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Relationship of Sleep Duration and Regularity with Dietary Intake among Preschool-Aged Children with Obesity From Low-Income Families

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Abstract

Objective—Diet is a modifiable factor associated with pediatric obesity outcomes, but few studies have evaluated the relationships of sleep duration and regularity on dietary intake of young preschool-aged children. The goal of this study was to evaluate whether short sleep duration and irregular sleep timing were associated with greater calorie, carbohydrate and fat consumption among young children with obesity from low-income families.

Methods—Fifty-one, ethnically diverse children, aged 2–4 years old were recruited from Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) clinics in a southeast BLINDED county. Sleep behaviors were parent-reported using the Child Sleep Assessment tool. Dietary intake data were obtained by 24-hour recall interviews (two weekdays and one weekend day).

Results—Short sleep duration (< 11 hours) was highly prevalent among this cohort of preschool-aged children. Short sleep duration was associated with greater fat and decreased carbohydrate consumption. Children with greater variability in sleep duration and timing had greater energy intake from fat and protein sources.

Conclusions—Allowing for the opportunity to educate parents on the importance of maintaining regular, adequate sleep and relationships between sleep and dietary intake may decrease the risk of childhood obesity in this high-risk pediatric population.

Keywords

Sleep duration; sleep variability; caloric intake; Hispanic; childhood obesity; dietary recall; macronutrients

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Introduction

Obesity in preschool-aged children is a major public health issue as the prevalence rate is now more than 12%.¹ Obesity (body mass index-for-age and sex greater than or equal to the 95th percentile) is more prevalent among preschool-aged children from low-income families and minority groups.^{2,3} Short sleep duration and sleep irregularity may be important contributors to pediatric obesity,⁴⁻⁸ specifically to obesity among minority youth from low income families.⁹ Sleep duration has also been found to be significantly less among low-income, minority youth.^{10,11} Therefore, young children from low-income families and minority groups are particularly vulnerable to obesity, which may be compounded by the higher prevalence of poor sleep in this population.

Sleep Duration and Timing – Obesity Associations

Short sleep duration has consistently been associated with increased prevalence of obesity, future weight gain, and adiposity among young children, ages 3-7 years.^{4,5} Although there is less evidence of this association among toddlers to preschool-aged children, one longitudinal cohort study of low-income children followed from infancy to mid-childhood found that chronic sleep curtailment was associated with greater, future adiposity.⁶ Moreover, variable sleep duration and irregular sleep timing also were associated with weight gain in children and adolescents.^{7,8} Variability in sleep duration was associated with abdominal obesity in adolescents after controlling for habitual sleep duration suggesting that irregularity in sleep may play an even greater role in the development of abdominal obesity than habitual sleep duration.¹² Further evidence for a greater role of sleep irregularity was found among a cohort of young Danish adolescents such that the association between sleep duration and adiposity was attenuated when accounting for oversleeping on weekends.¹³ Evidence also suggests that short sleep duration coupled with irregular sleep timing from weekdays to weekends is associated with the greatest risk for poor metabolic outcomes among 4-10 year olds.¹⁴

Sleep Among Children from Low-Income Families

Socio-economic status is a modifier of sleep in children. The quantity and quality of sleep among children from low-income families was documented as being subpar compared to children not from low-income families.^{10,11,15} Evidence suggests that preschool-aged children from low-income families often sleep in suboptimal sleep environments that affect their sleep duration.¹⁶ Further, children from low-income and disadvantaged households are less likely to follow or maintain consistent bedtimes and bedtime routines compared to children from more advantaged households.¹⁷ These differences may contribute to further sleep inequities that may affect other health outcomes and behaviors such as dietary intake and quality.

Poor Sleep and Dietary Intake

One mechanism that may explain the association between short or irregular sleep and obesity in young children is increased food intake and/or poor diet quality.¹⁸ Altered food consumption patterns in response to inadequate and irregular sleep may start at an early age and endure long-term, thereby leading to negative metabolic consequences later in life.¹⁹

Sleep Duration and Dietary Intake/Quality—Experimental sleep restriction studies indicate greater caloric intake among school-aged children and adolescents after sleep restriction.^{20,21} Observational studies of school-aged children have also demonstrated that shorter sleep duration is associated with greater total caloric intake particularly from consumption of energy-rich foods (i.e., high calorie).^{22,23} For example, results from the Gemini Twin cohort study of preschool-aged children found that increased food intake in association with short sleep duration (105 kcal/day greater in short sleepers) was attributed to greater consumption of milk products especially during the evening.²⁴ Regarding the association between sleep duration and macronutrient composition, studies have found comparable though nuanced results. Among preschool-aged children, short sleep durations were associated with greater consumption of carbohydrate (10 g more per day) and fat (3 g more per day) than moderate sleep durations,²⁵ whereas in a study of adolescents, short sleep duration was associated with less carbohydrate and more fat consumption as a proportion to total caloric intake.²⁶ In contrast, one study that experimentally restricted sleep in school-aged children, found no difference in macronutrient composition of total caloric intake between sleep restricted and control conditions.²⁰

