Do sleep-deprived adolescents make less healthy food choices?

Allison K. Kruger, MPH Candidate, Stony Brook University
Eric N. Reither, PhD, Utah State University
Paul E. Peppard, PhD, University of Wisconsin-Madison
Patrick M. Krueger, PhD, University of Colorado, Denver
Lauren Hale, PhD, Stony Brook University*

*Corresponding author can be reached at Lauren Hale, Associate Professor of Preventive Medicine, HSC Level 3, Room 071, Graduate Program in Public Health, Stony Brook, NY 11794-8338, 631-444-1007, 631-444-3480 (fax), Lauren.Hale@stonybrook.edu

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ABSTRACT

Background: Short sleep duration among children and adolescents has been associated with higher body mass index and other adverse health outcomes. Food choices are one proposed mechanism through which this association may occur.

Objective: We examined whether self-reported habitual sleep duration is associated with vegetable and fruit consumption and fast food consumption.

Design: Using cross-sectional data from the National Longitudinal Study of Adolescent Health (n=13,284), we estimated three nested logistic regression models for two outcome variables: daily vegetable and fruit consumption and prior week's fast food consumption. Adjusted models included demographic and social/behavioral covariates.

Results: Self-reported habitual short sleep duration (<7 hours/night) was associated with reduced odds of vegetable and fruit consumption compared to recommended sleep duration (>8 hours/night) (OR=0.66, $p<0.001$), even after adjusting for demographic and social/behavioral factors (OR=0.75, $p<0.001$). Short sleep duration was also associated with increased odds of prior week's fast food consumption, as compared to those sleeping >8 hours/night (OR=1.40, $p<0.001$), even after adjusting for demographic and social/behavioral factors (OR=1.20, $p<0.05$).

Conclusions: Food choices are significantly associated with sleep duration and may play an important role in mediating the association between sleep and health among adolescents.

INTRODUCTION

Short sleep duration and poor sleep quality are associated with a wide range of negative health outcomes, including obesity, Type II diabetes, heart disease, and some cancers.(1-10) However, the mechanisms by which these associations occur are not well understood. One potential mechanism through which sleep duration may be associated with these negative health outcomes is through dietary choices. Previous literature has found significant associations between sleep duration and leptin and ghrelin, two hormonal appetite regulators.(11-13) Changes in appetite due to changes in these hormones may therefore affect both quantity and quality of food.(14, 15) In addition, sleep duration may have an impact on decision-making over food.(16) Finally, adolescents who are sleeping less may have different lifestyles – e.g., more sedentary activities – that are associated with less healthy food choices.(17, 18)

Few studies have specifically examined the association between sleep duration and dietary choices(19-24) with most using highly specified sample populations such as young children,(19, 22) motor freight workers,(20) middle-aged non-obese Japanese men, (21) and Iranian young women.(23) One study of 10- and 11-year-old children found that shorter sleep duration was associated with consumption of more energy-rich foods and fewer nutrient-dense foods, with boys showing a stronger association than girls.(19) Another study found that adequate sleep was associated with healthier food choices among male motor freight workers.(20) Additionally, a national study of American adults found that short and long sleep were associated with lower food diversity as compared to individuals who slept 7-8 hours/night.(24) Furthermore, a recent study of European adolescents found that the proportion of adolescents eating adequate amounts of fruits and vegetables was significantly lower in short sleepers as compared to those who slept eight or more hours per night.(25) A 2010 study of 240

adolescents found that sleeping less than eight hours per night was associated with consuming a higher percentage of calories from fat (as compared to adolescents sleeping eight or more hours per night) but did not examine specific food choices.(26) Finally, a 2012 study of Iranian female youths found that short sleep was associated with lower diet quality as compared to longer sleep, despite similar diet energy density. To date, no U.S.-based nationally representative studies have explored whether dietary choices vary by habitual sleep duration during adolescence.

Adolescence is a critical period of developmental transition between childhood and adulthood and represents a "critical period for normal growth and development in which sleep…plays an important role."(27) Previous literature suggests that there is a positive association between both sleep and dietary habits in adolescence and in adulthood.(28, 29)

This study examined associations between sleep duration and both healthy and unhealthy food choices in a large nationally representative sample of American teenagers. We hypothesized that short sleep duration is associated with lesser consumption of healthy foods and greater consumption of unhealthy foods.

