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# What Role Does Sleep Play in Weight Gain in the First Semester of University?

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## Abstract

**Objectives—**We hypothesized that shorter sleep durations and greater variability in sleep patterns are associated with weight gain in the first semester of university.

**Methods—**Students (N=132) completed daily sleep diaries for 9-weeks, completed the MEQ (chronotype) and CES-D (depressed mood) at week9, and self-reported weight/height (weeks 1&9). Mean and variability scores were calculated for sleep duration (TST,TSTv), bedtime (BT,BTv), and wake time (WT,WTv).

**Results—**An initial hierarchical regression evaluated (block1) sex, ethnicity; (block2) depressed mood, chronotype; (block3) TST; (block4) BT, WT; and (block5; $R^2$change=0.09, p=0.005) TSTv, BTv, WTv with weight change. A sex-by-TSTv interaction was found. A final model showed that ethnicity, TST, TSTv, and BTv accounted for 31% of the variance in weight change for males; TSTv was the most significant contributor ($R^2$ change=0.21, p<0.001).

**Conclusions—**Daily variability in sleep duration contributes to males' weight gain. Further investigation needs to examine sex-specific outcomes for sleep and weight.

### Keywords

sleep; weight gain; sleep duration; sleep variability; sleep patterns

Obesity rates have risen with an estimated 1 in 3 American teens and young adults classified as overweight or obese (Sira & Pawlak, 2010). Adolescents who are overweight and obese

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increase their risk of physical morbidity and premature mortality as adults (Reilly & Kelly, 2011). They face numerous potential health consequences, including Type II diabetes, obstructive sleep apnea, metabolic disorder, asthma, cardiovascular disease, and poor health-related quality of life (Wille et al., 2010). Children, adolescents, or young adults who are overweight also carry an increased risk of being overweight or obese into adulthood (Serdula et al., 1993). These risks highlight the need to find modifiable mechanisms that could inform prevention strategies and interventions to reduce the risk for and rates of obesity.

Several studies show an association between being overweight or obese and sleep, specifically with shortened sleep duration, poor sleep quality, later bedtimes and variable sleep times from day-to-day (Cappuccio, D'Elia, Strazzullo, & Miller, 2010; Chaput et al., 2010; Hart, Larose, Fava, James, & Wing, 2012; Moore et al., 2011). Short sleep, the most frequent sleep behavior examined, is associated with obesity (Garaulet et al., 2011), hyperglycemia (Koren et al., 2011), and adverse changes in metabolic factors (Koren et al., 2011; Leproult & Van Cauter, 2010). In addition, insufficient sleep is associated with poor impulse control, risk-taking behaviors, and other cognitive and psychological deficits (Beebe, 2011; Carskadon, Acebo, & Jenni, 2004; Roberts, Roberts, & Xing, 2011) that may contribute to weight gain.

Other reports, however, suggest that short sleep may not independently influence obesity (Olds, Maher, & Ridley, 2011; Sung et al., 2011). For instance, Olds and colleagues' naturalistic longitudinal study found that later bedtimes and wake times—but not sleep duration—were associated with reduced physical activity and higher weight (2011). These conflicting reports on the role of sleep duration may be due in part to the influence of sleep/wake schedules and variability in the timing of sleep and its duration. A few studies support a connection between bedtime and obesity suggesting that later bedtimes allows for opportunities to consume more calories while also decreasing access to healthier food options (Baron, Reid, Kern, & Zee, 2011; Sato-Mito, Shibata, Sasaki, & Sato, 2011). In addition, adolescents with greater variability in their sleep schedules are more likely to have higher body mass indexes than their peers with more regular schedules (Moore et al., 2011). In adults, shift workers are more likely to be overweight and obese than day workers, perhaps due to a chronic circadian misalignment (Antunes, Levandovski, Dantas, Caumo, & Hidalgo, 2010; Esquirol et al., 2009; Scheer, Hilton, Mantzoros, & Shea, 2009) or a mismatch in biologically-driven and society-imposed sleep and wake times (Antunes et al., 2010). Despite evidence that other sleep factors beyond sleep duration contribute to obesity, previous studies have not compared these factors simultaneously; thus independent contributions of sleep duration, timing, and variability to obesity are unclear.