Sleep Irregularity and Dietary Intake/Quality—The extant literature has mostly focused on sleep duration and has rarely focused on other aspects of sleep behavior especially in preschool-aged children, such as changes in sleep duration and timing regularity from weekdays to weekends. Greater variability in sleep duration and timing is associated with greater adiposity and energy intake in school-aged children and adolescents.^{7,12,23} One study of adolescents found that total caloric (~200kcal increase in total caloric intake per 1-hour increase in sleep duration variability), fat, and carbohydrate intake mediated the association between variability in sleep duration and abdominal adiposity.¹² Similarly, greater variability in sleep duration was associated with greater consumption of sugar-sweetened beverages in older children.²³ Greater irregularity in sleep may induce misalignment of the circadian rhythm which regulates both the sleep/wake cycle and appetite.²⁷

Sleep, Dietary Intake, and Obesity Among Preschool-Aged Children

Sleep duration and regularity may affect food preferences and quantities consumed by children, particularly those who are obese. Few studies have looked at these relationships in preschool-aged children who are obese. Even fewer have reported on children with obesity from low-income families. One study indicated that higher caloric intakes were more prevalent in children from minority groups who were overweight.²⁸ Another study conducted among Hispanic toddlers from low-income families found that greater servings of daily fat were positively associated with weight/height percentiles.²⁹ Further, Hispanic children (regardless of obesity status) were more likely to consume sugar-sweetened beverages and fast food than non-Hispanic White children.⁹ However, it is unknown whether short and/or irregular sleep is related to greater dietary intake and poorer diet quality among preschool-aged, minority children with obesity from low-income families. Greater understanding of these relationships may initiate development of new approaches for intervention in this vulnerable population.²⁷

Study Objectives

In the current study, we investigated the following aims among preschool-aged ethnically-diverse children with obesity from low-income families: (a) to describe sleep patterns and behaviors in this at-risk population; and (b) to examine the cross-sectional associations between these sleep patterns/behaviors and dietary intake including total calories and macronutrients. We hypothesized that short sleep duration and greater irregularity in sleep duration and timing from weekdays to weekends would be associated with greater total caloric intake, and greater consumption of carbohydrate and fat.

METHODS

Sample and Study Design

Multi-ethnic children ages two to four years old from low-income families who were enrolled in the Women, Infants, and Children (WIC) program in a southeast BLINDED county were recruited from 2008 to 2010 as part of an intervention study focusing on reducing body mass index among preschool-aged children with obesity.³⁰ This intervention study utilized the WIC program as a recruitment source because of its service to low-income infants, women, and children in the US (~8 million)³¹ thus enhancing the potential to address childhood overweight on a large scale. Inclusion criteria consisted of a body mass index (BMI) equal to or greater than the 95th percentile for age and sex, be recruited as part of a mother-child dyad, and have no metabolic illnesses. Other exclusion criteria included current major illnesses (e.g., diabetes mellitus or other endocrine disorders, cancer, gastrointestinal disease, cardiovascular disease), neurological or developmental delay, and height < 5th percentile. Mothers of the recruited children provided written consent and completed questionnaires about their children's sleep and dietary patterns. A total of 124 mother-child dyads were approached to participate in the study, and 55 mother-child dyads were enrolled. Four dyads did not provide complete dietary intake information; thus the final sample size was 51. The protocol was approved by the University of BLINDED Institutional Review Board. The present study is a secondary analysis of data collected at the baseline assessment.

Measures

Sleep—The Child Sleep Assessment (CSA) by Lee and Ward (2005) is a brief screening tool used in clinical practice for identifying children at risk for sleep disorders.³² The CSA has previously been administered among preschool-aged minority children.³³ The CSA is a parent-reported tool comprising of seven items that assess difficulties with sleep. The CSA includes items assessing frequency of medication used to promote sleep, sleep quality (i.e., good, fairly bad, very bad), bedtime on week nights/school nights and weekends, final awakening time on week days and weekends, difficulties falling asleep and waking up (i.e., not at all difficult, somewhat of a struggle, a constant struggle), frequency of waking up during the night, and level of daytime sleepiness.³² In addition to these primary items, the CSA includes information on whether there is a television in the child's bedroom and if the child sleeps alone.³² The CSA was completed once at the initial assessment by each mother. Sleep duration on weekdays/school days and weekends was calculated as the difference between reported, habitual bedtimes and wake times. Sleep duration was further categorized

as < 11 hours and ≥ 11 hours of nocturnal sleep per night according to the National Heart, Lung, and Blood Institute recommendations for the minimum required nightly sleep duration among preschool-aged children.³⁴ Sleep irregularity was defined in two ways: sleep duration shift (i.e., weekend minus weekdays sleep duration), and social jetlag. Social jetlag, as defined in the literature as the misalignment between biological and social timing,³⁵ was calculated as the difference in mid-sleep time (midpoint between reported bedtime and final awakening) on week days and weekends.³⁶ This difference in the timing of sleep was conceptualized as the extent the child was affected by social and cultural practices that may induce an experience similar to jet lag. One study used this measurement approach among children previously.³⁷

Dietary Intake Assessment—Dietary data were collected from the mothers about their children on three nonconsecutive days including two weekdays and one weekend day over a two-week period by trained research staff through home visits and phone calls, using the multiple pass approach for 24-hour dietary recall interviews.^{38,39} This method was chosen because parents are often most involved in preparing meals and feeding their children. Additionally, this approach is inexpensive, and previous studies indicate moderate to high correlations between parental reports of preschool-aged children's food intake compared to food weighing and home observations.^{40,41} Dietary data were entered and coded in the Nutrition Data System for Research by nutrition interns in the General Clinical Research Center, University of BLINDED. Primary outcome measures were mean total energy intake, fat (grams and percentage of daily calories), carbohydrate (grams and percentage of daily calories), protein (grams and percentage of daily calories), saturated fat, monounsaturated fat, polyunsaturated fat, and animal protein across the three days.

