Nutrition; Weight Control

New Pathways From Short Sleep to Obesity? Associations Between Short Sleep and "Secondary" Eating and Drinking Behavior

Gabriel S. Tajeu, DrPH, MPH; Bisakha Sen, PhD

Abstract

Purpose. *The association between short sleep and obesity risk is well established. However, we explore a new pathway between short sleep and obesity: whether short sleep is linked to more time spent in secondary eating or drinking, that is, eating or drinking (beverages other than water, such as sugar-sweetened beverages) while primarily engaged in another activity, such as television watching.*

Design. *This pooled cross-sectional study uses data from the American Time Use Survey (ATUS) from 2006 to 2008.*

Setting. *The study takes place in the United States.*

Subjects. *Subjects are 28,150 adults (55.8% female) aged 21 to 65 who were surveyed in the ATUS.*

Measures. *Outcomes are time spent on (1) secondary eating and drinking and (2) primary eating and drinking. Our main predictor variable is sleep duration.*

Analysis. *Controlling for demographic and socioeconomic characteristics of the respondents, we estimate multivariate regression-analysis models for the full sample, as well as by weekday/weekend status, race, and gender subgroups.*

Results. *In multivariate models, compared to respondents reporting normal sleep, short sleep was associated with additional 8.7 (SE = 2.1) minutes per day of secondary eating ($p < .01$) and additional 28.6 (SE = 4.2) and 31.28 (SE = 5.0) minutes per day of secondary drinking on weekdays and weekends, respectively ($p < .01$).*

Conclusions. *We find that short sleep is associated with more time spent in secondary eating and, in particular, secondary drinking. This potentially suggests a pathway from short sleep to increased caloric intake in the form of beverages and distracted eating and thus potential increased obesity risk, although more research is needed.*

Key Words: Public Health, Beverages, Sleep, Obesity, Distracted Eating, Prevention Research. Manuscript format: research; Research purpose: modeling/relationship testing; Study design: nonexperimental; Outcome measure: behavioral; Setting: state/national; Health focus: nutrition, weight control; Strategy: education, skill building/behavior change, policy; Target population age: adults; Target population circumstances: race/ethnicity

INTRODUCTION

The prevalence of obesity in the United States has increased steadily over the past decades,[1–3] and obesity is considered a leading cause of preventable death in this country. Obesity in the United States is often attributed to such causes as calorically dense diet, sedentary lifestyle, and inadequate physical activity.[4–6] In addition to these factors, inadequate sleep is now receiving increased attention in the recent obesity literature as another potential contributing factor to the obesity epidemic.[5,7–9]

As obesity rates have increased in the United States, so too have rates of chronic sleep deprivation.[9–14] Researchers have identified short-sleep duration, commonly defined as sleeping less than 7 hours a night,[5,10,15,16] as a predictor for obesity, and there is currently a growing literature exploring this association.[5,9,10] In a systematic review of articles investigating the association between short sleep and obesity, Patel et al.[9] reported that 74% (N = 17) of the 23 cross-sectional articles and all three longitudinal studies they reviewed found an association between short sleep and weight

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gain in adults. As well, a meta-analysis of studies on the association between short sleep and obesity found an increase in the odds of obesity for short-sleepers (odds ratio = 1.55, $p < .01$).[10] While causal pathways between inadequate sleep and obesity are yet to be well established, new research is looking at short sleep and its relationship to various obesogenic behaviors such as lack of exercise,[14] sedentary activities such as television watching,[17–19] and increased caloric intake[17,19,20] to better understand what the pathways may be. This article adds to the literature by exploring the relationship between short sleep and secondary eating and drinking behaviors among adults that could potentially lead to increased caloric intake.

Observational studies have found an association between short sleep and increased caloric intake and speculate that increased caloric intake is an attempt to counteract fatigue associated with short sleep.[5,16,21,22] As well, randomized control trials (RCTs) have found a causal link between short sleep and increased caloric intake. One 14-day sleep restriction RCT on 11 sedentary, middle-aged men and women found that individuals in the short-sleep cohort had increased caloric intake in the form of snacking, increased carbohydrate consumption, and no accompanying increase in energy expenditure when compared to individuals who had normal sleep (7–9 hours).[16] Increased caloric intake is also observed in another RCT of 12 healthy men after only one night of sleep restriction.[7] These RCTs were limited by the small sample sizes ($N \leq 12$) and the lack of generalizability to larger populations. Additionally, a generalizable pattern of food and beverage consumption associated with short sleep that could explain the increased caloric intake is yet to be established. For example, while increased snacking was observed in one of the studies,[16] caloric intake in the form of beverages and its link to short sleep is largely unexplored. Thus, more research is called for to better understand the pathways between inadequate sleep and increased caloric intake.

