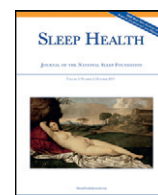




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Associations of short sleep duration with childhood obesity and weight gain: summary of a presentation to the National Academy of Science's Roundtable on Obesity Solutions



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ABSTRACT

This article summarizes a presentation made in February 2017 as part of the National Academy of Sciences' Roundtable on Obesity Solutions webinar, "The Potential Role of Sleep in Obesity Prevention and Management: A Virtual Workshop." Briefly described are the patterns of childhood sleep duration in the United States, the state of the science relating insufficient sleep to overweight and obesity in infancy and early childhood, and the potential mechanisms for the association. Also discussed are intervention efforts to date. Despite research gaps, interventions aimed at increasing sleep quality and quantity may help prevent childhood obesity.

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Introduction

In the United States, approximately 32% of children ages 2–19 years are overweight (age- and sex-specific body mass index [BMI] 85th–94th percentile) or obese (BMI ≥ 95th percentile), with the highest prevalence among racial/ethnic minority children.¹ Obesity in children is associated with both short- and long-term adverse outcomes.^{2–4} The rising prevalence of childhood obesity has been paralleled by secular trends of shorter sleep durations in children. A 2012 meta-analysis by Matricciani et al on nearly 700,000 children, with data from 20 countries over a period of more than 100 years, found that, on average, children today sleep 20–25 minutes less each day than their parents did when they were their age.⁵

In February 2017, the National Academy of Sciences' Roundtable on Obesity Solutions convened the webinar, "The Potential Role of Sleep in Obesity Prevention and Management: A Virtual Workshop." In this article, we briefly describe the patterns of childhood sleep duration in the United States; discuss the state of the science and research gaps relating insufficient sleep to overweight and obesity

in infancy and early childhood, including mechanisms; and summarize interventions to improve sleep for obesity prevention.

Epidemiology of child sleep duration

Worldwide, nightly sleep duration for children has decreased by 0.75 minute per year since 1905.⁵ Child sleep duration recommendations, seldom evidence based and considerably variable, have also decreased over time.⁶ However, the average sleep duration of children has consistently been lower than recommended. The current number of hours per day of sleep recommended by age by the National Sleep Foundation is as follows: newborn (0–3 months), 14–17 hours; infant (4–11 months), 12–15 hours; toddler (1–2 years), 11–14 hours; preschool-age (3–5 years), 10–13 hours; school-age (6–13 years), 9–11 hours; and teenage (14–17 years), 8–10 hours.⁷ In 2004, the National Sleep Foundation commissioned a national survey among approximately 1500 parents and caregivers of children 10 years of age and younger living in the United States.⁸ The average nightly sleep duration reported for school-aged children was 9.4 hours, and for preschoolers, it was 9.6 hours. For toddlers and infants, the average reported duration was 9.8 and 9.0 hours, respectively, much lower than recommendations.⁸

Sleep disparities across race/ethnicity and household income, commonly reported in adults, have also been examined in children. Children from low socioeconomic status households and Black,

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Hispanic, and Asian children sleep less than their high socioeconomic status White counterparts.^{9–11} In addition to disparities in total sleep duration, disparities in sleep curtailment, shorter sleep than the average for a given age, have also been examined.¹² In a study of almost 13,000 children followed longitudinally from 6 months of age to 7 years, Black (β : -1.92 ; 95% confidence interval [CI]: $-2.39, -1.45$), Hispanic (β : -1.58 ; 95% CI: $-2.43, -0.72$), and Asian (β : -1.71 ; 95% CI: $-2.55, -0.86$) children were found to have lower sleep score than White children, with the prevalence of chronic sleep curtailment for the various racial/ethnic groups as follows: Black, 11.6%; Hispanic, 10.3%; Asian, 5.3%; and White, 1.4%.¹² After adjusting for sociodemographic variables, the differences were slightly attenuated for Black and Hispanic children but strengthened for Asian children. Adjustment for environmental and behavioral covariates further attenuated racial/ethnic differences, but they continued to remain significant, suggesting that a combination of factors unique to the experience of being a particular race, or cultural factors, sociodemographic, environmental, and behavioral factors explain child sleep disparities.

Regarding sleep problems, an estimated 25% of all children experience some kind of sleep problem at some point in their childhood, with estimates for the prevalence of sleep problems in preschool-aged children ranging between 25% and 50%.¹³ Twenty percent of parents report that their children are overtired during the day at least a few days per week, with at least 70% reporting the presence of some other negative sleep-related behavior (eg, resistance, complaints, nightmares) at least a few times per week.⁸

Predictors of child sleep duration

Evidence suggests that the decrease in sleep duration across childhood over the last 20 years is due largely in part to later bedtimes over time, whereas wakeup times have remained fixed.^{14,15} Other predictors of child sleep duration have also been investigated. The aforementioned survey commissioned by the National Sleep Foundation found that infants and toddlers in the lowest quartile of sleep duration are more likely to be put to bed asleep as opposed to drowsy or awake.⁸ Putting an infant to bed asleep may impact the infant's ability to self-regulate his or her sleep patterns.^{16,17} These infants also are more likely to wake earlier, have difficulty falling asleep, and wake up during the night.⁸ Presence of parents in the room where the child sleeps is associated with more frequent night wakings compared with children with parents not present in the room while they are sleeping.^{8,18} A 2010 study by Nevarez et al,⁹ which examined correlates of sleep in infants specifically, found that early introduction to solids (<4 months of age) and attending childcare outside of the home were additional predictors of short sleep duration for this population.

