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Insufficient sleep among elementary and middle school students is linked with elevated soda consumption and other unhealthy dietary behaviors

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Abstract

Objective—This study examines the extent to which insufficient sleep is associated with diet quality in students taking part in the Massachusetts Childhood Obesity Research Demonstration Project.

Methods—Data were collected in Fall 2012 for all 4th and 7th grade children enrolled in public schools in two Massachusetts communities. During annual BMI screening, students completed a survey that assessed diet, physical activity, screen time, and sleep. Of the 2456 enrolled students, 1870 (76%) had complete survey data. Generalized estimating equations were used to examine associations between sleep duration and dietary outcomes (vegetables, fruit, 100% juice, juice drinks, soda, sugar-sweetened beverages and water), accounting for clustering by school. Models were adjusted for community, grade, race/ethnicity, gender, television in the bedroom, screen time, and physical activity.

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Results—In adjusted models, students who reported sleeping <10 hours/day consumed soda more frequently (β=0.11, 95% CI:0.03, 0.20) and vegetables less frequently (β=−0.09, 95% CI: −0.18, −0.01) compared with students who reported ≥10 hours/day. No significant associations were observed between sleep duration and fruit, 100% juice, juice drinks or water.

Conclusions—In this population, insufficient sleep duration was associated with more frequent soda and less frequent vegetable consumption. Longitudinal research is needed to further examine these relationships.

Introduction

The prevalence of childhood obesity remains high in the United States, with approximately one in five children classified as obese and one in three classified as overweight or obese (Ogden et al. 2014). In considering reasons for this high prevalence, there is accumulating evidence that insufficient sleep is a risk factor for obesity (Hu 2008; Taveras, Gillman, et al. 2014b; Hart et al. 2011; Patel & Hu 2008). The National Sleep Foundation recommends 10 to 11 hours of sleep for children ages 5 to 12 (National Sleep Foundation n.d.). However, according to the 2014 Sleep in America poll, 31% of children aged 6–11 years sleep less than 9 hours per night (National Sleep Foundation n.d.). There are a variety of potential mechanisms whereby insufficient sleep may increase risk of obesity, including increased hunger, opportunity to eat, altered thermoregulation, and fatigue (Hu 2008), as well as reduced executive function and inhibition (Burt et al. 2014; Sadeh et al. 2002). More specifically, metabolic effects of sleep deprivation include abnormalities in appetite regulatory hormones that may lead to increased appetite, including lower leptin (an appetite suppressant) and higher ghrelin (an appetite stimulant) (Hu 2008). Given the apparent relationship between sleep deprivation and obesity, there is a growing interest in targeting sleep as a component of obesity interventions (Taveras et al. 2012).

In addition, there is a substantial body of evidence that demonstrates the association between diet quality and obesity (Hu 2008). For example, it has been well established that sugar-sweetened beverages (SSBs) are associated with weight gain (Malik et al. 2013; de Ruyter et al. 2012; Ebbeling et al. 2012), and it has been shown that long term weight gain is inversely associated with consumption of foods such as fruits, vegetables and whole grains (Mozaffarian et al. 2011).

Given that sleep and diet quality are both associated with elevated obesity risk, a developing body of literature is considering the association between these risk factors (Chaput 2013; Kjeldsen et al. 2014; Bel et al. 2013; Stern et al. 2014). Previous cross-sectional (Kjeldsen et al. 2014; Westerlund et al. 2009) and prospective (Tatone-Tokuda et al. 2011) work has shown an association between short sleep duration and increased intake of added sugar and SSBs (Kjeldsen et al. 2014; Tatone-Tokuda et al. 2011), as well as increased energy density (Westerlund et al. 2009; Kjeldsen et al. 2014), and decreased intake of fruits and vegetables (Tatone-Tokuda et al. 2011). As noted above, the pathway between insufficient sleep and obesity may be in part due to increased hunger and increased opportunity to eat. It is also possible that the association between sleep and diet is confounded by television viewing and television in the bedroom. Higher levels of television viewing have been associated with

