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Circadian Preference and Sleep-Wake Regularity: Associations With Self-Report Sleep Parameters in Daytime-Working Adults

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Abstract

The aim of this study was to explore how interindividual differences in circadian type (morningness) and sleep timing regularity might be related to subjective sleep quality and quantity. Self-report circadian phase preference, sleep timing, sleep quality, and sleep duration were assessed in a sample of 62 day-working adults (33.9% male, age 23–48 yrs). The Pittsburgh Sleep Quality Index (PSQI) measured subjective sleep quality and the Sleep Timing Questionnaire (STQ) assessed habitual sleep latency and minutes awake after sleep onset. The duration, timing, and stability of sleep were assessed using the STQ separately for work-week nights (Sunday–Thursday) and for weekend nights (Friday and Saturday). Morningness-eveningness was assessed using the Composite Scale of Morningness (CSM). Daytime sleepiness was measured using the Epworth Sleepiness Scale (ESS). A morning-type orientation was associated with longer weekly sleep duration, better subjective sleep quality, and shorter sleep-onset latency. Stable weekday rise-time correlated with better self-reported sleep quality and shorter sleep-onset latency. A more regular weekend bedtime was associated with a shorter sleep latency. A more stable weekend rise-time was related to longer weekday sleep duration and lower daytime sleepiness. Increased overall regularity in rise-time was associated with better subjective sleep quality, shorter sleep-onset latency, and higher weekday sleep efficiency. Finally, a morning orientation was related to increased regularity in both bedtimes and rise-times. In conclusion, in daytime workers, a morning-type orientation and more stable sleep timing are associated with better subjective sleep quality.

Keywords

Chronotype; Human; Regularity; Sleep

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INTRODUCTION

Circadian rhythms play an integral role in facilitating sleep. Circadian phase preference (chronotype) is associated with interindividual differences in the timing of the endogenous circadian pacemaker (Kerkhof & Van Dongen, 1996), which informs the timing of the sleep-wake cycle (Lavie, 2001). Thus, the circadian time when individuals attempt sleep can be an important determinant of its quality and quantity. However, for most adults there is a necessary compromise between the trait-like disposition towards a certain sleep-wake schedule and the requirements of the individual's daily lifestyle, most potently, paid daytime occupation. Due to daytime work, the sleep schedule, primarily rise-time, is constrained on weekdays and more flexible on the weekends in a large proportion of individuals.

Given the importance of circadian rhythms in facilitating sleep, it follows that circadian phase preference is associated with sleep characteristics. Specifically, morning types tend to report higher sleep efficiency (Lehnkering & Seigmund, 2007), better sleep quality (Barclay et al., 2010; Kitamura et al., 2010), shorter time in bed (Carrier et al., 1997), longer total sleep time (Ishishara et al., 1988; Kitamura et al., 2010), and less daytime sleepiness (Taillard et al., 1999) compared to evening types.

In addition to preferred sleep timing, one can also consider how the *regularity* of the sleep-wake schedule influences sleep. Cross-sectional studies illustrate that high daily lifestyle regularity, including high regularity in sleep timing, is associated with better subjective sleep in college students (Carney et al., 2006), young and middle-aged adults (Monk et al., 2003a), and seniors (Zisberg et al., 2010). Stable bedtimes and rise-times have been found to be related to better sleep quality in retired older adults without the constraints of daytime work (Monk et al., 2011). In a prospective study, irregularity in sleep-wake timing also predicted daytime sleepiness (Manber et al., 1996). Indeed, stability of the bedtime and rise-time is considered to be key for proper entrainment of the circadian system and, as such, structured sleep schedules are a central target of behavioral treatments for insomnia (Morin et al., 1994) and circadian rhythm sleep disorders (Morgenthaler et al., 2007).

There is also evidence that circadian phase and sleep timing stability are interrelated. In a general population study, only 48% of morning types modified their sleep schedules over a week, compared to 59% of intermediate types and 72% of evening types (Taillard et al., 1999). Additionally, morning types exhibited less variability in bedtime and sleep duration than evening types (Park et al., 1998). Insomniacs with an evening preference displayed greater variability in wake-up time compared to insomniacs who indicated an intermediate or morning preference (Ong et al., 2007). However, as previously mentioned, sleep timing is inexorably linked to social factors shaping daytime schedules.

