and (2) toddlers with a shorter nighttime sleep duration experience poor sleep behaviors.

Methods

Sample

Biological mothers of toddlers (age 12–32 months, born at term with birth weight >2500 g) were recruited from two Maryland sites: a Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) clinic in a suburban location and an urban pediatric clinic. Both sites serve low-income families living in the surrounding communities.

Protocol

This study was approved by Institutional Review Boards from the University of Maryland, Baltimore, and the Maryland Department of Health and Mental Hygiene. All mothers provided written informed consent. Evaluations were conducted by trained evaluators. Two evaluations were conducted, ~1 week apart. During the first visit, mothers completed self-administered, computer-based questionnaires using voice-generating software and mouse responses and accelerometers were placed. During the second visit, the accelerometers were removed and the 24-hour recall was administered. Mothers were compensated for their time; 304 eligible mothers of toddlers were recruited and 290 completed the full evaluation (first and second visits).

Demographics

Mothers reported their toddler's birth date, sex, and race/ethnicity and their own birth date, marital status, education, and employment status. They also reported number of household members and annual household income, used to calculate a poverty ratio based on 2009 thresholds determined by the US Census Bureau.[21]

The Brief Infant Sleep Questionnaire

The Brief Infant Sleep Questionnaire (BISQ)[22] includes 11 questions about daytime and nighttime sleep patterns and behaviors. The BISQ has been validated with children from 5–30 months with high (>0.82) test–retest reliability.[22] Mothers completed this questionnaire based on their child's sleep during the past week.

As part of the BISQ, mothers reported nighttime and daytime sleep duration over the past week, specifying nocturnal sleep (7:00 pm to 7:00 am) and daytime sleep (7:00 am to 7:00 pm). Extreme over-/underreporting was identified, based on (1) extreme outliers [±2 standard deviation (SD); sample mean ± SD before cleaning for nighttime sleep = 9.1 ± 2.1; daytime sleep = 3.1 ± 2.3; total sleep = 11.8 ± 2.0] (2) average recommended sleep amounts for toddlers (11–14 hours of total sleep/day),[23] and (3) recommended BISQ cutoffs.[22] Exclusions included (1) >14 or <5 hours nighttime sleep; (2) >8 hours daytime sleep; (3) >17 or <7 hours total sleep.

BISQ items were used to create a Toddler Sleep Behavior Scale (TSBS-BISQ), including (1) number of night awakenings; (2) nocturnal sleep-onset time; (3) settling time (latency to falling asleep); (4) location of sleep (parent's room or not); (5) sleeping arrangements (own bed or not), and (6) sleep problems (not at all, small, or serious). Each behavior was dichotomized based on toddler-specific recommendations and previous studies.[24,25] Nocturnal wakefulness (duration of nighttime wakefulness following an awakening) was excluded from the analysis due to poor quality data. The TSBS-BISQ is the sum of six dichotomized constructs, with higher scores representing better sleep behaviors, categorized for analysis (low 0–2, mid 3–4, high 5–6).

Anthropometry

Mothers undressed their toddler to a clean diaper/ underpants for anthropometric measures. Trained evaluators measured weight (kg) in triplicate using a TANITA 1584 Baby Scale (TANITA, Tokyo, Japan) and recumbent length (cm) in triplicate using a Shorr Measuring Board (Shorr Productions, Olney, MD). Sex-specific weight-for-length percentiles and z-scores were calculated according to CDC growth charts.[26] Weight status was examined both continuously (weight-for-length z-scores) and as a dichotomous variable (obesity defined as ≥95th percentile weight-for-length[27]).

Accelerometry

An Actical accelerometer (Philips Respironics) was placed on the nondominant or left ankle, superior to the lateral malleolus, with a nonremovable, reinforced hospital band during the first visit. The Actical is small, lightweight, and waterproof, worn during bathing, sleep, or play without interference. Toddlers wore the accelerometer for ≥7 consecutive days, next to the skin, under socks. Activity counts were collected in 1-minute intervals. During the second visit, the band was removed. Actical software (version 2.12) was used for data reduction. Only complete days (*i.e.*, full 24-hour periods) with a daily average of ≥80 counts were included in the analysis. For >7 full days, data were truncated after 7. Valid data were available for 69% of the sample,[28] limiting the sample size for analyses, including physical activity. The average number of full days of data was 5.3 (range 1–7); 83.2% had ≥4 days. Toddler physical activity was not associated with wear-time,[28] and therefore, wear-time was not included in analyses. A threshold of >2200 counts/minute was applied to describe minutes/day in moderate-to-vigorous physical activity (MVPA).[28] Continuous raw data were also examined as average activity counts/minute.

