



Sleep Duration and Obesity among Adolescents Transitioning to Adulthood: Do Results Differ by Sex?

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Objectives To examine the association between short sleep duration and obesity among adolescents (mean age 16 years) transitioning into young adulthood (mean age 21 years) in the National Longitudinal Study of Adolescent Health (N = 10 076).

Study design Self-reported sleep duration was categorized as <6, 6-8, or >8 hours. Obesity status, using measured height and weight, was defined as body mass index $\geq$ 95th percentile in adolescence and body mass index $\geq$ 30 kg/m² in young adulthood.

Results Cross-sectionally, short sleep duration was associated with obesity in adolescent males (prevalence ratio 1.8 [95% CI, 1.3-2.4]) but not in females (prevalence ratio 1.0 [95% CI, 0.7-1.4]). In longitudinal analyses, short sleep duration in adolescence was associated with incident obesity in both males and females (risk ratio 1.2 [95% CI, 1.0-1.6]) in young adulthood. No interactions by sex were noted.

Conclusions Analyzing the association of sleep duration and obesity longitudinally resolved sex discrepancies observed in earlier cross-sectional analyses. Optimizing sleep duration during adolescence may be an effective intervention to prevent excess weight gain in young adults. (*J Pediatr* 2014;165:750-4).

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The high prevalence of obesity among children and adolescents in the US is likely to be multifactorial,¹ including social, environmental, and behavioral risk factors. Short sleep duration, a modifiable health behavior, has been hypothesized to affect weight gain through disruption of several hormones, including leptin, insulin, cortisol, ghrelin, and growth hormones.²⁻⁵ Furthermore, daytime sleepiness and fatigue as a result of short sleep duration can alter eating behaviors and physical activity, potentially leading to weight gain.⁶⁻⁸

An association between short sleep duration and obesity among school age children and preadolescents has been reported.⁹⁻¹² In a 2008 meta-analysis children <10 years of age with short sleep duration had a 58% greater odds of overweight or obesity compared with children with longer sleep duration.⁹ Findings among adolescents are not as clear.¹³ Most studies among adolescents have relied on cross-sectional data and have noted significant positive associations between short sleep duration and obesity.¹⁴⁻¹⁶ However, within the National Longitudinal Study of Adolescent Health (Add Health), no significant associations between short sleep duration in adolescence and obesity risk after a 1-year follow-up was noted.^{17,18} Although the length of follow-up time was short, these contradictory findings raise the possibility that the effects previously noted in cross-sectional studies are attributed to the effects of obesity on sleep duration and not of sleep duration on obesity, as previously thought. Because many health behaviors are established in adolescence, it is plausible that sleep duration during the adolescent years is closely related to sleep duration in adulthood, which has been associated with various adult health outcomes, including obesity.^{19,20}

Another potential source of discrepancies among results from previous studies of adolescents is differences in sex. Differential effects for males and females could lead to an average null effect. Only a few studies have investigated sex differences. A few studies have noted an effect of short sleep duration on childhood obesity only among males^{18,21,22}; however, the authors of one cross-sectional US study noted a positive association between short sleep duration and being overweight among female high school students.²³ Sleep duration also has been negatively associated with body mass index (BMI) among Hispanic, white, and Asian adolescent boys and positively associated with black adolescent girls after a 1-year follow-up.²⁴ The discrepancy in study findings could be attributable to the cross-sectional nature of these studies or short follow-up period.

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Add Health	National Longitudinal Study of Adolescent Health
BMI	Body mass index
TV	Television

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We explored both the cross-sectional association between adolescent short sleep duration and obesity and the longitudinal associations between adolescent short sleep duration and incident obesity during the transition to young adulthood. Given the potential for differential effects of short sleep duration, we examined whether the associations differ by sex.