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increased intake of food and beverages heavily advertised on television (Falbe et al. 2014; Wiecha et al. 2006; Pearson et al. 2011), as well as lower levels of fruit and vegetable intake (Falbe et al. 2014; Boynton-Jarrett et al. 2003; Pearson et al. 2011), while television viewing and television in the bedroom may also predict suboptimal sleep (Cain and Gradisar 2010; Falbe et al. 2015). Further understanding these associations will help to inform the development of future interventions. This study examines the extent to which insufficient sleep is associated with adverse diet in elementary and middle school students taking part in a multi-sector, community-based obesity prevention intervention (Davison et al. 2014; Taveras, Blaine, et al. 2014a).

Methods

Participants and Setting

Data were drawn during the Fall semester of the 2012–13 school year from baseline surveys of 4th and 7th graders in public schools located in two communities participating in the Massachusetts Childhood Obesity Research Demonstration Study (MA-CORD) (Davison et al. 2014; Taveras, Blaine, et al. 2014a). MA-CORD is a multi-sector community intervention to address childhood obesity, particularly among low-income children.

Children in this sample originated from two MA-CORD communities that are predominantly non-Hispanic white (68%) with sizeable Hispanic populations (17% and 22%). Per capita incomes in MA-CORD communities were substantially lower (approximately $22,900 and $21,300) than in the state overall (approximately $35,500) in 2012 (United States Census Bureau n.d.). A total of 2456 student across 29 schools were invited to complete the baseline survey. All data collection procedures were approved by the Internal Review Board at the Massachusetts Department of Public Health.

Measures

Students completed a self-reported survey during the annual BMI screening mandated in all public schools in Massachusetts. Trained school nurses and/or teachers read survey items aloud to 4th graders; 7th grade students completed the survey independently.

Diet indicators examined the frequency of consumption on the previous day of: vegetables (cooked or uncooked, not including French fries, fried potatoes, or potato chips), fruit (fresh, frozen, canned or dried), 100% juice, juice drinks (punch, Kool-Aid®, sports drinks, or other fruit-flavored drinks), soda (regular, non-diet), and water (plain water, sparkling or any other water drink that has 0 calories). These variables were assessed with the following question and response options: Yesterday, did you eat any ____? No, I did not eat any ____ yesterday; Yes, I ate ____ 1 time yesterday; Yes, I ate ____ 2 times yesterday; Yes, I ate ____ 3 or more times yesterday. Outcomes were modeled as continuous frequency of consumption. The highest response category, 3 or more times, was conservatively coded as 3 times per day. Composite measures for SSBs (the sum of juice drinks and regular soda) and caloric beverages (juice drinks, regular soda and 100% juice) were also examined. Dietary recall questions were obtained from the School Physical Activity and Nutrition

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Project (SPAN) survey, for which there is evidence for moderate validity in students as young as 4th grade (Thiagarajah et al. 2008).

The exposure of interest was optimal weekday sleep duration (National Sleep Foundation n.d.), modeled dichotomously: ≥10 hours/weekday (optimal) vs. <10 hours/weekday (insufficient). Usual weekday sleep duration was estimated by taking the difference between self-reported bedtime and wake time for a usual weekday in the past week, assessed with the following questions: “On a usual weekday this past week, when did you go to bed at night?” and “When did you wake up the next morning?” Self-reported questionnaire items assessing sleep duration among youth have generally been moderately to strongly correlated with sleep duration calculated from actigraphy measures and sleep diaries (Matricciani et al. 2012).

