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Original Research

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Bed and Breakfast: The Role of Sleep in Breakfast Intake

Ashley R. MacPherson, M.S.
Virginia Commonwealth University, Richmond, Virginia, United States
https://orcid.org/0000-0001-9654-4640

Natalie D. Dautovich, PhD
Virginia Commonwealth University, Richmond, Virginia, United States
https://orcid.org/0000-0003-2909-7996

Contact: macphersona@vcu.edu

Abstract

Breakfast intake is associated with numerous positive physical and mental health outcomes, yet skipping breakfast remains common in adults. Sleep behaviors show potential as predictors of breakfast intake; the existing literature, however, has methodological limitations. The current investigation explored the association of means and intraindividual variability of a variety of sleep behaviors (bedtime, midsleep, sleep duration) as predictors of the frequency of eating breakfast and frequency of high-protein breakfast intake. Hierarchical regressions were conducted to assess direct associations between sleep behaviors and breakfast intake frequency. Variability in bedtime was a significant predictor of the frequency of breakfast intake, with greater variability associated with less frequent intake. Variability in sleep duration and midsleep was not significant predictors of the frequency of breakfast intake. Both variability and mean sleep behaviors were not significant predictors of the frequency of breakfast intake or high-protein breakfast intake. Because greater regularity in bedtimes was associated with more frequent breakfast intake, it is plausible that there should be increased education regarding the importance of regularity of sleep behaviors.

Keywords: *breakfast, sleep, diet, health behaviors*

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Introduction

Breakfast, the first meal of the day that breaks the nightly fasting period, is often regarded as the most important meal of the day (Spence, 2017). Breakfast has also been shown to have a crucial impact on physical and mental well-being. For example, breakfast intake is associated with better cognitive (Galioto & Spitznagel, 2016; Smith, 1998), mental health (Lee et al., 2016; Lesani et al, 2016), cardiometabolic (Cahill et al., 2013; Kubota et al., 2016), and weight outcomes (Megson et al., 2016). In addition to the positive outcomes

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Correspondence concerning this article should be addressed to Ashley R. MacPherson, 806 W. Franklin St., Richmond VA 23231. Email: macphersona@vcu.edu

associated with breakfast intake, a small body of literature has begun to examine the positive outcomes associated with higher-protein breakfasts. Similar to literature examining general breakfast intake, higher-protein breakfasts have been linked to better cognitive functioning (Galioto & Spitznagel, 2016) and better weight outcomes (Leidy et al., 2015).

Although the positive outcomes associated with breakfast intake are well established, American adults commonly skip breakfast (Kant & Graubard, 2014). Consequently, it is necessary to examine factors that can promote breakfast intake. Because eating breakfast is a behavior that occurs roughly on a 24-hour rhythm, it is likely affected by other daily rhythms, such as the sleep-wake cycle. One model of sleep, the two-process model, described how sleep is regulated by the interaction between two processes, the homeostatic process of sleep and the circadian process of sleep (Borbély et al., 2016). The homeostatic process of sleep is the accumulation of sleep debt throughout wakefulness, which ultimately increases the drive for sleep. The circadian process of sleep involves the synchronizing of sleep and wakefulness to cues such as daylight (Markov et al., 2012). Circadian cycles last approximately 24 hours and are governed by the human “body clock” located in the suprachiasmatic nucleus (Reddy & O’Neill, 2010). This master clock guides the timing of multiple physical, mental, and behavioral processes (Delezie & Challet, 2011). According to the two-process theory of sleep, the circadian process is necessary for maintaining wakefulness during the day. Otherwise, based on the homeostatic process, we would become increasingly sleepy as the day continues (e.g., falling asleep by evening). Although one of the most obvious circadian rhythms in humans is the sleep-wake cycle, feeding behaviors are also regulated by the master biological clock (Escobar et al., 2011). Given the shared chronobiology of sleep and eating behaviors, it follows that disruption in one of these rhythms could negatively impact the other. Consequently, research on breakfast intake and diet has begun to examine the impact of sleep on dietary behaviors, such as eating breakfast.