An additional factor in the consideration of sleep timing is chronotype, a measure that reflects preferred times of sleep and wakefulness (Horne & Ostberg, 1976). Inconsistent connections exist between chronotype and obesity-related measures; however, literature supports an association of evening preference in adolescents with self-reported higher levels of inactivity (Urbán, Magyaródi, & Rigó, 2011), depressed mood, and lifestyle irregularity (Fleig & Randler, 2009). Later meal times are also a common occurrence for evening types that can contribute to obesity (Baron et al., 2011).

Prior literature suggests that males may be more susceptible to the adverse weight outcomes associated with shorter sleep durations (Araujo, Severo, & Ramos, 2012; Knutson, 2005; Sayon-Orea et al., 2013; Skidmore et al., 2013), while others show that females are at greater risk for weight gain (Quick et al., 2013). Additional research evaluating the effects of short sleep durations and sleep variability in males versus females is needed to understand how sex may interact with sleep patterns to impact weight.

Mixed and inconsistent findings highlight a need for further evaluation of the roles of sleep duration, timing, and variability in weight gain. We used the first semester of college as a model system to pursue this investigation because of expected changes in weight (Lloyd-Richardson, Bailey, Fava, Wing, & Tobacco Etiology Research, 2009) and sleep patterns (Forquer, Camden, Gabriau, & Johnson, 2008) that occur in this transitional timeframe. We hypothesized that sleep duration, sleep timing, and sleep variability are each independently associated with weight gain in first-semester college students.

# METHODS

## Procedures

The current analyses utilize data from a larger study examining the effects that transitioning from high school to the first semester of college has on sleep and mood. In the spring of 2011, students over the age of 18 years admitted to Brown University as first year students were contacted and invited to complete a brief paper survey. Just before fall classes began, students were re-contacted and invited to participate in a second study. After providing informed consent the week classes began, students received instructions via email on how to log into a secure online portal to complete daily sleep diaries. Diaries were available to complete each day from early evening until the next morning from September 7, 2011 to November 15, 2011. The first time participants logged into the portal, they were given the option to receive daily e-mail reminders to complete the sleep diaries. Students who opted in received an email around 1700 each night reminding them to login and complete their daily diary. Included in the email was a direct link to the diary.

Students were queried about their initial weight and height on the second day they logged into complete a diary. During week 9, students completed a final survey that consisted of several measures including chronotype, depressed mood, and a self-assessment of current weight and height. Students received $1 per diary they completed with bonuses for completing three consecutive diaries and seven consecutive diaries. Students also received $18 for completing the final survey. At the study's conclusion, students were invited to attend a debriefing session where aggregated data were shared with students. This study was approved by the Lifespan Institutional Review Board. The software Illume™ (DatStat, Inc.) was used to create the surveys and collect the data online. Analyses were performed using SPSS 18 (IBM®).

**Height and weight assessment—**Students were instructed to measure and weigh themselves before reporting height and weight each time (“please measure your current [height/weight] for accuracy”). Students reported their weight and height in units according to their preference (lb or kg; ft and in or cm). All values were converted to kg and cm for analyses. We evaluated height and weight data at each time point for extreme outliers. Previous literature shows that young and normal weight adults show relatively low bias in self-reported weight (Stommel & Schoenborn, 2009) and height remains fairly stable during the freshman year of college for males and females (Lloyd-Richardson et al., 2009). In order to examine reliability of these data, stability in self-reported height was a proxy for reliability of self-reported data since the primary outcome was weight change. Students were excluded if they reported a decrease in height (12%), an increase over 5 cm (1%), or did not report height (1%). Weight change was computed from self-reported weights at weeks 1 and 9.