Occupation and schooling, in particular, have been shown to interact with chronotype and sleep-wake regularity to impact sleep. Regarding occupation, the majority of the literature has focused on the profound ramifications of atypical work schedules on sleep timing and quality (see Boivin et al., 2007, for review). Individuals who engage in shiftwork (e.g., Åkerstedt et al., 2010b; Ohayon et al., 2010), have long work hours (e.g., Ferguson et al., 2010; Lombardi et al., 2010; Virtanen et al., 2009; Wirtz & Nachreiner, 2010), or adhere to early morning work start times (e.g., Åkerstedt et al., 2010a; Kecklund et al., 1997) tend to have shorter sleep duration, poorer sleep quality, and more daytime sleepiness than their counterparts with a daytime work schedule. Furthermore, chronotype and sleep timing appear to contribute to how well people adjust to these demanding work schedules (e.g., Gamble et al., 2011). Yet, less attention has been given to the more subtle demands of daytime work. Akin to adolescents in school, daytime workers must adapt to a less drastic, albeit still constrained, weekday schedule. In adolescents, an evening circadian phase preference and the tendency to delay sleep timing on weekends are both associated with poorer sleep and increased daytime sleepiness (e.g., Crowley & Carskadon, 2010; Urner et al., 2009). We seek to replicate these findings in a set of daytime workers. However, most studies assessing sleep-wake stability primarily focus on the transition from weekday to weekend. This study aims to extend current knowledge by examining the association between sleep disturbance and daytime sleepiness with variability in sleep timing across *weekdays*, as well as the weekend. In sum, for daytime workers, the relationship between circadian phase preference and sleep timing stability may be particularly salient, as a morning-type orientation could help facilitate weekday sleep-wake regularity, whereas an evening-type orientation could impede it. Conversely, a high level of regularity in behavioral circadian rhythms (e.g., sleep timing) could be considered as a way of enhancing circadian zeitgebers in daytime workers, keeping circadian system properly entrained to their work schedule, thereby improving their sleep.

The aim of the present study was to explore how inter-individual differences in (i) circadian type and the stability of (ii) bedtimes and (iii) rise-times might each be associated with overall sleep quality (as measured by the Pittsburgh Sleep Quality Index [PSQI]), daytime sleepiness (as measured by the Epworth Sleepiness Scale [ESS]), and measures of self-reported time in bed, time spent asleep, sleep latency, time awake after sleep onset, and sleep efficiency (as measured by the Sleep Timing Questionnaire [STQ]) in a healthy adult daytime-working sample. The hypotheses tested include the following: Hypothesis 1: Higher levels of *morningness* would be associated with better reported sleep quality, efficiency, and continuity; longer sleep duration; and lower daytime sleepiness. Hypothesis 2: Higher levels of (a) *bedtime stability* and (b) *rise-time stability* would be associated with better reported sleep quality, efficiency, and continuity; longer sleep duration; and lower daytime sleepiness. Hypothesis 3: Higher levels of *morningness* would be associated with higher levels of (a) *bedtime stability* and (b) *rise-time stability*.

METHODS

Participants

A total of 225 alumni of the University of Pittsburgh were sent a letter explaining that researchers at the university were conducting an experiment on normal sleep patterns that was funded by the National Aeronautics and Space Administration (NASA). These alumni were chosen on the basis that they had graduated within 20 yrs of the date of the study and that their address was on file and in the Greater Pittsburgh area. Enclosed in the letter sent to alumni was a self-addressed stamped postcard, which they were asked to mail back if they were interested in participating in the study and were not currently shift-workers. The study conformed to both the University of Pittsburgh and NASA Johnson Space Center institutional review boards (IRBs), as well as the ethical standards required of the journal (Portaluppi et al., 2010). The 79 persons whose addresses were current and who responded positively were then sent a package of materials that included a cover letter, an informed-consent signature form, a battery of questionnaires, and a stamped, self-addressed envelope for their return. Subjects were rewarded with a $20 payment for completing the materials in the package, and 72 subjects out of the 79 returned forms. Out of those 72 subjects, only 62 subjects (33.9% male, ages 23–48 yrs, mean age 31.51 yrs, SD = 5.93 yrs) returned a complete set of data and reported a daytime work schedule on weekdays (Monday through Friday), and were thus included in the present analysis.

