Associations between Sleep and Dietary Patterns among Low-Income Children Attending Preschool

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ABSTRACT

Background Sleep disturbances and low-quality diets are prevalent among children in low-income settings, yet the nature of their relationship remains unclear. In particular, whether aspects other than sleep duration, including timing and quality, are associated with dietary patterns has rarely been examined, especially among preschool-aged children.

Objective To evaluate whether nightly and total sleep duration, sleep timing, differences in timing and duration from weekdays to weekends, and sleep quality were related to dietary patterns.

Design A cross-sectional analysis of children attending preschool. Parents completed questionnaires about children's sleep habits as well as a semiquantitative food frequency questionnaire.

Participants/setting Three hundred fifty-four English-speaking children (49.9% boys) with no serious medical conditions aged 3 to 5 years who were enrolled in Head Start in Michigan (2009-2011) with complete information on sleep and diet.

Main outcome measures Dietary pattern scores derived from food frequency questionnaire.

Statistical analyses performed Principal component analysis was used to identify dietary patterns. Separate linear regression models with dietary pattern scores as the dependent variable and continuous sleep measures as independent variables were used to evaluate associations between sleep and diet, adjusting for sex, age, parent education level, and sleep hygiene.

Results Three dietary patterns were identified: Vegetables, Healthy Proteins, and Sides; Breads and Spreads; and Processed and Fried. Longer average weekend sleep duration and a greater difference in weekend-to-weekday sleep duration was related to lower Vegetables, Healthy Proteins, and Sides pattern scores. Later sleep midpoint during weekdays was related to lower Vegetables, Healthy Proteins, and Sides pattern scores, whereas later sleep midpoint on the weekend was associated with higher Processed and Fried pattern scores. Similarly, a larger weekend–weekday midpoint difference was associated with higher Processed and Fried pattern scores.

Conclusions Later sleep timing and differences in sleep duration and timing from weekends to weekdays were related to less-optimal dietary pattern scores in young children.
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CHILDREN FROM LOWER-SOCIOECONOMIC ENVIronments have a higher likelihood of disordered sleep,[1] poorer quality diets,[2] and high rates of childhood obesity.[3] Sleep disturbances and low diet quality are both predictive of obesity risk in children[4]; thus, examining the associations between sleep and dietary patterns is an important step toward understanding the pathways to obesity risk, particularly in vulnerable populations.[5,6] Further, sleep and dietary habits are established at a young age,[7,8] and habits developed even as early as preschool age may have implications for later risk.[9,10]

In populations of older children, there is evidence of associations between sleep and diet. For example, cross-sectional studies of school-aged children and adolescents in the United States showed that short sleep duration was related to greater energy density, sugar-sweetened beverage intake, and added sugar intake.[11,12] Similarly, studies among children in Portugal[13] and Finland[14] found that shorter sleep duration was related to energy-dense dietary patterns. Other aspects of sleep, including timing (ie, late bedtimes and wake times and late midpoint of sleep), have also been related to lower-quality diets.[12,15] One comprehensive 12-country study among children aged 9 to 11 years[16] found that shorter sleep duration, lower sleep efficiency, and later bedtimes were each associated with unhealthy dietary patterns high in added fats and sugars (eg, fast food, hamburgers, soft drinks, and sweets), whereas earlier bedtimes were related to healthy dietary patterns (eg, vegetables, fruit, and whole grains). A similarly conducted study of children aged 9 to 11 years from New Zealand showed that children in the late sleep/late wake category had a lower "Fruit and Vegetables" pattern score.[17]

In contrast to the growing number of studies on sleep and diet in school-aged children and adolescents, there are fewer studies in preschool-aged children. One potential reason for the lack of studies is that parents are assumed to have considerable control over their young children's habits. Nonetheless, child eating behaviors (eg, picky eating or temper tantrums) and temperament (eg, negative emotionality)[18] may influence parental feeding practices.[19,20] Further, there is recent experimental evidence that short sleep alters dietary preference and intake even among young children.[21] In this study, researchers found that US preschool-aged children whose sleep was restricted by ~3 hours (bedtime delay and no nap) had a 20% increase in total calories the next day due to higher intake of sugar, carbohydrates, and fat compared with baseline. Whether these associations persist in free-living environments is less clear, although one observational study showed that longer sleep duration in children aged 2 to 4 years was associated with greater fat but lower carbohydrate intake, and that higher shifts in sleep duration from weekdays to weekends was related to higher calorie consumption.[22,23] In contrast, a different study in low-income preschool-aged children did not find associations between nighttime sleep duration and diet after accounting for confounding factors.[24]

Thus, the overarching aim of our study was to evaluate how multiple indicators of sleep health related to diet in children attending preschool from low-income households. We chose to focus on dietary patterns because foods naturally cluster in the diet (eg, milk and cereal); thus, the analysis of dietary patterns may provide interpretations that are more intuitive and relevant for public health than examination of single foods.[25] We hypothesized that multiple distinct dietary patterns would be identified within this dataset, and that longer sleep duration, earlier sleep timing, less difference in weekday to weekend sleep duration and timing, and higher sleep quality would each be associated with higher healthy dietary pattern scores and lower unhealthy dietary pattern scores.

