2014

Effects of Acute and Chronic Sleep Deprivation on Eating Behavior

Stephanie Frank
University of Kentucky, stephaniefrank@gmail.com

Effects of Acute and Chronic Sleep Deprivation on Eating Behavior

Investigator: Stephanie Frank, Human Nutrition, School of Human Environmental Sciences, University of Kentucky

Research Question: How do acute and chronic sleep deprivation affect eating behavior in university students? Does lack of sleep decrease fruit & vegetable intake or increase sweet & starchy food intake?
Aims: 1) determine the affect average hours of sleep or acute sleep deprivation (defined as less than 6 hour sleep per night) has on consumption of nutritious foods, measured by examining average fruit and vegetable servings overall and on sleep-deprived days; 2) examine the effect of average hours of sleep or acute deprivation on consumption of sweet and starchy foods, defined by servings per day of French fries, potato chips, and dessert foods, such as cookies or cake, both overall and on sleep deprived days.
Hypothesis: Inadequate sleep, defined as less than six hours per night, will increase sweet and starchy food consumption, and decrease average fruit and vegetable consumption in college students.

ABSTRACT
Background: Sleep-deprivation is thought to be a factor in the rising American obesity epidemic. Altered sleep cycles affect appetite-regulating hormone levels and enhance the hedonic effect of food consumption. As a result, sleep restriction has been associated with an increased daily energy intake of more than 500 calories and high-carbohydrate/high-fat consumption. However, past studies have not examined the relationship between sleep deprivation and decreased intake of nutrient-dense fruits and vegetables as a factor in increased energy consumption.

Methods: Data was collected from 152 students (110 females and 42 males) between 18 and 53 years old at the University of Kentucky. Students self-reported data on daily and weekly sleep habits, dietary habits, weight, height, and demographics via an online Qualtrics cross-sectional survey. Descriptive, correlations and t-test analyses were performed in Microsoft Excel.

Results: The data concluded that acute sleep deprivation is not correlated with the amount of meals prepared at home, weekly fast food meals, fruit/vegetable (F/V) consumption, or sweet/starch (S/S) consumption (r=.029, .099, .096, .109, respectively). Chronic sleep deprivation was not correlated with home meals, fast food, F/V or S/S intake (r=-.084, .052, -.112, -.096, respectively). BMI showed no correlation with meals consumed at home, fast food, F/V, S/S, acute sleep deprivation or chronic deprivation (r=.046, .020, -.103, -.040, -.097, .094, respectively). P-values in all compared variables were significant ($p<0.001$). Though data indicated that students, on average, consumed less fruit and vegetables and more sweets and starches on sleep-deprived days, variance across the population was high. Most of the students surveyed were undergraduate freshmen (48.0%) and/or living with roommates (81.6%).

Conclusion: These results run contrary to previous studies that have demonstrated a connection between sleep deprivation, and increased high-carbohydrate/high fat food consumption and BMI. The well-established correlation between increased energy consumption and sleep deprivation, as well as the high variance within this survey population, indicate the need for a larger sample population to accurately assess variable relationships. In addition, factors this survey neglected to consider, such as the use of university meal plans amongst students, possibly affected the descriptive capacity of the study.

Background

Sleep-deprivation is thought to be a factor in the rising American obesity epidemic. Altered sleep cycles tend to change ghrelin and leptin hormone levels, leading to an increase in appetite [1]. In addition, lack of sleep enhances the hedonic effect of food consumption in the brain ([2]. As a result, sleep restriction has been associated with an increased daily energy intake of more than 500 calories [3]. These studies indicate that a lack of sleep leads to weight gain because of increased caloric consumption. However, in animal studies, weight gain attributed to sleep deprivation cannot be directly explained by increase in energy consumption alone [4]. Therefore, it is necessary to look at other factors in sleep-deprivation and food consumption.