**Chronotype—**The Horne-Östeberg Morningness Eveningness Questionnaire (Horne & Ostberg, 1976), a 19-item scale, assessed current circadian preference at week 9. Total scores on the MEQ ranged from 26-65 with lower scores indicating an evening preference and higher scores indicating a morning preference. Internal consistency for our sample on the MEQ was Cronbach's alpha = .76.

**Depressed mood—**At week 9, the Center for Epidemiologic Studies-Depression Scale (Radloff, 1977), a 20-item scale, assessed depressed mood during the previous week. Total scores on the CES-D ranged from 1-46 with higher scores indicating more depressive symptomology. Internal consistency on the CES-D was Cronbach's alpha = .69.

**Sleep duration, timing, and variability—**Daily online sleep diaries queried sleep patterns across the nine-week period from which the following variables were derived for each diary: total sleep time (TST), bedtime (BT), and wake time (WT). BT was defined as the time the participant reported attempting to fall asleep and WT was defined as the time the student reported waking for the day. TST was defined by the interval between reported bedtime and reported wake time subtracting any reported periods of wakefulness (i.e., latency to sleep onset and middle of the night awakenings). For these analyses, “TST” and “sleep duration” refer to the same interval – the calculated duration, or amount, of reported sleep. Individual mean scores were calculated across the nine-week period for TST, BT, and WT.

An *a priori* decision was made to calculate variability scores for each measure using the mean range in 4-day moving windows (range computed for days 1-4, days 2-5, days 3-6, etc.). The difference was calculated between the smallest and largest values within each window for each measure. Windows required at least two days of data for variability scores to be calculated. Average daily completion rate was 94.6% (range = 89 – 98%). Fridays and Saturdays showed lower completion rates (mean = 89% and 91%, respectively); however, Sunday night completion (mean = 97%) was on par or better than most other nights providing a solid sampling of week days and weekends.

These ranges were then averaged to determine the mean variability in total sleep time (TSTv), bedtime (BTv), and wake time (WTv). For these analyses, “TSTv” and “sleep duration variability” refer to the same measure. Calculating the variability in this way allowed for an evaluation of the variability within the context of the adjacent days versus in relation to participants’ means across 9 weeks. Variability was evaluated with a day-to-day model to account for the flexibility students have with their schedules resulting in "weekend" being individually-defined versus the "typical" weekday/weekend schedule with Saturday and Sunday being considered weekend days.

### Data analyses

We explored the effects of self-reported sleep duration (total sleep time), timing (bedtime, wake time), and sleep variability (variability in sleep duration and times) on weight change in the first semester of college using hierarchical regression analysis. Interaction effects were also examined between sleep patterns and sex. The interactions between sleep parameters and sex were also entered into a hierarchical regression to examine potential differences in the level of impact the different sleep parameters have on males versus females. Sex, race/ethnicity, depressive mood symptoms (CES-D scores), and chronotype (MEQ scores) were evaluated as predictors because of previously identified associations with sleep (Beebe, 2011; Fernández-mendoza et al., 2010) and weight (Luppino et al., 2010; Sato-Mito et al., 2011). Model significance was set at ($p < .05$). Models were evaluated for homoscedasticity and multicollinearity. Tolerance values are reported.

## RESULTS

### Participants

Students were 18-20 years old (mean=18.6 years; SD = 0.4) and included 71 females (54%) and 61 males (46%). See Table 1 for race/ethnicity distribution. Two-hundred sixty one students completed at least one daily diary of which 232 students (89%) continued participation until the study conclusion. On average, students completed 56 diaries (SD = 3; range = 46 - 60) and at least 71% of the students completed 100% of the diaries each week (range = 71.2 – 86.4%). Of the 232 participants who completed the study, data were analyzed for the 132 participants who met the inclusion criteria of (a) providing height and weight at weeks 1 and 9, (b) completing the CESD and MEQ, and (c) completing at least 4 sleep diaries per week. Examination for systematic attrition bias found no significant difference between those students included in analyses and those who were not with regards to sex or race/ethnicity.

