HHS Public Access

Author manuscript

Pediatr Obes. Author manuscript; available in PMC 2019 February 21.

Published in final edited form as:

Pediatr Obes. 2018 July ; 13(7): 406–412. doi:10.1111/ijpo.12281.

Overnight Sleep Duration and Obesity in 2-5 Year-Old American Indian Children

David G Ingram[1], **Leah A Irish**[2], **Emily J Tomayko**[3], **Ronald J Prince**[4], **Kate A Cronin**[4], **Tassy Parker**[5], **KyungMann Kim**[6], **Lakeesha Carmichael**[6], **Vernon M Grant**[4], **Judith N Sheche**[7], and **Alexandra K Adams**[4]

[1]Division of Pulmonary and Sleep Medicine, Children's Mercy Hospital, Kansas City, MO 64108, USA

[2]Department of Psychology, North Dakota State University, Fargo, ND, 58102, USA

[3]Department of Nutrition, School of Biological and Population Health Sciences, College of Public Health and Human Sciences, Oregon State University, Corvallis, OR, USA

[4]Department of Family Medicine and Community Health, School of Medicine and Public Health, University of Wisconsin, Madison, WI, 53715, USA

[5]Department of Family and Community Medicine, School of Medicine, University of New Mexico, Albuquerque, NM, 87131, USA

[6]Department of Biostatistics and Medical Informatics, School of Medicine and Public Health, University of Wisconsin, Madison, WI, 53729, USA

[7]First Nations Community Healthsource, Albuquerque, NM, 87108, USA

Abstract

Background/Objectives: Sleep has emerged as a potentially modifiable risk factor for obesity in children. The purpose of this investigation was to evaluate the association between overnight sleep duration and obesity among American Indian (AI) children ages 2–5 years.

Methods: Data were examined from the baseline assessment of children enrolling in the Healthy Children, Strong Families (HCSF2) study, which is a randomized lifestyle intervention trial in 5 diverse rural and urban AI communities nationally among children ages 2–5 years. Multivariable models were built to assess the relationship between sleep duration and BMI z-score while controlling for potential sociodemographic and behavioral covariates.

Results: Three-hundred and ninety-eight children had sufficient data to be included in analysis. In multivariable models controlling for potential covariates, overnight sleep duration was significantly and inversely associated with BMI z-score (B=−0.158, t=−1.774, p=0.006). Similarly, when controlling for covariates, children who slept 12 or more hours had significantly lower BMI z-scores compared to those who slept 8 to 10 hours (p=0.018) or less than 8 hours (p=0.035); the

Address correspondence to: David G Ingram, 2401 Gillham Road, Kansas City, Missouri 64108. dgingram@cmh.edu. Phone: (816) 983-6644.

Conflicts of interest: The authors have no conflicts of interest relevant to this manuscript.

difference between 12+ hours and 10–12 hour groups did not reach statistical significance (p=0.073) but supported a linear relationship between overnight sleep duration and BMI. Weekday to weekend variability in overnight sleep duration was not associated with BMI z-score (B=0.010, t=0.206, p=0.837).

Conclusions: Overnight sleep duration is independently and inversely related to BMI z-score among AI children ages 2–5 years, even when controlling for important sociodemographic and obesogenic lifestyle factors. This represents the first report, to our knowledge, of sleep duration as a risk factor for obesity among AI children.

Keywords

Obesity; sleep duration; pediatric; American Indian

Introduction

Approximately one-third of children in the United States are obese or overweight.[1, 2] Weight patterns may start to form early in life, with those children who enter kindergarten overweight being four times more likely to become obese by high school compared to normal weight children,[3] and two thirds of adolescents who are obese remain obese into adulthood.[4] Obesity rates among American Indian (AI) children are the highest of any race or ethnic group in the United States.[5]

Sleep duration has emerged as a potential modifiable risk factor for obesity in children. Prior meta-analysis including more than 30,000 children found a pooled odds ratio for short sleep duration and obesity of 1.8 (CI 1.4 to 2.4).[6] A more recent meta-analysis of prospective studies similarly found an increased odds of obesity among children with short sleep duration, but geographical location also explained variability in effect size across studies.[7] Furthermore, sleep schedule characteristics beyond sleep duration may play an important role in the sleep-obesity association, such as an evening chronotype or variable sleep schedules between weekday and weekend.[8] Possible underlying mechanisms explaining this relationship include changes in leptin and ghrelin secretions, changes in eating behavior and dietary quality, and timing of eating.