RESEARCH SNAPSHOT

Research Question: Are measures of sleep—nightly and total sleep duration, sleep timing, and sleep quality—associated with dietary patterns in low-income preschool-aged children?

Key Findings: Longer average weekend sleep duration and a greater difference in weekend-to-weekday sleep duration was related to lower Vegetables, Healthy Proteins, and Sides pattern scores. Later sleep midpoint during weekdays was related to lower Vegetables, Healthy Proteins, and Sides pattern scores, whereas later sleep midpoint on the weekend was associated with higher Processed and Fried pattern scores. Similarly, a larger weekend−weekday midpoint difference was associated with higher Processed and Fried pattern scores.

METHODS

Study Population

Participants were children enrolled in a longitudinal study of stress and eating behavior; the present study is a secondary analysis of the recruitment visit, which occurred during the school year (October at the earliest) from 2009 to 2011. Families were recruited from Head Start, a federally funded preschool program for low-income families. The study was approved by the University of Michigan Institutional Review Board and parents/legal guardians (typically mothers) provided written informed consent and families were compensated $90 for participating. Inclusion criteria were that the child was enrolled in Head Start (either in the first or second year), not in foster care, born at ≥35 weeks' gestation without serious perinatal/neonatal complications, and had no serious medical problems that influence growth or appetite. Additional criteria were that the parent and child spoke English and that one parent did not have a 4-year college degree. All questionnaires were interviewer-administered. Of the full sample of 380 children, 25 were excluded either due to missing or implausible dietary data.

Sleep Measures

A parent reported his or her child's usual bedtime and wake time on weekdays and weekends, as well as the number of days per week the child napped and the typical nap duration. From these data, we calculated average weeknight sleep duration, average weekend-night sleep duration, difference between weekend and weeknight sleep duration, and total average 7-day sleep duration with naps. These were all reported in hours and minutes.

The midpoint of sleep, calculated as the median time of the sleep period (bedtime to wake time), was the measure of sleep timing. We also calculated the difference in midpoint from weekend to weekday.

Parents completed the 25-item Children's Sleep-Wake Scale, which has been validated in preschool-aged children with sleep diaries and actigraphy, to assess sleep quality (Cronbach's α=.89 based on the present sample). The scale includes five components: going to bed, falling asleep, maintaining sleep, reinitiating sleep, and returning to wakefulness; individual questions pertaining to these components were rated from 1=never to 6=always and a mean sleep quality score was generated.[26] Higher scores indicated better sleep quality, and included items such as whether the child typically resists bedtime, has difficulty falling asleep, is restless during the night, or is difficult to get out of bed in the morning.

Parents also completed the 22-item Children's Sleep Hygiene Scale (Cronbach's α=.73 based on the present sample), which has been assessed for internal consistency and content validity in preschool-aged children; items were rated from 1=never to 6=always and a mean sleep hygiene score was generated.[27] Higher scores indicated more optimal sleep hygiene practices such as avoiding caffeine and maintaining a consistent sleep–wake schedule.

Child Dietary Pattern Scores

Parents completed the Harvard Service Food Frequency Questionnaire,[28] which estimates usual intake habits of preschool-aged children and has been validated in low-income populations, with energy-adjusted correlation coefficients ranging from 0.26 for dietary fiber to 0.63 for magnesium.[29] Parents were asked to recall how often in the past month the child typically consumed a single serving of a standard portion size of 84 different food items. The dietary recall period included preschool meals at which a parent was not present but, per state regulations, Head Start classrooms are required to inform parents of the daily food offerings.[30] Response options to the dietary frequency questions ranged from never to ≥6 times per day, which we converted into times per day (eg, once per month would be described as: 1/30.4=0.03 times/day). US Department of Agriculture Food Composition tables (National Nutrient Database for Standard Reference, release 24, 2011) were also used to convert the portions per day into average daily total energy intake, and a trained nutritionist evaluated the plausibility of each participant's total energy intake (<500 kcal or >3,500 kcal were deemed implausible) and response option variance (<1.27 overall variation was deemed implausible).