### Weight status

Students' average weight was 64.3 kg (SD = 11; range = 45.8-120.7) at week 1 and 65.3kg (SD =11; range = 45-120) at week 9. Bivariate correlation analysis showed weight at weeks 1 and 9 were significantly correlated ($r = 0.98$, $p < 0.001$). Males' average weight was 70.6 kg (SD = 11) and 71.8 kg (SD = 13) for weeks 1 and 9, respectively; females' average weights were 59 kg (SD = 8) and 59.6 kg (SD = 7). Mean calculated weight change was .9 kg (SD = 2) with an average weight gain of 2.5 kg (SD = 1.5) in students whose weight increased and an average weight loss of 1.6 kg (SD = 1) in students whose weight decreased.

Mean calculated BMI was 21.9 (SD = 3; males: mean = 22.5 [SD = 3]; females: mean = 21.3 [SD = 3]) at week 1 and 22.1 (SD = 3; males: mean = 22.8 [SD = 3]; females: mean = 21.5 [SD = 3]) at week 9. Based on calculated BMI, BMI categories were 9% underweight, 76.5% normal weight, 13.6% overweight, and 1% obese for week 1 (males: 7%, 75%, 16%, and 2%; females: 11%, 78%, 11%, 0%; respectively) and 7.6%, 76.5%, 14.4%, and 1.5%, respectively, for week 9 (males: 3%, 75%, 18%, 3%; females: 11%, 78%, 11%, 0%; respectively)

## Sleep duration and timing

Table 1 shows sleep duration and timing by sex and race/ethnicity. All times are reported in 24-hour format. Students' mean reported sleep duration across the nine weeks was 7 hr 15 min (SD = 36 min). On average, they reported going to bed at 0136 (SD = 54 min) and waking at 0936 (SD = 42 min). Variability computations across 4-day windows show average variability of 2 hr 37 min (SD = 41 min) in total sleep times, 2 hr and 12 min (SD = 36 min) in bedtimes, and 2 hr and 42 min (SD = 47 min) in wake times. A multivariate ANOVA showed significant differences between the sexes for mean bedtime ($F$[1, 130] = 6.12, $p = 0.015$), wake time ($F$[1, 130] = 8.64, $p = 0.004$), and wake time variability ($F$[1, 130] = 9.48, $p = 0.003$). Compared to males, females went to bed earlier, woke earlier, and showed less variability in their wake times. The sexes, however, did not differ statistically in their mean sleep duration ($F$[1, 130] = 0.02, $p = 0.888$), sleep duration variability ($F$[1, 130] = 0.03, $p = 0.803$), or bedtime variability ($F$[1, 130] = 0.22, $p = 0.638$).

## Associations between sleep and weight

Bivariate correlations for each predictor and the outcome variable are shown in Table 2. An exploratory repeated measures ANOVA was performed to examine group differences in sleep patterns between students who gained weight (N=68) and students who did not (N=64). This initial analysis did not include covariate variables, but instead was a rudimentary examination of possible group differences. Findings showed that the amount of sleep variability differed significantly between students who gained weight and those who did not, $F(5, 3.191) = 27094.72$, $p < 0.001$. Specifically, students who gained weight showed greater variability in daily sleep duration (TSTv = 2h 48m) compared to students who did not gain weight (TSTv = 2h 30m; $p = 0.015$). While not significant, trend findings suggested that students who gained weight compared to students who did not reported shorter mean sleep durations ($p = 0.069$) and more variable bedtimes ($p = 0.097$), and wake times ($p = 0.074$).