METHODS

Data

Data analyzed in this study come from the National Longitudinal Study of Adolescent Health (Add Health), which has conducted in-home interviews on a nationally-representative sample of American teenagers and young adults over the period 1994-2008. We used in-home interview data from Wave II, which were collected in 1996 from 14,738 adolescent participants (88.6% response rate). More details on study design are available online.(30) Wave II data were analyzed, as Wave II is the only wave in which all participants are adolescents. Wave I includes

younger participants (under 12 years old), while Waves III and IV examine the cohort in young adulthood and adulthood, respectively. Furthermore, Wave II is the only wave that asked adolescents questions about specific dietary choices, allowing us to collect information about fruit and vegetable consumption. This analysis used the restricted-use dataset, resulting in 13,284 adolescents with non-missing data.

Measures

Outcome variables – food choices

The main outcomes analyzed include vegetable and fruit consumption and fast food consumption. The vegetable and fruit consumption variable was defined as whether or not the adolescent reported eating at least one vegetable and one fruit in the previous day. The interviewer prompted the adolescent participant with the following: "Think about everything you had to eat and drink yesterday. This includes snacks as well as your regular meals." The interviewer then asked a series of questions about specific food consumption in the previous day, such as "Yesterday, did you eat cantaloupes, melons, mangoes, or papayas?" and "Yesterday, did you eat string beans, green beans, peas, or snow peas?" Participants responded with a dichotomous yes/no or had the option to select "Don't know."

The fast food consumption variable was created from information about how often the adolescent ate fast food, classified as a dichotomous variable: eating fast food 0-1 times in the past seven days or eating fast food 2+ times in the last seven days. More than 50% of adolescents reported eating fast food two or more times in the last seven days with only 15.9% of the sample reporting not eating fast food in the past week. We tested several different specifications of the fast food cutoff and the results did not significantly change. We chose to present the 2+ times

results because of the extremely high prevalence of adolescents reporting eating fast food one or more times per week.

Main explanatory variable – self-reported habitual sleep duration

The sleep duration variable was created from adolescents' self-reports of how many hours of sleep they usually get. Responses were organized into three categories in accordance with previous literature and recommendations from the American Academy of Pediatrics: short sleep duration (<7 hours/night), midrange sleep duration (7-8 hours/night), and recommended sleep duration (>8 hours/night).(31, 32)

Covariates

Demographic covariates included sex, age (continuous), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, and all other races), and pubertal status (=1 if adolescent has reached puberty; =0 otherwise).

Social and behavioral covariates included family socioeconomic status, perception of neighborhood safety, physical activity level, screen time, number of siblings, and presence of two biological parents in the home. Family socioeconomic status variable was proxied by adolescent report of mother's level of education with three categories: less than high school education, high school diploma/GED, and some college or more education. We used conditional mean imputation to predict mother's level of education for adolescents with missing values because 1,502 participants (>10% of the sample) had missing observations for this variable. Each imputed value was randomly drawn from the distribution of likely values, conditional on the observed covariates, so that that imputed values would better reflect the variability in the observed data.(33)

The perception of neighborhood safety variable was created using adolescent self-report of feeling unsafe in his/her neighborhood (=1 if the adolescent reported feeling unsafe; =0 otherwise). Physical activity level was measured by how often the adolescent reported playing an active sport or exercising in the past week. While the Centers for Disease Control recommend that adolescents participate in one hour of physical activity every day,(34) only 33.1% of the adolescents reported playing an active sport or exercising five or more times in the last seven days. Thus, the variable was divided into three categories: 0-1 times per week, 2-4 times per week, and 5+ times per week.

Screen time was assessed as self-reported hours spent watching television and videos and playing video and computer games in the past week, divided into three categories: 0-14 hours per week, 15-28 hours per week, and 29+ hours per week. The low screen time category of ≤14 hours/week was based on the Academy of Pediatrics' guidelines for recommended screen time.(35) Number of siblings in the home, a continuous variable, was determined from adolescent self-report about family members in the household. The biological parent variable was also determined from adolescent self-report about family members in the home (=1 if the adolescents reported two biological parents at home; =0 otherwise).