Healthy Children, Strong Families (HCSF2) is a family-based early childhood intervention that addresses the growing problem of AI childhood obesity. HCSF2 builds on our previous work of an obesity prevention intervention (HCSF1)[9] and was tested in a randomized trial of HCSF vs. control (child safety intervention) in a 2-year design in 5 diverse rural and urban AI communities nationally to assess its efficacy in reducing obesity among children ages 2–5 years and their primary caregivers.

While multiple prior studies have demonstrated an increased risk of obesity with short sleep duration, this has not, to the best of our knowledge, previously been explored in AI children. While most prior studies examining this relationship have been performed in school-aged children, a recent meta-analysis including only children 0–4 years did find that 10 of 18 cross-sectional and 10 of 13 longitudinal studies reported a significant association between shorter sleep duration and measures of adiposity.[10] Importantly, sleep duration, obesity risk,

and their interaction may differ depending on culture. For example, a recent study of sleep duration and obesity risk in young children found that sleep duration was inversely associated with obesity in South Asian children, but not White children.[11] The purpose of the present investigation was to examine cross-sectional baseline data from HCSF2 to elucidate the relationship between overnight sleep duration and obesity in a large, community-based sample of AI preschool-aged children. Although we collected a broad range of data relevant to health behavior using nearly 20 surveys, we are including here only that from the specific sleep questionnaires, relevant demographic variables, measures of obesity status, and a screening instrument on overall family environment for health behaviors. Our hypotheses were that overall shorter overnight sleep duration as well as increased variability in weekday to weekend overnight sleep duration would be associated with increased risk of obesity.

Methods

This cross-sectional study was based on the HCSF2 baseline data. HCSF2 was a randomized controlled trial of an obesity prevention intervention that has been described in detail elsewhere.[12]

Participants

Adult and child dyads were recruited by community coordinators via a combination of informational flyers sent home through preschools and child care settings and on-site advertisement (e.g., display table) in five American Indian communities. This was a non-probability sample. Inclusion criteria consisted of a child between the ages of 2 and 5 years, the ability to attend data collection visits over a two-year period, and a working cell phone (due to delivery of some intervention components via text messaging). This paper reports on baseline data analyses related to night time sleep schedule characteristics and prevalence of obesity as below. Baseline data collection was completed in March 2015. Institutional review board (IRB) approvals were obtained from the University of Wisconsin, other collaborating academic institutions, and the participating tribal councils, and where applicable, tribal IRBs.

Measures

Adult, child, and family-level demographics (e.g., age, family income, caregiver educational attainment) were collected from a survey developed by the HCSF2 research team. A sleep questionnaire was developed by the HCSF research team based on the Child Sleep Habits Questionnaire[13] for children and the Pittsburg Sleep Quality Index[14] for adults. The following questions were asked for both children and adults: “on weeknights, what time do you usually go to bed,” “on weekdays, what time do you usually wake up,” “how long does it take you to fall asleep on most nights,” “do you sleep longer on the weekend,” “what time do you usually go to bed on the weekend,” “what time do you usually get up on the weekend,” and “do you usually fall asleep or go to bed with the TV on?”. For children, the term “you” was replaced with “your child”, and the following additional questions were included: “does your child wake up during the night, and if so, how many times,” and “is

there a working TV in your child's bedroom." Instructions referred to "the past 7 days" for adults and "this week" for the child. Reported sleep onset latency was subtracted.