Questionnaires

The package of materials sent to the participants contained a form regarding demographics and occupation details and a battery of questionnaires. The battery of questionnaires included the Sleep Timing Questionnaire (STQ; Monk et al., 2003b), Composite Scale of Morningness (CSM; Smith et al., 1989), Pittsburgh Sleep Quality Index (PSQI; Buysse et al., 1989), and Epworth Sleepiness Scale (ESS; Johns, 1991). These are described below.

The STQ is a questionnaire designed to gain information equivalent to that gleaned from a week-long sleep diary. It yields measures of habitual bedtime and habitual rise-time separately for weekday nights (Sunday through Thursday nights) and weekend nights (Friday and Saturday nights). These values could then be used to calculate time in bed (TIB) separately for weeknights and weekend nights. The STQ also yields measures of regularity/irregularity of bedtime and rise-time (on an arbitrary 1–11 scale, with higher numbers indicating greater irregularity), as well as overall subjective estimates of average sleep latency (SL) and minutes of awake after sleep onset (WASO) experienced on a "typical night."

The CSM yields a single score representing the level of morningness-eveningness, with scores ranging from 13 to 55. Higher scores are indicative of a more morning-type orientation. The CSM correlates (at about $r = .9$) with the earlier Horne and Östberg (1976) instrument (Smith et al., 1989).

The PSQI yields a single global score of sleep pathology, ranging from 0 to 21, with higher numbers indicating worse sleep (Buysse et al., 1989). Values of >5 indicate possible sleep pathology. Two groups were created on the basis of the PSQI score: good sleepers with a PSQI score ≤5 (n = 45) and poor sleepers with a PSQI score of >5 (n = 17).

The ESS was used to assess daytime sleepiness. ESS scores range from 0 to 24, with higher scores indicating greater levels of daytime sleepiness (Johns, 1991).

Data Analysis

The present study focuses only on responses given on the CSM, STQ, PSQI, and ESS (as well as demographics). First, descriptive statistics were generated for key variables, as presented in Table 1. Preliminary analyses revealed a significant relationship between sex and sleep stability variables. No significant effect of age was seen in this age-restricted (23–

48-yr-old) sample. Thus, we controlled for sex in intercorrelations and a multivariate analysis of covariance (MANCOVA). Intercorrelations were used for continuous comparisons, and the MANCOVA compared outcomes between the good sleeper and poor sleeper groups.

Sleep Variability—There were four measures of bedtime regularity: (i) stability of weekday bedtime, (ii) stability of weekend bedtime, (iii) stability of weekday rise-time, and (iv) stability of weekend rise-time, each as measured by the STQ. Each question yielded a number between 1 and 11, corresponding to the magnitude of variability in timing (1 = 0–15 min, 2 = 16–30 min, 3 = 31–45 min, 4 = 46–60 min, 5 = 61–75 min, 6 = 76–90 min, 7 = 91–105 min, 8 = 106–120 min, 9 = 2–3 h, 10 = 3–4 h, 11 = over 4 h), with higher numbers representing greater variability. Overall weekly bedtime and rise-time stability were calculated using a weighted average ([5 × weekday stability + 2 × weekend stability]/7).

Sleep Parameters—Sleep quality was assessed by the PSQI global score (Buysse et al., 1989). The following variables were derived from the STQ. Time in bed (TIB) was calculated as the number of minutes between habitual bedtime and habitual rise-time, for both weekdays and weekends. To obtain an overall weekly TIB estimate, a weighted average of weekday TIB and weekend TIB was tabulated ([5 × weekday TIB + 2 × weekend TIB]/7). The average amount of time it takes to fall asleep (sleep latency [SL]) and unwanted wakefulness thereafter (wake after sleep onset [WASO]) were also reported on the STQ. Time spent asleep (TSA) was calculated as TIB – SL – WASO; this calculation was repeated for weekday TSA, weekend TSA, and overall TSA. Sleep efficiency (SE) was then calculated as 100 × TSA/TIB; this calculation was repeated for weekday SE, weekend SE, and overall SE.

RESULTS

Descriptive Statistics

Descriptive characteristics of the sample are illustrated in Table 1. Average work start time was 08:03 h (SD = 49 min), and average work end time was 16:22 h (SD = 176 min). The average number of hours worked/wk was 46.19 (SD = 8.79 h).