Though energy expenditure is likely a factor in sleep-deprivation's role in weight gain, study results are conflicting. While some studies indicate that caloric expenditure is decreased during sleep deprivation [5], others indicated an increase [6]. However, studies have shown that sleep curtailment is associated with greater consumption of snacks, especially those high in carbohydrates [7]. In fact, recovery sleep led to a decrease in energy consumption, especially in the form of carbohydrates and fats [6]. Sleep deprivation causes individuals to choose larger portion sizes in snack items, while meal choices were similar to those of non-sleep deprived individuals [8]. In addition, altered hormones might lead to a preference for energy dense foods [9]. These studies indicate that the types of foods chosen, not just the overall amount of calories consumed or expended, change during a sleep-deprived state.

Studies have examined the hormonal, caloric and neurological reasons behind sleep-deprivation's impact on weight gain. Altered levels of ghrelin and leptin, as well as increased pleasure from food consumption, seem to encourage weight gain in a sleep-deprived state. This study examines university students because that population is particularly prone to chronic and acute sleep deprivation. Varying schedules, intermittent exams, adjustment to an independent

lifestyle, and abundant extracurricular opportunities possibly increase the likelihood of inadequate sleep patterns. One study found that only 29.4% of one university's student population reported getting at least 8 hours of sleep per night, while 25% received less than 6.5 hours (Lund et. al. 2010). In addition, 20% of those students reported staying up all night at least once in the past month and 35% stayed up until 3 a.m. at least once a week. Past studies have demonstrated a relationship between sleep deprivation and high-carbohydrate/high-fat food consumption (Weiss et. al. 2010). This study will look at that relationship, in addition to decreased intake of nutrient-dense fruits and vegetables, as a possible mechanism for weight gain in sleep-deprived individuals.

Methods

Sample & Setting

The sample population consists of n=152 students from the University of Kentucky, ages 18 to 53. Demographics of the University for the 2012-13 academic year, as reported by the Office of Institutional Effectiveness, are as follows:

Table 1: UK Student Demographics

Male Students	14,013
Female Students	14,915
White (non-Hispanic)	22,211
Black (non-Hispanic)	1,928
Asian or Pacific Islander	792
Hispanic	741
American Indian	44
Other Races	1,591

International Students	1,621
Undergraduate	20,878
Graduate/Professional	7,159
Other Degree Classification	891
24 & Younger	21,696
25 & Older	7,232

Students at the University of Kentucky provide a reasonably diverse sample population. The student body is slightly more female (51.6%) than male (48.4%). White, non-Hispanics make up the majority at 81.3%. Prominent minorities include Black, non-Hispanics (7.1%), Asian of Pacific Islanders (3.0%), Hispanics (2.7%) and American Indians (1.6%). International students account for 5.6% of the population. Most students are undergraduates (72.2%) and/or under 24 years old (75%). However, graduate or professional students or those over 25 years old make up 24.7% and 33.3% of the sample, respectively.

Data Collection

This cross-sectional study used a survey format that was available to all students at the University of Kentucky. The online Qualtrics survey was distributed primarily through e-mails to the UK Honors Program and Dietetics and Human Nutrition students during the Spring 2014 semester. Survey demographic questions covered basic characteristics of age, height, weight, gender, enrollment classification and living arrangements. Respondents' self-reported information on the independent, exposure variables of average sleep duration over a 24-hour period and number of days with less than 6 hours of sleep in a 24-hour period. The survey also included

dependent, outcome variable questions on the level of fruit and vegetable servings per day, and the level of starchy or sweet food servings per day.