Covariates

Parents provided relevant sociodemographic information, including child's age and race/ethnicity, his/her highest level of education attained, and household income from all sources. Trained research assistants measured height (in meters) and weight (in kilograms) of children during home visits using calibrated equipment (Seca 213/217 portable stadiometer and Detecto Portable Scale Model #DR550C, respectively). Child race/ethnicity was classified as non-Hispanic/Latino white, non-Hispanic/Latino black, other non-Hispanic/Latino, and Hispanic/Latino of any race. Body mass index (BMI) *z* scores for sex and age were calculated and weight status categories generated (overweight/obese as BMI ≥85th percentile for sex and age, vs not overweight as BMI <85th percentile for sex and age) based on Centers for Disease Control and Prevention reference norms.[31] Parental education was classified into three categories: did not complete a high school education or general equivalency diploma, completed a high school diploma or equivalent, or completed at least some education after high school. Income-to-needs ratio was calculated as the total reported household income divided by the federal poverty line for a family of the same size during the corresponding year. Household chaos was measured as the sum of 15 true or false items on the Confusion, Hubbub, and Order Scale[32] (CHAOS) (Cronbach's α=.79 based on the present sample; theoretical range=0 to 15), with higher scores indicating more chaotic environments. Household routines were measured with the 14-item Child Routines Inventory,[33] which assesses how regularly the child engages in family routines that involve interaction with or supervision by a parent (eg, eating together), on a 5-point scale (from 0=never to 4=nearly always), with higher scores indicating greater presence of routines (Cronbach's α=.709 based on present sample).

Statistical Analyses

First, dietary patterns were identified based on how the intake of food groups correlate, using an often-used methodology.[34] Figure 1 provides a flowchart of the process followed. Briefly, similar food items were first grouped into food groups based on nutritional similarity (Figure 2), and total-energy adjusted food group intakes were computed using the residual method.[35] Next, a principal component analysis of the food groups was performed and the components were transformed with Varimax rotation to obtain uncorrelated components and improve interpretation. The number of components to retain was determined based on visual inspection of the Scree plot, eigenvalues >1, and interpretability of the components. The food groups with the highest component loadings enabled interpretation of the pattern; groups with component loadings ≥|0.25| are shown in Table 1. To determine how closely each child's diet aligned with the dietary pattern, scores were computed by multiplying the component loadings of each food group by the child's frequency of intake in that food group and then summing (because there were food groups with negative component loadings, this meant that the overall raw scores could have been <0). Each child received a score for each of the dietary patterns, with higher scores representing a closer correspondence to the dietary pattern. Finally, each score was converted to *z* scores with a mean of zero and standard deviation (SD) of one to facilitate comparisons between the three dietary patterns.

In bivariate analysis, the associations between dietary patterns and potential confounders were first examined by comparing the distributions or mean±SD of the potential confounders in lower vs higher dietary pattern categories (split at the median of dietary pattern scores). To evaluate the primary study questions on sleep and diet, linear regression models were run with dietary pattern scores as the continuous dependent variable and sleep measures as a continuous independent variable (separate models for each sleep measure and for each dietary pattern). In multivariable models, child age, sex, race/ethnicity, parent education, and sleep hygiene were added to each of the models. These variables were selected as confounders based on the results of the bivariate confounder analysis and prior research.[36,37]

Three sets of sensitivity analyses were implemented. First, to evaluate the dose–response relationship between the sleep variables and dietary pattern scores, linear regression models were run with each sleep measure as a categorical variable (in quartiles). Because there was evidence of dose–response relationships, only the continuous beta estimates are presented. Second, the following variables were added to the multivariable models separately to evaluate their potential confounding role: income-to-needs ratio, household CHAOS, and household routines. Because the addition of these variables did not substantially alter the estimates, they were not included in the final multivariable models. Third, to evaluate whether associations with sleep duration and timing were independent, regression models were run with mutual adjustment for all sleep variables (separately for weekend vs weekday variables). Because estimates were not substantially different in mutually adjusted models, analyses from separate models are presented. Analyses were conducted using Stata version 14.0.[38] The criterion of statistical significance was $P<0.05$.