Circadian Type and Sleep Parameters

As evident in Table 2, a higher score on the CSM, meaning a more morning-type circadian preference, was correlated with better sleep quality, shorter sleep-onset latency, longer sleep duration, and a smaller delay in bedtime and rise-time from weekday to weekend. Morningness score was also associated with habitual bedtime and rise-time throughout the week. When group differences were assessed, compared to participants with poor sleep, those with good sleep had a significantly higher score on the CSM, indicating greater morningness (Table 3).

Sleep Timing Stability

Table 4 demonstrates that weekday and weekend bedtime and rise-time stability were largely intercorrelated. However, weekday rise-time only correlated with weekday bedtime, which is in line with the constraint placed upon weekday rise-time by occupation.

Weekday Sleep Stability

Sleep-wake stability was associated with several self-report sleep variables (Table 5). Regarding weekday parameters, a more stable weekday rise-time was associated with better sleep quality, shorter sleep-onset latency, and earlier habitual rise-time. A more stable weekday bedtime was related to earlier habitual rise-time. Weekday bedtime and rise-time stability did not differ between participants with good sleep compared to those with poor sleep (Table 3).

Weekend Sleep Stability

Weekend sleep-wake regularity was related to a host of sleep characteristics (Table 5). An unstable weekend bedtime was associated with longer sleep-onset latency, lower weekend sleep efficiency, later habitual weekend bedtime, and larger change in weekday bedtime. Likewise, a more unstable weekend rise-time was related to shorter weekday sleep duration, shorter overall sleep duration, later weekend bedtime, later weekend rise-time, larger delay in weekend rise-time compared to weekdays, and more daytime sleepiness. Weekend bedtime stability did not differ between participants with good sleep compared to those with poor sleep (Table 3). Respondents with poor sleep did, however, endorse a significantly more irregular weekend rise-time than good sleepers.

Overall Sleep Stability

As evident in Table 5, a more irregular bedtime throughout the week was associated with later overall bedtime and rise-time. Lower overall rise-time stability was related to lower weekday sleep efficiency, lower sleep quality, longer sleep-onset latency, and a later overall rise-time. Overall bedtime stability did not significantly differ between participants with good sleep versus those with poor sleep; however, rise-time was rated as more unstable in respondents with poor sleep (Table 3).

Circadian Phase and Sleep Stability

Overall, participants who endorsed a more morning-type orientation on the CSM also reported greater sleep-wake stability (Table 6). Specifically, greater regularity in weekday, weekend, and overall bedtime and rise-time was related to a more morning-type orientation.

DISCUSSION

To the best of our knowledge, this is the first study to investigate how interindividual differences in chronotype and sleep timing stability relate to subjective sleep quality and quantity in daytime workers. The current findings suggest that daytime workers with an earlier preferred circadian phase have better sleep quality, shorter sleep-onset latency, longer sleep duration, earlier bedtimes, earlier rise-times, and smaller change in sleep timing on weekends. Importantly, the present participants were daytime workers, with rise-times particularly restricted during weekdays. Our findings largely parallel those found in adolescents (e.g., Chung & Cheung, 2008; Gianotti et al., 2002), who tend to have a more delayed circadian phase (Crowley et al., 2007) yet must adhere to early school start times. These results suggest that when constraints are placed upon sleep scheduling, such as school or work start times, chronotype can have a profound influence on sleep quality and recovery sleep. Although previous research has shown that chronotype varies with age, with older individuals being more likely to rate themselves as morning types (e.g., Carrier et al., 1997; Taillard et al., 1999), in the present study we did not find a correlation between chronotype and age. However, absence of significant relationship between age and chronotype in this sample may be due to the limited age range (23–48 yrs; mean = 31.51 yrs, SD = 5.93 yrs). Interestingly, chronotype has been associated with sleep quality even when there are no limitations resulting from daytime work. A recent cross-sectional study by Monk et al. (2011) in a sample of retirees >65 yrs found a relationship between morning-type orientation and better sleep quality, suggesting that sleep quality is enhanced when in synchrony with circadian characteristics in the absence of a constricted daytime schedule. Although the age range of the present study is younger, with the biological tendency to have *later* bedtimes, a mismatch between chronotype and daytime schedule may have a detrimental effect on sleep quality and quantity across the age range.