Other Variables—Height and weight were measured to calculate BMI. Height was measured with a stadiometer to the nearest mm and weight was measured to the nearest 0.1 kg using a balance beam scale with shoes removed and participants wearing indoor clothing. Child age (in months), gender, and maternal education (< 8th grade; some high school; high school graduate) were also all collected as part of a parent-reported demographic data questionnaire.

Statistical Analysis

To address the first aim of the study, to describe the sleep behaviors and patterns of this population, data on demographic characteristics, sleep behaviors/patterns were analyzed using descriptive statistics. Normally distributed data were presented using means and standard deviations; non-normally distributed data were described using median and interquartile ranges. To address the second aim of the study, separate analysis of covariance models were conducted to examine differences in dietary intake (total calories, carbohydrate, total fat, saturated fat, monounsaturated fat, polyunsaturated fat, total protein, animal protein) by sleep duration on weekdays and weekends while controlling for child age (in months), gender, and maternal education (< 8th grade; some high school; high school graduate). Ordinary least squares (OLS) regression analyses were also performed to explore relationships between sleep irregularity (i.e., sleep duration shift, social jet lag) and dietary intake. In the models for the relationships between sleep duration shift and carbohydrate (g),

fat (g), saturated fat (g), polyunsaturated fat (g), and animal protein (g), one to two outliers were removed to meet model assumptions. In the model for the relationship between social jetlag and polyunsaturated fat, one outlier was removed to meet model assumptions. Other sleep variables (e.g., difficulty falling asleep, frequent awakenings) were not assessed as predictors of dietary intake because previous studies provided the most evidence for an association between sleep duration and timing with dietary intake.^{7,12,20-26} All statistical analyses were two-tailed. To correct for multiple comparisons we used a Bonferroni correction for each set of dietary intake variables in association with an individual sleep variable (i.e., sleep duration on week days, sleep duration on weekends, sleep duration shift, social jet lag). There were a total of 11 dietary intake outcome variables. Therefore, a P-value < 0.0045 (i.e., 0.05/11) was considered statistically significant for each independent effect of a given sleep variable. The data were analyzed using the Statistical Package for the Social Sciences 22.0 for Windows (SPSS, Inc., an IBM Company, Chicago, Illinois, USA).

RESULTS

Participant demographic, sleep and behavioral characteristics are provided in Table 1. Mean age was 40.6 months (~3 years, 4 months) and the majority of the sample was girls (62.7%). The ethnic distribution was as follows: 54.5% Hispanic, 7.3% African American, and 38.2% non-Hispanic White. About half of the mothers had less than a high school education. Average sleep duration on both weekdays and weekends was slightly less than the recommended minimum (i.e., 11 hours). Approximately 55% of the sample obtained inadequate nocturnal sleep duration (< 11 hours) on weekdays and weekends. Mean sleep duration did not change substantially from weekdays to weekends, though the range of change in the sample was considerable (-3 to 3 hours). On average, social jetlag from weekdays to weekends was 40 minutes. The majority of the sample reported few nocturnal awakenings and minimal daytime sleepiness. However, almost half (43.2%) of the sample had difficulty falling asleep and more than two thirds had a television in the bedroom. About four out of ten children did not fall asleep alone but rather co-slept with others, which was most often with a parent(s).

Sleep Duration

We examined the association of habitual sleep duration (< 11hrs vs. ≥ 11hrs) on weekdays and weekends with each of the dietary intake variables (see Table 2). Compared to children obtaining adequate sleep duration, children with short sleep duration on weekdays consumed more fat and less carbohydrate as a percentage of their total caloric intake. Approximately 37% and 47% of their daily caloric intake on average (i.e., marginal means) comprised of fat and carbohydrate, respectively, compared to 28% and 58% among children obtaining adequate sleep duration, respectively. There was no difference in dietary intake by sleep duration on weekends.

Sleep Irregularity

Table 3 presents the association between sleep duration shift and dietary intake. Results indicated that each 1-hour increase in sleep duration shift (i.e., more sleep on weekends) was associated with a 381.1 kcal increase in total caloric intake. Sleep duration shift explained

26% of the variability in overall caloric intake after adjusting for age, gender, and maternal education level. Each additional hour of sleep duration shift was associated with 13.7g more total protein, 10.1g more animal protein, 16.5g more total fat, 4.8g more saturated fat, and 6.6g more monounsaturated fat. Thus, protein and fats accounted for most of the additional caloric intake associated with greater sleep duration shift.

We examined the association between social jetlag and dietary intake in Table 3. Similar to the results for sleep duration shift, each 15-minute increase in social jet lag (i.e., 15-minute delay in mid-sleep time from weekdays to weekends) was associated with a 126.7 kcal increase in total caloric intake. Social jetlag explained 26% of the variability in overall caloric intake after adjusting for age, gender, and maternal education level. Each 15-minute increase in social jetlag was associated with 6.7g more total fat, 2.4g more saturated fat, and 2.1g more monounsaturated fat. Thus, fats accounted for the greater caloric intake associated with greater social jetlag.