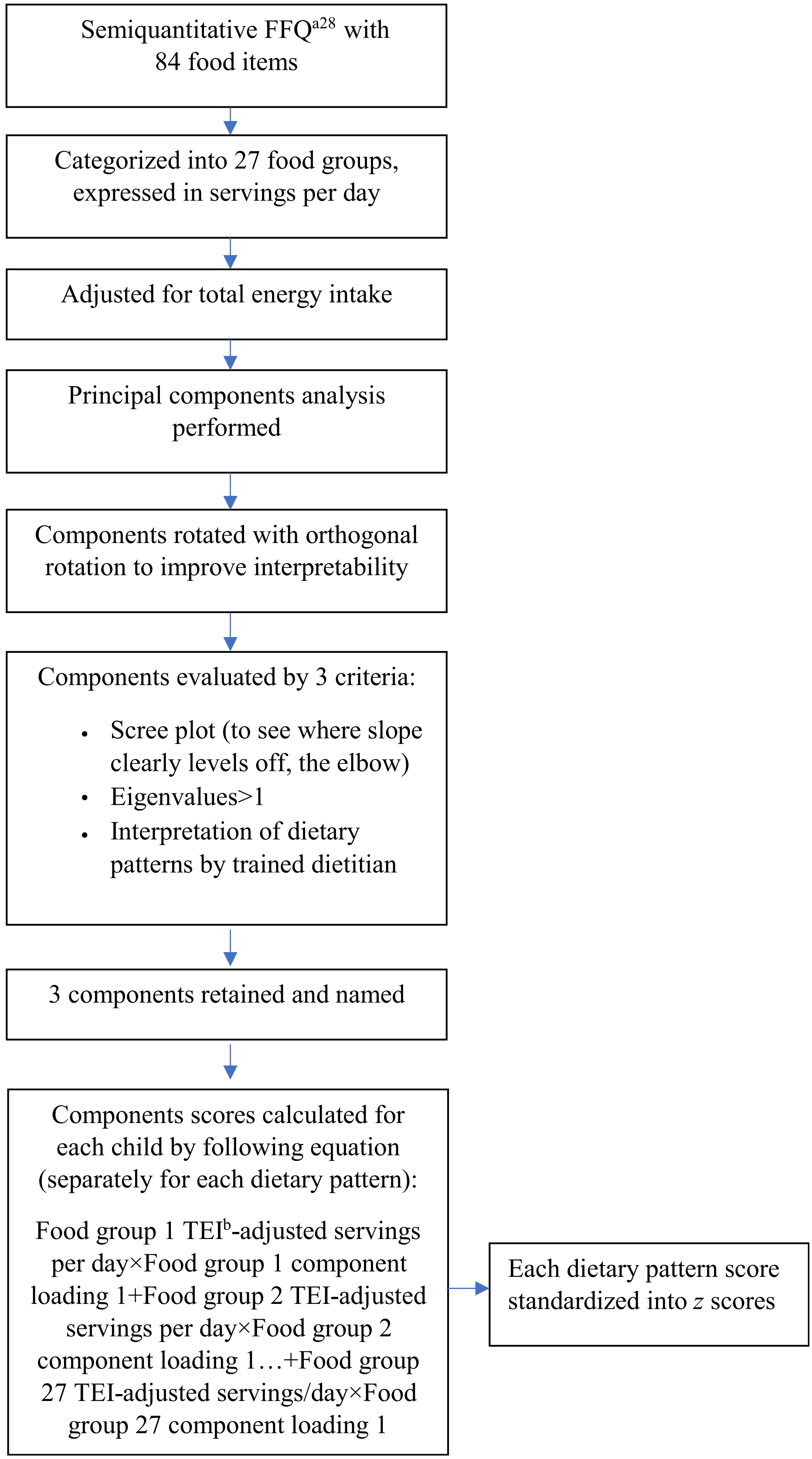

Figure 1. Flowchart depicting the creation of dietary pattern scores in a sample of 355 low-income Head Start preschoolers enrolled in a study on stress and eating behavior. [a]FFQ=Harvard Service Food Frequency Questionnaire. [b]TEI=Total energy intake.

Food group	Foods
Potatoes	Potatoes, sweet potatoes or yams
French fries	French fries, fried potatoes, potato rounds
Soup	Vegetable soup, other soup
Vegetables	Corn; peas; tomatoes, tomato sauce, salsa; peppers; carrots; broccoli; green beans; spinach; mixed vegetables; squash; zucchini; cabbage, coleslaw; cauliflower; lettuce salad
Rice	Rice
Legumes	Beans
Fruit	Banana; peaches; fruit cocktail, mixed fruit; orange or grapefruit; apple or pear; applesauce; grapes; strawberries; melon; pineapple; raisins or prunes
Juice	orange juice or grapefruit juice, other juice
Cheese	Cheese
Yogurt	Yogurt
Milk	Milk
Peanut butter and other nuts	Nuts, peanut butter
Hot cereal	Hot cereal, grits
Cold cereal	Cold cereal
Bread	Bread, toast, roll or pita; English muffin or bagel; biscuit; cornbread or tortilla
Salty snacks	Chips, popcorn or pretzels, crackers
Mixed dish	Macaroni and cheese; pizza; spaghetti or other pasta; tacos, burritos
Processed meat	Hot dogs, sausage, cold cuts, fried chicken or turkey, bacon
Nonprocessed meat	Hamburger, other chicken or turkey, pork or ham, roast beef or steak, liver or organ meats
Fish	Canned tuna; fried fish, fish sticks; other fish
Spreads with fat	Mayonnaise, salad dressing, butter, margarine
Eggs	Eggs
Breakfast pastries	Donut; sweet roll or muffin; pancake, waffle, or French toast
Sweetened dairy	Hot chocolate, ice cream, pudding
Sweets	Cookies or brownies, cake or cupcake, pie, chocolate or candy bar, other candy
Sugar-sweetened beverages	Fruit drinks; soda, soft drink, pop (not sugar free); other juice
Diet soda	Soda, soft drink, pop (sugar free)