The purpose of our study is to explore the relationship between sleep deprivation and increased time spent in primary and secondary eating and drinking. We use a large ($N = 28{,}150$), national-level data set to explore the association between short sleep and eating patterns. Given that there is evidence that distracted eating,[23,24] snacking, and sugar-sweetened beverage consumption may all increase caloric intake and is associated with higher obesity risk,[25,26] we investigate whether any relationship exists between short sleep and secondary eating and drinking behaviors. "Secondary" eating and drinking is defined by the Economic Research Service of the US Department of Agriculture as eating and drinking while primarily engaged in another activity (for example, watching television, working at a desk, or driving a car).[27] Thus, by definition, secondary eating/drinking qualifies as distracted eating/drinking since it is being done along with another primary activity. Hence, if short sleep is associated with more time spent in secondary eating and drinking, it is a potential pathway through which short sleep leads to increased caloric consumption and hence increased obesity risk. Furthermore, we also explore whether any relationship exists between short sleep and time spent on eating and drinking as a primary activity. (The ATUS asks respondents to report only their primary [main] activities in their diary, with the exception of simultaneous child care. See http://www.ers.usda.gov/data-products/eating-and-healthmodule-(atus)/documentation.aspx for reference.)

METHODS

ATUS Data

We used data from the American Time Use Survey (ATUS) as well as the ATUS Eating & Health (EH) module. ATUS data are publicly available, with no individual level identification, and is deemed non-human subject data by the institutional review board at the authors' university. The ATUS is an annual survey, initiated in 2003 by the Bureau of Labor Statistics (BLS) and conducted by the U.S. Census Bureau, which asks how respondents spent the past 24 hours (measured from 4 A.M. to 4 A.M.), and is used to provide comprehensive information about how Americans spend their time. Although the data set is a survey and subject to the limitations of such data collection methodology, several studies find that the ATUS estimates show little evidence of nonresponse bias.[28–30] Additionally, as a result of a 10-year development process and field testing by the BLS, the ATUS survey is considered one of the most advanced retrospective time diary collection methods.[30,31] The target population of the ATUS is the U.S. noninstitutionalized civilian population aged 15 years or older. The ATUS is a stratified, random sample drawn from the outgoing rotation groups of the Current Population Survey, and one individual from each selected household is chosen to participate in a computer-assisted telephone interview. Readers who are interested in an in-depth description of the ATUS sampling strategy and methodology can access that information on the ATUS website (http://www.bls.gov/news.release/atus.tn.htm). The ATUS questionnaire is organized so as to account for every minute of the participant's day by asking him or her what primary activities the participant engaged in throughout the day. For instance, participants are asked, "yesterday, at 12 P.M., what were you doing?" After identifying what type of primary activity a participant is engaged in, eating for example, the participant would then be asked "how long did you spend eating?,"[32] thus creating a time diary. Time engaged in sleep was assessed with this method as well. Individuals are only surveyed once, and respondents' time diaries are aggregated in order to estimate time spent in activities by the average American. The full list of activities participants can choose from is available from Hamermesh et al.[31] We obtained sleep duration and time spent in primary eating and drinking from this data set. In addition to data on how participants spend their time, the ATUS also contains extensive sociodemographic information.

The ATUS EH module was administered to a subset of the original ATUS respondents in 2006–2008 and asks about eating and drinking as a secondary activity. To our knowledge, this is the only type of secondary activity available in ATUS. Secondary eating and drinking is defined as eating or drinking (beverages other than water) while engaged in some other primary activity, for example, driving or watching television. For instance, participants in the EH module were asked "were there any other times you were eating any meals or snacks yesterday, for example, while you were doing something else? If [so] ... during which activities? Were you eating the entire time you were [engaged in the activity]?"[33] Parallel questions are asked about drinking beverages other than water. ATUS then provides calculated amounts of the total minutes during which a respondent was engaged in the activity in the past 24 hours. One difference between the consumption measures in the ATUS and ATUS EH module is that the ATUS data set gives time spent on "primary eating and drinking" as a single activity and does not provide separate estimates for the two activities. The ATUS EH module, however, reports time spent in "secondary eating" and "'secondary drinking" separately. The EH module also contains information on body mass index (BMI).

We combined the EH module with the main ATUS data information on demographic and other individual characteristic from 2006 through 2008. We excluded adolescent and elderly ATUS respondents, those younger than 21 years of age and older than 65 years of age, as research suggests that sleep patterns as well as the relationship between sleep and obesity of these groups differ from nonelderly adults.[9,34] After pooling the yearly samples and excluding by age, the final sample in this article includes information on 28,150 time diaries.

Empirical Methods

Our key research questions are whether associations exist between short sleep and time spent in secondary eating, short sleep and time spent in secondary drinking, and short sleep and time spent in primary eating and drinking. Our primary empirical approach technique is multivariable ordinary least squares regression analyses, and our main outcome variables are time spent in primary eating and drinking, secondary eating, and secondary drinking in the past 24 hours. We also estimate the relationship between short sleep and BMI in order to see whether this relationship in ATUS is generally consistent with those reported in the obesity and sleep literature (higher BMI associated with less sleep).