Survey

Demographics:

1. What is your age in years? (age)
2. What is your gender?(gender)
    a. Male = 0
    b. Female = 1
3. What is your height? _____feet _____inches (height)
4. What is your weight in pounds? _____ (weight)
5. What is your race? (race):
    a. Caucasian = 0
    b. African American = 1
    c. American Indian = 2
    d. Asian or Pacific Islander = 3
    e. Hispanic or Latino = 4
    f. Other = 5
6. How many years have you been in school? (year_school):
    a. Freshman = 0
    b. Sophomore = 1
    c. Junior = 2
    d. Senior = 3
    e. Graduate/Professional = 4
    f. Other = 5
7. Do you live with (living):

a. Roommates = 0

b. Spouse/Partner = 1

c. Parents = 2

d. Alone = 3

e. Other = 4

Study Questions:

8. On average, how many hours of sleep do you get in a 24-hour period? (average_24)

    a. 0-4 = 0

    b. 5-6 = 1

    c. 7-8 = 2

    d. 9-10 = 3

    e. 11 or more = 4

9. On average, how many days per week do you get less than six hours of sleep? (average_wk)

    a. 0 = 0

    b. 1 = 1

    c. 2 = 2

    d. 3 = 3

    e. 4 = 4

    f. 5 = 5

    g. 6 = 6

    h. 7 = 7

10. How many meals per week do you prepare at home? (home_meal)

    a. None = 0

b. 1-3 = 1

c. 4-9 = 2

d. 10+ = 3

11. How many fast food meals per week do you consume? (fast_meal)

    a. None = 0

    b. 1-3 = 1

    c. 4-9 = 2

    d. 10+ = 3

12. Not counting potatoes, how many servings of fruits and vegetables do you usually eat per day? (fruit_veg_norm)

    a. None = 0

    b. 1-2 = 1

    c. 3-5 = 2

    d. 6+ = 3

13. On days when you have slept less than 6 hours, how many servings of fruits and vegetables do you usually eat (not counting potatoes)? (fruit_veg_depr)

    a. None = 0

    b. 1-2 = 1

    c. 3-5 = 2

    d. 6+ = 3

14. How many servings of sweet or starchy foods do you usually eat per day (including French fries, potato chips, cookies, cakes, pies, etc)? (starch_norm)

    a. None = 0

    b. 1-2 = 1

    c. 3-5 = 2

d. 6+ = 3

15. On days when you have slept less than 6 hours, how many servings of sweet or starchy foods do you usually eat? (starch_depr)

    a. None = 0

    b. 1-2 = 1

    c. 3-5 = 2

    d. 6+ = 3

Data Analysis

Data from the survey was analyzed through Pearson Correlation and t-tests. The independent, exposure variables of average sleep time and number of days with less than 6 hours sleep were separately compared to the dependent, outcome variables of fruit and vegetable intake and sweet and starchy food consumption. Pearson Correlations were used to analyze how changes in exposure variables correlated with the outcome variables. Student t-tests were used to determine whether these correlations were significant.

Results

Survey demographics, found in Table 1, indicate that the majority of respondents were white, normal BMI females in the midst of their first two years of university, and living with roommates. The mean age was 20.05±4.03 years and mean weight was 148.13±28.27 pounds. Average body mass index (BMI) was 23.28±3.79 kg/m^2. Most of the individuals in the study (69.08%) had a BMI in the normal range between 18.5 and 24.9 kg/m^2. However, 21.05% were overweight, and 5.26% were obese. Despite the 18.7% minority population that attends the University of Kentucky, the overwhelming majority of survey respondents were Caucasian (90.79%). Most respondents lived with roommates (81.58%), though a

Table 1. Demographics of Participants (College Students) 2014

	Mean±SD
Age (years)	20.05±4.03
Weight (pounds)	148.13±28.27
BMI (kg/m^2)	23.28±3.79

BMI Category	**Percentage**
Underweight	4.61%
Normal	69.08%
Overweight	21.05%
Obese	5.26%
School Year	
Freshman	48.03%
Sophomore	24.34%
Junior	13.16%
Senior	10.53%
Graduate	2.63%
Other	1.32%
Race	
White	90.79%
Black	0.66%
Asian	3.29%
Native American	0.66%
Hispanic	2.63%
Other	1.97%
Living Accommodation	
Roommates	81.58%
Spouse	3.95%
Parents	3.29%
Alone	10.53%
Other	0.66%
Daily Sleep	
0 to 4 hours	0.66%
5 to 6 hours	25.00%
7 to 8 hours	68.42%
9-10 hours	5.92%