Figure 2. Foods in each food group, derived from a semiquantitative food frequency questionnaire[a] completed by parental proxy for 355 low-income preschoolers attending Head Start. [a]Food frequency questionnaire used was the Harvard Service Food Frequency Questionnaire.

RESULTS

The mean±SD age of children was 4.2±0.5 years. The sample was nearly equally divided by sex (49.9% boys). Other descriptive statistics are shown in Table 2.

Using principal components analysis, three dietary patterns that together explained 22% of the variance in the energy-adjusted food groups were identified: Vegetables, Healthy Proteins, and Sides; Breads and Spreads; and Processed and Fried (Table 2). The Vegetables, Healthy Proteins, and Sides pattern was characterized by high energy-adjusted intake of vegetables, nonprocessed meat, legumes, fish, potatoes, eggs, and rice, and low frequency of sugar-sweetened beverage and juice. The Breads and Spreads pattern was marked by high energy-adjusted intake of bread, peanut

Table 1. Component loadings for dietary patterns derived from semiquantitative food frequency questionnaire data completed by parental proxy for 355 low-income preschool-aged children attending Head Start

Food group	Component 1[a]	Component 2[b]	Component 3[c]
Vegetables	0.63		
Nonprocessed meat	0.49		
Legumes	0.48		
Fish	0.48		
Sugar-sweetened beverages	−0.48		
Potato	0.46		
Juice	−0.43		
Eggs	0.43		
Rice	0.39		
Cheese	−0.27		
Mixed dish	0.25		
Bread		0.68	
Peanut butter and other nuts		0.51	
Fruit		−0.50	
Spreads with fat		0.41	
Yogurt		−0.35	
Breakfast pastry		0.27	
Milk			−0.58
French fries			0.51
Processed meat			0.45
Salty snacks			0.43
Sweets			0.33
Cold cereal			−0.29
Variance explained (%)	9	7	6

[a]Component 1, called Vegetables, Healthy Proteins, and Sides, is characterized by high energy-adjusted intake of vegetables, nonprocessed meat, legumes, fish, potatoes, eggs, and rice, and low frequency of sugar-sweetened beverage and juice.

[b]Component 2, called Breads and Spreads, is characterized by high energy-adjusted intake of bread, peanut butter and other nuts, spreads with fat, and breakfast pastry intake and low intake of fruit.

[c]Component 3, called Processed and Fried, is characterized by high energy-adjusted intake of french fries, processed meat, salty snacks, sweets, and diet soda, and low energy-adjusted intake of milk.

butter and other nuts, spreads with fat, and breakfast pastry intake and low intake of fruit. The Processed and Fried pattern included high energy-adjusted intake french fries, processed meat, salty snacks, sweets, and unsweetened carbonated beverages, and low energy-adjusted intake of milk. Parent education was associated with the Breads and Spreads pattern, such that children with higher scores on the Breads and Spreads pattern were more likely to have parents who completed at least some posthigh school education (Table 3) compared with children who had lower scores on this pattern. In addition, black, non-Hispanic (or other race/ethnicity) children were more likely to be in the upper half of the Processed and Fried pattern scores compared with white, non-Hispanic/Latino children.

In regression analysis, 1 hour longer sleep duration during the weekend was related to a −0.13 lower Vegetables, Healthy Proteins, and Sides SD score after adjustment for potential confounders (95% CI −0.22 to −0.04), and every 1 hour greater difference in sleep duration from the weekend to weekdays was associated with −0.14 SD score (95% CI −0.23 to −0.04, respectively) (Table 4). Later sleep midpoint during weekdays was related to lower Vegetables, Healthy Proteins, and Sides pattern scores, such that every 1 hour later in the sleep midpoint was related to a −0.20 SD lower score (95% CI −0.40 to −0.01). Later sleep midpoints on the weekend was associated with higher Processed and Fried pattern scores; every 1-hour later sleep midpoint was associated with a 0.18 SD higher Processed and Fried pattern score (95% CI 0.06 to 0.29). Similarly, each hour of difference in weekend-weekday midpoints was associated with a 0.21 SD higher Processed and Fried pattern score (95% CI 0.07 to 0.35). Sleep quality was not associated with dietary pattern scores.