Methods

The Add Health study is a nationally representative school-based, longitudinal study of the health-related behaviors of adolescents and their outcomes in young adulthood. An in-school questionnaire was administered to a nationally representative sample of students in grades 7 through 12, plus selected oversampled minority groups, stratified by age and sex, during the 1994-1995 school year in 132 schools. The study design has been described in detail elsewhere.²⁵ To summarize, 80 high schools representative of US schools were selected with respect to region of country, urbanicity, size, type, and ethnicity. Eligible schools included an 11th grade and enrolled more than 30 students. The first wave of in-home interviews was conducted among adolescents 12-18 years of age between 1994 and 1995 (wave 1). Wave 2 (1996; mean age 16 years) follow-up was conducted 1 year after wave 1 and included 13 570 adolescents who would still be enrolled in high school during 1996, including dropouts, who were part of the nationally representative sample. Wave 3 (2001; mean age 20 years) included 10 393 of those wave 2 respondents (76.5%).

In these analyses, our sample consists of participants with either height and weight measurements or self-reported measures at waves 2 and 3 and complete information on covariates of interest ($N = 10\,076$). The Add Health study was approved by the institutional review board of the University of North Carolina, Chapel Hill. Informed consent by participants was provided in written form. The current analyses were approved by the institutional review board of Columbia University, New York.

During wave 2, 1 year after the baseline examination, home visits were conducted to assess the adolescent's height and weight. Height and weight were measured by trained study staff at the participant's home. BMI was calculated from measured height and weight (kg/m^2) or self-reported height and weight for participants missing measured height and weight at wave 2 ($N = 103$) or wave 3 ($N = 324$). The Center for Disease Control and Prevention 2000 BMI growth references²⁶ were used to determine age- and sex-specific BMI percentiles. Obesity during adolescence was defined as BMI ≥ 95 th percentile at the wave 2 assessment. During wave 3, height and weight were again measured during home visits by trained study staff. Obesity in adulthood was defined as BMI $\geq 30 \text{ kg}/\text{m}^2$.

At wave 2, adolescents were asked: "How many hours of sleep do you usually get?" The current sleep recommendations for adolescents range between 8 and 9 hours of sleep per night depending on the entity issuing the

recommendations.²⁷ Sleep duration in adolescence was categorized as, less than 6 hours, between 6 and 8 hours, and more than 8 hours of sleep.

Questionnaires ascertained information on sociodemographic factors, including age, sex, race/ethnicity, parental highest education level achieved (wave 2), hours spent watching television (TV), and self-reported leisure-time physical activity. Age was categorized as 11-13, 14-15, 16, or 17 years of age or older. Race/ethnicity was categorized as white non-Hispanic, African American, Hispanic, or other race/ethnic group. Parental education was based on the highest education level attained by either the mother or the father and was classified as: less than high school, high school graduate or vocational school, some college, college graduate, or graduate education. Hours per week spent watching TV were characterized as more or less than 2 hours of TV watching per day. Physical activity was defined as 5 or more bouts of moderate-to-vigorous physical activity per week, based on self-report at wave 2.

Data Analyses

Binomial regression analyses were conducted to estimate the association between adolescent sleep duration at wave 2 and adolescent obesity at wave 2, with adjustment for socio-demographic factors (age, education, race/ethnicity). A second model examined the longitudinal association between adolescent short sleep duration (wave 2) and young adult incident obesity (wave 3), with adjustment for socio-demographic factors. Sex-by-sleep duration interactions were tested in both models. Additional analysis further adjusted for TV watching and physical activity. All analyses were weighted to account for the complex sampling design and clustering of the data and conducted in SAS version 9.0 (SAS Institute, Cary, North Carolina).

Results

In the final sample of 10 076 participants, 53% were female, 14% were African American, and 11% Hispanic (**Table 1**). The mean age of participants at adolescence was 16 years, and the mean age in the adult follow-up was 21 years. In adolescence, 14% of participants were obese. In young adulthood, the prevalence of obesity increased to 21%. Sex differences were noted for health behaviors, sleep duration, and obesity (**Table 1**). Men were more likely to be physically active, more likely to be obese in adolescence, were more likely to sleep less than 6 hours a night in adulthood, and were more likely to report watching more than 2 hours of TV in adolescence, compared with women (all $P < .05$).

In cross-sectional analyses adjusted for demographic factors, sleeping less than 6 and between 6 and 8 hours per night during adolescence was associated with adolescent obesity among males compared with those sleeping more than 8 hours per night: (prevalence ratio 1.8 [95% CI, 1.3-2.4] and prevalence ratio 1.3 [95% CI, 1.0-1.7], respectively) but not among females (sex interaction

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