Although there are many markers of the sleep–wake cycle that warrant consideration as predictors of breakfast intake, currently only one study has specifically examined sleep as a predictor of breakfast intake (Ogilvie et al., 2017). Skipping breakfast was more likely in those who had bedtimes after 00:30 hours (12:30 a.m.), suggesting that sleep timing might predict breakfast behaviors. Circadian disruption was cited as a mechanism underlying the association between sleep timing and breakfast intake, such that later sleep timing disrupts other circadian rhythms, which then impacts breakfast intake (Ogilvie et al., 2017). Although the study by Ogilvie et al. (2017) is novel in that it examined the association between sleep and breakfast intake, only one characteristic of sleep was examined, and the macronutrient composition of breakfast was unexplored. Additionally, sleep timing and breakfast intake were measured using a single-time self-report questionnaire that retrospectively inquired about participants’ usual bedtimes and wake times. The use of retrospective questionnaires is problematic in that this method is vulnerable to recall bias (Shadish et al., 2002). Lastly, this study is limited in that it relied solely on information about mean sleep timing, which does not account for the typical variations in sleep behaviors (Bei et al., 2016; Dillon et al., 2015). Given that highly variable sleep is associated with less healthy dietary behaviors (Duncan et al., 2016; He et al., 2015), there is a need to examine sleep in association with breakfast intake while preserving sleep’s inherent night-to-night variability.

Although there is little research examining sleep patterns as a predictor of breakfast behaviors specifically, there is good justification for examining sleep as a predictor of breakfast intake given sleep’s known association with diet in general. A large body of research has found an association between inadequate sleep duration and weight gain (Chan et al., 2018; Fatima et al., 2016; Itani et al., 2017), suggesting that sleep duration contributed to the energy balance equation (diet and exercise). Additionally, research suggested that later bedtimes are linked to poorer dietary choices, such as increased intake of sugar-sweetened beverages, energy drinks, and fast food (Ogilvie et al., 2017). Of note, the timing of bedtimes appeared to be distinct from chronotypes in that chronotypes refer to the timing of the entire sleep period, whereas the timing of bedtimes focused on the start of the sleep period. Although less research has examined the role of sleep timing in dietary behaviors overall, existing literature supports the hypotheses that short sleep duration, long sleep duration, and later bedtimes would be associated with less frequent breakfast intake.

Beyond the examination of specific sleep behaviors, much of the current research on the association between sleep and breakfast intake has focused on chronotype, or time-of-day preference. These time-of-day preferences are known as chronotypes and can be classified as morning types (preference for wakening early and going to bed early), evening types (preference for wakening late and going to bed late), and intermediate types (preferring neither early wakenings nor late bedtimes; Horne & Östberg, 1976). Chronotypes have been examined as predictors of diet behaviors including breakfast intake. Although specific breakfast composition has not yet been examined, evening chronotypes are associated with greater likelihood of skipping breakfast in general (Meule et al., 2013; Reutrakul et al., 2014; Teixeira et al., 2017). Similar results have been found when investigating the association between chronotype and dietary behaviors and attitudes other than breakfast intake. Those with earlier chronotypes had more servings of fruits and vegetables (Patterson et al., 2016), and those with evening chronotypes had higher total caloric intake, carbohydrate intake, and lipid intake (Teixeira et al., 2017). These results support the contention that earlier chronotypes tend to have healthier dietary behaviors, including breakfast consumption, in comparison with evening chronotypes.

Summary and Purpose of Current Study

A small body of research has begun to identify the importance of sleep and chronotypes as predictors of breakfast intake in adults. However, these studies are limited in that they have only used single-time retrospective self-report measures of sleep or chronotype and breakfast intake. Additionally, less research has investigated how other sleep variables, such as sleep duration, may predict breakfast intake. Lastly, information about the macronutrient composition was unexplored, despite evidence suggesting the benefits of a higher-protein breakfast (Blom et al., 2006; Galioto & Spitznagel, 2016; Leidy et al., 2009; Leidy et al., 2015). Based on the gaps in the current literature, the current study investigated the association between sleep and breakfast in adults. The current study expanded upon existing literature by examining sleep duration, sleep timing, chronotype, and breakfast intake using an archival analysis of data collected with an ecological momentary assessment approach across 14 days. This methodology involved the collection of data in real-time and in a variety of settings and conditions, which reduced recall bias and more accurately reflected the day-to-day lives of participants. Intraindividual variability in sleep timing, sleep duration, and midsleep were also examined because daily variations in sleep patterns are common.