Stability of sleep timing was also related to sleep characteristics in this study. Previous research has shown that morning types appear to have high daily lifestyle regularity compared to evening types, leading to the suggestion that this chronotype might also have a more robust behavioral circadian amplitude (Monk et al., 2004). Thus, a high level of regularity in behavioral circadian rhythms, such as sleep timing, can be considered as a way of enhancing circadian zeitgebers, keeping the circadian system properly entrained and thereby improving sleep. The present results largely support this finding. Beginning with regularity of weekday rise-times, we found that more unstable rise-times were associated with poorer sleep quality and longer sleep-onset latency. Intriguingly, although weekday rise-time was perhaps the most constrained by work hours and there was less room for variability, it appeared that even minor fluctuations in weekday rise-time were associated with poorer sleep quality. Overall rise-time stability shared a similar relationship with subjective sleep quality and sleep latency. Weekday bedtime stability was not related to any measures pertaining to sleep quality; however, it was strongly correlated with weekday rise-time stability. With respect to weekend sleep timing, a more irregular bedtime was associated with a longer habitual sleep-onset latency. More irregular weekend rise-time was related to shorter weekday sleep duration and increased daytime sleepiness. Instability in sleep timing across the week has been associated with insomnia, wherein variability in sleep timing is considered characteristic of the disorder (e.g., Vallieres et al., 2005). Given that contemporary definitions of insomnia now rely in large part upon how the sleep is *perceived* by the insomnia patient (Buysse, 2005), the present findings may also be important in validating the advice regarding sleep timing regularity that is given in many behavioral treatments of insomnia. Almost all behavioral treatments prescribe regularity in rise-times, and many prescribe regularity in bedtimes within the restriction of only going to bed when sleepy (Morin & Espie, 2003). The present results suggest that in daytime workers, regularity in sleep timing can be associated with better perceived sleep quality, with the relationship being stronger for rise-times than bedtimes. An important caveat, though, is that the cross-sectional nature of the present study precludes testing the *direction* of that relationship.

In previous studies of the relationship between chronotype and sleep timing, irregularity in sleep-wake timing has typically been defined as weekend oversleep and/or a delay in weekend bedtime and rise-time (e.g., Crowley & Carskadon, 2010; Gianotti et al., 2002; Taillard et al., 1999). However, it is important to differentiate the likely origins of these two phenomena. Prolonged sleep during weekends may actually be the result of reduction of sleep during weekdays, whereas the delay of bedtime seems to be associated with a tendency of circadian system to maintain a delayed phase (Valdez et al., 1996). Consistent with previous findings, in this study evening orientation was associated with delayed bedtimes and rise-times, and more variability in sleep timing on the weekends. However, we additionally found that an evening orientation was associated with increased sleep timing irregularity throughout the weekdays. Although the directionality of this relationship cannot be inferred from this study, it may very well be bidirectional in nature. For instance, in insomniacs an evening-type orientation is associated with increased sleep timing irregularity (Ong et al., 2007). Thus, chronotype may be an important consideration in regularizing sleep scheduling in insomniacs with daytime work, as circadian phase preference appears to affect not only delayed sleep timing on weekends, but also variability in sleep timing throughout the week. More broadly, behavioral stability in sleep timing may be particularly important for maintaining favorable circadian entrainment in daytime workers who do not have a morning orientation, facilitating better sleep and possibly more productive workdays.

Although our results provide a new viewpoint on the potential impact of daytime work on sleep, in interpreting these findings, one must take into consideration the limitations of the cross-sectional design and subjective nature of self-report measures. Additionally, this is a small sample of highly educated University of Pittsburgh alumni, which likely does not generalize to the US population. Initial response rate to the preliminary survey was relatively low (35.1%), particularly from males, who made up 33.9% of the final sample. Respondents self-excluding due to current shiftwork or incorrect address information could have influenced low initial response to the survey. Response rate to the final survey from those with current addresses and indicating interest was 91.1%; however, the final sample with complete data was relatively small (n = 62). Participants returning questionnaires may possibly have held a greater interest in the study due to current or past sleep problems. In sum, the applicability of these results is likely limited to a subset of highly educated daytime workers. Despite these limitations, the hypotheses were generally supported by the present findings. Specifically, a morning-type orientation was associated with longer weekly sleep duration and better subjective sleep quality. Likewise, a more stable rise-time correlated with better self-report sleep quality and higher weekday sleep efficiency. Furthermore, a morning orientation was related to increased regularity in both bedtimes and rise-times. Thus, in addition to being interrelated, both early preferred phasing and more regular sleep timing were also associated with better self-rated sleep.