DISCUSSION

The results of our study suggest that among a sample of preschool-aged ethnically-diverse children with obesity from low-income families, more than half the sample had short, nocturnal sleep durations (< 11 hours). Most of the children had a television present in the bedroom, almost half had difficulty falling asleep, and about four out of ten children had co-sleeping arrangements. Short sleep duration on weekdays was associated with a greater proportion of fat consumption and a decreased proportion of carbohydrate intake compared to adequate sleep duration. Greater sleep duration shift and social jetlag from weekdays to weekends were associated with greater caloric consumption mostly from fats and protein (i.e., saturated and monounsaturated fats, and animal protein).

Sleep Duration

Our results are inconsistent with experimental and observational studies that associate short sleep duration or sleep restriction, respectively, among school-aged children and adolescents with greater caloric intake.²⁰⁻²³ Short sleep duration was not related to greater caloric intake in this sample, which may have occurred because the population sampled was obese, whereas previous studies did not exclusively sample children with obesity. Intuitively, mean caloric intakes of children who are already obese are unlikely to differ by sleep duration. However, the dietary quality of that intake may differ by sleep duration. Previous studies have found positive relationships between better dietary quality and adequate sleep duration.^{42,43} To the best of our knowledge, our study was the first to find among preschool-aged children that short sleep duration on weekdays among obese children was related to decreased carbohydrate intake (46.6% vs. 57.6%) and greater fat intake (36.8% vs. 27.9%) as a proportion of total energy intake. One previous study also found this association between short sleep duration and decreased carbohydrate intake among school-aged children.²⁷ In studies of adults, evidence suggests carbohydrate-rich meals may be a natural tranquilizer through the sleepiness-promoting effects of tryptophan, a precursor,^{44,45} of which is often more easily absorbed and transported across the blood-brain barrier after consumption of carbohydrate.⁴⁶ Further support of this notion was found among healthy

young children who experienced longer sleep duration after a carbohydrate-rich meal in the evening.⁴⁷ In addition, greater caloric consumption from protein and carbohydrate at the expense of fat during infancy was associated with longer sleep duration during toddlerhood.⁴⁸ Thus, diet quality (based on macronutrient composition) among short sleepers in this sample may be non-sleep promoting, and likely pro-obesogenic directly via greater fatty-food intake and indirectly through inadequate sleep. However, clinical and experimental trials are needed to validate this proposition.

Sleep Irregularity

Our study evaluated both sleep duration shift and social jetlag (i.e., shifts in sleep timing) from weekday to weekend; similar to the few studies that have studied variables related to sleep variability,^{7,12,23} we found that greater sleep duration shift and social jetlag were associated with greater energy intake among ethnically-diverse, low-income preschool-aged children with obesity. Previous studies documented associations between irregular sleep and weight gain in children,^{7,8} which might be explained by irregularly timed and increased eating opportunities,²⁴ and/or poor diet quality. Indeed, later bedtimes are not only associated with shorter sleep duration but with greater energy consumption in the evenings.²⁵ In addition, previous studies found that after controlling for covariates, late bedtimes increased the risk for obesity and suboptimal diet quality in children and adolescents.^{49,50} Children with obesity may be at particular risk for both short sleep duration and variable sleep timing and quantity. High variability in sleep duration and timing may lead to a chronic state of circadian rhythm misalignment, which impact behavioral, appetite, and metabolic changes.²⁸ As children transition from life at home to daycare/school, maintaining a regular sleep schedule may be important for obesity prevention.

Other Sleep Behaviors

The children in our population frequently had televisions present in the bedroom and co-sleeping arrangements. Previous studies have determined that inadequate sleep could be associated with parental behaviors at bedtime and during the night.⁵¹ Anderson and colleagues found that regular family dinners, adequate nighttime sleep, and limited screen time lowered the prevalence of obesity by 40% in US preschool-aged children.⁵² Television viewing as a risk factor for childhood obesity has long been a concern; however, with more screen-based technologies (i.e. computers, telephones, and tablets) the relationship between screen-viewing, sleep, and obesity could be more substantial.

Cultural Factors

The disadvantaged status of the children in this sample may have contributed to the documented associations between sleep parameters and dietary intake. As mentioned previously, the culture of being raised in a low-income household is associated with a poorer sleep environment and lower adherence to consistent bedtimes and sleep hygiene behaviors.^{16,17} Further, observational studies suggest that these households are more prone to poor family functioning, chaos, and greater maternal stress, all of which are associated with problematic sleep behaviors and shorter sleep duration.^{53,54} Inconsistency in sleep-related routines is also likely predictive of inconsistency in other health behavior routines such as child feeding. Indeed, in a sample of preschool-aged children from England, parental

rules regarding various anti-obesogenic health behaviors such as sleep, diet, and television viewing tended to be clustered together and associated with longer sleep duration.⁵⁵ Lack of use or consistency in these rules was associated with lower socioeconomic status and with a more obese body composition.⁵⁵ Consistency in childhood routines for sleep and dietary intake may buffer the negative effects associated with disadvantaged households on the sleep and diet relationships found in this population.

Strengths and Limitations

There are several strengths to our study. The evaluation of the relationship of sleep duration and dietary intake but also sleep irregularity and dietary intake adds to the growing body of literature gauging factors contributing to pediatric obesity. Our exclusive sampling of children with obesity also contributes to the literature by demonstrating that these relationships are present independent of BMI, and suggests that inadequate and irregular sleep may contribute to the development and maintenance of obesity. This study is also one of the first of its kind to examine the association between nocturnal sleep and dietary intake, assessed with a comprehensive set of macronutrients, among a vulnerable and underrepresented population.