The Family Nutrition and Physical Activity (FNPA) screening tool was used to assess family environmental and behavioral factors that can predispose to obesity in children.[15] This caregiver-report questionnaire provides a global score as well as ten, two-item subscores as follows: family meal patterns, family eating habits, food choices, beverage choices, restriction/reward, screen time behavior and monitoring, health environment, family activity involvement, child activity involvement, and family schedule/sleep routine. Higher scores indicate a less obesogenic environment and habits. It has the advantage of covering areas included in the HCSF intervention and doing so via questions asked and scored in a similar fashion. Also, it has been used in populations with similar characteristics to those in the present study.

Children were measured in light clothing without shoes. Height was measured twice with a Seca stadiometer to the nearest 0.1 cm and averaged. Weight was measured twice with a digital scale to nearest 0.1 kg and averaged. BMI was calculated as (kg)/height(m)^2. Child BMI was converted to z-scores using CDC age- and sex-specific parameters.[16]

Statistical Analysis

Because sleep schedule was assessed during the week and weekend separately, we computed a weighted average for the week as a whole for overnight sleep duration as follows: [(weekday sleep duration × 5) + (weekend sleep duration × 2)] ÷ 7. In addition, we calculated the difference between weekday and weekend sleep duration. Our hypotheses were that overall shorter sleep duration as well as increased variability (difference) in weekday to weekend sleep duration would be associated with increased risk of obesity. Therefore, we built multivariable models to assess for a relationship between sleep duration and BMI z-score while controlling for the following potential covariates: child age, gender, community site, caregiver education level, family income, parent BMI, and FNPA domain scores. Of note, only 9 of the 10 FNPA domains were entered in analysis; the family schedule/sleep routine domain was not included because this domain assesses if a family ensures adequate sleep time for their child and would be redundant with and likely result in problematic collinearity with our overnight sleep duration measure. All analyses were performed in IBM SPSS Statistics (V23, Armonk, NY, USA) and validated with analyses performed in SAS (V9.3, Cary, NC, USA), and a P-value of <0.05 was taken as statistically significant without adjustment multiplicity.

Results

Participant Sample

Of the original 450 children, 398 had complete data for analysis. Largest number of missing data were due to pregnancy (adult BMI, 27 cases) and failure to report income (10 cases). Half (50%) of the sample was female, and the average age was 3.3 (SD=1.0) years. BMI z-scores ranged from −4 to 4 with an average of 0.76 (SD=1.0). The average overnight sleep duration was 10.15 (SD=0.97) hours, and children slept in for 0.13 (SD=1.05) more hours

(about 9 mins) during the weekend compared to the week. Over 58% of families had a total household income of <$20,000 and 38% and 52% of adults had no college or some college, respectively.

Multivariable Linear Regression Models

Regression results are presented in Tables 1 and 2. We first examined overnight sleep duration as a continuous variable. Longer overnight sleep duration was significantly associated with lower BMI z-scores after controlling for covariates (p=0.006). In addition, higher family income, higher caregiver education, lower caregiver BMI, and healthier family eating habits were associated with lower child BMI z-scores.

Clinically, sleep duration is often viewed categorically. Therefore, we next examined overnight sleep duration as a categorical variable binned as follows: </=8 hours, 8.01 to 10 hours, 10.01 to 12 hours, and >12 hours. As a categorical variable, overnight sleep duration remained significantly associated with BMI z-score. Similarly, higher family income, more family education, lower adult BMI, and healthy family eating habits also remained significantly associated with lower child BMI z-scores.

In post-hoc analysis, controlling for covariates, children with >12 hours of overnight sleep had significantly lower BMI z-scores compared to those with </=8 hours (p=0.035) and 8.01 to 10 hours (p=0.018); the difference between 10.01 to 12 hours and >12 hours did not reach statistical significance (p=0.073). Estimated marginal means are presented in Figure 1.

We examined the difference in overnight sleep duration from weekday to weekend. There was no significant association between sleep duration variability and BMI z-score in multivariable models controlling for the same covariates as above (B=0.010, t=0.206, p=0.837). Similarly, in unadjusted analyses, no sleep duration measure was significantly associated with BMI z-score; this likely reflects the larger effect sizes of other factors, such as adult BMI and family eating habits, such that the smaller effect of sleep duration was only seen when those differences were taken into account.