Covariates included self-reported gender, grade, race/ethnicity, physical activity, screen time and presence of a television in the bedroom. Students described their race/ethnicity by selecting one or more of the following: white, black or African American, Hispanic or Latino, Asian, Native Hawaiian or other Pacific Islander, American Indian or Alaska Native, or other. Race/ethnicity was categorized into Hispanic, non-Hispanic White, non-Hispanic Black, non-Hispanic other, non-Hispanic multiracial. Due to small numbers, American Indian or Alaska Natives, Asian, and Hawaiian or Pacific Islander who were not Hispanic were collapsed into the non-Hispanic other category. A measure of physical activity was obtained from the SPAN survey (Thiagarajah et al. 2008), in which physical activity was assessed by asking students on which days in the last week they took part in physical activity that made their heart beat fast or made them breathe hard for at least 30 minutes. Responses were summed to 0–7 days and modeled as a continuous variable. Presence of a television in the bedroom was determined with the following yes/no response question, “Is there a television in the room where you sleep?” To determine screen time, children were asked separately about how much time they spent with television/DVDs and video/computer games on a usual weekday and weekend in the past week (data on smartphones and/or tablets were not collected). Moderate validity has been reported for similar surveys of self-reported screen time among youth (Gortmaker et al. 1999; Schmitz et al. 2004).

Although BMI is associated with diet quality, it was not included as a covariate because it is likely a down-stream consequence of diet and therefore does not meet the structural definition of a confounder. Furthermore, evidence is mixed regarding the association between BMI and sleep duration for children and adolescents (Guidolin & Gradisar 2012).

Analytic Sample

Eligible subjects had complete data on sleep, dietary outcomes, gender, age, school, presence of a television in the bedroom, screen time, and physical activity. After excluding students with missing data on exposures, outcomes and covariates, our analytic sample consisted of 1870 children.

Statistical analyses

We used linear regression to examine the associations of sleep duration with dietary indicators (vegetables, fruit, 100% juice, juice drinks, soda, and water). Generalized

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estimating equations were used for estimation, specifying an exchangeable covariance structure to account for clustering by school (Hanley 2003; Liang & Zeger 1986).

Model 1 was unadjusted. Model 2, a partially adjusted model, adjusted for community, gender, grade, and race/ethnicity. Model 3, the fully adjusted model, additionally adjusted for physical activity, presence of a television in the bedroom, and screen time. To test for potential heterogeneity of associations by grade and gender, grade- and gender-stratified models were examined, and cross-products of these terms with optimal sleep duration were assessed in fully adjusted models. Analyses were conducted using SAS (version 9.3; SAS Institute, Cary, NC, USA).

Results

Characteristics of students in the sample are described in Table 1. The students had a mean age (SD) of 10.6 (1.5) years, while Hispanic (41%) and non-Hispanic White (39%) were the predominant racial/ethnic groups. Approximately 48% were overweight or obese. A higher proportion of 7th graders reported insufficient sleep (less than 10 hours per 24 hours) in comparison to 4th graders (80% and 49% respectively). Furthermore, 75% of students reported the presence of a television in the bedroom. Overall, students reported an average of 5.06 ± 4.31 hours of screen time per day.

Results from models examining the association between optimal sleep duration and dietary outcomes are presented in Table 2. In the unadjusted model, children reporting insufficient sleep duration (<10 hours of sleep per 24 hours) consumed vegetables less frequently (β= −0.11, 95% CI: −0.20, −0.03), regular soda more frequently (β=0.16, 95% CI:0.08, 0.24), and SSBs more frequently (β=0.22, 95% CI:0.09, 0.35) than children reporting optimal sleep duration.

Similar associations between sleep duration and students' vegetable and soda consumption were identified in the partially adjusted and fully adjusted models but were slightly attenuated (vegetables: β=−0.09, 95% CI: −0.18, −0.01; soda: β=0.11, 95% CI:0.03, 0.20). The association between sleep duration and students' SSB consumption was attenuated more substantially, and was no longer significant, following adjustment for covariates (β=0.13, 95% CI: −0.03, 0.29). Similarly, our analysis of the composite measure for caloric beverages showed that the effect estimate was attenuated and non-significant across all models (results not shown). Sleep duration was not significantly associated with consumption of fruit, 100% juice, juice drinks, or water. Stratified results by grade and gender are presented in Table 3a and 3b; tests for heterogeneity did not detect significant differences in results by grade or gender (all p-values >0.05).