This study had two specific aims:

The first aim was to examine how sleep behaviors predict breakfast intake. Specifically, whether mean sleep duration, bedtime, and midsleep predicted more frequent and higher-protein breakfast intake. Based on a review of the literature, we hypothesized that shorter mean sleep duration, later mean bedtime, and later mean midsleep would be associated with more frequent and higher-protein breakfast intake.

The second aim of the study was to examine how variability in sleep behaviors predict breakfast intake. Specifically, whether variability in sleep duration, bedtime, and midsleep predict frequency and protein level of breakfast intake. Informed by existing research, we hypothesized that greater variability in sleep duration, bedtime, and midsleep would be associated with less frequent and lower protein breakfast intake.

Method

Design

A secondary data analysis was performed using data from baseline assessments and ecological momentary assessments (EMA) included in the Pittsburgh Cold Study 3 (PCS3). The PCS3 was a prospective viral challenge study that collected data from 2007 to 2011. The study aimed to investigate the role of childhood experiences, social variables, psychological variables, and behavioral measures in common cold susceptibility. These data were collected by the Laboratory for the Study of Stress, Immunity, and Disease at Carnegie Mellon University, under the directorship of Sheldon Cohen, PhD, and were accessed via the Common Cold Project (CCP) website (www.commoncoldproject.com). CCP data are made publicly available through a grant from the National Center for Complementary and Integrative Health (AT006694). The conduct of the studies was supported by grants from the National Institute of Allergy and Infectious Diseases (AI066367), with secondary support provided by a grant from the National Institutes of Health to the University of Pittsburgh Clinical and Translational Science Institute (UL1 RR024153 and UL1 TR000005). The study was approved by both the Carnegie Mellon University and University of Pittsburgh Internal Review Boards.

Participants

Participants completed the PCS3. All eligible participants were English-speaking adults in good general health, between 18 and 55 years of age. Participants also had to meet criteria necessary for testing the effects of inoculation of a cold virus, such as having no allergies to egg products, no psychiatric hospitalizations within last 5 years, no regular medication regimens, etc. Data collection for PCS3 took place from 2007 to 2011, and the sample consisted of 213 participants (57.75% men).

Procedure

Prior to participation in the study, all participants completed an informed consent process. During the baseline phase of PCS3, participants completed a pencil-and-paper self-report questionnaire measuring demographic variables (age, sex, race/ethnicity, education, employment status, and income). Additionally, participants completed daily evening telephone interviews 5–7 weeks after completing baseline questionnaires. Measures of the daily sleep variables and breakfast intake variables were collected during the daily evening telephone interviews. The daily interviews took place over 14 days and lasted about 30 minutes each. The interviews were scheduled to be at the same time each evening, between the hours of 5:00 p.m. and 9:30 p.m. Participants who missed interviews were scheduled to have make-up interviews, and if a participant missed more than four of the interviews, they were dropped from the study. Finally, 5 weeks after completing daily interviews, subjects participated in a viral challenge. Participants were administered a common cold virus and observed throughout 5 days of a quarantine protocol.

Measures

Sleep

Daily sleep variables (sleep duration, bedtime, and midsleep) were computed using items from the Daily Social Rhythm Metric included in the daily interviews (Monk et al., 1994). This measure was originally designed to assess the extent to which an individual is regular or irregular in terms of the timing of daily events and was adapted for the PCS3 to be a 16-item measure by excluding one item. The original measure included two optional items that asked participants if they engaged in an activity other than the activities listed in prior items. The adapted measure used in this study only included one of the two optional items. Participants were asked whether/when and with whom they engaged in 16 daily activities (first contact with another person, had morning beverage, etc.). The original measure demonstrated fair test–retest reliability in adults ($r = 0.48$, $p < .002$), good construct validity, and good criterion validity (Monk et al., 1990, Monk et al., 1994).