DISCUSSION

In this sample of low-income children attending preschool, three dietary patterns were identified— Vegetables, Healthy Proteins, and Sides; Breads and Spreads; and Processed and Fried—that were related to several dimensions of sleep health reported by parents. In particular, after accounting for potential confounders, longer sleep duration on weekends, later sleep midpoints on both weekends and weekdays, and greater differences in sleep duration and timing from weekends to weekdays were related to less-healthy diet quality—either lower Vegetables, Healthy Proteins, and Sides dietary pattern scores or higher Processed and Fried pattern scores.

This study extends prior literature because it specifically focused on sleep and diet associations in preschool-aged children, and evaluated sleep duration, timing, and quality. Among the primary findings was that timing of sleep in young children may be associated with obesogenic eating behaviors. These associations are in line with recent findings among older children and young adults, showing that later sleep timing relates to lower intake of specific healthy foods and/or to higher intake of energy-dense foods.[12,39-41] Similarly, a greater mismatch in sleep timing from weekend to weekday, also referred to as social jetlag, has been related to obesity and unhealthy eating in older children[42] and undergraduate students.[43]

There are several potential mechanisms to explain our findings with sleep timing, and it is important to consider the possibility of bidirectional associations.[44] Regarding potential pathways linking sleep to diet, there is evidence that delayed sleep timing alters hormonal appetite regulators,[45] which might influence food preferences.[46] In addition, sleep timing may influence mood and stress levels,[47] which have also been associated with eating behaviors in young children.[48] Sleep timing can also influence the timing of food intake, and

Table 2. Sociodemographic and sleep characteristics of a sample of 355 low-income preschool-aged children attending Head Start who were enrolled in a study on stress and eating behavior

Variable	Result
Child sex	%
Male	49.9
Female	50.1
Child race/ethnicity	
White, non-Hispanic/Latino	57.8
Black, non-Hispanic/Latino or other[a]	31.6
Hispanic/Latino, any race	10.7
Child weight status	
Not overweight	60.5
At risk for overweight[b]	39.6
Parent education	
Less than high school	15.5
High school diploma or GED[c]	30.4
Some education beyond high school	54.1
	mean±standard deviation
Child age (y)	4.23±0.53
Child body mass index *z* score[d]	0.80±1.04
Household income-to-needs ratio[e]	0.87±0.76
Household CHAOS[f]	4.09±3.29
Household routine[g]	45.43±6.23
Weeknight sleep duration	10 h 22 min±47 min
Weekend-night sleep duration	10 h 45 min±1 h 8 min
Total sleep per day[h]	10 h 39 min±2 h 33 min
Child's usual bedtime on weekdays	8:35 pm±45 min
Child's usual waketime on weekdays	6:57 am±35 min
Child's usual midpoint of sleep on weekdays	1:45 am±33 min
Child's usual bedtime on weekend nights	9:40 pm±1 h 7 min
Child's usual waketime on weekend days	8:25 am±1 h 11 min
Child's usual midpoint of sleep on weekend nights	3:01 am±60 min
Sleep hygiene[i]	4.84±0.50
Sleep quality[j]	4.13±0.73

[a]Includes Asian, Asian Pacific Islander, and biracial, non-Hispanic.
[b]Risk was considered increased when it was >85th percentile.
[c]GED=General equivalency diploma.
[d]From Centers for Disease Control.[31]
[e]1.0 indicates poverty.
[f]CHAOS=Confusion, Hubbub, and Order Scale. Higher score indicates more chaotic environment; range=0 to 15.
[g]Higher indicates more routine; range=0 to 56.
[h]Hours per night plus naps during the day.
[i]Higher score indicates better sleep hygiene; range=0 to 10.
[j]Higher score indicates higher quality sleep; range=0 to 10.

studies in adults show that the timing of food intake may have implications for energy metabolism and weight loss.[49] In contrast, individual components in the dietary patterns could influence sleep. For example, the Vegetables, Healthy Proteins, and Sides pattern contains sources of dietary fiber and polyunsaturated fat, which have been related to more favorable sleep measures.[50,51] These nutrients may influence sleep by promoting melatonin production and regulation.[52]

Table 3. Cross-sectional associations among sociodemographic characteristics and dietary patterns among 355 low-income preschool-aged children attending Head Start who were enrolled in a study on stress and eating behavior