The ATUS contains data on what day of the week a participant took the survey. We used this variable to stratify our sample into those individuals who took the ATUS on a weekday and those who took it on a weekend day (weekends are oversampled in ATUS). This is primarily motivated by the fact that both time spent sleeping and time spent eating could vary based on whether it was a weekday or weekend.[9,11,35]

Our main predictor variable of interest is time spent sleeping. Sleep is defined in the ATUS data set in the following manner: "sleeping, falling asleep, dozing off, napping, getting up, waking up, dreaming, catnapping, getting some shut-eye, dozing" and also includes time spent in sleeplessness (i.e., insomnia, tossing and turning, lying awake, counting sheep).[32,36] Given the potentially parabolic relationship between sleep and obesity risk, and hence sleep and obesogenic behaviors, we define three categories of sleep: short sleep (<7 hours), long sleep (≥9 hours), and the reference category of normal sleep (7–8 hours).[5,10,13,15,16] We further controlled for the following demographic and socioeconomic characteristics of the respondent: gender; race; the respondent's age in years as well as its squared value to account for the nonlinearity of the relationship between age and time spent in sleep (time spent in sleep decreases as adolescents mature and then increases later in life)[36,37]; binary indicators for the presence of a spouse or a partner in the household; the total number of children in the household; the respondent's education level (less than high school, high school, less than 4 years of college, 4 years of college, and graduate studies); and the respondent's job status (working or unemployed looking for work). We also control for the month of the year when the interview occurred as sleep patterns may fluctuate seasonally.[38] Additionally, because some studies suggest that blacks on average sleep less per night and have lower sleep quality than whites[39] and other studies indicate that the association between short sleep and BMI varies by gender,[9,40] we used interaction terms to determine if there was evidence that gender and race significantly moderated the association between sleep duration and our outcome variables. We used Stata (version 12; StataCorp, College Station, Texas) for all estimations.

RESULTS

Our final sample included 28,150 observations. Our sample participants had an age range from 21 to 64 years old and a mean age of 42.7 (SD = 11.3) and contained more women (55.8%) than men (44.2%); the majority of our sample identified their race as white (81.2%). Regarding ethnicity, 14.2% of our sample identified as Hispanic. The majority of our sample (64.5%) had at minimum attended some college. The average number of children living in a household was around one (1.1), and over half of the households in our sample had a spouse living at home (58.8%) (Table 1). When looking at the total ATUS sample, the largest portion of participants in the ATUS data set engaged in long sleep (41.0%). Normal sleep was recorded in 39.8% of our observations, and short sleep was recorded in 19.2%. When analyzing our sample based on whether the respondents participated in the ATUS during a weekday or during a weekend day, the distribution of sleep patterns changed. The difference between groups was statistically significant ($p < .01$). Of our sample, 24.8% engaged in short sleep during the week, while 13.8% engaged in short sleep during the weekend.

In our regression models for the full sample, after controlling for sociodemographic characteristics, we found a statistically significant association between sleep duration and our outcome variables of main interest (time spent in primary eating and drinking, secondary eating, and secondary drinking) (Table 2). In general, we found that short sleep tends to be associated with more time spent in secondary

Table 1
Descriptive Statistics (American Time Use Survey Data 2006–2008, N = 28,150)*

	Total Sample, %		Weekday, %		Weekend, %	
Sleep duration						
Short	19.2		24.8		13.8	
Normal	39.8		47.6		32.1	
Long	41.0		27.5		54.1	
Gender						
Male	44.2		44.5		43.8	
Female	55.8		55.5		56.2	
Race						
White	81.2		81.2		81.3	
Black	13.1		13.1		13.1	
Asian	3.4		3.4		3.3	
Other	2.3		2.3		2.3	
Hispanic origin						
Yes	14.2		13.8		14.7	
No	85.8		86.2		85.3	
Presence of spouse						
Spouse present	58.8		58.3		58.6	
Unmarried partner present	2.9		3.1		3.4	
No spouse or partner present	38.3		38.6		38.0	
Education						
Not a high school graduate	9.6		9.6		9.8	
High school graduate	25.9		26.0		25.8	
Some college <4 y	29.6		29.7		29.4	
4-y degree	22.6		22.4		22.7	
>4 y of college	12.3		12.3		12.3	
Employment status						
Employed (at work)	74.2		74.6		79.8	
Unemployed (looking for work)	3.2		3.1		3.3	
Other	22.6		22.3		16.9	
	Mean (SD)	**Range**	**Mean (SD)**	**Range**	**Mean (SD)**	**Range**
Age	42.7 (11.3)	21–64	42.9 (11.3)	21–64	42.6 (11.3)	21–64
Body mass index	27.6 (5.9)	11.6–64.4	27.6 (5.9)	11.6–64.4	27.6 (6.0)	11.6–62.7
Number of children in house	1.1 (1.2)	0–9	1.0 (1.2)	0–8	1.1 (1.2)	0–9

Sleep duration: short indicates sleeping less than 7 hours a night; normal, sleeping 7 or 8 hours per night; and long, sleeping 9 or more hours per night.