24-Hour Dietary Recall

Toddler dietary intake was assessed by trained research assistants via 24-hour dietary recall conducted with mothers, using the US Department of Agriculture Automated Multiple-Pass Method (AMPM). The AMPM is a well-tested, computerized, 24-hour dietary recall collection system linked to a comprehensive food and nutrient database.[29] Food and nutrient intakes were summarized, diet quality was assessed using the Healthy Eating Index 2005 (HEI-2005; data collection predated the 2010 Healthy Eating Index).[30] HEI-2005 scores reflect adherence to the 2005 Dietary Guidelines for Americans[31] and are calculated using a density approach, which assesses the relative proportion of foods eaten regardless of energy requirements, providing a common standard across sexes.[32] The HEI-2005 consists of 12 food grouping component scores summed for the total diet quality score (range 0–100, higher scores indicate higher diet quality). We also examined overall energy consumption (kcal). Valid dietary data are available for 88% of the sample. Reasons for missing data: incomplete visit/data (11%), <300 kcals (0.7%), and refusal (0.7%).

Data Analysis

Frequencies, means, and SDs for all variables were examined. Tests of normality (Shapiro–Wilk) were conducted to examine normal distribution of continuous variables for regression analyses. All associations were examined using bivariate models (independent *t*-tests or one-way analysis of variance, Spearman correlations, chi-square analyses), followed by Least Squares Difference (LSD) *post-hoc* tests. Multivariable models were used to examine associations between nighttime sleep duration (independent variable) and obesogenic behaviors/obesity (dependent variables, three separate models), including adjusted linear and binary logistic regression. Covariates were as follows: toddler age and sex, maternal marital status, and recruitment location. Daytime sleep duration was considered as a covariate in the physical activity model due to concern that those with longer daytime sleep durations may be less active, however, no association was observed and it was removed from the model. Covariates were chosen based on previous empirical or theoretical reports of associations with the dependent variables.[28] All analyses were conducted using SPSS 22.0 (IBM Corp, Somers, NY). Significance was set as $p < 0.05$ and marginal significance as $p < 0.10$.

Results

Sample Description

Of the 290 mother–toddler dyads who completed the evaluation, 50 reported sleep duration values outside coding rules (11 report no nighttime sleep, 3 reported >24 hours, 13 reported >14 or <5 hours of nighttime sleep; 18 reported >8 hours of daytime sleep; when total sleep was examined, 5 reported >17 or <7 hours). The final sample included 240 mother–toddler dyads (82.8% of sample). Compared with excluded mothers, the included sample mothers had a higher mean poverty ratio (0.82 vs. 0.61, $t = 2.41$, $p = 0.018$) and were less likely to be unemployed (76.2% vs. 86.1%, $\chi^2 = 4.24$, $p = 0.040$). Other factors (demographic, obesogenic behaviors, obesity) did not differ.

Mean toddler age was 20.2 months, (71.3% between 12 and 24 months), 55% were male, and 58.8% were recruited from the urban location (Table 1). Mothers reported that 69% of toddlers were black, 23% white, 3% Hispanic, 2% Asian or Native American, and 4% wrote in black/white. Race differed by recruitment location; 80.6% from the urban location were black compared with 19.4% from the suburban location ($\chi^2 = 104.1$, $p < 0.001$). Toddlers engaged in an average 55.4 minutes/day of MVPA, had a mean HEI-2005 score of 55.4 (range 24.0–84.0, maximum possible 100), and 12.6% were obese. Mean maternal age was 27.1 years, 28.0% were married, and 61.3% were unemployed. Mean poverty ratio was 0.82 (median = 0.52). Most were in poverty (68.1% poverty ratio ≤1.0), and 11% were above 200% poverty.