Limitations of the study include its cross-sectional design (precluding ability to assess causality), small sample size (limiting generalizability and power to detect associations), and the use of parent-reported, retrospective sleep data from a clinical screening tool (instead of prospective measures such as polysomnography and wrist actigraphy). In addition, sleep and dietary intake were not assessed synchronously or prospectively, so the day-by-day relationships between sleep and diet cannot be established. Napping during the day was also not assessed, which, accounting for may have altered the results. Furthermore, temporal effects or seasonality was not considered and may have had a confounding influence on the results. We also did not collect data related to meal and snack timing, quantity and duration. This is especially important in a low-income population that may rely on meals provided by daycare/schools and might have limited access to food at home.

Conclusion

Sleep duration and timing may contribute to childhood obesity among preschool-aged ethnically-diverse children from low-income families by influencing dietary intake. We encourage that sleep be assessed during routine medical visits to allow an opportunity to educate parents on the relationships between sleep, diet, and obesity, and the importance of maintaining regular, adequate sleep. Although, there is a growing body of literature pertaining to sleep and dietary intake, there is a paucity of large prospective, observational studies in children from low-income families that evaluate sleep, dietary intake, energy expenditure, meal timing/frequency, and weight gain from infancy or early childhood to mid-childhood. Further research needs to prospectively evaluate the effects of variability in sleep duration and timing on dietary intake as well as meal frequency, quality, and timing in this population.

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ER and MRG conceived and carried out the protocol. MEP conceived the study design for the paper, and analyzed and interpreted the data. MWM collected and analyzed the data. All authors interpreted the data and were involved in writing the paper and had final approval of the submitted and published versions

References

1. Ogden CL, Carroll MD, Kit BK, et al. Prevalence of Childhood and Adult Obesity in the United States, 2011-2012. *JAMA*. 2014; 311:806–814. [PubMed: 24570244]
2. Kimbro RT, Brooks-Gunn J, McLanahan S. Racial and ethnic differentials in overweight and obesity among 3-year-old children. *Am J Public Health*. 2007; 97:298–305. [PubMed: 17194857]
3. Weedn AE, Hale JJ, Thompson DM, et al. Trends in obesity prevalence and disparities among low-income children in Oklahoma, 2005–2010. *Child Obes*. 2014; 10:318–325. [PubMed: 25019336]
4. Patel SR, Hu FB. Short sleep duration and weight gain: a systematic review. *Obesity*. 2008; 16:643–653. [PubMed: 18239586]
5. Chen X, Beydoun MA, Wang Y. Is sleep duration associated with childhood obesity? A systematic review and meta-analysis. *Obesity*. 2008; 1:265–274.
6. Taveras EM, Gillman MW, Peña M, et al. Chronic sleep curtailment and adiposity. *Pediatrics*. 2014; 133:1013–1022. [PubMed: 24843068]
7. Chung KF, Kan KKK, Yeung WF. Sleep duration, sleep-wake schedule regularity, and body weight in Hong Kong Chinese adolescents. *Biol Rhythm Res*. 2013; 444:169–179.
8. Scharf RJ, DeBoer MD. Sleep timing and longitudinal weight gain in 4- and 5-year old children. *Pediatr Obes*. 2015; 10:141–148. [PubMed: 24919802]
9. Taveras EM, Gillman MW, Kleinman K, et al. Racial/ethnic differences in early-life risk factors for childhood obesity. *Pediatrics*. 2010; 125:686–695. [PubMed: 20194284]
10. Wong WW, Ortiz CL, Lathan D, Moore LA, Konzelmann KL, Adolph AL, Smith EO, Butte NF. Sleep duration of underserved minority children in a cross-sectional study. *BMC Public Health*. 2013; 13:648. [PubMed: 23849231]
11. Felden ÉPG, Leite CR, Rebelatto CF, et al. Sleep in adolescents of different socioeconomic status: a systematic review. *Rev Paul Pediatr*. 2015; 33:467–473. [PubMed: 26298657]
12. He F, Bixler EO, Liao J, et al. Habitual sleep variability, mediated by nutrition intake, is associated with abdominal obesity in adolescents. *Sleep Med*. 2015; 16:1489–1494. [PubMed: 26611945]
13. Jarrin D, McGrath J, Drake C. Beyond sleep duration: distinct sleep dimensions are associated with obesity in children and adolescents. *Int J Obes*. 2013; 37:552–558.
14. Spruyt K, Molfese DL, Gozal D. Sleep duration, sleep regularity, body weight, and metabolic homeostasis in school-aged children. *Pediatrics*. 2011; 127:e345–e352. [PubMed: 21262888]
15. Crabtree VM, Korhonen JB, Montgomery-Downs HE, et al. Cultural influences on the bedtime behaviors of young children. *Sleep Med*. 2005; 6:319–324. [PubMed: 15978515]
16. Wilson KE, Miller AL, Lumeng JC, et al. Sleep environments and sleep durations in a sample of low-income preschool children. *J Clinical Sleep Medicine*. 2014; 10:299–305.
17. Hale L, Berger LM, LeBourgeois MK, et al. Social and demographic predictors of preschoolers' bedtime routines. *J Dev Behav Pediatr*. 2009; 30:394–402. [PubMed: 19745760]
18. Combs D, Goodwin JL, Quan SF, et al. Longitudinal differences in sleep duration in Hispanic and Caucasian children. *Sleep Med*. 2016; 18:61–66. [PubMed: 26299467]
19. Chaput JP. Sleep patterns, diet quality and energy balance. *Physiol Behav*. 2014; 134:86–91. [PubMed: 24051052]
20. Entin A, Kaufman-Shriqui V, Naggan L, et al. Parental feeding practices in relation to low diet quality and obesity among LSES children. *J Am Coll Nutr*. 2014; 33(4):306–314. [PubMed: 24992282]
21. Hart CN, Carskadon MA, Considine RV, et al. Changes in children's sleep duration on food intake, weight, and leptin. *Pediatrics*. 2013; 134(6):e1473–e1480.