* Paired *t*-tests between sleep categories between weekday and weekends found a statistically significant difference ($p < 0.01$).

eating and drinking, but less time spent in primary eating and drinking. Specifically, for respondents interviewed during weekdays, individuals engaged in short sleep on average spent 8.65 minutes per day more in secondary eating ($p < .05$) and 28.63 minutes per day more in secondary drinking ($p < .05$) compared to individuals in the reference category of normal sleep. Among respondents interviewed during the weekend, individuals with short sleep on average spent 28.63 minutes more in secondary drinking ($p < .05$) and spent 3.13 minutes less per day in primary eating and drinking ($p < .05$) compared to individuals in the reference category of normal sleep. In contrast, those engaging in long sleep did not spend statistically higher amounts of time in secondary drinking compared to the reference category of normal sleep. But they did report less time spent on primary eating and drinking (–6.06 minutes, $p < .05$, for weekday respondents and –5.85 minutes, $p < .05$, for weekend respondents).

In addition to finding an association between sleep length and our primary outcomes of interest (primary eating and drinking, secondary eating, and secondary drinking), we also found a statistically significant association between sleep duration and BMI. On average, short-sleepers in our sample had a .41 point higher BMI compared to individuals in our sample who engaged in normal sleep ($p < .05$).

With respect to the other control variables, we also found evidence of gender, race, and ethnicity differences in time spent eating. For example, among those interviewed during weekdays, male respondents spent more time in primary eating and drinking (5.73 minutes more, $p < .05$) and less time in secondary eating (3.79 minutes less, $p < .05$) and secondary drinking (16.31 minutes less, $p < .05$) compared to females. Black respondents spent less time in primary eating and drinking (13.99 minutes less, $p < .05$) and secondary drinking (30.79 minutes less, $p < .05$) and more time in secondary eating (7.83 minutes more, $p < 0.05$) compared to whites (Table 2). Additionally, Hispanic respondents spent less time in secondary eating (3.26 minutes less, $p < .05$) compared to non-Hispanics. In Table 3 we present results in which short sleep and long sleep interact with race and gender. While all but one interaction term in our model were not statistically significant, we did find that compared to females who engaged in long sleep during the week, males who engaged in long sleep spent less time in primary eating and drinking (3.79 minutes less, $p < .05$) (Table 3).

DISCUSSION

While obesity in the United States has been attributed to more traditional causes, such as calorically dense diet, sedentary lifestyle, and inadequate physical activity,[4–6] lack of sleep has also been receiving increased attention as a potential contributing factor to the

Table 2
Sleep and Demographic Characteristics' Association With Time Spent in Eating and Drinking Behaviors (ATUS Data 2006–2008, N = 28,150)†