Table 1. Sample Description and Associations with Nighttime Sleep Duration ($n = 240$)				
		Nighttime sleep duration (hours)		
	Mean (range) or %	**r (p)**	**Mean**	**t or F (p)**
Nighttime sleep duration (hours)	9.1 (5.5–13.0)	—	—	—
Daytime sleep duration (hours)	2.6 (0–7.4)	−0.08 (0.194)		
Toddler				
Age, months	20.2 (11.9–31.9)	0.01 (0.838)	—	—
Sex				
Male, %	55.0	—	9.1	0.21 (0.838)
Female, %	45.0	—	9.1	
Race/ethnicity				
Black, %	68.8	—	8.8	20.9 (<0.001)
White, %	22.9		10.1	
Other, %	8.3	—	9.5	
Physical activity				
Minutes/day in MVPA	55.4 (0–192)	0.193 (0.012)	—	—
Activity counts/minute	390.3 (89–913)	0.212 (0.006)	—	—
Diet				
Diet quality: total HEI-2005 score	55.4 (24.0–84.0)	0.127 (0.062)	—	—
Energy (kcals)	1288.0 (330–3049)	0.019 (0.784)		
Weight status				
Weight-for-length z-score	0.17 (−3.0 to 3.8)	−0.092 (0.131)	—	—
Healthy weight (<95th percentile)	87.4	—	9.2	2.78 (0.006)
Obese (≥95th percentile)	12.6	—	8.5	
Mother				
Age, years	27.1 (18.1–46.3)	0.12 (0.057)	—	—
Marital status				
Married, %	28.0	—	9.7	3.71
Not married, %	72.0	—	8.9	(<0.001)
Employment status	61.3	—	9.2	1.3 (0.194)
Unemployed, %	38.7	—	9.0	
Employed, %				
Poverty				
Poverty ratio	0.82 (0.1–3.2)	0.20 (0.002)	—	
Below poverty threshold	68.1	—	9.5	3.1 (0.002)
At/above poverty threshold	31.9	—	8.9	
Recruitment location				
Urban	58.8	—	8.9	3.6 (<0.001)
Suburban	41.3	—	9.5	

HEI-2005, Healthy Eating Index 2005; MVPA, moderate-to-vigorous physical activity.

Demographic Factors Associated with Nighttime Sleep Duration

Toddlers slept an average of 9.1 hours/night (Table 1). Total average sleep duration was 11.8 hours (range 7.1–16.9), with a mean daytime sleep duration of 2.6 hours (median = 2.5, range 0–7.4; 97.1% reported daytime sleep). Nighttime sleep duration varied by race, maternal marital status, household poverty status, and recruitment location (Table 1); toddlers who were black (vs. white), had unmarried mothers (vs. married), living in poverty (vs. above the poverty threshold), and from the urban location (vs. suburban) slept fewer hours/night. Each of these variables was correlated with the others (toddlers from the urban location were more likely to be black, have unmarried mothers, live in poverty compared with toddlers from the suburban location). Remaining demographic variables were not associated with nighttime sleep duration ($p > 0.05$).

Relationship Between Nighttime Sleep Duration and Obesogenic Health Behaviors/Obesity

Bivariate analyses (Table 1) reveal that longer nighttime sleep duration was associated with more physical activity (MVPA minutes/day: $r = 0.19$, $p = 0.012$; activity counts: $r = 0.21$, $p = 0.006$) and marginally associated with higher quality diet ($r = 0.13$, $p = 0.062$). No association was observed with overall energy (kcal) consumption. Healthy weight toddlers sleep 0.7 hours longer/night compared with obese toddlers ($t = 2.78$, $p = 0.006$).

Three multivariable models, adjusted for toddler age, sex, maternal marital status, and recruitment location, were examined to test the hypotheses that obesogenic health behaviors (low physical activity and poor diet quality) and obesity are associated with a shorter nighttime sleep duration (Table 2). Minutes/day in MVPA was skewed (Shapiro–Wilk statistic = 0.916, $p < 0.001$) and normalized by square root (Shapiro–Wilk statistic = 0.991, $p = 0.358$). In Model No. 1, physical activity was positively associated with nighttime sleep duration ($\beta = 0.332$, $p = 0.017$). In Model No. 2, diet quality was not related to nighttime sleep duration ($p = 0.229$). In Model No. 3, obese toddlers had a significantly shorter nighttime sleep duration compared with healthy weight toddlers (odds ratio = 0.687, $p = 0.014$).

Relationship Between Nighttime Sleep Duration and Toddler Sleep Behaviors

Included in the TSBS-BISQ (Table 3) were six constructs: sleep arrangements, sleep location, sleep onset time, latency, number of night awakenings, and reported sleep problems. With the exception of "sleep problem," each recommended sleep behavior was significantly associated with longer average nighttime sleep duration.

The TSBS-BISQ was analyzed as a categorical variable based on number of recommended sleep behaviors endorsed. Mean nighttime sleep duration significantly differed by TSBS-BISQ category (Table 4); toddlers with high TSBS-BISQ scores slept more hours/night (9.6 hours/night) than toddlers with low and mid-TSBS-BISQ scores (8.9 hours/night for both categories, *post-hoc* test $p = 0.008$).