Discussion

The objective of this study was to examine the extent to which insufficient sleep was associated with indicators of diet quality in students taking part in the MA-CORD Project. After controlling for covariates, we found that students who reported sleeping <10 hours/day consumed soda more frequently (β=0.11, 95% CI:0.03, 0.20) and vegetables less frequently (β=−0.09, 95% CI: −0.18, −0.01) compared with students who reported optimal sleep. This

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study adds to the developing body of literature regarding the relationship between sleep and diet. Results from the current study substantiate previous findings that sleep duration is associated with diet quality (Kjeldsen et al. 2014; Tatone-Tokuda et al. 2011; Westerlund et al. 2009), in particular noting the association of both lower vegetable and higher soda consumption with insufficient sleep in this population. Relatively few studies to date have examined this association in a population of children (Kjeldsen et al. 2014; Tatone-Tokuda et al. 2011; Westerlund et al. 2009), and no known studies to date have been conducted in a low-income, diverse sample in the United States.

An important aspect of the current study was the consideration of soda and juice drinks separately as well as together (as SSBs). We found that intake of soda, but not juice drinks, was significantly associated with sleep duration in this population of children. Because many sodas contain caffeine, which may interfere with sleep onset, these results raise the question of whether inadequate sleep promotes soda consumption or vice-versa. The association could also be bidirectional, whereby children intentionally drink soda to stay up later, then feel tired following insufficient sleep and drink soda to reduce fatigue. The direction of the association could not be assessed given the cross-sectional nature of the data. Future longitudinal studies will be needed to further consider causality.

Screen time was included in the fully adjusted model as a covariate. It has been shown that increased screen time is associated with increased consumption of SSBs and decreased consumption of fruits and vegetables (Falbe et al. 2014; Boynton-Jarrett et al. 2003; Wiecha et al. 2006; Pearson et al. 2011). Screen time may be either a confounder or a mediator of the sleep-diet relationship. For instance, if children stay up later as a result of watching television and consume more soda (the second most advertised food/beverage item on television) (Federal Trade Commission 2012) as a result of exposure to food advertising (Harris et al. 2009; Anschutz et al. 2009; Halford et al. 2007), screen time would act as a confounder. If, instead, children who have difficulty falling asleep use screen time as a sleep aid (Eggermont & Van den Bulck 2006), it may act as a mediator, in which case our fully adjusted estimates would be attenuated. While the role of screen time in the sleep-diet relationship warrants further consideration, the fact that the observed associations persisted following adjustment for screen time suggests that other mechanisms are at play as well.

Other potential mechanisms for the sleep-diet relationship include the possibility that lack of sleep leads to more eating in general, and it may be that the types of foods and beverages available to youth late at night are more likely to be convenience items, in contrast to vegetables, which typically require more preparation and are eaten with meals. Extra calories consumed while staying up late may be displacing appetite during meals the next day, reducing vegetable intake. Lack of parental supervision could also be associated with youth's dietary intake later at night. Lack of supervision may be associated with age, whereby older children have less supervision. While there were no significant differences by grade, it is worth noting that there is a possibility of greater measurement error in younger grades, which would lead to attenuated associations.

Given that some schools had a higher proportion of completed surveys than others, we examined the relationship between survey completeness and demographics using linear

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regression. We found a weak relationship between % non-white students in each school and % survey completeness, indicating that schools with a higher proportion of non-white students were slightly less likely to complete surveys than schools with lower proportions of non-white students. Future studies might examine this relationship further.

The primary limitation of this study is its cross-sectional design. Another limitation is that measures were self-reported, introducing random error and the possibility of bias due to social desirability. We did not collect comprehensive dietary intake data, so we were unable to examine other dietary outcomes, such as total calories and consumption of fast food, snacks, and other convenience foods like microwaveable items. Moreover, we did not collect data on socioeconomic status, parental education or parenting style, which are also potential confounders of the association between sleep and diet. This study has several strengths, including the large and racially/ethnically diverse sample, the fact that we were able to consider variability by grade and gender, and our consideration of soda and juice drinks separately as well as together

In light of the growing body of evidence regarding the association between sleep and diet quality, as well as the independent associations of each with obesity, there is a clear need for further research in this area. There is also a need for further consideration of the mechanisms at play, particularly given the caffeine content of many sodas. More detailed data collection regarding consumption, including time of day for caffeine consumption, could be informative with regards to teasing out the potential direction of causality between SSBs and sleep. In the meantime, there is little risk to including sleep recommendations as a component of obesity prevention interventions, and possibly much to gain. Future interventions should consider sleep as a component, potentially via prompts in the medical setting and/or targeted education for parents and children via community- and school-based programs.