Discussion

To the best of our knowledge, this study represents the first examination of overnight sleep duration and obesity prevalence among American Indian children, who experience disproportionate risk for childhood obesity. Therefore, it is critical to understand sleep as a risk factor for obesity in this vulnerable population. Similar to the majority of published studies in other populations to date, we did find an association between short overnight sleep duration and increasing weight status in our sample. In contrast, weekday to weekend variability in overnight sleep duration was not associated with BMI z-score. Importantly, the observed association between overnight sleep duration and obesity was independent of sociodemographic and self-reported obesity-related family environmental factors such as eating habits, screen time behaviors, and physical activity.

These data support and extend findings from previous studies. The role of sleep patterns in the development of obesity has been the subject of much investigation. Most prior studies

have demonstrated an association between short sleep duration and the presence or development of obesity in children.[6–8, 17–20]. The mechanisms underlying this association are not fully understood, but it is thought that short sleep duration may affect leptin and ghrelin secretion, increase energy consumption, and alter timing of eating, all leading to increased weight.[8] Furthermore, sleep deprivation may actually alter an individual's response to diet therapy such that lack of sleep decreases the efficacy of decreased caloric intake for weight loss.[21] More recently, Hart and colleagues demonstrated with a within-subject counterbalanced design that experimentally decreasing sleep duration increases television watching and decreasing mean activity levels,[22] both of which may contribute to obesity. Our observation of this association is the first to date within American Indian children. Interestingly, childhood obesity is associated with increased risk of obstructive sleep apnea in middle age,[23] and exercise training may improve sleep duration in obese children.[24] Sleep schedule characteristics beyond sleep duration have also been implicated as potentially obesogenic.[8] We did not find any association between weekday to weekend sleep duration variability and BMI z-score. While increased variability, also known as social jetlag, is quite common in adolescents and has been shown to be related to obesity, a study in young low-income children did not demonstrate this association.[20] On average, weekday to weekend variability was quite low with children sleeping only 9 minutes longer on the weekends. Thus, the link between social jet lag and obesity may not be present until later childhood for most individuals. In addition, sleep architecture may also play a role in weight regulation, as a recent study demonstrated significant associations between total rapid eye movement sleep, slow wave sleep, and hunger scores in children.[25]

Reliance on parent report sleep duration is a primary limitation of this study, although consistent with prior studies on the association. It should be noted that almost all prior studies have relied on parent-report, rather than objective actigraphy, to assess sleep schedule characteristics, and this may have important implications. A recent study of Canadian children utilizing actigraphy to objectively characterize sleep demonstrated an association between sleep efficiency, but not sleep duration or timing, and measures of adiposity.[26] Likewise, a study of children from the Penn State Child Cohort utilizing actigraphy found that habitual sleep variability, not sleep duration, was associated with caloric intake and abdominal obesity in adolescents.[27, 28] In addition, sleep disturbances beyond duration are likely important. For example, Jarrin and colleagues found that sleep disturbances, as assessed by the Children's Sleep Habits Questionnaire, were more closely associated with adiposity compared to short sleep duration;[29] the authors speculated that diminished sleep quality and altered sleep architecture may be linked to metabolic and neurophysiological changes that are obesogenic. Importantly, self-reported perceived sleep duration should not be discounted because it may be a factor likely to motivate action and behavior change.

The current study had several strengths. First, our findings are novel in that we examined the sleep duration and obesity association within AI children. Examining this population in particular is of importance because of potentially unique cultural norms around health behaviors, limited access to healthcare and education, food deserts, and overall higher rates of obesity. Second, we examined weekday to weekend variability in sleep schedule in addition to absolute sleep duration. Third, we were able to control for several important

covariates in analyses, including child age, gender, caregiver education, caregiver BMI, and obesity related behaviors including eating habits, physical activity, and screen time. Fourth, while the current data represent a baseline assessment, the HCSF2 is a randomized controlled lifestyle intervention trial, and we anticipate being able to build on these results when follow-up data are available.