Demographic Factors Associated with Toddler Sleep Behaviors

A higher proportion of toddlers who were black, urban, with unmarried mothers, and living in poverty were in the low and mid-TSBS-BISQ groups vs. high (Table 4). Fewer male toddlers were in the mid-group compared with low/high. Toddler age and maternal age were not associated with the TSBS-BISQ.

Relationship Between Toddler Sleep Behaviors and Obesogenic Health Behaviors/Obesity

Toddlers with high TSBS-BISQ scores engaged in more minutes/day in MVPA than toddlers with mid-TSBS-BISQ scores (F = 3.67, $p = 0.028$, LSD *post-hoc* $p = 0.008$, Table 4), with no significant difference between low/mid-TSBS-BISQ categories. Toddlers with mid/high TSBS-BISQ scores had higher HEI-2005 scores than toddlers in the low TSBS-BISQ category (F = 5.26, $p = 0.006$, *post-hoc* $p = 0.009$ and $p = 0.002$, respectively). There were no significant differences in prevalence of obesity, weight-for-length z-score, or energy consumption by TSBS-BISQ.

Discussion

This study was conducted to examine how nighttime sleep duration and sleep behaviors relate to obesogenic behaviors

Table 2. Multivariable Linear Regression or Binary Logistic Regression Models Examining Relationships between Nighttime Sleep Duration and Obesogenic Factors

Model[a]	Dependent variable: Obesogenic factors	Independent variable: Nighttime sleep duration (hours)		
		β/OR	SE	p
No. 1: MLR	Physical activity (square root—minutes/day in MVPA)	0.332	0.138	0.017
No. 2: MLR	Diet quality (total HEI-2005 score)	0.664	0.551	0.229
No. 3: BLR	Obese status (healthy weight = 0, obese = 1)	0.687	0.036	0.014

[a]Each model adjusted for toddler age and sex, maternal marital status, and recruitment location.

BLR, binary logistic regression; MLR, multivariable linear regression; OR, odds ratio; SE, standard error.

Table 3. Toddler Sleep Behavior Scale (TSBS-BISQ) Components and Nighttime Sleep Duration

		Nighttime sleep duration (hours)	
	%	Mean	t (p)
Sleeping arrangements			
In bed with parent or sibling	32.1	8.8	2.40 (0.017)
In own bed	67.9	9.3	
Sleeping location			
In parents' room	60.4	9.0	2.35 (0.020)
Not in parents' room	39.6	9.4	
Sleep onset time			
9 pm or later	63.5	8.9	3.96 (<0.001)
Before 9 pm	36.5	9.7	
Latency, time took to fall asleep at night			
More than 1 hour	85.6	8.6	2.51 (0.013)
1 hour or less	14.4	9.2	
Night awakenings, No.			
More than 1	26.9	8.8	2.09 (0.039)
One or none	73.1	9.3	
Sleep problem			
Problem (small to very serious)	15.8	8.9	0.83 (0.410)
Not a problem	84.2	9.2	

and obesity among toddlers from low-income families and to characterize toddlers at highest risk for shorter nighttime sleep durations and poor sleep behaviors. We found that (1) sleep duration is associated with physical activity and obesity, (2) sleep behaviors are associated with physical activity and diet quality, (3) specific sleep behaviors are associated with nighttime sleep duration, and (4) among low-income families, subgroups are at high risk for shorter nighttime sleep duration and poor sleep behaviors. Using the social ecological model as a framework, we conceptualize how proximal and distal factors relate to behaviors, and how the interplay among these factors could be considered.

A shorter nighttime sleep duration was associated with less time in MVPA and increased risk for obesity. Relationships between sleep and obesity have been demonstrated in multiple cross-sectional studies of older children,[33] with little attention to the mechanisms underlying the association or the use of gold standard field measures of physical activity or diet. Targeting nighttime sleep duration, in addition to physical activity and healthy eating, may be an effective obesity prevention strategy. A recent obesity prevention trial among young children (ages 2–5) reported decreased body size and increased sleep duration with an intervention that included sleep behaviors.[34]

We found that toddlers with poor sleep behaviors engaged in fewer MVPA minutes/day and consumed lower quality diet, compared with toddlers with better sleep behaviors. Although this pattern may increase obesity risk, sleep behaviors were not related to toddler obesity. Identifying relationships between sleep behaviors and obesogenic behaviors may reflect common, interconnected parenting practices; parents who provide bedtime routines may also provide opportunities for physical activity and high-quality diets. A study among 8550 four-year olds found that children exposed to three household routines (regular family dinners, adequate nighttime sleep, and limited screen time) had lower obesity rates than children not exposed to those routines.[35]