Weekly Sleep	**Percentage**
0 Days	17.76%
1-2 Days	52.63%
3-4 Days	25.00%
5-7 Days	4.61%
Weekly Homemade Meals	
None	17.11%
1 to 3	32.24%
4 to 9	34.87%
10+	15.79%
Weekly Fast Food Meals	
None	23.03%
1 to 3	52.63%
4 to 9	23.03%
10+	1.32%
Rested F/V Servings	
None	3.95%
1 to 2	55.92%
3 to 5	31.58%
6+	8.55%
Sleep Deprived F/V Servings	
None	10.53%
1 to 2	57.89%
3 to 5	23.68%
6+	7.89%
Rested S/S Servings	
None	5.92%
1 to 2	54.61%
3 to 5	36.84%
6+	2.63%
Sleep Deprived S/S Servings	
None	3.95%
1 to 2	44.74%
3 to 5	42.76%
6+	8.55%

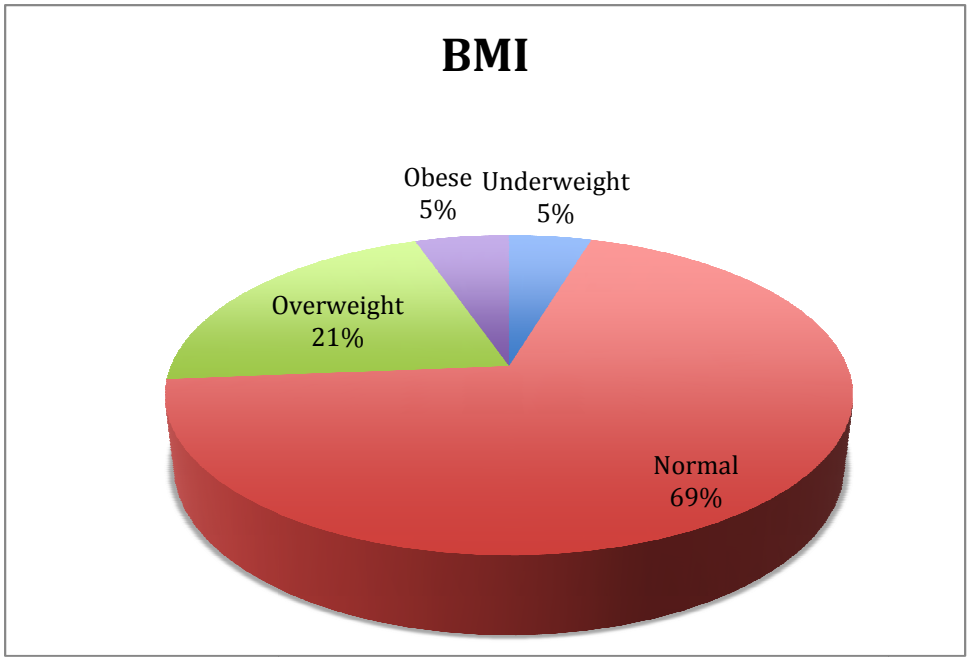

Figure 1: Population BMI

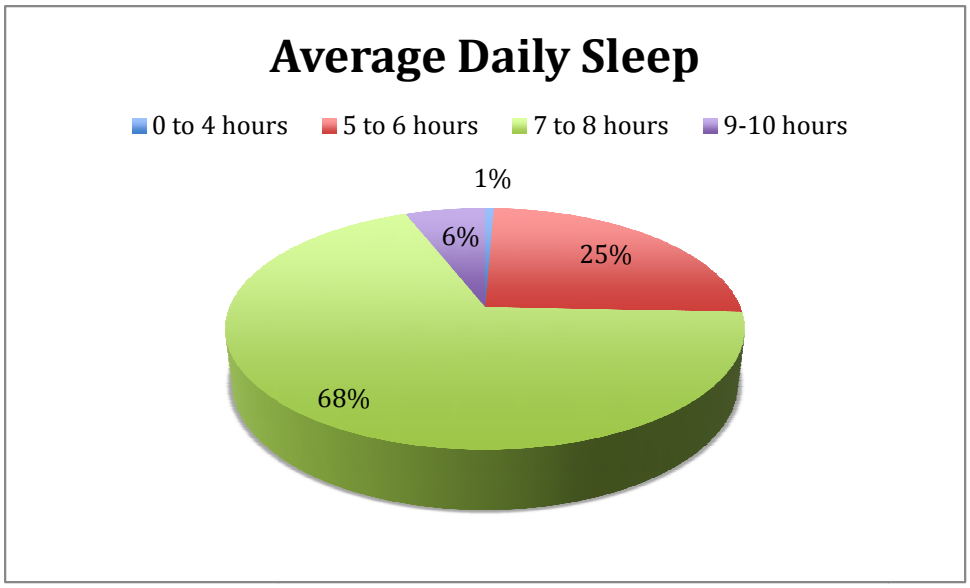

Figure 2: Average Daily Sleep

substantial portion lived alone (10.53%). One-fourth of respondents reported daily sleep deprivation consisting of six or less hours of sleep, but a majority, 68.42% of participants slept within the acceptable range of 7 to 8 hours per night. Though most participants slept the recommended number of hours per night, 82.23% slept less than 6 hours on one or more nights per week. On rested days, 40.53% of participants ate at least three servings of fruits and vegetables (F/V), and 60.53% ate two or less servings of sweet or starchy food

(S/S) per day. When sleep deprived, both percentages dropped to 31.57% of participants eating at least three F/V servings and 48.69% eating less than two S/S servings for the day.

Table 2. Corrleation between Starch Consumption and Sleep Deprivation in UK College Students 2014

	Rested Fruit	Deprived Fruit	Rested Starch	Deprived Starch	BMI
Acute Sleep Deprivation	0.135	0.096	0.081	0.109	-0.097
Chronic Sleep Deprivation	-0.112	-0.048	-0.096	-0.073	0.094

Table 3. Association between Sleep Deprivation and Food Consumption in UK College Students 2014

	Fruit Rested	Fruit Deprived	Starch Rested	Starch Deprived	BMI
Acute Sleep Deprivation	<0.0001	<0.0001	<0.0001	<0.0012	<0.0001