Despite its strengths, this study also has several important limitations. First, these data are cross-sectional rather than longitudinal, although we anticipate additional results will be forthcoming as mentioned above. Second, our sleep questionnaire only allowed estimation of nocturnal sleep and did not include information regarding daytime napping, which contributes significantly to total 24-hour sleep duration in this age group of children. That said, prior research in young children has demonstrated the daytime sleep duration is less relevant for obesity prevention.[30] Third, our measures of sleep schedule characteristics were caregiver-report rather than objective; future studies with actigraphy may help to address this potential bias. Fourth, we operationalized weight status with BMI z-score, but alternative metrics may more fully capture the obesity phenotype, such as waist circumference or body fat percentage. Fifth, multiple obesogenic behaviors were operationalized via a single questionnaire, the FNPA. While this is subjective and self-report, it is a measure that is widely used and covers many lifestyle behaviors of interest.

In conclusion, these data demonstrate an inverse association between overnight sleep duration and BMI z-score in preschool-aged children living in American Indian communities independent of important sociodemographic and obesogenic lifestyle behaviors. These findings highlight the fact that pediatric providers caring for AI children should be cognizant of sleep duration as a modifiable risk factor for obesity in this population. Additional follow-up is needed to assess for the potential role of sleep in weight trajectory and response to lifestyle intervention. Future studies utilizing actigraphy-derived sleep schedule and improved measures of obesity are needed.

Acknowledgements

DGI, LAI, RJP, LC all contributed to the study design, data collection, data analysis, data interpretation, literature search, generation of figures, and writing of manuscript. All other authors contributed to all of the above except data analysis and generation of figures. We gratefully acknowledge all the communities and families who participated in the design, development, and implementation of the Healthy Children, Strong Families intervention. Without their continued engagement, this project would not be possible. We also are indebted to the research coordinators at each site who worked so hard to recruit and retain our participants. Work supported by grant R01HL114912.

References

1. Ogden CL, Carroll MD, Kit BK and Flegal KM. Prevalence of Childhood and Adult Obesity in the United States, 2011–2012. JAMA. 2014;311:806–14. [PubMed: 24570244]
2. Ogden CL, Carroll MD, Lawman HG, et al. Trends in Obesity Prevalence among Children and Adolescents in the United States, 1988–1994 through 2013–2014. JAMA. 2016;315:2292–9. [PubMed: 27272581]
3. Cunningham SA, Kramer MR and Narayan KM. Incidence of Childhood Obesity in the United States. N Engl J Med. 2014;370:403–11. [PubMed: 24476431]
4. Watts AW, Loth KA, Peterson C, Boutelle KN and Neumark-Sztainer D. Characteristics of a Favorable Weight Status Change from Adolescence to Young Adulthood. J Adolesc Health. 2016;58:403–409. [PubMed: 26552739]