Sleep variability was computed by calculating intraindividual variability in sleep behaviors for each participant across 14 days. To calculate intraindividual variability, intraindividual standard deviations were calculated and then detrended for time to control for any variations due to the effects of observing behaviors over time. Specifically, detrending for time produces a variable that precisely reflects variability over time that is not due to the effects of time (e.g., practice effects, participation fatigue, etc.), but rather due to inherent variations in the behavior of interest. Detrending was conducted via linear regression analyses for all participants, where time (linear, quadratic, and cubic functions) was input as the independent variable with the sleep variables as the dependent outcomes. This detrending process resulted in measures of sleep variability that were independent of any influences of time. Intraindividual standard deviation values were then calculated for the sleep behavior variables using the time-independent residuals from the aforementioned linear regression analyses.

Sleep duration

Mean sleep duration was calculated by subtracting the time participants went to sleep from the time participants woke up and taking the average across 14 days of daily interviews. Variability in sleep duration was quantified by calculating intraindividual variability in sleep duration over 14 days of daily interviews.

Bedtime

Bedtime was assessed using the item that asks participants what time they went to sleep. Mean bedtime was calculated by taking the average of the bedtime values over 14 days. Variability in bedtime was quantified by calculating intraindividual variability in bedtime over 14 days of daily interviews.

Chronotype

Midsleep was used as an indicator of chronotype. Midsleep, defined as the midpoint between sleep onset and wake time, is a unique indicator of chronotype that takes into account both sleep duration and sleep timing (Reutrakul et al., 2014). Midsleep was assessed using established metrics (Reutrakul et al., 2014) to calculate mean midsleep values and midsleep variability. Mean midsleep values were calculated by subtracting the time participants went to sleep from the time they woke up, dividing this by two, and adding this value to the time participants went to sleep. Mean midsleep was calculated as the average of midsleep values across 14 days. Variability in midsleep was quantified by calculating intraindividual variability in midsleep over 14 days of daily interviews.

Frequency of breakfast intake

Breakfast intake was assessed by calculating the frequency of breakfast intake over 14 days of daily interviews. Breakfast intake was measured using an item from the Daily Interview Health Behavior scale, which was created for the PCS3 and informed by prior research (Brissette & Cohen, 2002; Cohen et al., 2009; Cohen & Lemay, 2007). Participants were asked "what did you have for breakfast this morning?" Responses were coded as either consuming breakfast or not consuming breakfast based on the open-ended responses.

Frequency of high-protein breakfast intake

High-protein breakfast intake was assessed by calculating the frequency of high-protein breakfast intake over 14 days of daily interviews. High-protein breakfast intake was measured using an item from the Daily Interview Health Behavior scale, which was created for the PCS3 and informed by prior research (Brissette & Cohen, 2002; Cohen et al., 2009; Cohen & Lemay, 2007). Participants were asked "what did you have for breakfast this morning?" Responses were coded as either consuming a high-protein breakfast or not consuming a high-protein breakfast based on the open-ended responses.

Potential covariates

Although the current study focused on the associations between sleep and breakfast intake; there are potential covariates that are important to consider. Age, income, and education have been associated with breakfast intake (Lee et al., 2016; Morgan et al., 1986; Walker & Christopher, 2015). Additionally, race/ethnicity, gender, income, and employment status have been associated with sleep (Crain et al., 2018; El-Sheikh et al., 2014; Mallampalli & Carter, 2014). Therefore, potential covariates examined in the current study included age, income, education, gender, race/ethnicity, and employment status. These variables were obtained from the baseline questionnaires. The measure of race/ethnicity consists of six categories (e.g., White/Caucasian, Black/African-American, Native American/Eskimo/Aleut, Asian/Pacific Islander, Hispanic/Latino, Other) and educational level includes nine categories (did not finish high school to doctoral degree). Employment status was assessed by asking participants if they were employed and coded as “yes” or “no.” Lastly, annual income is a continuous variable that is based on a question assessing participants’ total household income.

Statistical Analyses

To assess the current study’s aims, hierarchical regressions were conducted while controlling for selected covariates. Power calculations using G*Power (Faul et al., 2009) suggested that a hierarchical regression analysis with three predictors, and a maximum of seven potential covariates, would require a sample size of at least 55 participants to predict an effect size of at least .15 at an alpha level of .05, with a power of .80. In the current study, assuming a medium effect size, 213 participants was sufficient to detect an effect.