Chronic Sleep Deprivation	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Despite the move toward increased sweet and starch consumption and decreased fruit and vegetable consumption, no correlation was found between sleep deprivation and food consumption of any kind. In addition, no correlation existed between BMI and sleep deprivation. As seen in Table 2, acute sleep deprivation compared to food consumption was not correlated. With sleep deprivation compared to rested F/V consumption, sleep deprived F/V consumption, rested S/S consumption, sleep deprived S/S consumption and BMI (r-value= 0.135, 0.096, 0.081, 0.109, and -0.097, respectively). Chronic sleep deprivation yielded weak to no correlated relationships (r-value=-0.112, -0.048, -0.096, -0.073, and 0.094) when compared to rested F/V consumption, sleep deprived F/V consumption, rested S/S consumption, sleep deprived S/S consumption and BMI, respectively. Table 3 shows that the association between acute sleep deprivation and S/S

consumption on sleep deprived days was significant ($p<0.0012$). All other compared variables had a significant p-value as well ($p<0.0001$). Though all association values were significant, the lack of even moderate correlations indicates that there is no connection between sleep deprivation and food consumption in this study.

Discussion

The results did not corroborate a significant relationship between sleep deprivation and increased sweet/starchy food intake or decreased fruit & vegetable intake. Previous studies have found that sleep deprivation is related to increased consumption of calorically dense foods[6-10]. On the basis of those preliminary findings, this study hypothesized that acute and chronic sleep deprivation would lead to decreased fruit and vegetable intake and increased sweet and starchy food intake. Unexpectedly, the findings indicate that neither type of sleep deprivation is related to altered food consumption or increased BMI, so the hypothesis was disproven. Though some previous studies support the notion that weight gain caused by sleep deprivation cannot be accounted for by increased caloric consumption alone [4, 5], and instead may be a result of decreased physical activity and metabolic rate, most studies do support the idea that sleep loss leads to weight gain.