5. Zephier E, Himes JH, Story M and Zhou X. Increasing Prevalences of Overweight and Obesity in Northern Plains American Indian Children. Arch Pediatr Adolesc Med. 2006;160:34–9. [PubMed: 16389208]
6. Cappuccio F, Taggart F, Kandala N, Currie A, Pelie E, Stranges S and Miller M. Meta-Analysis of Short Sleep Duration and Obesity in Children and Adults. Sleep. 2008;31:619–26. [PubMed: 18517032]
7. Wu Y, Gong Q, Zou Z, Li H and Zhang X. Short Sleep Duration and Obesity among Children: A Systematic Review and Meta-Analysis of Prospective Studies. Obes Res Clin Pract. 2017;11:140–150. [PubMed: 27269366]
8. Miller AL, Lumeng JC and LeBourgeois MK. Sleep Patterns and Obesity in Childhood. Curr Opin Endocrinol Diabetes Obes. 2015;22:41–7. [PubMed: 25517022]
9. Tomayko EJ, Prince RJ, Cronin KA and Adams AK. The Healthy Children, Strong Families Intervention Promotes Improvements in Nutrition, Activity and Body Weight in American Indian Families with Young Children. Public Health Nutr. 2016;19:2850–9. [PubMed: 27211525]
10. Chaput JP, Gray CE, Poitras VJ, et al. Systematic Review of the Relationships between Sleep Duration and Health Indicators in the Early Years (0–4 Years). BMC Public Health. 2017;17:855. [PubMed: 29219078]
11. Collings PJ, Ball HL, Santorelli G, et al. Sleep Duration and Adiposity in Early Childhood: Evidence for Bidirectional Associations from the Born in Bradford Study. Sleep. 2017;40.
12. Tomayko EJ, Prince RJ, Cronin KA, et al. Healthy Children, Strong Families 2: A Randomized Controlled Trial of a Healthy Lifestyle Intervention for American Indian Families Designed Using Community-Based Approaches. Clin Trials. 2017;14:152–161. [PubMed: 28064525]
13. Owens JA, Spirito A and McGuinn M. The Children's Sleep Habits Questionnaire (CSHQ): Psychometric Properties of a Survey Instrument for School-Aged Children. Sleep. 2000;23:1043–51. [PubMed: 11145319]
14. Buysse DJ, Reynolds CF, Monk TH, 3rd, Berman SR and Kupfer DJ. The Pittsburgh Sleep Quality Index: A New Instrument for Psychiatric Practice and Research. Psychiatry Res. 1989;28:193–213. [PubMed: 2748771]
15. Ihmels MA, Welk GJ, Eisenmann JC and Nusser SM. Development and Preliminary Validation of a Family Nutrition and Physical Activity (FNPA) Screening Tool. Int J Behav Nutr Phys Act. 2009;6:14. [PubMed: 19284631]
16. Kuczmarski RJ, Ogden CL and Grummer LM. CDC Growth Charts: United States, Advance Data from Vital and Health Statistics. Health Statistics. 2000;314.
17. Patel SR and Hu FB. Short Sleep Duration and Weight Gain: A Systematic Review. Obesity (Silver Spring). 2008;16:643–53. [PubMed: 18239586]
18. Ruan H, Xun P, Cai W, He K and Tang Q. Habitual Sleep Duration and Risk of Childhood Obesity: Systematic Review and Dose-Response Meta-Analysis of Prospective Cohort Studies. Sci Rep. 2015;5:16160. [PubMed: 26537869]
19. Chen X, Beydoun MA and Wang Y. Is Sleep Duration Associated with Childhood Obesity? A Systematic Review and Meta-Analysis. Obesity (Silver Spring). 2008;16:265–74. [PubMed: 18239632]
20. Miller AL, Kaciroti N, Lebourgeois MK, Chen YP, Sturza J and Lumeng JC. Sleep Timing Moderates the Concurrent Sleep Duration-Body Mass Index Association in Low-Income Preschool-Age Children. Acad Pediatr. 2014;14:207–13. [PubMed: 24602585]
21. Nedeltcheva AV, Kilkus JM, Imperial J, Schoeller DA and Penev PD. Insufficient Sleep Undermines Dietary Efforts to Reduce Adiposity. Ann Intern Med. 2010;153:435–41. [PubMed: 20921542]
22. Hart CN, Hawley N, Davey A, et al. Effect of Experimental Change in Children's Sleep Duration on Television Viewing and Physical Activity. Pediatr Obes. 2017;12:462–467. [PubMed: 27417142]
23. Bazzano LA, Hu T, Bertisch SM, et al. Childhood Obesity Patterns and Relation to Middle-Age Sleep Apnoea Risk: The Bogalusa Heart Study. Pediatr Obes. 2016;11:535–542. [PubMed: 26780975]

24. Mendelson M, Borowik A, Michallet AS, et al. Sleep Quality, Sleep Duration and Physical Activity in Obese Adolescents: Effects of Exercise Training. Pediatr Obes. 2016;11:26–32. [PubMed: 25727885]

25. Arun R, Pina P, Rubin D and Erichsen D. Association between Sleep Stages and Hunger Scores in 36 Children. Pediatr Obes. 2016;11:e9–e11. [PubMed: 26460505]