Among slightly older children, those in the lowest quartile of sleep duration are more likely to share a room or bed, which is also associated with taking longer to fall asleep and more frequent night wakings.⁸ A well-established predictor of short sleep duration in children, as well as having a later bedtime, is the presence of a television (TV) in the room where the child sleeps.^{8,9,12,19} Our team has investigated the exposures of daily sleep and TV viewing as predictors for probability of overweight at age 3 years. Both sleep and TV viewing are associated with overweight, with the combination of sleeping less than 12 hours per day and watching more than 2 hours of TV per day being particularly risky.²⁰ A bedtime routine containing of TV watching is associated with shorter sleep duration, whereas a bedtime routine containing reading is associated with longer sleep duration.⁸ Recently, studies have also begun looking at the role of small screens, such as smartphones and tablets, on child sleep. A study of more than 2000 fourth and seventh graders found that children who slept near a small screen slept 20.6 minutes

(95%: $-29.7, -11.4$) than those who did not sleep near a small screen.²¹ These children also had a significantly higher prevalence of perceived insufficient sleep. Among adolescents, of which only 1 in 5 reports getting an optimal 9 hours of sleep on school nights, more than half acknowledge that they know they are getting less sleep than they need to feel their best.⁸ Not surprisingly, nearly all adolescents (97%) report having at least one electronic item (TV, computer, phone, or music device) in their bedroom.⁸

Dietary behaviors have been linked to child sleep duration as well. The National Sleep Foundation's Sleep in America Poll found that children who drink one of more caffeinated beverages during the day experience shorter sleep duration and later bedtimes than those who do not consume caffeinated beverages.⁸ This is consistent with findings from another large study which found that children who report sleeping less than 10 hours per day have more frequent soda consumption (β : 0.11; 95% CI: 0.03, 0.20).²² These children also consumed vegetables less frequently.

Additional child-centered factors that may impact sleep include temperament, behavioral style, and cognitive functioning.^{9,13} Related family-centered factors include parenting style, relationship status, physical and mental health, maternal age, and level of education.^{9,12,13,18,19} Parents' own sleep, and family size are also correlated with child sleep duration.^{9,11,13,19} Additionally, a number of environmental factors are relevant, both specific to the sleeping environment as well as, more broadly, the environment in which a child spends time.^{13,18,23}

Child sleep duration and obesity

A wealth of studies has investigated the relationship between child sleep duration and obesity including a number of reviews.^{24–29} In 2008, Chen et al²⁵ conducted a systematic review and meta-analysis on the association between sleep duration and childhood obesity. The pooled odds ratio (OR) for the 11 included studies indicated a significant inverse association between child sleep duration and obesity (OR: 1.58; 95% CI: 1.26, 1.98).²⁵ Another meta-analysis by Cappuccio et al,²⁶ published that same year, also revealed a significant association but acknowledged difficulty in establishing temporality due to the lack of longitudinal studies. In yet another systematic review a few years later by Hart et al,²⁷ results from 29 studies, conducted in 16 countries, showed again that short sleep duration was associated with an increased risk for being or becoming overweight or obese. The study also found that later bedtimes were an independent risk factor for overweight and obesity.

In recent years, the field has seen an increase in studies with rigorous study designs, including assessments of sleep duration and BMI at multiple time points, and the measurement and adjustment for a number of covariates. One such study, conducted by our research team, found that chronic insufficient sleep in midchildhood (7–10 years of age) was associated with a higher BMI z score even after controlling for maternal age, education, BMI, and parity; household income; child race/ethnicity; and midchildhood TV.³⁰ There have since been 2 meta-analyses published on longitudinal studies examining causality between sleep duration and child weight status.^{28,29} The first, by Fatima et al,²⁸ which included 11 longitudinal studies comprising about 25,000 children, found that children with short sleep duration had twice the risk of overweight or obesity as those sleeping for long duration (OR: 2.15; 95% CI: 1.64, 2.81). The second, conducted by Ruan et al,²⁹ consisting of 25 studies and over 50,000 children, found similar but slightly less robust results (OR: 1.76; 95% CI: 1.39, 2.23). Each 1-hour increase in sleep duration decreased the risk of overweight or obesity by 21% (OR: 0.79; 95% CI: 0.70, 0.89).²⁹

There remains, however, some debate about the relationship of sleep and obesity in infancy.³¹ Whereas some studies have reported

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