Several aspects of the study design and population could have led to the unexpected results. Similar to a previous study of university students, roughly one fourth of students slept less than six hours per day [11]. However, the population in this study was abnormally healthy in terms of body mass index. Only 26.3% of respondents were overweight or obese, while American Heart Association statistics indicate that 68.2% of adults over 20 and 31.8% children 2 to 19 years old in the US are overweight or obese[12]. Perhaps unforeseen aspects of this study's population influenced food consumption and BMI. For instance, a large portion of students were in the first two years of school, and possibly participate in

the campus dining program. The dining program provides nutritious meals to students with little effort on their part. The ease of procuring healthy foods could have alleviated some of the usual weight gain from sleep deprivation. An alternative reason for skewed results in this survey could be that survey participants were mostly freshman or sophomores in college. For most people, weight gain increases over the course of a lifetime, and one study has shown that university students gain weight increasingly over the course of their college career [13]. The same study indicated that weight fluctuation in college is highly variable, ranging from -13.2 to +20.9 kg, which may explain some of the extreme variability that proved a limitation in this study.

Future studies could overcome the limitations of the present study by surveying a larger sample population, and examining confounding factors, such as meal plans and physical activity. Though the majority of past studies have found a significant relationship between sleep deprivation and weight gain, the reasons for that connection are debatable. While university populations are especially useful populations to study given their tendency toward acute and chronic sleep deprivation, their access to nutritious foods and exercise venues is unique and must be considered.

References:

1. Shlisky, J.D., et al., *Partial sleep deprivation and energy balance in adults: an emerging issue for consideration by dietetics practitioners.* J Acad Nutr Diet, 2012. **112**(11): p. 1785-97.
2. Benedict, C., et al., *Acute sleep deprivation enhances the brain's response to hedonic food stimuli: an fMRI study.* J Clin Endocrinol Metab, 2012. **97**(3): p. E443-7.
3. Calvin, A.D., et al., *Effects of experimental sleep restriction on caloric intake and activity energy expenditure.* Chest, 2013. **144**(1): p. 79-86.
4. Barf, R.P., et al., *Metabolic consequences of chronic sleep restriction in rats: changes in body weight regulation and energy expenditure.* Physiol Behav, 2012. **107**(3): p. 322-8.
5. Schmid, S.M., 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**(6): p. 1476-82.
6. Markwald, R.R., et al., *Impact of insufficient sleep on total daily energy expenditure, food intake, and weight gain.* Proc Natl Acad Sci U S A, 2013. **110**(14): p. 5695-700.

7. Nedeltcheva, A.V., et al., *Sleep curtailment is accompanied by increased intake of calories from snacks.* Am J Clin Nutr, 2009. **89**(1): p. 126-33.
8. Hogenkamp, P.S., et al., *Acute sleep deprivation increases portion size and affects food choice in young men.* Psychoneuroendocrinology, 2013. **38**(9): p. 1668-74.
9. Chamorro, R.A., et al., *[Sleep deprivation as a risk factor for obesity].* Rev Med Chil, 2011. **139**(7): p. 932-40.
10. Weiss, A., et al., *The association of sleep duration with adolescents' fat and carbohydrate consumption.* Sleep, 2010. **33**(9): p. 1201-9.
11. Lund, H.G., et al., *Sleep patterns and predictors of disturbed sleep in a large population of college students.* J Adolesc Health, 2010. **46**(2): p. 124-32.
12. Go, A.S., et al., *Executive summary: heart disease and stroke statistics--2013 update: a report from the American Heart Association.* Circulation, 2013. **127**(1): p. 143-52.
13. Racette, S.B., et al., *Changes in weight and health behaviors from freshman through senior year of college.* J Nutr Educ Behav, 2008. **40**(1): p. 39-42.