26. McNeil J, Tremblay MS, Leduc G, et al. Objectively-Measured Sleep and Its Association with Adiposity and Physical Activity in a Sample of Canadian Children. J Sleep Res. 2015;24:131–9. [PubMed: 25266575]

27. He F, Bixler EO, Berg A, et al. Habitual Sleep Variability, Not Sleep Duration, Is Associated with Caloric Intake in Adolescents. Sleep Med. 2015;16:856–61. [PubMed: 26002758]

28. 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;16:1489–94. [PubMed: 26611945]

29. Jarrin DC, McGrath JJ and Drake CL. Beyond Sleep Duration: Distinct Sleep Dimensions Are Associated with Obesity in Children and Adolescents. Int J Obes (Lond). 2013;37:552–8. [PubMed: 23419602]

30. Bolijn R, Gubbels JS, Sleddens EF, Kremers SP and Thijs C. Daytime Sleep Duration and the Development of Childhood Overweight: The Koala Birth Cohort Study. Pediatr Obes. 2016;11:e1–5. [PubMed: 26132159]

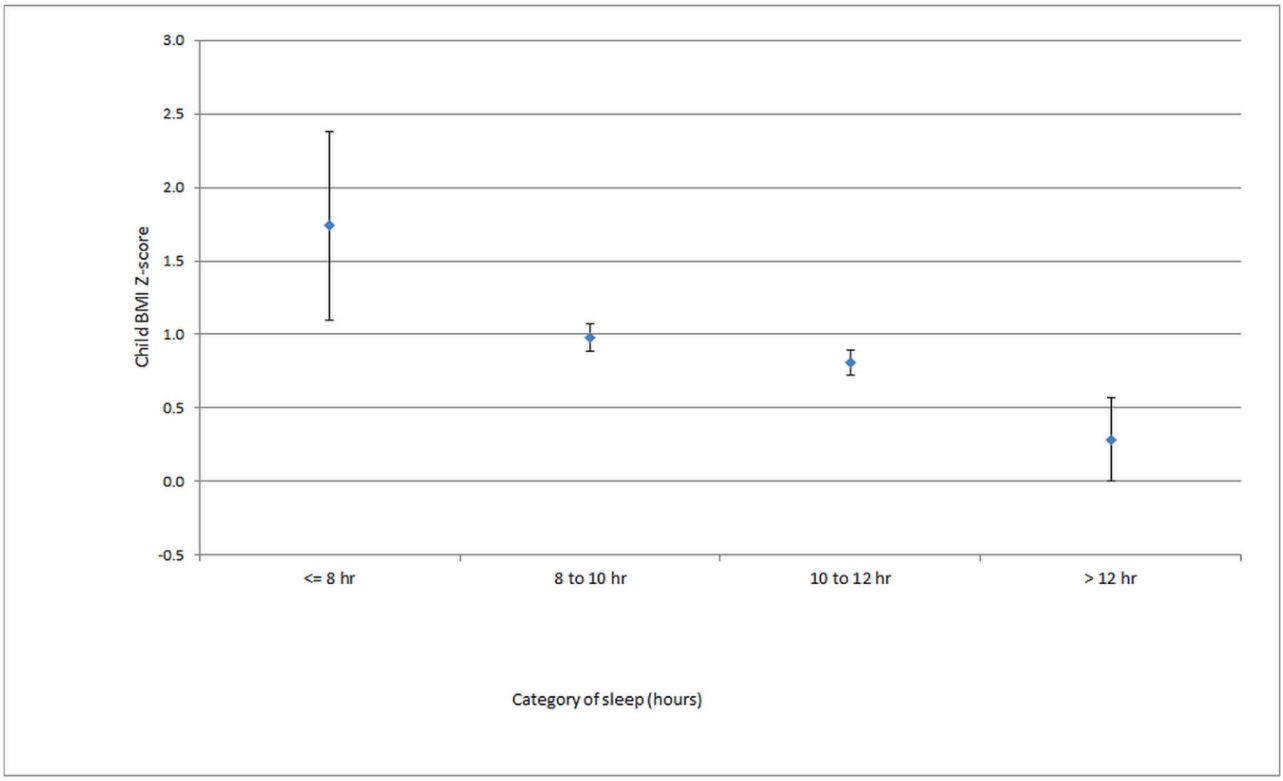

Figure 1.