A hierarchical regression analysis was performed to determine the contribution of each variable in explaining the change in weight (Table 3). The intact traits sex and race/ethnicity were entered into the first block. Depressed mood was entered in block 2 as prior research supports an association between weight and depression although findings have been mixed (Dave, Tennant, & Colman, 2011; Dong et al., 2013; Luppino et al., 2010). MEQ score, a measure of chronotype/circadian phase preference, was also entered in in block 2 of the initial hierarchical regression analysis prior to measures of sleep patterns collected during the study. Total sleep time was entered in block 3 to account for the impact insufficient sleep on weight before examining timing and variability. The timing variables bedtime and wake time were entered in block 4, and sleep variability measures (TSTv, BTv, WTv) in block 5 allowing examination of the contribution of sleep duration variability after accounting for other potential sleep-related predictors. The initial model accounted for 12% of the variance in weight change, $F(3, 128) = 2.71$, $p = .005$. Sleep timing (BT, WT) did not account for a significant portion of the variance; however, 3% of the variance in weight gain could be accounted for by sleep duration. An additional 9% of variance could be accounted for by sleep duration variability.

Hierarchical regression analyses examined the potential for interactions between sex and sleep behavior to evaluate whether certain sleep behaviors differentially impact weight gain in the sexes. Analyses were run using sex (block 1), an individual sleep behavior (block 2), and the interaction between sex and the individual sleep behavior (block 3). No interaction effect was found between sex and sleep duration ($R^2$ change = 0.01, $p = 0.177$), bedtime ($R^2$ change = 0.01, $p = 0.356$), wake time ($R^2$ change = <0.01, $p = 0.679$), or wake time variability ($R^2$ change = 0.01, $p = 0.417$); however, hierarchical regression analyses examining the interactions between (1) sex and sleep duration variablity and (2) sex and bedtime variability were significant. Sex (block 1), TSTv (block 2), and the interaction between sex and TSTv accounted for 16% of the variability in weight change, $F(3, 128) = 7.92$, $p < .001$, such that variability in sleep duration was a significant predictor of weight change for males ($r = 0.53$, $p < 0.001$), but not for females ($r = 0.09$, $p = 0.236$). Sex (block 1), BTv (block 2), and the interaction between sex and BTv accounted for 8% of the variability in weight change, $F(3, 128) = 3.7$, $p = 0.014$. Like TSTv, bedtime variability was a significant predictor of weight change for males ($r = 0.35$, $p = 0.005$), but not for females ($r = -0.08$, $p = 0.518$).

A final simplified hierarchical regression analysis was performed for each sex with weight gain as the dependent variable and the predictors sleep duration, sleep duration variability, and bedtime variability with the cofactor of race/ethnicity. Sleep duration variability provided significant predictive information for males, but did not significantly predict weight change in females, $F(4, 56) = 6.33$, $p < .001$ and $F(4, 66) = 0.69$, $p = .602$, respectively. For males, 31% of the variability in weight change was accounted for by race/ethnicity, sleep duration, sleep duration variability, and bedtime variability with sleep duration variability alone accounting for 21% of the variance. Bedtime variability accounted for less than 1% of the variability in weight change once included with sleep duration variability.

## CONCLUSION

The aim of the current study was to examine the role of sleep duration, sleep timing, and sleep pattern variability in weight change during the first semester of college as supported by previous literature. We found that variability in sleep duration was a significant predictor of weight gain for males, but not females, in our sample suggesting that sex could be a moderating factor in the impact of sleep on weight. Higher levels of variability in sleep duration for males led to a relative increase in reported weight. Bedtime variability showed some predictive properties, but was not a distinctive predictor with sleep duration variability in the model.

Sleep duration variability was a significant predictor of weight change in males. We expected greater variability in sleep duration to predict weight change in the direction of weight gain given recent literature that has shown variability in sleep durations are associated with body mass index (Moore et al., 2011). Further research is needed to evaluate variability in sleep duration as a marker for an inherent irregularity in an individual's lifestyle (Moore et al., 2011) especially since bedtime variability also was found to be a predictor of weight gain in males before the inclusion of sleep duration variability. Sleep variability may indicate or lead to a pervasive behavior pattern of poor planning. Poor planning or chaotic schedules may lead to food choices that are not pre-determined, insufficient exercise periods, and fewer healthy lifestyle behaviors. For many students, the transition to college marks a point in which they regulate their health behaviors independently for the first time. Thus, the association between variable sleep duration and weight increase may reflect students' struggle with behavioral self-regulation.