		Vegetables, Healthy Proteins, and Sides Pattern		Breads and Spreads Pattern		Processed and Fried Pattern	
Sociodemographic variable	**n**	**Lower scores**	**Higher scores**	**Lower scores**	**Higher scores**	**Lower scores**	**Higher scores**
Child sex							
Male	177	50.0	49.7	51.7	48.0	47.8	52.0
Female	178	50.0	50.3	48.3	52.0	52.3	48.0
P value[a]		0.96		0.49		0.43	
Child race/ethnicity							
White, non-Hispanic/Latino	205	55.6	60.0	53.9	61.6	64.0	51.4
Black, non-Hispanic/Latino or other[b]	112	36.0	27.1	31.5	31.6	25.3	37.9
Hispanic/Latino, any race	38	8.4	13.0	14.6	6.8	10.7	10.7
P value		0.12		0.05		0.03	
Child overweight status[c]							
Not overweight	214	58.4	62.5	64.6	56.3	60.5	60.5
Overweight	140	41.6	37.5	35.4	43.8	39.6	39.6
P value		0.43		0.11		0.99	
Parent education							
Less than high school	55	16.9	14.1	14.0	17.0	12.9	18.1
High school diploma or GED[d]	108	33.7	27.1	36.5	24.3	29.2	31.6
Some education beyond high school	192	49.4	58.8	49.4	58.8	15.5	50.3
P value for trend		0.21		0.04		0.27	
		←*mean±standard deviation*→					
Child age, per year	355	4.2±0.5	4.3±0.5	4.2±0.5	4.2±0.5	4.2±0.6	4.3±0.5
P value[e]		0.10		0.79		0.40	
Household income-to-needs ratio, per unit	339	0.9±0.9	0.9±0.6	0.9±0.9	0.9±0.6	0.8±0.6	0.9±0.9
P value		0.85		0.81		0.47	
Household CHAOS[f]	355	4.2±3.2	4.0±3.3	3.7±3.1	4.4±3.4	4.1±3.3	4.1±3.3
P value		0.67		0.05		0.83	
Household routine[g]	343	45.2±5.8	45.7±6.6	45.6±6.1	45.3±6.3	46.1±6.0	44.8±6.4
P value		0.40		0.71		0.06	

[a]*P* values for categorical variables are from χ^2 tests (for more than three categories, a significant *P* value indicates at least two of the categories are different from one another).
[b]Includes Asian, Asian Pacific Islander, and biracial, non-Hispanic.
[c]From Centers for Disease Control and Prevention.[31]
[d]GED=General equivalency diploma.
[e]*P* values for continuous variables are from Wald tests.
[f]CHAOS=Confusion, Hubbub, and Order Scale. Higher score indicates more chaotic environment.
[g]Higher score indicates more routine.

Table 4. Cross-sectional associations among sleep duration, timing, and quality and dietary patterns among 355 low-income preschool-aged children attending Head Start who were enrolled in a study on stress and eating behavior

	Vegetables, Healthy Proteins, and Sides		Breads and Spreads		Processed and Fried	
Sleep measure	**Unadjusted beta[a] (95% CI)**	**Adjusted beta[bcd] (95% CI)**	**Unadjusted beta (95% CI)**	**Adjusted beta[bcd] (95% CI)**	**Unadjusted beta (95% CI)**	**Adjusted beta[bcd] (95% CI)**
Duration						
Weeknight sleep (h/night)	.05 (−0.09 to 0.18)	.01 (−0.13 to 0.14)	.00 (−0.13 to 0.14)	−.02 (−0.16 to 0.11)	−.05 (−0.19 to 0.08)	−.01 (−0.14 to 0.13)
Weekend night sleep (h/night)	−.12 (−0.21 to −0.02)*	−.13 (−0.22 to −0.04)**	−.04 (−0.14 to 0.05)	−.04 (−0.13 to 0.06)	.00 (−0.09 to 0.10)	.02 (−0.08 to 0.11)
Weekend−weekday duration difference	−.14 (−0.23 to −0.05)**	−.14 (−0.23 to −0.04)**	−.05 (−0.14 to 0.05)	−.02 (−0.12 to 0.07)	.03 (−0.06 to 0.13)	.03 (−0.07 to 0.12)
Total average sleep with naps (h/d)	−.04 (−0.18 to 0.11)	−.08 (−0.22 to 0.07)	−.04 (−0.19 to 0.11)	−.06 (−0.20 to 0.09)	−.03 (−0.17 to 0.12)	.02 (−0.13 to 0.16)
Timing						
Midpoint of sleep during week[e]	−.23 (−0.42 to −0.04)*	−.20 (−0.40 to −0.01)*	.01 (−0.18 to 0.21)	.05 (−0.14 to 0.25)	.20 (0.01 to 0.39)*	.13 (−0.06 to 0.33)
Midpoint of sleep during weekend[e]	−.15 (−0.25 to −0.04)**	−.11 (−0.22 to 0.01)	−.08 (−0.19 to 0.02)	−.04 (−0.15 to 0.08)	.21 (0.11 to 0.32)***	.18 (0.06 to 0.29)**
Weekend−weekday midpoint difference	−.13 (−0.26 to 0.00)	−.06 (−0.20 to 0.08)	−.15 (−0.28 to −0.01)*	−.10 (−0.24 to 0.04)	.25 (0.12 to 0.39)***	.21 (0.07 to 0.35)**
Quality[f]	.12 (−0.03 to 0.26)	.08 (−0.10 to 0.25)	−.05 (−0.19 to 0.09)	.00 (−0.17 to 0.18)	−.05 (−0.19 to 0.10)	.02 (−0.15 to 0.20)