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Highlights

- We examined the association between sleep and diet in 4th and 7th grade students
- Students who reported sleeping <10 hours/day consumed soda more frequently
- Students who reported sleeping <10 hours/day consumed vegetables less frequently
- No significant associations were found for fruit, 100% juice, juice drinks or water

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Table 1

Sample characteristics, Massachusetts Childhood Obesity Research Demonstration Project (Fall 2012).

	All (N=1870)	Grade 4 (N=1104)	Grade 7 (N=766)	Boys (N=916)	Girls (N=954)
Child characteristics, mean±SD or %					
Female	51.0	51.7	50.0	0	100.0
Age, years	10.6 ± 1.5	9.4 ± 0.6	12.3 ± 0.6	10.7 ± 1.6	10.5 ± 1.5
Race/Ethnicity					
Hispanic	40.8	39.2	43.0	40.1	41.4
White, non-Hispanic	38.6	38.4	38.8	39.9	37.3
Black, non-Hispanic	9.7	10.8	8.2	9.9	9.5
Other, non-Hispanic[a]	4.0	4.6	3.1	4.4	3.7
Multiracial, non-Hispanic[b]	7.0	7.0	6.9	5.8	8.1
Overweight (BMI ≥85th–<95th percentile[c])	19.5	19.5	19.4	18.4	20.4
Obese (BMI ≥95th percentile[c])	28.5	27.7	29.6	30.2	26.9
Days in past week participated in ≥30 minutes of physical activity	3.16 ± 2.20	3.35 ± 2.22	2.90 ± 2.14	3.27 ± 2.28	3.06 ±2.11
Screen time (hours/day)	5.06 ± 4.31	4.64 ± 4.07	5.66 ± 4.57	5.50 ± 4.29	4.63 ± 4.28
Television in the bedroom	75.2	74.8	75.9	78.4	72.2
Sleep duration per 24 hours on a weekday in the past week					
≥10 hours (optimal)	38.5	51.5	19.6	34.7	42.0
Diet indicators, mean±SD (frequency consumed on previous day)					
Vegetables	0.92 ± 0.92	0.93 ± 0.95	0.90 ± 0.88	0.85 ± 0.92	0.99 ± 0.92
Fruit	1.18 ± 0.98	1.20 ± 0.99	1.14 ± 0.97	1.14 ± 0.99	1.21 ± 0.98
100% juice	0.99 ± 0.97	1.01 ± 0.97	0.95 ± 0.98	0.96 ± 1.00	1.01 ± 0.95
Juice drinks	0.86 ± 0.96	0.85 ± 0.96	0.86 ± 0.97	0.91 ± 0.99	0.80 ± 0.93
Soda	0.59 ± 0.84	0.56 ± 0.82	0.64 ± 0.87	0.63 ± 0.87	0.56 ± 0.81
Water	1.67 ± 1.08	1.69 ± 1.07	1.64 ± 1.10	1.61 ± 1.10	1.72 ± 1.06
SSBs[d]	1.45 ± 1.37	1.42 ± 1.37	1.50 ± 1.37	1.54 ± 1.42	1.36 ± 1.32

[a] Includes American Indian or Alaska Natives, Asian, Hawaiian or Pacific Islander.

[b] Includes youth who indicated more than one race but did not identify as Hispanic/Latino.

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[c]Determined by 2000 CDC growth charts.

[d]SSBs: Sugar-sweetened beverages, composite measure included juice drinks (punch, Kool-Aid®, sports drinks, or other fruit-flavored drinks, not including 100% juice), and regular soda (regular, non-diet).