The sex by sleep duration variability interaction was not unexpected given the emerging sex difference literature in regards to the association between sleep and obesity (Araujo et al., 2012; Knutson, 2005). The current findings show that males with greater variability in their day-to-day sleep durations appear more susceptible to weight gain. While mean sleep duration and sleep duration variability did not statistically differ between the sexes, females did go to bed and wake-up roughly 20-minutes earlier than males. In addition, females evidenced less variability in wake times, but not bedtimes. Our findings are consistent with previously reported sex differences in sleep patterns (Lee, 1999). These sex differences may indicate that although females show similar sleep durations and variability in their sleep duration, their bed and wake times being slightly earlier and their wake time being less variable than males may provide a buffer that allows them to maintain behaviors that reduce the risk of obesity (e.g., eating breakfast) in context of imposing social schedules. Future studies involving verified weight measures, assessment of caloric intake, mealtimes, and exercise to evaluate how sleep variability behaviors ultimately result in weight gain are needed.

Despite previous literature showing an association between sleep duration and/or sleep timing and obesity, our data did not show that short sleep or later sleep timing were statistically significant predictors of weight gain. A larger sample, more diverse sample or a greater change in weight may have been necessary for associations involving shortened sleep durations including interactions between variables to emerge. Similarly, the lack of a statistically significant interaction between sex and sleep duration, despite previous literature showing sex differences, could be the result of a smaller sampling of overweight and obese students. Another possibility, given that sleep duration did not exhibit an independent effect on weight change when sleep duration variability was included, is that other factors aside from sex influence the impact sleep duration has on weight change.

Further research is also needed to evaluate the relationship between variability in sleep duration, circadian misalignment, and weight gain. Frequent fluctuations in sleep durations likely contribute to circadian misalignment, which refers to a mismatch in biologically-driven and society-imposed sleep and wake times. Circadian misalignment, also known as social jetlag (Wittmann, Dinich, Merrow, & Roenneberg, 2006), adversely changes metabolic hormones (Scheer et al., 2009) that influence physiologic cues for hunger and satiety; this cascade may manifest in eating behaviors that contribute to obesity (Antunes et al., 2010). Such changes in physiologic cues for hunger and eating behaviors also provide feedback into our circadian timing system that can help maintain circadian misalignment (Antunes et al., 2010).

Average weight change in our sample was +0.9 kg, with an average weight gain of 2.5 kg among those who gained weight. The net weight gain observed here is consistent with weight changes reported in other studies of college students (Lloyd-Richardson et al., 2009). Small incremental weight gain over time is associated with overweight and obesity in adulthood (Lewis et al., 2000). Thus, our findings indicate that many students experienced clinically-significant weight gain during the first 9 weeks of the first semester.

Our findings are limited by the use of self-reported data, which may carry risks for inaccuracy and/or expectancy bias, although quality checks were used to minimize these risks (e.g., evaluating data for outliers). The current data are limited by their observational nature. Thus, while these findings suggest that sleep variability increases the risk of weight gain, actual causation cannot ascertained from these data. In addition, although we might postulate that sleep pattern variability contributes to weight gain via irregular mealtimes, the actual mechanism of sleep patterns on obesity-related behaviors could not be examined with the current data because we did not assess mealtimes, caloric intake, or physical activity in this study.