Statistical analysis

All statistical tests were conducted using Stata version 12.1 (Stata Corporation, College Station, Texas). We examined the prevalence of both healthy and unhealthy food choices among the short, midrange, and recommended sleepers. We adjusted for complex, multi-stage sample design in all analyses using sample weights with **svy** commands. ANOVA and Pearson's chi-squared tests were conducted to test for differences in food choices and covariates across food choice categories. Logistic regression analysis was used to examine associations between food

choices and sleep duration. For both food choice outcome variables, we estimated three nested models. Model 1 examined the association between the food choice and sleep duration. Model 2 added in adjustment for demographic covariates (i.e., age, sex, race/ethnicity, pubertal status) and Model 3 additionally adjusted for social and behavioral covariates (i.e., mother's education, neighborhood, physical activity, screen time, siblings in the home, presence of biological parents in the home). We tested for an interaction between sleep duration and sex, but the interaction term failed to reach statistical significance. Therefore, we did not stratify our analyses by sex. We conducted sensitivity analyses by categorizing sleep duration and our food consumption variables in multiple different specifications (e.g., as a continuous variable and at various categorical cutpoints).

RESULTS

Characteristics of the sample

The mean age of adolescents in this sample was 16 years old and half of the sample was male (49.9%) (Table 1). Non-Hispanic white adolescents made up 67.4% of the sample, with 15.2% non-Hispanic black adolescents, 12.2% Hispanic adolescents, and the remaining 5.2% other races. A large percentage of the adolescents reported having reached puberty (73.6%).

More than 80% of the adolescents reported that their mother had received at least a high school diploma/GED with 16.4% reporting that their mother had less education. Few adolescents reported feeling unsafe in their neighborhood (10.2%). The majority of adolescents reported engaging in physical activity at least twice per week, with 17.3% reporting 0-1 times per week, 49.6% reporting 2-4 times per week, and 33.1% reporting engaging in physical activity five or more times per week. Almost one-half of the sample (48.2%) reported viewing a non-excessive

level of screen time, with 27.4% viewing 15-28 hours/week, and 24.4% reporting viewing 29+ hours/week. The mean number of siblings in the home was 1.35 and 52.9% of the adolescents reported having two biological parents living with them at home.

More than one-half of the adolescents (55.9%) reported eating at least one vegetable and one fruit in the previous day and the majority of adolescents (57.7%) also reported consuming fast food two or more times in the previous seven days.

Bivariate analyses showed that age, physical activity, screen time, number of siblings in the home, and sleep duration significantly varied by both fruit and vegetable consumption and fast food consumption (Table 1). Adolescents reporting unhealthy food choices (i.e., not consuming at least one fruit and one vegetable in the previous day, consuming fast food two or more times in the previous week) were significantly older and had significantly fewer siblings in the home. Adolescents reporting high levels of physical activity had significantly greater fruit and vegetable consumption and significantly less fast food consumption. Greater screen time was associated with significantly less fruit and vegetable consumption and significantly greater fast food consumption. Finally, short sleepers reported significantly lower vegetable and fruit consumption and significantly greater fast food consumption.

Sex significantly varied by fast food consumption, with males reporting higher fast food consumption. Race/ethnicity, mother's education, and the presence of two biological parents in the home varied significantly by fruit and vegetable consumption. Black adolescents reported lesser fruit and vegetable consumption, while Hispanic adolescents and adolescents in the other race/ethnicity category reported significantly higher fruit and vegetable consumption. Adolescents reporting mother's education level of high school diploma/GED reported significantly greater fruit and vegetable consumption, while adolescents reporting mother's

education of some college or more education reported significantly lower fruit and vegetable consumption. Finally, adolescents reporting having two biological parents in the home had significantly greater fruit and vegetable consumption.

Our sensitivity analyses yielded similar results to the presented analyses.