22. Beebe DW, Simon S, Summer S, et al. Dietary intake following experimentally restricted sleep in adolescents. *Sleep*. 2013; 36:827–834. [PubMed: 23729925]
23. Westerlund L, Ray C, Roos E. Associations between sleeping habits and food consumption patterns among 10-11-year-old children in Finland. *Br J Nutr*. 2009; 102:1531–1537. [PubMed: 19664303]
24. Kjeldsen J, Hjorth MF, Andersen R, et al. Short sleep duration and large variability in sleep duration are independently associated with dietary risk factors for obesity in Danish school children. *Int J Obes*. 2014; 38:32–39.
25. McDonald L, Wardle J, Llewellyn C, et al. Sleep and nighttime energy consumption in early childhood: a population-based cohort study. *Pediatr Obes*. 2015; 10:454–460. [PubMed: 25565402]
26. Fisher A, McDonald L, van Jaarsveld CHM, et al. Sleep and energy intake in early childhood. *Int J Obes*. 2014; 38:926–929.
27. Weiss A, Xu F, Storfer-Isser A, et al. The association of sleep duration to adolescents' fat and carbohydrate consumption. *Sleep*. 2010; 33:1201–1209. [PubMed: 20857867]
28. Miller AL, Lumeng JC, LeBourgeois MK. Sleep patterns and obesity in childhood. *Curr Opin Endocrinol Diabetes Obes*. 2015; 22:41–47. [PubMed: 25517022]
29. Butte NF, Puyau MR, Adolph AL, et al. Physical activity in nonoverweight and overweight Hispanic children and adolescents. *Med Sci Sports Exerc*. 2007; 39:1257–1266. [PubMed: 17762358]
30. Reifsnider E, Bishop SL, An K, et al. We stop for no storm: Coping with an environmental disaster and public health research. *Public Health Nurs*. 2014; 31:500–507. [PubMed: 25284575]
31. United States Department of Agriculture, Food and Nutrition Service. [August 16, 2016] WIC Program Data. [United States Department of Agriculture Web site]. Aug 5. 2016 Available at: <http://www.fns.usda.gov/pd/wic-program>
32. Lee KA, Ward TM. Critical components of a sleep assessment for clinical practice settings. *Issues Ment Health Nurs*. 2005; 26:739–50. [PubMed: 16126649]
33. Gallagher MR, Cron SG, Meininger JC. Nocturnal sleep duration and its relation to obesity in Latino women and preschool children. *Hisp Health Care Int*. 2010; 8:209–216.
34. National Heart, Lung, Blood Institute. Your Guide to Healthy Sleep. US Department of Health and Human Services; Published 2005; Revised 2011, Available at: www.nhlbi.nih.gov/health/public/sleep/healthy_sleep.pdf. [May 19, 2015]
35. Wittmann M, Dinich J, Mellow M, et al. Social jetlag: misalignment of biological and social time. *Chronobiol. Int*. 2006; 23:497–509. [PubMed: 16687322]
36. Roenneberg T, Allebrandt KV, Mellow M, et al. Social jetlag and obesity. *Curr Biol*. 2012; 22:939–943. [PubMed: 22578422]
37. Randler C, Fontius I, Vollmer C. Delayed weekend sleep pattern in German infants and children aged 0–6 years. *Biol Rhythm Res*. 2012; 43:225–234.
38. Reifsnider E, Keller CS, Gallagher M. Factors related to overweight and risk for overweight among low income Hispanic children. *J Pediatr Nurs*. 2006; 21:186–196. [PubMed: 16713509]
39. Butte NF, Fox MK, Briefel RR, et al. Nutrient intakes of US infants, toddlers, and preschoolers meet or exceed dietary reference intakes. *J Am Diet Assoc*. 2010; 110:S27–37. [PubMed: 21092766]
40. Klesges RC, Klesges LM, Brown G, et al. Validation of the 24-hour dietary recall in preschool children. *J Am Diet Assoc*. 1987; 87:1383–1385. [PubMed: 3655169]
41. Basch CE, Shea SA, Contento IR, et al. Validation of mother's reports of dietary intake by four to seven year-old children. *Am J Public Health*. 1990; 80:1314–1317. [PubMed: 2240296]
42. Cespedes EM, Hu FB, Redline S, et al. Chronic insufficient sleep and diet quality: Contributors to childhood obesity. *Pediatr Obes*. 2015; 24:184–190.
43. Hoppe C, Rothausen BW, Biloft-Jensen A, et al. Relationships between sleep duration and dietary intake in 4- to 14-year old Danish children. *J Nutr Sci*. 2013; 2:1–7.
44. Afaghi A, O'Connor H, Chow CM. High-glycemic-index carbohydrate meals shorten sleep onset. *Am J Clin Nutr*. 2007; 85:426–430. [PubMed: 17284739]