		Weekday			Weekend		
		Primary Eating and Drinking	Secondary Eating	Secondary Drinking	Primary Eating and Drinking	Secondary Eating	Secondary Drinking
	BMI (SE)	Minutes (SE)			Minutes (SE)		
Short sleep	0.41 (0.14)*	0.03 (0.92)	8.65 (2.08)*	28.63 (4.21)*	−3.16 (1.41)*	3.38 (2.44)	31.28 (5.03)*
Normal sleep	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Long sleep	−0.15 (0.12)	−6.06 (0.92)*	0.47 (2.07)	−6.91 (4.21)	−5.85 (0.98)*	−5.40 (1.70)*	−15.60 (3.51)*
Female	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Male	3.10 (0.11)*	5.73 (0.76)*	−3.79 (1.72)*	−16.31 (3.49)*	2.81 (0.89)*	1.82 (1.55)	−5.30 (3.20)
Age	0.32 (0.04)*	−0.93 (0.26)*	0.44 (0.58)	5.10 (1.19)*	−0.29 (0.31)	0.60 (0.53)	1.75 (1.10)
Age squared	−0.003 (0.01)*	0.01 (0.01)*	−0.01 (0.01)	−0.06 (0.01)*	0.004 (0.01)	−0.009 (0.01)	−0.03 (0.01)*
White	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Black	1.73 (0.16)*	−13.99 (1.16)*	7.83 (2.61)*	−30.79 (5.31)*	−14.98 (1.35)*	1.59 (2.35)	−33.18 (4.85)*
Asian	−1.78 (0.29)*	8.58 (2.06)*	−2.92 (4.66)	−32.26 (9.46)*	15.65 (2.50)*	−5.47 (4.34)	−45.01 (8.95)*
Other	1.37 (0.35)*	−3.34 (2.50)	0.24 (5.64)	−24.99 (11.39)*	0.22 (2.92)	−1.59 (5.11)	22.65 (10.48)*
Non-Hispanic	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Hispanic	0.03 (0.10)	−0.05 (0.71)	−3.26 (1.59)*	1.41 (3.23)	0.59 (0.81)	−3.91 (1.41)*	−7.61 (2.92)*
Unmarried partner present	0.33 (0.30)	−2.25 (2.18)	4.41 (4.91)	58.90 (10.00)*	−0.76 (2.45)	0.63 (4.30)	31.82 (8.87)*
No spouse or partner present	0.71 (0.12)*	−4.75 (0.86)*	0.53 (1.94)	6.73 (3.93)*	−9.22 (1.01)*	3.73 (1.75)*	8.33 (3.60)*
Children in household	0.08 (0.05)	−1.78 (0.38)*	−1.25 (0.86)	−0.87 (1.74)	−0.23 (0.44)	0.44 (0.77)	−0.71 (1.58)
Not a high school graduate	Reference	Reference	Reference	Reference	Reference	Reference	Reference
High school graduate	1.17 (0.20)*	0.54 (1.42)	0.78 (3.21)	30.64 (6.53)*	0.68 (1.66)	6.51 (2.89)*	25.79 (5.95)*
Some college <4 y	1.25 (0.20)*	6.26 (1.40)*	4.33 (3.16)	36.89 (6.44)*	5.96 (1.64)*	7.66 (2.85)*	31.11 (5.87)*
4-y degree	0.04 (0.20)	3.34 (1.47)*	4.68 (3.33)	27.81 (6.76)*	12.41 (1.72)*	9.73 (2.99)*	22.01 (6.16)*
>4 y of college	−0.53 (0.23)*	7.66 (1.65)*	5.96 (3.71)	30.13 (7.55)*	16.67 (1.93)*	12.19 (3.35)*	23.53 (6.91)*
Unemployed	Reference	Reference	Reference	Reference	Reference	Reference	Reference
Employed—at work	−0.27 (0.13)*	−5.79 (0.96)*	1.39 (2.17)	13.75 (4.40)*	−2.01 (1.10)*	−2.90 (1.90)	2.11 (3.93)
Unemployed—looking for work	0.79 (0.31)*	−3.17 (2.6)	1.00 (5.08)	10.57 (10.34)	−2.44 (2.60)	−6.87 (4.51)	7.80 (9.28)
Time	−0.001 (0.01)	−0.01 (0.06)	0.80 (0.14)*	1.88 (0.29)*	−0.05 (0.07)	0.79 (0.13)*	2.36 (0.26)*

BMI indicates body mass index. Short sleep indicates sleeping less than 7 hours a night; normal sleep (reference category), sleeping 7 or 8 hours per night; and long sleep, sleeping 9 or more hours per night.
† The sample is based on ATUS EH data, 2006–2008. Adults aged 21–65 years are included.
* $p < 0.05$.

obesity epidemic.[5,7–9] Researchers have identified short sleep duration as a predictor for obesity,[5,9,10] although the pathways from short sleep to obesity risk are still being investigated. We contribute to this literature by using a national-level data set on time use by the civilian population in the United States and explore whether there are associations between sleep duration and specific eating behaviors. Distracted eating has been linked to increased caloric intake. Therefore, we explore whether short sleep is associated with time spent in secondary eating and drinking (that is, eating and drinking while engaged in another primary activity), as well as time spent in eating as the primary activity. Notably, we find positive associations between short sleep and BMI in the overall ATUS sample, which supports current research suggesting a positive association between short sleep and BMI.[9]

A unique contribution of our study is finding a statistically significant association between short sleep and additional time spent in secondary eating and drinking behaviors among participants who responded to the ATUS. Literature exists on the relationship between short sleep and increased caloric intake, including more frequent snacking.[5,16] This has been explained in several ways in the literature. Chronic sleep restriction has been linked to increases in appetite-stimulating hormones such as ghrelin and cortisol,[5,41] and increases in cortisol levels are also associated with body fat increases.[5,42] Garaulet et al.[12] find an association between types of foods consumed and amount of sleep, with short-sleepers eating more fast food, fatty foods, and carbohydrates. Magee et al.[5] and Nedeltcheva et al.[16] posit that increased caloric intake is an attempt to counteract fatigue associated with short sleep and that more time awake potentially leads to more time for eating. However, to our knowledge our article is the first to detail an association between short sleep and secondary eating and drinking behaviors using a national-level data set. While we only identify an association between short sleep and increased

Table 3
Differential Association of Sleep Duration and Time Spent in Primary and Secondary Eating and Drinking by Gender and Race (ATUS 2006–2008)†