Association between sleep duration and food choices

Adolescents reporting short sleep (<7 hours/night) were less likely than adolescents reporting the recommended amount of sleep (>8 hours/night) to consume at least one vegetable and one fruit in the previous day (Model 1, OR=0.66, 95% CI: 0.57, 0.76) (Table 2). This association was significant after adjustment for demographic covariates (Model 2, OR=0.74, 95% CI: 0.64, 0.86) as well as in the fully adjusted model, which also adds social/behavioral covariates (Model 3, OR=0.75, 95% CI: 0.64, 0.88). Short sleepers also reported significantly greater fast food consumption than recommended sleepers (Model 1, OR=1.40, 95% CI: 1.18, 1.66) (Table 3). This association was persisted after adjusting for demographic covariates (Model 2, OR=1.20, 95% CI: 1.01, 1.43) and in the fully adjusted model (Model 3, OR=1.20, 95% CI: 1.01, 1.43).

Engaging in physical activity was associated with vegetable and fruit consumption, with adolescents reporting physical activity five or more times per week showing significantly greater vegetable and fruit consumption than peers who exercised less (Table 2, OR=2.80, 95% CI: 2.39, 3.28). Physical activity was not significantly associated with the fast food consumption variable (Table 3).

Screen time showed a significant association with both food choice outcomes. For example, adolescents reporting high screen time activity (29+ hours/week) were 23% less likely than adolescents reporting low screen time (0-14 hours/week) to consume fruits and vegetables

on the previous day in the fully adjusted model (Table 2, OR=0.77, 95% CI: 0.66, 0.89). Adolescents reporting medium (15-28 hours/week) and high screen time activity also reported significantly higher odds of consuming fast food two or more times in the past week as compared to adolescents who reported low screen time activity (Table 3; medium: OR=1.17, 95% CI: 1.03, 1.33; high: OR=1.34, 95% CI: 1.18, 1.52).

Other covariates that showed statistically significant associations with vegetable and fruit consumption in the fully-adjusted model included age, sex, Hispanic ethnicity, other race, mother's education, and the presence of two biological parents in the home (Table 2). Similarly, age, sex, mother's education, and number of siblings in the home showed statistically significant associations with the fast food consumption outcome in the fully-adjusted model (Table 3).

DISCUSSION

This investigation found that short sleep duration (<7 hours per night) was associated with 25% decreased odds of adequate vegetable and fruit consumption and 20% increased odds of fast food consumption. These associations were robust to the inclusion of several important covariates. This suggests that sleep duration is independently associated with both healthy and unhealthy food choices per se, and may also support the hypothesis that food choices may contribute to the association between sleep duration and obesity for American adolescents.

Interestingly, while the recommended sleep duration for adolescents is >8 hours/night, the analyses show that midrange sleepers (7-8 hours/night) do not have significantly decreased odds of consuming vegetables and fruit or increased odds of consuming fast food compared to the recommended duration. This suggests that the association of short sleep duration on dietary choices might occur only below a set threshold of habitual short sleep duration.

This study used a large, nationally representative sample with a wide range of covariates to address the association between sleep duration and dietary choices in an adolescent sample. While prior studies have established significant associations between sleep duration and dietary choices, they were conducted in small, non-representative samples.(19-22) Additionally, this study examines both unhealthy and healthy food consumption variables, building on previous literature which focused only on unhealthy dietary variables.

While self-reported sleep duration has been shown to be moderately associated with actigraphically-assessed sleep duration on school nights data,(36) a more accurate measure of sleep, such as actigraphy, was not available at the time this study was conducted, but should be considered for future population- based data collection efforts. In addition, the Add Health in-home interview questions regarding food consumption, while detailed, lack specific information about quantity and timing. Quantity of food consumed is especially important, since it would allow us to control for total caloric intake, which has been hypothesized in previous literature to mediate the association between sleep duration and obesity.(37, 38)

This study demonstrates that sleep may be related to both healthy and unhealthy food choices of adolescents, with short sleepers (<7 hours of sleep/night) being more vulnerable than adolescents with 7 or more hours of sleep/night. Future research should seek to investigate the causal pathways of the observed associations. If evidence supports that chronic sleep deficiency is causally linked to poorer food choices, then programs that improve sleep and sleep hygiene might be an important and underappreciated component of health promotion and obesity-prevention interventions.

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LH conceived of the project. AKK and LH conducted the data analysis, interpreted the data, and drafted the manuscript. ENR, PMK, and PEP assisted with data interpretation, multiple imputation, sensitivity testing of data analyses, and manuscript revisions. None of the authors have any conflicts of interests.