45. Grandner MA, Jackson N, Gerstner JR, et al. Dietary nutrients associated with short and long sleep duration. Data from a nationally representative sample. *Appetite*. 2013; 64:71–80. [PubMed: 23339991]
46. Wurtman RJ, Wurtman JJ, Regan MM, et al. Effects of normal meals rich in carbohydrates or proteins on plasma tryptophan and tyrosine ratios. *Am J Clin Nutr*. 2003; 77:128–132. [PubMed: 12499331]
47. Diethelm K, Remer T, Jilani H, et al. Associations between the macronutrient composition of the evening meal and average daily sleep duration in early childhood. *Clin Nutr*. 2011; 30:640–646. [PubMed: 21641703]
48. Kocavska D, Voortman T, Dashti HS, et al. Macronutrient intakes in infancy are associated with sleep duration in toddlerhood. *J Nutr*. 2016; 146:1250–1256. [PubMed: 27146923]
49. Golley RK, Maher CA, Matricciani L, et al. Sleep duration or bedtime? Exploring the association between sleep timing behaviour, diet and BMI in children and adolescents. *Int J Obes*. 2013; 37:546–551.
50. Olds T, Maher C, Matricciani L. Sleep duration or bedtime? Exploring the relationship between sleep habits and weight status and activity patterns. *Sleep*. 2011; 34:1299–1307. [PubMed: 21966061]
51. Mindell JA, Sadeh A, Kohyama J, et al. Parental behaviors and sleep outcomes in infants and toddlers: a cross-cultural comparison. *Sleep Med*. 2010; 11:393–399. [PubMed: 20223706]
52. Anderson SE, Whitaker RC. Household routines and obesity in US preschool-aged children. *Pediatrics*. 2010; 125:420–428. [PubMed: 20142280]
53. Boles RE, Halbower AC, Daniels S, et al. Family chaos and child functioning in relation to sleep problems among children at risk for obesity. *Behav Sleep Med*. In press.
54. Caldwell BA, Redeker NS. Maternal stress and psychological status and sleep in minority preschool children. *Public Health Nurs*. 2015; 32:101–111. [PubMed: 24386915]
55. Jones CH, Pollard TM, Summerbell CD, et al. Could parental rules play a role in the association between short sleep and obesity in young children?. *J Biosoc Sci*. 2014; 46:405–418. [PubMed: 23750569]

Table 1

Descriptive characteristics of the sample (N = 51)

Variable	N(%) or Mean (SD)	Range
Age (months)	40.6 (7.4)	25-59
Girls (n, %)	32 (62.7)	-
Maternal education		-
Grade School (through 8 th grade)	10 (20.4)	
Some High School	15 (30.6)	
High School Degree	24 (49.0)	
Sleep duration on weekdays (hrs)	10.6 (1.2)	7.5 – 13
Sleep duration on weekends (hrs)	10.8 (1.0)	8.5 – 13
Sleep duration shift (hrs)	0.1 (1.0)	-3 – 3
Bedtime on weekdays	21:12 PM (0:56)	20:00 PM – 12:30 AM
Bedtime on weekends	21:43 PM (1:01)	20:00 PM – 1:00 AM
Wake time on weekdays	7:45 AM (1:04)	5:00 AM – 10:00 AM
Wake time on weekends	8:28 AM (1:09)	6:30 AM – 12:00 PM
Mid-Sleep time on weekdays	2:25 AM (0:50)	1:00 AM – 5:00 AM
Mid-Sleep time on weekends	3:04 AM (1:00)	1:15 AM – 6:30 AM
Social Jet Lag (min)	0:40 (0:42)	-50 – 142
Difficulty falling asleep (n, % Yes)	22 (43.2)	-
Falls asleep alone (n, % No)	18 (35.3)	-
# Awakenings per night		-
0-1	32 (62.7)	
1+	19 (37.3)	
Difficulty waking in morning (n, % No)	11 (21.6)	-
Daytime sleepiness		-
Not at all	23 (45.1)	
A little	23 (45.1)	
Most days	5 (9.9)	
Television in bedroom (n, % Yes)	34 (68.0)	-
Sleep location		-
Alone in bed	28 (59.6)	
Shared bed with someone other than parent(s)	7 (14.9)	
Parent bed	11 (23.4)	
Total energy intake (kcal/d) *	1,455.2 (1,096.3 – 1,903.8)	663.3 – 3799.6
Fat (g/d) *	53.1 (35.0 – 70.2)	15.9 – 204.7
Carbohydrate (g/d) *	184.0 (134.7 – 271.0)	81.8 - 625
Protein (g/d) *	53.0 (40.2 – 73.1)	19.0 – 150.0
Fat (% of kcal)	32.2 (8.5)	12.7 – 51.6
Carbohydrate (% of kcal)	52.2 (9.7)	30.8 – 75.6
Protein (% of kcal) *	14.4 (13.0 – 17.8)	10.1 – 27.7

Variable	N(%) or Mean (SD)	Range
Saturated Fat (g/d) *	20.4 (11.8 – 26.0)	6.0– 71.6
Monounsaturated Fat (g/d) *	17.3 (11.2 – 24.3)	4.8 – 69.2
Polyunsaturated Fat (g/d) *	7.2 (4.9 – 10.6)	2.3 – 61.9
Animal Protein (g/d) *	34.8 (28.2 – 51.4)	12.0 – 130.6