		Weekday			Weekend		
		Primary Eating and Drinking	Secondary Eating	Secondary Drinking	Primary Eating and Drinking	Secondary Eating	Secondary Drinking
	Interaction Term	Minutes (SE)			Minutes (SE)		
Interactions by gender							
	Female × short sleep	Reference	Reference	Reference	Reference	Reference	Reference
	Male × short sleep	−0.90 (1.84)	0.19 (4.15)	12.86 (8.42)	−0.54 (2.81)	−6.09 (4.88)	2.87 (10.06)
	Female × long sleep	Reference	Reference	Reference	Reference	Reference	Reference
	Male × long sleep	−3.79 (1.80)*	−1.56 (4.06)	−14.12 (5.46)	2.43 (1.96)	2.48 (3.39)	−7.06 (7.00)
Interactions by race							
	White × short sleep	Reference	Reference	Reference	Reference	Reference	Reference
	Black × short sleep	2.17 (2.75)	0.83 (6.20)	−6.76 (12.58)	5.26 (4.00)	−6.83 (6.97)	−28.14 (14.37)
	Asian × short sleep	4.41 (5.10)	16.64 (11.50)	11.98 (23.40)	−5.65 (8.11)	5.94 (14.06)	−45.39 (28.82)
	Other × short sleep	−2.90 (6.19)	−8.02 (13.88)	−37.77 (28.06)	12.38 (9.79)	22.55 (17.63)	68.41 (36.20)
	White × long sleep	Reference	Reference	Reference	Reference	Reference	Reference
	Black × long sleep	−3.90 (2.64)	5.26 (5.95)	15.48 (12.11)	1.24 (3.05)	−4.14 (5.29)	−4.48 (10.90)
	Asian × long sleep	6.83 (4.80)	2.48 (10.84)	−21.98 (21.95)	1.23 (5.57)	1.19 (9.65)	8.20 (19.93)
	Other × long sleep	−0.82 (5.88)	0.53 (13.32)	−19.55 (26.83)	1.00 (6.46)	9.69 (11.30)	25.78 (23.11)

Short sleep indicates sleeping less than 7 hours a night; normal sleep (reference category), sleeping 7 or 8 hours per night; and long sleep, sleeping 9 or more hours per night.
† All models controlled for other variables listed in Table 2.
* $p < 0.05$.

time spent in secondary and eating drinking behavior rather than short sleep and increased caloric consumption, our results potentially uncover an additional pathway to obesity, namely that short-sleepers are more likely to eat and drink while engaged in another, primary activity. There is evidence that individuals who are engaged in distracted eating, eating while engaged in other activities, do not feel as full and are more likely to snack later in the day than individuals who primarily focus on eating.[23,24,43] Thus, the associations between short sleep and more engagement in secondary eating and secondary drinking, along with less time spent on primary eating and drinking, indicate pathways through which short sleep could be linked to increased obesity risk. Notably, aside from potentially being a source of increased caloric intake, secondary or distracted eating has the capacity to impact future eating behavior, potentially leading to poor diet habits that could influence weight gain in the long run.[43]

We particularly note the strong associations between short sleep and time spent in secondary beverage consumption on weekdays as well as weekend days. We speculate that one reason for this association could be explained by consumption of beverages containing caffeine to counteract the effects of short sleep. It is possible that some or all of the respondents might be drinking zero or low-calorie beverages such as black coffee and diet caffeinated sodas that will not necessarily increase obesity risk. However, it is likely that at least some of them are consuming calorically dense coffee beverages or sugar-sweetened beverages, and it is well established that sugar-sweetened beverages are associated with higher obesity risk,[25,26] with the relationship likely to be causal.[44,45]

We acknowledge several limitations. We know how much time is spent in eating and drinking behaviors, but one limitation of the ATUS data is that it does not inform on what the respondents are eating and drinking (except the fact that secondary drinking excludes water), limiting our ability to assess caloric intake. Perhaps future work should assess what types of foods and beverages are consumed by those individuals who engage in secondary eating and drinking for longer versus shorter periods of time. Similarly, although we have data on sleep duration, we do not have data on sleep quality. Additionally, although the ATUS is a large, nationally representative data set, the observational, cross-sectional nature of the data implies that the results of this analysis can only be interpreted as associative and not causal. This is especially true given that we cannot assess the temporal relationship between sleep and time engaged in eating and drinking as a result of having access to only 1 day's data for each participant. Furthermore, although several studies find that the ATUS estimates show little evidence of nonresponse bias,[28–30] the self-reported nature of ATUS raises concerns about the accuracy of the respondents' responses to the survey, including the height and weight information that is used to compute BMI. As well, while ATUS computes time spent in secondary drinking and secondary eating separately, primary eating and drinking are combined into a single activity. Finally, while our estimate of sleep duration for our population is similar to other literature that uses ATUS data, such as that of Basner et al.[36] published in the journal *Sleep*, our sleep duration estimates are higher than those found in other studies.[46,47] However, as we mention previously, the ATUS measure for sleep includes such activities as "napping," "dozing off," and even "tossing and turning," activities that may not be included in more stringent, physiological definitions of sleep.[36]

CONCLUSION

We believe our study points to useful directions for future research. For example, our findings indicate that future research should investigate if short sleep has causal effects on increased consumption of sugar-sweetened or other calorically dense beverages. At the same time, our findings indicate that the pathways from short sleep to obesity risk vary by race and gender and that considerable caution should be exercised before making generalizations about potential pathways for the overall U.S. population.