A major strength of our study is the daily collection of daily sleep data for the first 9 weeks of students' first semester of college. Previous studies of sleep and weight gain have assessed sleep using a single question (Shi et al., 2010), retrospective recall (T. S. Olds, Maher, & Matricciani, 2011), or a week's worth of activity monitoring (Baron et al., 2011). Our approach allowed us to capture day-to-day sleep patterns for more than 50 days, providing a detailed measure of students' sleep patterns and behavior as independent variables in our analyses.

Our findings underscore the need for more research to tease apart the roles of sleep duration, sleep timing, and sleep variability and sex in weight gain. Sleep behaviors may be underlying, modifiable mechanisms that promote weight gain in different ways for men and women. Thus, more rigorous exploration into the independent, additive, and moderating roles of these modifiable mechanisms would provide valuable information to develop practical interventions for reducing weight gain, and potentially, obesity rates. Specifically, studies that include measurements of physical activity, mealtimes, and caloric intake in order to better control for these factors when looking at sleep and weight gain. In addition, future studies should use objective measurements such as activity monitors that would allow for validation of self-report data and physical activity measures and in-lab assessments to capture height and weight data. Finally, more rigorous experimental studies that induce variable sleep patterns and not just changes in duration of the sleep period (i.e., restricted sleep, extended sleep) need to be done to better tease apart the role each play in obesity. Such studies would also offer valuable information that could be used to develop targeted treatments.

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## TABLE 1

Mean (Standard Deviation) of Predictor Variables by Sex and Race/Ethnicity.

| | Weight Change* | TST | BT** | WT** | TSTv† | BTv† | WTv† | MEQ | CES-D |
|---|---|---|---|---|---|---|---|---|---|
| ALL (n=132) | 0.92 (2) | 7h 15m (36m) | 0129 (50m) | 0906 (42m) | 2h 37m (41m) | 2h 12m (37m) | 2h 23m (47m) | 45.9 (7) | 14.3 (9) |
| Sex | | | | | | | | | |
| Male (n=61) | 1.2 (2) | 7h 15m (38m) | 0141 (53m) | 0915 (48m) | 2h 38m (46m) | 2h 10m (38m) | 2h 37m (56m) | 45.2 (9) | 13.4 (9) |
| Female (n=71) | 0.7 (2) | 7h 16m (34m) | 0120 (45m) | 0854 (34m) | 2h 36m (37m) | 2h 13m (36m) | 2h 12m (35m) | 46.5 (6) | 15.1 (9) |
| Ethnicity | | | | | | | | | |
| Asian (n=19) | .5 (1.5) | 7h 6m (36m) | 0148 (54m) | 0912 (48) | 2h 48m (60m) | 2h 0m (30m) | 2h 36m (60m) | 42.1 (9) | 11.9 (6) |
| Black (n=2) | 4.1 (6) | 7h 0m (6m) | 0124 (12m) | 0900 (18m) | 3h 12m (54m) | 2h 24m (32m) | 3h 0m (60m) | 47.5 (9) | 19.5 (12) |
| Caucasian (n=83) | 0.9 (2) | 7h 24m (30) | 0124 (48m) | 0906 (42m) | 2h 30m (36m) | 2h 12m (36m) | 2h 18m (48m) | 46.9 (7) | 13.9 (9) |
| Multiracial (n=8) | 0.7 (2) | 7h 18m (42m) | 0148 (48m) | 0918 (42m) | 2h 42m (42m) | 2h 6m (36m) | 2h 24m (36m) | 44 (7) | 13.6 (6) |
| Unknown (n=20) | 1.3 (2) | 7h 0m (48m) | 0136 (54m) | 0842 (24m) | 2h 54m (30m) | 2h 18m (30m) | 2h 24m (30m) | 46.2 (8) | 18.3 (10) |
| Hispanic (n=25) | 0.8 (2) | 7h 5m (41m) | 0135 (48m) | 0857 (34m) | 2h 46m (35m) | 2h 10m (30m) | 2h 19m (30m) | 45 (8) | 18.4 (12) |

Note.