Results

Data Preparation and Data Cleaning

SPSS 24.0 was used for all data analyses. To assure that data met assumptions of planned analyses, data were cleaned, and descriptive statistics were first calculated (means, standard deviations, and frequencies). Skewness, kurtosis, and outliers for all main variables and covariates of interest were calculated to check assumptions of normality and outliers. Skewness and kurtosis values for mean midsleep as well as frequency of breakfast intake and high-protein breakfast intake were close to or below an absolute value of 1, indicating that they were approximately normally distributed. Additionally, intraindividual variability of wake time, bedtime, duration, and midsleep presented with normal distributions. Mean sleep timing and income were positively skewed and had positive kurtosis (i.e., values greater than 1). After winsorizing identified outliers for each variable, newly calculated skewness and kurtosis values indicated the variables were normally distributed. Mean sleep duration and mean wake time were negatively skewed and had negative kurtosis (i.e., values less than -1). After winsorizing identified outliers for each variable, newly calculated skewness and kurtosis values indicated the variables were normally distributed. In addition to a review of skewness, kurtosis, and outliers, assumptions of independence, normality, multicollinearity, and homoscedasticity were assessed. All remaining assumptions were sufficiently met. Less than 4% of the data from daily diaries used to calculate sleep, affect, and breakfast variables were missing.

Descriptive and Correlational Results

First, bivariate correlations were conducted between potential covariates (weight, age, income, education, race, gender, employment status) and dependent variables (breakfast intake frequency and high-protein breakfast intake frequency) to identify potential covariates to include in subsequent analyses. Income was significantly negatively correlated with breakfast intake frequency, and education and employment were significantly positively correlated with high-protein breakfast intake frequency. Therefore, income, education, and employment were included as covariates in all statistical models. Mean wake time was also included as a covariate in models assessing mean sleep characteristics as independent variables, and intraindividual variability of wake time was included as a covariate in models assessing intraindividual variability of sleep characteristics as independent variables.

Next, descriptive statistics for sociodemographic characteristics were examined (Table 1). On average, participants were 30.32 years old (*SD* = 10.91), primarily male (57.70%), and mostly White (65.40%). Descriptive statistics were also examined for variables of interest (Table 2). Participants had an average of 8.44 (*SD* = 4.53) days of breakfast intake of a possible 14 days, and an average of 3.40 (*SD* = 3.39) days of high-protein breakfast intake of a possible 14 days. Regarding sleep characteristics, the sample had a mean bedtime of approximately 12:30 a.m. (SD = 86.38 minutes), a mean midsleep of approximately 4:30 a.m. (*SD* = 87.65 minutes), a mean wake time of approximately 8:45 a.m. (*SD* = 93.37 minutes), and a mean sleep duration of approximately 7.61 hours (*SD* = 67.83 minutes). Next, Pearson correlations were conducted to examine bivariate associations between all main variables of interest (i.e., mean sleep characteristics, intraindividual variability of sleep characteristics, breakfast intake frequency, and high-protein breakfast intake frequency; Table 3).

Table 1: *Sociodemographic Characteristics of Participants*

	N	Percentage (%)
Age		
18–29	133	64.25
30–39	25	12.08
40–49	27	13.04
50–55	22	10.63
Gender		
Male	120	57.97
Female	87	42.03
Race/Ethnicity		
White/Caucasian	136	65.70
Black/African American	58	28.02
Native American/Eskimo/Aleut	1	.37
Asian/Pacific Islander	4	1.93
Hispanic/Latino	3	1.45
Other	5	2.42
Education		
Did not finish high school	6	2.90
High school graduate	59	28.50
Less than 2 years of college	41	19.81
Associate's degree or equivalent	49	23.67
Bachelor's degree	43	20.77
Master's degree	8	3.86
Doctoral degree	2	0.97

Table 2: *Descriptive Statistics for Breakfast, Sleep, and Affect Variables*

	M	*SD*	Range
Breakfast			
Frequency of breakfast intake over 14 days	8.44	4.53	0–14
Frequency of high-protein breakfast intake over 14 days	3.40	3.38	0–14
Sleep			
Wake time (Military Time)	08:44	93.37 minutes	04:22–12:58
Bedtime (Military Time)	00:39	86.38 minutes	21:02–05:41
Sleep duration (minutes)	456.74	67.83	235.77–673.93
Midsleep (Military Time)	04:28	87.65 minutes	00:34–06:26