[a]All estimates are from linear regression models with dietary pattern as the continuous outcome and sleep measure as a continuous predictor, separately for each sleep measure and dietary pattern combination.
[b]Adjusted for child age, sex, race, parent education level, and sleep hygiene.
[c]Sample sizes range from 345 to 352 in complete-case analysis.
[d]R^2 for the adjusted models range from 0.02 to 0.06.
[e]Midpoint refers to the median time between bedtime and wake time.
[f]Higher is better.
*$P<0.05$.
**$P<0.01$.
***$P<0.001$.

In contrast, the Processed and Fried pattern contains foods high in saturated fat, which have been connected to shorter sleep duration[53] and less slow wave sleep[50] in some studies.

Another finding was that longer sleep duration during the weekend only was associated with lower Vegetables, Healthy Proteins, and Sides pattern scores. Although the finding was not in the hypothesized direction, there are some potential explanations. Children with longer sleep on the weekends may be compensating for shorter or lower-quality sleep during weekdays,[54] and these weekday sleep characteristics may be responsible for the association. Indeed, associations with sleep quality and duration during the weekdays were in this expected direction but were not statistically significant. Further, the finding that a greater difference in duration from weekend to weekday was associated with lower Vegetables, Healthy Proteins, and Sides, and greater Processed and Fried pattern scores is in line with this explanation.

It remains a possibility that the sleep and diet associations we observed were due to confounding factors that are associated with dietary patterns as well as sleep health. For example, parents who promote healthy eating may be more likely to also maintain consistent bedtime routines. Residual confounding due to socioeconomic status is also a possibility. However, many of the associations between sleep and diet persisted despite adjusting for parental education as well as sleep hygiene. In addition, in models adjusting for measures of routine and household chaos, the estimates were unaltered.

There are both strengths and limitations of this study. Strengths include querying multiple aspects of children's sleep and examining several potential confounders (eg, household CHAOS score). In addition, the examination of dietary patterns is novel in this age group, and the percent variance explained by the components was in line other studies of adolescents and adults.[55-58] The cross-sectional study design was a limitation because it means that temporality of the sleep and diet associations are unclear. There is a possibility of recall bias of self-reported measures. Parents may have reported their children's diet and/or sleep to appear more favorably (social desirability bias). Parent characteristics such as weight status or socioeconomic status may also influence recall.[59,60] Further, although menus of all meals and snacks provided at Head Start are made available,[30] parents may not be fully aware of food actually consumed at preschool. Although this is a notable limitation to our capacity to accurately measure child intake in the field, prior work has shown that parent-completed food frequency questionnaires even for children attending preschool show reasonable validity.[29,61-64] As well, although we cannot rule out systematic error, it may be that parents' lack of knowledge about their child's diet primarily introduces random measurement error, which would decrease precision of the study estimates but should not unduly bias the results.[65] Finally, it is important to note that the generalizability of these findings may be limited because the study sample consisted of low-income preschool-aged children attending Head Start in southeast Michigan.

CONCLUSIONS

In a sample of low-income children attending preschool, delayed sleep timing, longer sleep duration on weekends, and greater differences in sleep timing and duration from weekends to weekdays were associated with less healthful dietary pattern scores. Longitudinal investigations are needed to further elucidate the relationship between sleep health and diet in young children.

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STATEMENT OF POTENTIAL CONFLICT OF INTEREST

No potential conflict of interest was reported by the authors.

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AUTHOR CONTRIBUTIONS

A. L. Miller and K. E. Peterson conceived of the study question. J. C. Lumeng, A. L. Miller, and N. Kaciroti were involved in the original study design and data collection. E. C. Jansen ran statistical analyses, interpreted the data, and wrote the first draft of the manuscript. K. E. Peterson, J. C. Lumeng, N. Kaciroti, M. K. LeBourgeois, K. Chen, and A. L. Miller contributed to interpretation of the findings and revision of the manuscript.