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Table 1. Descriptive statistics of the sample by dietary choices (n = 13,284)[+]

	Fruit & Vegetable Consumption[a]			Fast Food Consumption[a]			
	Yes (n=7,420)	No (n=5,864)	*p-value*	No (n=5,620)	Yes (n=7,664)	*p-value*	Total
Sleep Duration							
Short sleep (<7 hrs)	15.1%	21.6%	<0.0001***	15.8%	19.5%	0.0001***	18.0%
Midrange sleep (7-8 hrs)	62.7%	57.4%	<0.0001***	60.9%	60.0%	0.4941	60.3%
Recommended (9+ hrs)	22.2%	21.0%	0.2402	23.3%	20.5%	0.0230*	21.7%
Mean Age	15.8	16.1	<0.0001***	15.7	16.1	<0.0001***	16.0
Sex							
Male	49.6%	50.3%	0.6234	47.3%	51.8%	0.0003***	49.9%
Race/Ethnicity							
White	67.5%	67.3%	0.9007	67.4%	67.4%	0.9883	67.4%
Black	13.0%	17.8%	<0.0001***	14.7%	15.5%	0.4840	15.2%
Hispanic	13.4%	10.7%	0.0034**	12.3%	12.1%	0.8591	12.2%
Other	6.1%	4.1%	0.0011**	5.6%	5.0%	0.3470	5.2%
Pubertal status							
Undergone puberty	73.6%	73.5%	0.9681	73.7%	73.5%	0.8735	73.6%
Mother's education							
Less than high school	16.1%	16.7%	0.5622	16.9%	16.0%	0.2696	16.4%
High school diploma/GED	38.6%	43.7%	0.0001***	41.3%	40.5%	0.5046	40.8%
Some college or more	45.3%	40.0%	0.0001***	42.0%	43.5%	0.1960	42.8%
Perception of neighborhood safety							
Feel unsafe	9.5%	11.1%	0.0549	10.4%	10.0%	0.5346	10.2%
Physical activity							
Low (0-1 times/wk)	12.5%	23.4%	<0.0001***	16.1%	18.1%	0.0336*	17.3%
Medium (2-4 times/wk)	48.1%	51.5%	0.0056**	48.5%	50.4%	0.0739	49.6%
High (5+ times/wk)	39.4%	25.1%	<0.0001***	35.4%	31.4%	0.0007***	33.1%
Screen time							
Low (0-14 hrs/wk)	50.0%	46.0%	0.0034**	50.5%	46.4%	0.0048**	48.2%
Medium (15-28 hrs/wk)	27.9%	26.8%	0.3222	27.1%	27.7%	0.6394	27.4%
High (29+ hrs/wk)	22.2%	27.2%	0.0001***	22.3%	25.9%	0.0011**	24.4%
Mean Number of Siblings	1.38	1.31	0.017*	1.40	1.31	0.004**	1.35
Biological Parents							
Two in the home	56.5%	48.3%	<0.0001***	54.0%	52.1%	0.1770	52.9%

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

[a] **Note**: Fruit and Vegetable Consumption: Yes = Consumed at least one fruit & vegetable in previous day and No = Did not consume at least one fruit & vegetable in previous day; Fast Food Consumption: Yes = Consumed fast food two or more times in the previous week and No= Consumed fast food 0-1 times in the previous week

[+] **Note:** Missing Data: Participants were excluded if they had missing data on any of the following variables: sleep duration (total missing=47), age (none missing), sex (none missing), race/ethnicity (total missing=42), pubertal status (total missing=149), unsafe neighborhood (total missing=41), physical activity (total missing=3), screen time (total missing=75), biological parents (total missing=3), fruit & vegetable consumption (total missing=3), fast food consumption (none missing). Due to high missing data for the mother's education variable, we imputed these values. Another 1,168 participants were excluded from the analyses due to missing Grand Sample Weight variables. Inclusion of these Grand Sample Weights is necessary to ensure a nationally-representative sample.