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Table 2

Association between insufficient sleep duration (less than 10 hours per 24 hours) in the past week and dietary outcomes (# of occasions consumed on previous day); N =1870, Massachusetts Childhood Obesity Research Demonstration Project (Fall 2012).

	Model 1 (unadjusted) β (95% CI)	Model 2 (partially adjusted)[a] β (95% CI)	Model 3 (fully adjusted)[b] β (95% CI)
Vegetables	−0.11** (−0.20, −0.03)	−0.10* (−0.19, −0.01)	−0.09* (−0.18, −0.01)
Fruit	−0.07 (−0.16, 0.03)	−0.05 (−0.13, 0.04)	−0.06 (−0.13, 0.02)
100% juice	−0.06 (−0.15, 0.03)	−0.05 (−0.14, 0.03)	−0.07 (−0.15, 0.01)
Juice drinks	0.06 (−0.03, 0.15)	0.05 (−0.04, 0.14)	0.01 (−0.09, 0.11)
Regular soda	0.16*** (0.08, 0.24)	0.16*** (0.07, 0.24)	0.11** (0.03, 0.20)
SSBs[c]	0.22*** (0.09, 0.35)	0.21** (0.05, 0.37)	0.13 (−0.03, 0.29)
Water	−0.01 (−0.11, 0.09)	0.02 (−0.08, 0.11)	0.01 (−0.08, 0.11)

[a] Adjusted for grade, gender, race/ethnicity (Hispanic, non-Hispanic white, non-Hispanic black, non-Hispanic other, non-Hispanic multiracial), and city.

[b] Additionally adjusted for days in past week participated in ≥30 minutes of physical activity, screen time and presence of TV in the bedroom.

[c] SSBs: Sugar-sweetened beverages, composite measure included juice drinks (punch, Kool-Aid®, sports drinks, or other fruit-flavored drinks, not including 100% juice), and regular soda (regular, non-diet).

*** P<0.001,

** P<0.01,

* P<0.05

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Table 3

a. Association between insufficient sleep duration (less than 10 hours per 24 hours) in the past week and dietary outcomes (# of occasions consumed on previous day) – Stratified by grade. Massachusetts Childhood Obesity Research Demonstration Project (Fall 2012).

	Model 1 (unadjusted) β (95% CI)	Model 2 (partially adjusted)[a] β (95% CI)	Model 3 (fully adjusted)[b] β (95% CI)
Grade 4 (n = 1104)			
Vegetables	−0.11* (−0.23, 0.00)	−0.09 (−0.18, 0.01)	−0.08 (−0.18, 0.02)
Fruit	−0.07 (−0.19, 0.05)	−0.06 (−0.16, 0.05)	−0.06 (−0.17, 0.04)
100% juice	−0.04 (−0.15, 0.08)	−0.04 (−0.16, 0.07)	−0.06 (−0.18, 0.06)
Juice drinks	0.06 (−0.06, 0.17)	0.04 (−0.08, 0.17)	−0.01 (−0.13, 0.11)
Regular soda	0.15** (0.06, 0.25)	0.16** (0.05, 0.28)	0.10 (−0.02, 0.22)
SSBs[c]	0.21* (0.05, 0.37)	0.21 (−0.01, 0.42)	0.10 (−0.12, 0.31)
Water	−0.02 (−0.14, 0.11)	−0.01 (−0.13, 0.11)	0.01 (−0.12, 0.13)
Grade 7 (n = 766)			
Vegetables	−0.11 (−0.27, 0.04)	−0.10 (−0.29, 0.08)	−0.11 (−0.28, 0.05)
Fruit	−0.01 (−0.18, 0.16)	−0.01 (−0.19, 0.17)	−0.08 (−0.19, 0.03)
100% juice	−0.07 (−0.24, 0.10)	−0.09* (−0.17, −0.02)	−0.12** (−0.19, −0.04)
Juice drinks	0.08 (−0.10, 0.25)	0.08 (−0.06, 0.23)	0.05 (−0.11, 0.22)
Regular soda	0.15 (0.00, 0.30)	0.14** (0.05, 0.22)	0.13** (0.04, 0.21)
SSBs[c]	0.23 (−0.02, 0.47)	0.21* (0.04, 0.38)	0.14 (−0.05, 0.34)
Water	0.07 (−0.13, 0.26)	0.08 (−0.08, 0.23)	0.06 (−0.06, 0.19)

b. Association between insufficient sleep duration (less than 10 hours per 24 hours) in the past week and dietary outcomes (# of occasions consumed on previous day) – Stratified by gender. Massachusetts Childhood Obesity Research Demonstration Project (Fall 2012).