We also found that among low-income families, toddler nighttime sleep duration was associated with sleeping arrangements/location, bedtime, latency to fall asleep, and number of awakenings. Low-income families often lack structure/routine[36–38] and are more likely to share beds/bedrooms due to limited resourses,[39] which may interfere with sleep. Socially disadvantaged black and Hispanic families are estimated to be 30% less likely to provide their children with consistent bedtimes and bedtime routines than more advantaged families.[6]

Table 4. Factors Associated with Toddler Sleep Behavior Score (TSBS-BISQ)

	Toddler Sleep Behavior Score			
	0–2 "low"	3–4 "mid"	5–6 "high"	F(p) or χ^2(p)
Sample size, n (%)	39 (17.8)	96 (43.8)	84 (38.4)	—
Toddler				
Nighttime sleep duration, hours	8.9	8.9	9.6	6.1 (0.003)
Age, months	19.6	20.1	20.3	0.19 (0.829)
Sex				
Male (vs. female), %	61.5	44.8	63.1	6.9 (0.031)
Race/ethnicity				
Black (vs. white/other), %	87.2	78.1	47.6	27.2 (<0.001)
Physical activity				
Minutes/day in MVPA	58.3	45.3	65.3	3.7 (0.028)
Activity counts/minute	409.2	348.8	433.1	5.4 (0.005)
Diet				
Diet quality: total HEI-2005 score	50.0	55.7	57.0	5.3 (0.006)
Energy (kcals)	1293	1262	1305	0.19 (0.829)
Weight status				
Weight-for-length z-score	0.25	0.13	0.08	0.2 (0.788)
Obese (vs. healthy weight), %	15.4	14.6	7.1	2.9 (0.231)
Mother				
Age, years	26.9	25.8	27.9	2.9 (0.059)
Marital status				
Married (vs. not married), %	12.8	21.9	43.4	15.8 (<0.001)
Employment status				
Unemployed (vs. employed)	19.2	43.8	39.6	0.5 (0.765)
Poverty				
Poverty ratio	0.67	0.67	1.04	6.3 (0.002)
At/below poverty threshold (vs. above), %	77.1	79.8	54.3	14.5 (0.001)
Recruitment location				
Urban (vs. suburban), %	69.2	66.7	41.7	14.1 (0.001)

In this exclusively low-income sample, we identified socioeconomic, racial, and geographic disparities associated with toddler nighttime sleep duration and sleep behaviors, which is a unique contribution. Poverty is a well-documented risk factor for multiple adverse behavioral, educational, and health outcomes in children, including shorter sleep and obesity.[37,40] A recent global study of more than 10,000 children (age 0–5) found that bedtime routines improve sleep quality, including nighttime duration.[41] Parent–toddler behaviors impact one another in a reciprocal pattern, making parenting behavior an ideal focus for interventions that promote toddler sleep routines.[41] By identifying populations at highest risk for poor sleep behaviors and shorter nighttime

sleep durations, evidenced-based parenting interventions that target bedtime routines may be tailored to the needs of populations and families. Overlapping disparities are common and require further analyses to examine their interplay, including the examination of moderating and mediating effects. Through the social ecological model, we identified proximal factors to examine in relation to sleep duration/behaviors. Future studies should expand to distal systems, including community factors, and consider how relationships among proximal and distal factors relate to toddler sleep.

Strengths of this study include a relatively large and diverse population of low-income, geographically, and

racially diverse mothers and toddler-aged children, the use of a 24-hour recall and accelerometry, and measured height/weight to examine obesogenic behaviors/obesity. Limitations include the use of maternal self-report to establish nighttime sleep duration and sleep behaviors, rather than objective sleep patterns (*i.e.*, sleep algorithms were not available for the accelerometer used in this study). We focused primarily on nighttime sleep duration and associated sleep behaviors, with no association between daytime and nighttime sleep duration. Further analyses may be warranted to understand the role of napping. Measured height and weight were used to assess obesity; additional measures of toddler adiposity and body fat distribution may be useful. Finally, the study was cross sectional and causality cannot be supported.

Conclusions

A shorter nighttime sleep duration is associated with inactivity and obesity among toddlers from low-income families. Poor sleep behaviors are associated with inactivity and poor diet quality, suggesting multiple mechanisms that may link toddler sleep and obesity. Toddlers who are urban, black, living in poverty, or with unmarried mothers, are at high risk for poor sleep behaviors and a shorter nighttime sleep duration. Intervention trials are needed to evaluate the impact of sleep routines on sleep duration and obesity prevention.

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No competing financial interests exist.

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