Table 3: *Correlations Between Variables of Interest*

	Breakfast intake frequency	**High-protein breakfast intake frequency**
High-protein breakfast intake frequency	-.07	
Mean bedtime	-.28**	-.03
Mean sleep duration	-.06	-.10
Mean midsleep	-.30**	-.07
Mean wake time	-.34**	-.08
IIV bedtime	-.17*	-.02
IIV sleep duration	-.25**	-.04
IIV midsleep	-.15*	-.02
IIV wake time	-.19**	-.02

Note. **p* < .05, ***p* < .001

Association between mean sleep variables and breakfast intake

To investigate how well mean sleep duration, bedtime, and midsleep predicted frequency of breakfast intake when controlling for mean wake time, income, education, and employment, a hierarchical linear regression was computed. Mean wake time, income, education, and employment were entered as covariates into the first model and were significantly associated with breakfast intake, $F(4, 193) = 326.31$, $p < .001$, $R^2 = .83$. Lower income ($\beta = -.87$, $t(193) = -28.415$, $p < .001$) and lower education ($\beta = -.06$, $t(193) = -2.03$, $p = .044$) were associated with more frequent breakfast intake. Furthermore, earlier wake time (β -.13, $t(193) = -4.11$, $p < .001$) was associated with more frequent breakfast intake. This initial model shows that 83.00% of the variance in breakfast intake frequency can be predicted by mean wake time, income, education, and employment of participants. When mean sleep duration, bedtime, and midsleep were added to the model, they did not significantly improve the prediction $\Delta R^2 = .01$, $\Delta F(3, 190) = 2.47$, $p = .063$. In the final model, income was the only predictor that remained significant ($\beta < .01$, $t(190) = -28.28$, $p < .001$) with lower income predicting more frequent breakfast intake.

Table 5: *Mean Sleep Variables as Predictors of High-Protein Breakfast Intake*

	β	*t*	*F*	R^2
Model 1			4.97	.09*
Income	.08	1.21		
Education	.18	2.56*		
Employment	.19	2.82*		
Mean wake time	-.12	-1.67		
Model 2			3.05	.10*
Income	.07	1.05		
Education	.17	2.51*		
Employment	.19	2.73*		
Mean wake time	-.03	-.14		
Mean midsleep	-2.09	-.70		
Mean bedtime	2.02	.69		
Mean sleep duration	.71	.61		

Note. $^*p < .05$. $^{**}p < .001$.

Association between intraindividual variability of sleep variables and breakfast intake

To investigate how well intraindividual variability of sleep duration, bedtime, and midsleep predicted frequency of breakfast intake when controlling for intraindividual variability of wake time, income, education, and employment, a hierarchical linear regression was computed. Intraindividual variability of wake time, income, education, and employment were entered as covariates into the first model and significantly predicted frequency of breakfast intake, F (4, 191) = 211.22, $p < .001$, $R^2 = .82$. Both lower income (β = -.90, t (188) = -28.34, $p < .001$) and lower education (β = -.06, t (188) = -2.04, $p = .043$) were associated with more frequent breakfast intake. This initial model shows that 81.60% of the variance in breakfast intake frequency is predicted by the intraindividual variability of wake time, income, education, and employment of participants. When intraindividual variability of sleep duration, bedtime, and midsleep were added to the model, they significantly improved the prediction $\Delta R^2 = .01$, ΔF (3, 188) = 4.63, $p = .004$ (Table 6). Intraindividual variability of bedtime was a significant individual predictor (β = -.14, t (188) = -2.06, $p = .041$) with greater variability in bedtimes associated with less frequent breakfast intake. Income (β = -.89, t (188) = -28.71, $p < .001$) and education (β = -.07, t (188) = -2.37, $p = .052$) were also significant individual predictors of breakfast intake frequency. Lower income and education were associated with more frequent breakfast intake.

Table 6: *Intraindividual Variability of Sleep Variables as Predictors of Breakfast Intake*

	β	*t*	*F*	R^2
Model 1			211.22	.82**
Income	-.99	-28.34**		
Education	-.06	2.04*		
Employment	<-.01	-.05		
IIV wake time	-.03	-.96		
Model 2			129.55	.83**
Income	-.89	-28.71**		
Education	-.07	-2.37*		
Employment	-.01	-.20		
IIV wake time	-.04	-.57		
IIV midsleep	.13	-1.47		
IIV bedtime	-.14	-2.06*		
IIV sleep duration	-.06	-1.41		

Note. Intraindividual variability (IIV). *$p < .05$. **$p < .001$.