Relationship between overnight sleep duration and child BMI z-score in a multivariable model. Covariates included in the model are gender, site, age, family income, caregiver education, caregiver BMI, FNPA domain scores (meal patterns, eating habits, food choices, beverage choices, restriction/reward, screen time and monitoring, healthy environment, family activity behavior, and child activity behavior). In total, 398 children were included in the model.

Table 1.

Multivariable linear regression model predicting child BMI z-score with overnight sleep duration as a continuous variable.

Variable	B	SE	t	P-value
Intercept	0.510	0.816	0.625	0.552
Overnight sleep duration	−0.158	0.057	−2.774	0.006*
Age	−0.023	0.052	−0.445	0.743
Gender (Female)	−0.055	0.106	−0.521	0.602
Family income	−0.046	0.023	−1.990	0.046*
Caregiver education	−0.086	0.043	−2.023	0.045*
Caregiver BMI	0.032	0.007	4.689	<0.001*
FNPA- meal patterns	0.010	0.056	0.183	0.865
FNPA- eating habits	0.153	0.060	2.552	0.011*
FNPA- food choices	−0.018	0.059	−0.311	0.765
FNPA- beverage choices	−0.027	0.046	−0.55	0.559
FNPA- restriction/reward	0.068	0.045	1.513	0.130
FNPA- screen time	−0.024	0.035	−0.679	0.498
FNPA- healthy environment	0.005	0.053	0.101	0.923
FNPA- activity involvement	0.054	0.052	1.041	0.298
FNPA- child activity	0.072	0.048	1.479	0.144
Site #1	−0.207	0.222	−0.936	0.350
Site #2	−0.493	0.164	−3.015	0.003
Site #3	−0.222	0.185	−1.200	0.231
Site #4	−0.124	0.270	−0.460	0.645
Site #5	Ref	Ref	Ref	Ref

* $p < 0.05$.

B = unstandardized regression coefficient, SE = standard error of B, FNPA = Family Nutrition & Physical Activity scores. To protect anonymity, site names are not displayed in the table. In total, 398 children were included in the model.

Table 2.

Multivariable linear regression model predicting child BMI z-score with overnight sleep duration as a categorical variable.

Variable	B	SE	t	P-value
Intercept	−1.719	0.711	−2.417	0.015
Overnight sleep duration				
<8 hrs	1.459	0.688	2.120	0.035 *
8.01 to 10 hrs	0.694	0.293	2.372	0.018 *
10.01 to 12 hrs	0.522	0.290	1.798	0.073
>12 hrs	Ref	Ref	Ref	Ref
Age	−0.015	0.052	−0.284	0.868
Gender (Female)	−0.060	0.106	−0.563	0.573
Family income	−0.046	0.023	−1.988	0.046 *
Caregiver education	−0.085	0.043	−1.986	0.048 *
Caregiver BMI	0.031	0.007	4.493	<0.001 *
FNPA- meal patterns	0.011	0.056	0.194	0.858
FNPA- eating habits	0.155	0.060	2.574	0.011 *
FNPA- food choices	−0.014	0.059	−0.229	0.828
FNPA- beverage choices	−0.020	0.047	−0.425	0.672
FNPA- restriction/reward	0.066	0.045	1.458	0.144
FNPA- screen time	−0.026	0.035	−0.755	0.451
FNPA- healthy environment	0.006	0.054	0.103	0.922
FNPA- activity involvement	0.042	0.052	0.803	0.421
FNPA- child activity	0.076	0.049	1.562	0.122
Site #1	−0.199	0.223	−0.892	0.373
Site #2	−0.470	0.164	−2.862	0.004
Site #3	−0.191	0.186	−1.029	0.304
Site #4	−0.072	0.269	−0.238	0.788
Site #5	Ref	Ref	Ref	Ref

* $p < 0.05$.

To protect anonymity, site names are not displayed in the table. In total, 398 children were included in the model.