CONCLUSION

In a sample of daytime workers, a morning-type orientation and more regular weekly rise-times were associated with better subjective sleep quality. Morning orientation was also related to increased regularity in both bedtimes and rise-times.

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TABLE 1

Descriptive statistics for morningness scores, stability ratings, and sleep characteristics

	Overall		Weekday		Weekend	
Variable	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**
CSM	37.15	7.60	—	—	—	—
PSQI	4.44	2.70	—	—	—	—
SL (min)	16.40	14.95	—	—	—	—
WASO (min)	12.55	19.16	—	—	—	—
ESS	7.23	3.66	—	—	—	—
TIB (min)	457.15	54.20	438.31	63.81	504.27	72.25
TSA (min)	428.20	59.56	409.35	64.70	475.32	84.07
Sleep efficiency (%)	93.67	6.84	93.47	6.77	93.90	7.36
Bedtime stability	3.30	1.68	2.70	1.70	4.76	2.41
Rise-time stability	2.57	1.01	1.94	0.99	4.16	2.26
Habitual bedtime	23:25	65 min	23:04	66 min	00:14	85 min
Habitual rise-time	07:02	45 min	06:23	42 min	08:38	89 min
Bedtime change (min)[a]	68.71	65.94	—	—	—	—
Rise-time change (min)[b]	134.68	86.42	—	—	—	—

CSM = Composite Scale of Morningness; PSQI = Pittsburgh Sleep Quality Index; SL = sleep-onset latency; WASO = wake after sleep onset; ESS = Epworth Sleepiness Scale; TIB = time in bed; TSA = time spent asleep.

[a]Weekend habitual bedtime – weekday habitual bedtime.

[b]Weekend habitual rise-time – weekend habitual rise-time.

TABLE 2

Correlations between Composite Scale of Morningness (CSM) scores and sleep variables

Variable	Overall	Weekday	Weekend
PSQI	−.39**	—	—
SL (min)	−.38**	—	—
WASO (min)	−.06	—	—
ESS	.12	—	—
TIB (min)	.15	.12	.14
TSA (min)	.27*	.24+	.18
Sleep efficiency (%)	.24+	.24+	.23+
Habitual bedtime	−.49***	−.34**	−.42***
Habitual rise-time	−.52***	−.39**	−.35**
Bedtime change (min)[a]	−.37**	—	—
Rise-time change (min)[b]	−.27*	—	—

+ $p < .1$;

* $p < .05$;

** $p < .01$;

*** $p < .001$.

PSQI = Pittsburgh Sleep Quality Index; SL = sleep-onset latency; WASO = wake after sleep onset; ESS = Epworth Sleepiness Scale; TIB = time in bed; TSA = time spent asleep.

[a] Weekend habitual bedtime – weekday habitual bedtime.

[b] Weekend habitual rise-time – weekend habitual rise-time.

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TABLE 3

Group differences between daytime workers with Good Sleep (PSQI ≤ 5) versus Poor Sleep (PSQI > 5)