Discussion

The aim of the current study was to uncover what aspects of sleep are connected to healthier breakfast habits, including consuming breakfast more often and consuming higher-protein breakfasts. Although no associations were observed between mean sleep characteristics and breakfast behaviors, variability in bedtimes was associated with breakfast behaviors. Specifically, having more regular bedtimes was associated with consuming breakfast more often.

The current study's finding that more variable bedtimes are predictive of less frequent breakfast intake is similar to a broader body of research that found variability in sleep behaviors was associated with negative health outcomes including multiple physical health conditions, higher body mass index, weight gain, and unipolar and bipolar depression symptoms (Bei et al., 2016). Additionally, the current findings support research more specifically related to diet outcomes that has shown highly variable sleep is associated with less healthy dietary behaviors (Duncan et al., 2016; He et al., 2015). Specifically, more variable sleep, but not mean sleep duration, was associated with less healthy dietary behaviors, such as increased frequency of snack consumption, increased overall daily caloric intake (He et al., 2015), and decreased habitual dietary quality (Duncan et al., 2016). The current study builds upon these findings by examining the specific healthy dietary behavior of consuming breakfast daily.

Although the process by which variable bedtimes negatively predicts health behaviors is not fully known, it is possible that more variable bedtimes disrupt the sleep-wake cycle, which then contributes to the misalignment of other daily rhythms. Circadian rhythms are not only responsible for guiding the sleep-wake cycle, they also guide processes such as hormonal secretions controlling hunger and fullness and feeding behaviors (Delezie & Challet, 2011). Since the sleep-wake cycle and dietary behaviors follow daily rhythms, disruption of the timing of one cycle likely contributes to disruption in other cycles. Therefore, variability in sleep may disrupt other daily rhythms, such as feeding behaviors like breakfast intake (Escobar et al., 2011). For example, an individual may exhibit variable bedtimes by going to sleep at 1:00 a.m. one night and 8:00 p.m. the next night. This variability in bedtime could contribute to misalignment of the sleep-cycle and subsequent effects on other circadian rhythms. Daily rhythms of hormonal secretions that guide feeding behaviors could misalign, influencing hunger levels. When the sleep-cycle and other daily rhythms are aligned, hunger should occur in the morning to encourage the consumption of breakfast. In this example, after having highly irregular bedtimes, the individual may not experience hunger in the morning and, therefore, be less likely to consume breakfast. Although this study found variability in bedtime was associated with less frequent breakfast intake, mean sleep variables did not emerge as predictors of breakfast behaviors. Variations in sleep behaviors are common and, in fact, within-person variability in sleep behaviors is more prevalent than between-person variability (Dillon et al., 2015). Therefore, variability in sleep behaviors may provide a more accurate picture of true sleep behaviors in comparison with relying on mean information of sleep (Bei et al., 2016).

There are also unique characteristics of the sample that may have influenced the study findings. A large portion of the sample, 40.6%, reported having no part-time or full-time employment. The unemployment rate for the U.S. population was 3.6% as of January 2020, which is substantially lower than the unemployment rate found in the current study's sample (Bureau of Labor Statistics, 2020). The sample's employment characteristics suggest that the participants had the opportunity to follow different and more flexible schedules than typical adults, which could have increased the sleep variability in the sample. Therefore, variability may be an especially relevant marker of sleep in this sample, as opposed to mean sleep characteristics, as it captures the more variable and flexible schedules of participants.

To encourage more regularity in bedtimes, and potentially increase the likelihood of consuming breakfast more frequently, increased awareness of healthy sleep behaviors, such as regular bedtimes, is necessary. As such, clinical implications of the current study include increasing awareness of core sleep hygiene practices, such as maintaining regular bedtimes and wake times across weekdays and weekends. Additionally, other sleep hygiene recommendations that could improve regularity in bedtimes include spending less time in bed, not using electronics before bedtime, and setting up a consistent bedtime routine (Stepanski & Wyatt, 2003). Engaging in these sleep hygiene behaviors better entrains the circadian system to encourage healthful sleep and can become a cue for feeling sleepy at a similar time each night. By not using electronics before bed, and not spending excess time in bed (e.g., using the bed for activities other than sleep or sex), individuals may be better able to fall asleep easier, which then encourages more regular bedtimes.