BT=calculated mean bedtime. WT=calculated mean wake time. TSTv=calculated mean variability in sleep duration. BTv=calculated mean variability in bedtime. WTv=calculated mean variability in wake time. MEQ=mean phase preference score. CES-D=mean depression score.

*kg.

**24h clock time.

†h = hours; m = minutes. TST=calculated mean sleep duration.

## TABLE 2

Correlations between Predictor Variables.

| | Weight Change | Sex | Race/Ethnicity | MEQ | CES-D | TST | BT | WT | TSTv | BTv | WTv |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Weight Change | 1.00 | −0.13 | 0.04 | 0.03 | 0.04 | −0.17** | 0.04 | −0.05 | 0.32* | 0.13 | 0.27* |
| Sex | | 1.00 | 0.09 | 0.08 | 0.09 | 0.01 | −0.21* | −0.25* | −0.02 | 0.04 | −0.26* |
| Race/Ethnicity | | | 1.00 | 0.15** | 0.11 | 0.04 | −0.09 | −0.09 | −0.03 | 0.08 | −0.10 |
| MEQ | | | | 1.00 | 0.12 | 0.11 | −0.55* | −0.60* | −0.24* | −0.09 | −0.40* |
| CES-D | | | | | 1.00 | −0.10 | <0.01 | −0.03 | 0.11 | 0.08 | −0.02 |
| TST | | | | | | 1.00 | −0.61* | 0.16** | −0.28* | −0.18** | −0.14 |
| BT | | | | | | | 1.00 | 0.66 | 0.31* | 0.09 | 0.40* |
| WT | | | | | | | | 1.00 | 0.22* | 0.04 | 0.46* |
| TSTv | | | | | | | | | 1.00 | 0.51* | 0.67* |
| BTv | | | | | | | | | | 1.00 | 0.44* |
| WTv | | | | | | | | | | | 1.00 |

Note.

TST=calculated mean sleep duration. BT=calculated mean bedtime. WT=calculated mean wake time.

TSTv=calculated mean variability in sleep duration. BTv=calculated mean variability in bedtime.

WTv=calculated mean variability in wake time.

* p<0.01.

** p<0.05. MEQ=mean phase preference score. CES-D=mean depression score.

## TABLE 3

Initial Hierarchical Regression Analysis for Weight Change.

| | $R^2$ | *p* |
|---|---|---|
| Model fit | 0.19 * | 0.005 |

| | $R^2$ Change | B | *t* | Tolerance | *p* |
|---|---|---|---|---|---|
| Block 1 | 0.02 | | | | 0.305 |
| Sex | | −0.12 | −1.36 | 0.836 | 0.154 |
| Ethnicity/Race | | 0.07 | 0.80 | 0.942 | 0.372 |
| Block 2 | 0.003 | | | | 0.803 |
| MEQ scores | | 0.06 | 0.54 | 0.549 | 0.603 |
| CES-D scores | | −0.01 | −0.12 | 0.902 | 0.841 |
| Block 3 | 0.032 ** | | | | 0.043 |
| TST | | −0.45 | −1.49 | 0.074 | 0.117 |
| Block 4 | 0.037 | | | | 0.082 |
| BT | | −0.51 | −1.32 | 0.046 | 0.158 |
| WT | | 0.22 | 0.69 | 0.065 | 0.451 |
| Block 5 | 0.092 * | | | | 0.005 |
| TSTv | | 0.25 ** | 2.06 | 0.443 | 0.036 |
| BTv | | −0.13 | −1.25 | 0.657 | 0.215 |
| WTv | | 0.19 | 1.42 | 0.375 | 0.157 |

Note.

BT=calculated mean bedtime. WT=calculated mean wake time.

TSTv=calculated mean variability in sleep duration. BTv=calculated mean variability in bedtime. WTv=calculated mean variability in wake time.

* $p<0.01$.

** $p<0.05$. MEQ=mean phase preference score. CES-D=mean depression score. TST=calculated mean sleep duration.