	Model 1 (unadjusted) β (95% CI)	Model 2 (partially adjusted)[a] β (95% CI)	Model 3 (fully adjusted)[b] β (95% CI)
Boys (n = 916)			
Vegetables	−0.05 (−0.18, 0.07)	−0.09 (−0.22, 0.05)	−0.08 (−0.20, 0.05)
Fruit	0.02 (−0.11, 0.16)	0.01 (−0.09, 0.11)	0.01 (−0.08, 0.10)
100% juice	−0.03 (−0.17, 0.10)	−0.04 (−0.15, 0.07)	−0.04 (−0.16, 0.08)
Juice drinks	0.00 (−0.13, 0.14)	0.03 (−0.12, 0.18)	−0.02 (−0.16, 0.13)
Regular soda	0.19** (0.07, 0.31)	0.19** (0.07, 0.31)	0.15* (0.01, 0.29)
SSBs[c]	0.19* (0.00, 0.39)	0.22 (0.00, 0.43)	0.13 (−0.09, 0.36)
Water	0.05 (−0.10, 0.20)	0.04 (−0.09, 0.17)	0.04 (−0.11, 0.18)
Girls (n = 954)			
Vegetables	−0.15* (−0.27, −0.03)	−0.10 (−0.24, 0.05)	−0.10 (−0.24, 0.04)
Fruit	−0.14* (−0.26, −0.01)	−0.11 (−0.26, 0.03)	−0.13 (−0.26, 0.01)
100% juice	−0.08 (−0.21, 0.04)	−0.06 (−0.17, 0.05)	−0.09 (−0.19, 0.02)

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b. Association between insufficient sleep duration (less than 10 hours per 24 hours) in the past week and dietary outcomes (# of occasions consumed on previous day) – Stratified by gender. Massachusetts Childhood Obesity Research Demonstration Project (Fall 2012).

	Model 1 (unadjusted) β (95% CI)	Model 2 (partially adjusted)[a] β (95% CI)	Model 3 (fully adjusted)[b] β (95% CI)
Juice drinks	0.09 (−0.03, 0.21)	0.07 (−0.05, 0.19)	0.02 (−0.09, 0.14)
Regular soda	0.13* (0.02, 0.23)	0.12* (0.01, 0.24)	0.08 (−0.02, 0.19)
SSBs[c]	0.22* (0.05, 0.39)	0.20 (−0.01, 0.40)	0.11 (−0.08, 0.29)
Water	−0.04 (−0.18, 0.09)	0.01 (−0.11, 0.14)	0.01 (−0.11, 0.12)

[a] Adjusted for grade, gender, race/ethnicity (Hispanic, non-Hispanic white, non-Hispanic black, non-Hispanic other, non-Hispanic multiracial), and city.

[b] Additionally adjusted for days in past week participated in ≥30 minutes of physical activity, screen time and presence of TV in the bedroom.

[c] SSBs: Sugar-sweetened beverages, composite measure included juice drinks (punch, Kool-Aid®, sports drinks, or other fruit-flavored drinks, not including 100% juice), and regular soda (regular, non-diet).

*** P<0.001,

** P<0.01,

* P<0.05

[a] Adjusted for grade, gender, race/ethnicity (Hispanic, non-Hispanic white, non-Hispanic black, non-Hispanic other, non-Hispanic multiracial), and city.

[b] Additionally adjusted for days in past week participated in ≥30 minutes of physical activity, screen time and presence of TV in the bedroom.

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** P<0.01,

* P<0.05