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Table 2. Odds ratios (95% CI) of vegetable and fruit consumption (n = 13,284)

	Odds Ratio (95% CI)		
	Model 1	**Model 2[a]**	**Model 3[b]**
Sleep duration			
<7 hrs/night	0.66 (0.57, 0.76)***	0.74 (0.64, 0.86)***	0.75 (0.64, 0.88)***
7-8 hrs/night	1.03 (0.91, 1.17)	1.08 (0.95, 1.24)	1.07 (0.93, 1.23)
>8 hrs/night	REF	REF	REF
Age		0.91 (0.88, 0.94)***	0.96 (0.93, 0.99)*
Sex			
Male		0.98 (0.87, 1.10)	0.87 (0.78, 0.96)**
Female		REF	REF
Race/ethnicity			
White		REF	REF
Black		0.77 (0.68, 0.86)***	0.89 (0.79, 1.01)
Hispanic		1.29 (1.07, 1.55)**	1.43 (1.19, 1.72)***
Other race		1.54 (1.20, 1.98)***	1.60 (1.25, 2.05)***
Undergone puberty (=1)		1.02 (0.91, 1.16)	1.00 (0.88, 1.13)
Mother's education			
Less than high school			0.88 (0.75, 1.03)
High school diploma/GED			0.85 (0.75, 0.95)**
Some college or more			REF
Perception of unsafe neighborhood (=1)			0.90 (0.76, 1.07)
Physical activity			
Low (0-1 times/wk)			REF
Medium (2-4 times/wk)			1.70 (1.49, 1.94)***
High (5+ times/wk)			2.80 (2.39, 3.28)***
Screen time			
Low (0-14 hrs/wk)			REF
Medium (15-28 hrs/wk)			0.91 (0.81, 1.02)
High (29+ hrs/wk)			0.77 (0.66, 0.89)***
Number of Siblings			1.01 (0.97, 1.05)
Two Biological Parents			1.23 (1.13, 1.35)***

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

[a]Model 2 adjusts for demographic covariates (i.e, age, sex, race/ethnicity, pubertal status)

[b]Model 3 additionally adjusts for social/behavioral covariates (i.e., mother's education, neighborhood, physical activity, screen time, siblings, biological parents)

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Table 3. Odds ratios (95% CI) of fast food consumption (n = 13,284)

	Odds Ratio (95% CI)		
	Model 1	**Model 2[a]**	**Model 3[b]**
Sleep duration			
<7 hrs/night	1.40 (1.18, 1.66)***	1.20 (1.01, 1.43)*	1.20 (1.01, 1.43)*
7-8 hrs/night	1.12 (0.97, 1.29)	1.05 (0.91, 1.21)	1.05 (0.91, 1.21)
>8 hrs/night	REF	REF	REF
Age		1.16 (1.11, 1.20)***	1.16 (1.12, 1.21)***
Sex			
Male		1.20 (1.07, 1.34)**	1.17 (1.05, 1.30)**
Female		REF	REF
Race/ethnicity			
White		REF	REF
Black		1.01 (0.85, 1.20)	0.97 (0.82, 1.16)
Hispanic		0.96 (0.82, 1.12)	1.02 (0.86, 1.21)
Other race		0.84 (0.64, 1.11)	0.85 (0.65, 1.12)
Undergone puberty (=1)		1.03 (0.91, 1.17)	1.02 (0.90, 1.15)
Mother's education			
Less than high school			0.84 (0.72, 0.97)*
High school diploma/GED			0.91 (0.81, 1.02)
Some college or more			REF
Perception of nsafe neighborhood (=1)			0.97 (0.84, 1.11)
Physical activity			
Low (0-1 times/wk)			REF
Medium (2-4 times/wk)			1.01 (0.89, 1.16)
High (5+ times/wk)			0.91 (0.78, 1.06)
Screen time			
Low (0-14 hrs/wk)			REF
Medium (15-28 hrs/wk)			1.17 (1.03, 1.33)*
High (29+ hrs/wk)			1.34 (1.18, 1.52)***
Number of Siblings			0.95 (0.91, 1.00)*
Two Biological Parents			0.99 (0.88, 1.11)

* $p<0.05$, ** $p<0.01$, *** $p<0.001$

[a]Model 2 adjusts for demographic covariates (i.e, age, sex, race/ethnicity, pubertal status)

[b]Model 3 additionally adjusts for social/behavioral covariates (i.e., mother's education, neighborhood, physical activity, screen time, siblings, biological parents)

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