SO WHAT? Implications for Health Promotion Practitioners and Researchers

What is already known on this topic?

The association between short sleep and obesity risk is well established, but there is less research on the pathways from one to the other.

What does this article add?

We explore a new pathway between short sleep and obesity: whether short sleep is linked to more time spent in secondary or distracted eating or drinking, that is, eating or drinking (beverages other than water) while primarily engaged in another activity.

What are the implications for health promotion practice or research?

We find associations between short sleep and more time spent in secondary drinking, and we suggest that future research should investigate whether there is a causal link using randomized controlled trials. Our findings may provide clinicians with valuable insight into sources of weight gain for patients who are sleep deprived and better allow them to tailor nutrition advice for those patients.

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References

1. Flegal KM, Carroll MD, Ogden CL, Curtin LR. Prevalence and trends in obesity among US adults, 1999–2008. *JAMA*. 2010; 303:235–241.
2. Flegal KM, Carroll MD, Ogden CL, Johnson CL. Prevalence and trends in obesity among US adults, 1999–2000. *JAMA*. 2002;288:1723–1727.
3. Swinburn BA, Sacks G, Hall KD, et al. The global obesity pandemic: shaped by global drivers and local environments. *Lancet*. 2011;378:804–814.
4. Hill JO, Wyatt HR, Reed GW, Peters JC. Obesity and the environment: where do we go from here? *Science*. 2003;299:853–855.
5. Magee CA, Huang XF, Iverson DC, Caputi P. Examining the pathways linking chronic sleep restriction to obesity. *J Obes*. 2010; 2010:pii821710.
6. WHO. Obesity: preventing and managing the global epidemic. Report of a WHO consultation. *World Health Organ Tech Rep Ser*. 2000;894:i–xii, 1–253.
7. Brondel L, Romer MA, Nougues PM, et al. Acute partial sleep deprivation increases food intake in healthy men. *Am J Clin Nutr*. 2010;91:1550–1559.
8. Knutson KL, Spiegel K, Penev P, Van Cauter E. The metabolic consequences of sleep deprivation. *Sleep Med Rev*. 2007;11: 163–178.
9. Patel SR, Hu FB. Short sleep duration and weight gain: a systematic review. *Obesity*. 2008;16:643–653.
10. Cappuccio FP, Taggart FM, Kandala NB, et al. Meta-analysis of short sleep duration and obesity in children and adults. *Sleep*. 2008;31:619–626.
11. National Sleep Foundation. *2005 Sleep in America Poll*. Washington, DC: National Sleep Foundation; 2005.
12. Garaulet M, Ortega FB, Ruiz JR, et al. Short sleep duration is associated with increased obesity markers in European adolescents: effect of physical activity and dietary habits. The HELENA study. *Int J Obes*. 2011;35:1308–1317.
13. Knutson KL, Van Cauter E, Rathouz PJ, et al. Trends in the prevalence of short sleepers in the USA: 1975–2006. *Sleep*. 2010;33:37–45.
14. Schmid SM, Hallschmid M, Jauch-Chara K, et al. Short-term sleep loss decreases physical activity under free-living conditions but does not increase food intake under time-deprived laboratory conditions in healthy men. *Am J Clin Nutr*. 2009;90:1476–1482.
15. Dinges DF, Rogers NL, Baynard MD. Principles and practice of sleep medicine. In: Kryger MH, Roth T, Dement WC, eds. *Principles and Practice of Sleep Medicine*. 4th ed. Philadelphia, Pa: Elsevier; 2005:67–76.
16. Nedeltcheva AV, Kilkus JM, Imperial J, et al. Sleep curtailment is accompanied by increased intake of calories from snacks. *Am J Clin Nutr*. 2009;89:126–133.
17. Atkinson G, Davenne D. Relationships between sleep, physical activity and human health. *Physiol Behav*. 2007;90:229–235.
18. Drescher AA, Goodwin JL, Silva GE, Quan SF. Caffeine and screen time in adolescence: associations with short sleep and obesity. *J Clin Sleep Med*. 2011;7:337–342.
19. Sivak M. Sleeping more as a way to lose weight. *Obes Rev*. 2006;7:295–296.
20. Spiegel K, Tasali E, Penev P, Van Cauter E. Brief communication: sleep curtailment in healthy young men is associated with decreased leptin levels, elevated ghrelin levels, and increased hunger and appetite. *Ann Intern Med*. 2004;141:846–850.
21. Brownson RC, Baker EA, Housemann RA, et al. Environmental and policy determinants of physical activity in the United States. *Am J Public Health*. 2001;91: 1995–2003.
22. Resnick HE, Carter EA, Aloia M, Phillips B. Cross-sectional relationship of reported fatigue to obesity, diet, and physical activity: results from the third national health and nutrition examination survey. *J Clin Sleep Med*. 2006;2:163–169.
23. Bellisle F, Dalix AM. Cognitive restraint can be offset by distraction, leading to increased meal intake in women. *Am J Clin Nutr*. 2001;74:197–200.
24. Blass EM, Anderson DR, Kirkorian HL, et al. On the road to obesity: television viewing increases intake of high-density foods. *Physiol Behav*. 2006;88:597–604.
25. Malik VS, Schulze MB, Hu FB. Intake of sugar-sweetened beverages and weight gain: a systematic review. *Am J Clin Nutr*. 2006;84:274–288.
26. Vartanian LR, Schwartz MB, Brownell KD. Effects of soft drink consumption on nutrition and health: a systematic review and meta-analysis. *Am J Public Health*. 2007; 97:667–675.
27. US Dept of Agriculture. Eating and Health Module Documentation (ATUS). Available at: http://www.ers.usda.gov/data-products/eating-and-health-module-%28atus%29/documentation.aspx. Last updated July 5, 2012. Accessed July 10, 2012.