* Median, Interquartile Range

Table 2Dietary Intake by Sleep Duration on Weekdays and Weekends ^a

Variable	Weekdays				Weekends			
	< 11 hours (n = 24)	11 h (n = 20)	F	p	< 11 hours (n = 24)	11 h (n = 20)	F	p
Total Energy Intake (kcal/d) ^b	1794.4 (900.6)	1791.5 (454.4)	0.8	0.38	1500.0 (481.7)	1816.4 (874.7)	1.2	0.28
Carbohydrate (g/d)	224.9 (126.1)	215.5 (62.4)	0.2	0.67	206.0 (76.9)	238.2 (116.5)	1.1	0.31
Protein (g/d)	65.7 (32.4)	53.8 (19.8)	1.4	0.24	55.9 (20.5)	65.7 (31.8)	1.1	0.29
Fat (g/d)	72.1 (44.3)	48.5 (24.1)	4.1	0.05	52.4 (21.0)	69.1 (46.7)	1.9	0.18
Carbohydrate (% of kcal)	46.6 (7.4)	57.6 (9.4)	12.0 [*]	0.002	53.6 (10.7)	52.0 (10.1)	0.1	0.74
Protein (% of kcal)	16.6 (3.7)	14.5 (4.2)	1.4	0.25	15.7 (3.9)	15.4 (4.3)	0.2	0.66
Fat (% of kcal)	36.8 (7.9)	27.9 (7.3)	10.7 [*]	0.003	30.8 (9.8)	32.6 (8.2)	0.3	0.59
Saturated Fat (g/d)	27.6 (16.2)	17.9 (9.7)	4.8	0.03	19.6 (8.3)	26.2 (17.5)	2.0	0.16
Polyunsaturated Fat (g/d)	11.9 (14.7)	9.6 (5.9)	0.5	0.51	7.3 (3.8)	13.2 (13.0)	3.5	0.07
Monounsaturated Fat (g/d)	24.8 (17.2)	17.1 (9.8)	2.9	0.10	17.4 (8.7)	23.2 (16.5)	1.5	0.23
Animal Protein (g/d)	51.8 (30.8)	36.7 (19.5)	2.1	0.15	37.2 (13.6)	49.0 (30.8)	1.7	0.21

* $p < 0.0045$ was considered statistically significant following Bonferroni correction for multiple comparison (11 comparisons)^a Adjusted for child age, child gender, and maternal education^b ANCOVA used log-normalized dietary data

Table 3Associations between Sleep Duration Shift, Social Jet Lag, and Dietary Intake ^a

Variable	Sleep Duration Shift ^b				
	B (SE)	Beta	p ^c	Adjusted R ²	R ² change
Total Energy Intake (kcal/d)	381.1 (101.7)	0.53	0.001	3.9 **	.26
Carbohydrate (g/d) ^d	27.0 (13.0)	0.33	0.045	1.4	.10
Protein (g/d)	13.7 (3.8)	0.52	0.001	3.9 *	.25
Fat (g/d) ^d	16.5 (4.2)	0.56	<.001	4.0 **	.29
Carbohydrate (% of kcal)	-3.9 (1.5)	1.5	0.02	2.8 *	.15
Protein (% of kcal)	1.0 (0.6)	.25	0.10	4.0 *	.06
Fat (% of kcal)	2.9 (1.4)	.34	0.046	1.5	.11
Saturated Fat (g/d) ^d	4.8 (1.5)	.48	0.003	2.7 *	.21
Polyunsaturated Fat (g/d) ^d	2.5 (0.9)	.45	0.01	2.1	.19
Monounsaturated Fat (g/d)	6.6 (1.9)	.50	0.002	4.2 **	.24
Animal Protein (g/d) ^d	10.1 (3.0)	.50	0.002	4.2 **	.24

Variable	Social Jet Lag ^e				
	B (SE)	Beta	p ^c	Adjusted R ²	R ²
Total Energy Intake (kcal/d)	126.7 (35.4)	.50	0.001	3.6 *	.28
Carbohydrate (g/d)	12.9 (5.2)	.37	0.02	2.0	.17
Protein (g/d)	3.7 (1.4)	.40	0.01	2.3	.19
Fat (g/d)	6.7 (1.8)	.53	<.001	4.1 **	.30
Carbohydrate (% of kcal)	-1.2 (0.5)	-.34	0.04	2.3	.22
Protein (% of kcal)	-0.1 (0.2)	-.06	0.70	3.0 *	.18
Fat (% of kcal)	1.2 (0.5)	.42	0.01	2.3	.22
Saturated Fat (g/d)	2.4 (0.7)	.51	0.001	3.4 *	.26

Variable	Social Jet Lag ^e				
	B (SE)	Beta	p ^c	F (Overall Model)	R ²
Polyunsaturated Fat (g/d) ^f	0.4 (0.4)	.21	0.24	0.6	.07 .04
Monounsaturated Fat (g/d)	2.1 (0.7)	.46	0.004	3.7 [*]	.31 .21
Animal Protein (g/d)	3.1 (1.3)	.36	0.03	2.7 [*]	.25 .12

^{**} $p < 0.01$

^{*} $p < 0.05$

^a Adjusted for child age, child gender, and maternal education

^b Difference score was computed by subtracting sleep duration on weekdays from sleep duration on weekends in hours.^{cc}

^c Please note that $p < 0.0045$ was considered statistically significant for the independent effect of sleep variables on each dietary intake variable following Bonferroni correction for 11 comparisons.

^d One outlier removed.

^e Social jetlag was assessed in 15 minute increments

^f Two outliers removed.