The current study has many strengths and builds upon the previous literature; however, there are several limitations to address. Importantly, the study results need to be interpreted within the context of the unique study design. As participants were required to take part in a 5-day quarantine for the study's protocol, the employment and income characteristics of the sample may reflect the type of participant who is able to meet this eligibility criteria. It is likely that those who are unemployed, or have very flexible work schedules, are the type of participants who can participate in a quarantine protocol. Accordingly, the median annual household income of the current sample is lower than recent population estimates. The current sample's median annual household income between 2007 and 2011 was $12,500; however, reports from the U. S. Census Bureau indicate that the median household income in 2016 was $59,039 (Semega et al., 2018). Additionally, as mentioned earlier, it is of note that 40.6% of the sample reported having no part-time or full-time employment. Although no occupation-specific data were collected, it is possible that the employment and income demographics describe a sample of college students. The age of most of the sample was consistent with college-aged students (64.3% between the ages of 18 and 29), as the National Center for Education Statistics (2016) found that 75.97% of college students were between the ages of 18 and 29 in 2015. Consequently, it is possible that most of the sample may have been enrolled as students and, hence, had more flexible schedules that allowed them to participate in a quarantine protocol.

The sleep behaviors of the sample are also divergent from research using nationally representative samples. The current sample reported a mean bedtime of 12:30 a.m.; however, 73% of American adults go to bed between 10:00 p.m. and 12:00 a.m. on both weekdays and weekends (National Sleep Foundation, 2005). The current sample also reported a mean wake time of 8:45 a.m., which is much later than what 72% of American adults report (between 5:00 a.m. and 8:00 a.m.; National Sleep Foundation, 2005). These findings suggest that the current sample may have a different overall timing of the sleep period compared with most American adults, which could have differentially affected their breakfast behaviors. Despite the delayed timing of the sleep period, the sample had an average sleep duration of 7.61 hours a night, which is similar to averages reported by American adults (6.8–7.4 hours; National Sleep Foundation, 2005) and meets the National Sleep Foundation recommendations of 7–9 hours of sleep a night (National Sleep Foundation, 2005).

Although the current study includes several limitations, there are strengths in the study's design. Prior research has measured sleep and breakfast intake using one-time self-report questionnaires (Ogilvie et al., 2017). This methodology does not provide enough information to assess fluctuations in sleep behaviors, which are known to be highly variable (Bei et al., 2016). Additionally, retrospective single-time assessments are more subject to recall bias. Therefore, the current study used ecological momentary assessment over 14 days to capture the variability in these behaviors and reduce the risk of recall bias. The current study also calculated intraindividual variability in sleep behaviors as opposed to simply relying on the means of variables.

This study expanded upon prior literature by using ecological momentary assessment to measure sleep behaviors concurrently with breakfast behaviors; other methodological approaches, however, should be considered in the future. As actigraphy is regarded as an ecologically valid objective measure of sleep behavior, future studies should utilize actigraphy over 1–2 weeks to more accurately measure sleep behaviors in addition to sleep diaries (Ancoli-Israel, 2015). Additionally, the use of multiple within-day assessments may be beneficial. This approach using multiple within-day assessments could provide more insight into the within-day variations in daily behaviors that may be affected by bedtime variability. Future research should also account for which day of the week measurements are taken, as sleep behaviors are altered on weekend days in comparison with weekdays (Knutson et al., 2006). Additionally, it would be beneficial to measure breakfast intake, particularly the dietary quality and components of breakfast intake, using measures like dietary recalls to provide more information on macronutrient, micronutrient, and caloric composition of breakfasts. Since variability in bedtime may misalign circadian rhythms, future research should also consider examining other variables associated with circadian rhythms. For example, including measures that assess additional sleep characteristics (sleep quality, daytime fatigue), daily schedules, and ratings of hunger and fullness may provide enough information to assess how variability in bedtime is associated with decreased breakfast intake. Overall, these suggestions for future research would help better disentangle the relation between sleep and breakfast behaviors.

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