28. Abraham KG, Maitland A, Bianchi SM. Nonresponse in the American Time Use Survey: who is missing from the data and how much does it matter? *Public Opin Q.* 2006;70:676–703.
29. O'Neill G, Dixon, J. Nonresponse bias in the American Time Use Survey. Paper presented at the American Statistical Association Conference; August 7–11, 2005; Alexandria, Va.
30. Phipps P, Vernon, MK. Twenty-four hours: an overview of the recall diary method and data quality in the American Time Use Survey. In: Belli RF, Alwin DF, eds. *Calendar and Time Diary: Methods in Life Course Research.* Thousand Oaks, Calif: Sage; 2009.
31. Hamermesh DS, Frazis H, Stewart J. Data watch: the American Time Use Survey. *J Econ Perspect.* 2005;19:221–232.
32. US Dept of Labor. Bureau of Labor Statistics. ATUS Time Use Survey Questionnaire; 2012. Available at: http://www.bls.gov/tus/questionnaires.htm. Accessed July 10, 2012.
33. US Dept of Labor. Bureau of Labor Statistics. ATUS Time Use Survey Eating and Health Module Questionnaire; 2012. Available at: http://www.bls.gov/tus/questionnaires.htm. Accessed July 10, 2012.
34. Ohayon MM, Carskadon MA, Guilleminault C, Vitiello MV. Meta-analysis of quantitative sleep parameters from childhood to old age in healthy individuals: developing normative sleep values across the human lifespan. *Sleep.* 2004;27:1255–1273.
35. Lauderdale DS, Knutson KL, Yan LL, et al. Objectively measured sleep characteristics among early-middle-aged adults: the CARDIA study. *Am J Epidemiol.* 2006;164:5–16.
36. Basner M, Fomberstein KM, Razavi FM, et al. American Time Use Survey: sleep time and its relationship to waking activities. *Sleep.* 30:1085–1095.
37. US Dept of Labor. Bureau of Labor Statistics. ATUS Time Use Survey Sleep Results; 2012. Available at: http://www.bls.gov/tus/charts/sleep.htm. Accessed July 10, 2012.
38. Allebrandt KV, Teder-Laving M, Kantermann T, et al. Chronotype and sleep duration: the influence of season of assessment. *Chronobiol Int.* 2014;31:731–740.
39. Sherwood A, Routledge FS, Wohlgemuth WK, et al. Blood pressure dipping: ethnicity, sleep quality, and sympathetic nervous system activity. *Am J Hypertens.* 2011;24:982–988.
40. St-Onge MP, Perumean-Chaney S, Desmond R, et al. Gender differences in the association between sleep duration and body composition: The Cardia Study. *Int J Endocrinol.* 2010;2010:726071.
41. Wren AM, Seal LJ, Cohen MA, et al. Ghrelin enhances appetite and increases food intake in humans. *J Clin Endocrinol Metab.* 2001;86:5992.
42. Bjorntorp P. Do stress reactions cause abdominal obesity and comorbidities? *Obes Rev.* 2001;2:73–86.
43. Oldham-Cooper RE, Hardman CA, Nicoll CE, et al. Playing a computer game during lunch affects fullness, memory for lunch, and later snack intake. *Am J Clin Nutr.* 2011;93:308–313.
44. de Ruyter JC, Olthof MR, Kuijper LD, Katan MB. Effect of sugar-sweetened beverages on body weight in children: design and baseline characteristics of the double-blind, randomized intervention study in kids. *Contemp Clin Trials.* 2012;33:247–257.
45. de Ruyter JC, Olthof MR, Seidell JC, Katan MB. A trial of sugar-free or sugar-sweetened beverages and body weight in children. *N Engl J Med.* 2012;367:1397–1406.
46. Kripke DF, Garfinkel L, Wingard DL, et al. Mortality associated with sleep duration and insomnia. *Arch Gen Psychiatry.* 2002;59:131–136.
47. National Sleep Foundation. *2010 Sleep in America Poll.* Washington, DC: National Sleep Foundation; 2010.