	Good sleepers (N = 45)		Poor sleepers (N = 17)		
Variable	**Mean**	**SD**	**Mean**	**SD**	**Analysis[a]**
PSQI	3.2	1.5	7.8	2.4	$F(2, 60) = 42.64^{***}$
CSM	38.7	7.3	33.0	7.0	$F(2, 60) = 4.14^{*}$
SL (min)	11.6	7.8	29.1	21.2	$F(2, 60) = 11.31^{***}$
WASO (min)	6.2	10.2	29.4	26.5	$F(2, 60) = 16.71^{***}$
ESS (min)	7.1	3.7	7.6	3.7	$F(2, 60) = 1.23$
Overall TIB (min)	453.5	56.0	466.7	49.6	$F(2, 60) = 3.86^{*}$
Overall TSA (min)	435.7	53.4	408.3	71.4	$F(2, 60) = 7.35^{***}$
Overall sleep efficiency (%)	96.1	2.9	87.2	9.7	$F(2, 60) =19.06^{***}$
Weekday TIB (min)	432.1	62.7	454.7	65.5	$F(2, 60) = 3.06^{+}$
Weekday TSA (min)	414.3	58.9	396.2	78.6	$F(2, 60) = 4.87^{*}$
Weekday sleep efficiency (%)	96.0	2.9	86.9	9.3	$F(2, 60) = 20.32^{***}$
Weekend TIB (min)	507.1	69.2	496.8	81.5	$F(2, 60) = 2.35$
Weekend TSA (min)	489.3	70.7	438.3	105.7	$F(2, 60) = 5.70^{**}$
Weekend sleep efficiency (%)	96.4	3.0	87.3	10.8	$F(2, 60) = 16.47^{***}$
Overall bedtime stability	3.2	1.7	3.5	1.7	$F(2, 60) = 0.60$
Overall rise-time stability	2.4	0.9	3.1	1.8	$F(2, 60) = 4.07^{*}$
Weekday bedtime stability	2.7	1.7	2.7	1.9	$F(2, 60) = 0.02$
Weekday rise-time stability	1.8	0.8	2.3	1.3	$F(2, 60) = 2.12$
Weekend bedtime stability	4.6	2.4	5.3	2.4	$F(2, 60) = 2.99^{+}$
Weekend rise-time stability	3.8	2.1	5.0	2.5	$F(2, 60) = 6.28^{**}$
Habitual bedtime	23:24	66.6 min	23:28	63.6 min	$F(2, 60) = 1.15$
Habitual rise-time	06:58	45.6 min	07:14	43.2 min	$F(2, 60) = 1.22$
Bedtime change (min)[b]	56.7	56.1	100.6	80.2	$F(2, 60) = 3.42^{*}$
Rise-time change (min)[c]	131.7	81.5	132.7	100.5	$F(2, 60) = 0.27$

+ $p < .1$;

* $p < .05$;

** $p < .01$;

*** $p < .001$.

PSQI = Pittsburgh Sleep Quality Index; CSM = Composite Scale of Morningness; SL = sleep-onset latency; WASO = wake after sleep onset; ESS = Epworth Sleepiness Scale; TIB = time in bed; TSA = time spent asleep.

[a]MANCOVA controlling for sex.

[b]Weekend habitual bedtime–weekday habitual bedtime.

[c]Weekend habitual rise-time–weekend habitual rise-time.

TABLE 4

Correlations between stability variables

	Weekday		Weekend	
Variable	**Bedtime stability**	**Rise-time stability**	**Bedtime stability**	**Rise-time stability**
Weekday bedtime stability	—	—	—	—
Weekday rise-time stability	.32*	—	—	—
Weekend bedtime stability	.54***	.14	—	—
Weekend rise-time stability	.36**	.15	.62***	—

* $p < .05$;

** $p < .01$;

*** $p < .001$.

TABLE 5

Correlations between stability variables and sleep characteristics

Variable	Overall		Weekday		Weekend	
	Bedtime stability	Rise-time stability	Bedtime stability	Rise-time stability	Bedtime stability	Rise-time stability
PSQI	.01	$.44^{***}$	−.02	$.50^{***}$	.06	.14
SL (min)	−.11	$.35^{**}$	.01	$.27^{*}$	$.26^{*}$	$.25^{+}$
WASO (min)	−.12	.10	$-.24^{+}$	.06	.14	.09
ESS	.03	$.24^{+}$	−.05	.05	.16	$.34^{**}$
Overall TIB (min)	−.03	.05	.04	$.22^{+}$	−.14	−.18
Overall TSA (min)	−.02	−.08	.12	.12	$-.25^{+}$	$-.28^{*}$
Overall sleep efficiency (%)	.02	$-.23^{+}$	.15	−.15	$-.23^{+}$	−.21
Weekday TIB (min)	.02	.01	.06	.20	−.06	$-.22^{+}$
Weekday TSA (min)	.03	.10	.14	.12	−.17	$-.32^{*}$
Weekday sleep efficiency (%)	.03	$-.26^{*}$	.16	−.15	$-.22^{+}$	$-.23^{+}$
Weekend TIB (min)	−.12	.11	−.05	.12	$-.23^{+}$	.03
Weekend TSA (min)	−.10	.01	.01	.05	−.17	−.05
Weekend sleep efficiency (%)	.00	−.17	.15	−.10	$-.26^{*}$	−.16
Habitual bedtime	$.28^{*}$	.17	.19	.00	$.42^{***}$	$.37^{**}$
Habitual rise-time	$.36^{**}$	$.29^{*}$	$.39^{**}$	$.30^{*}$	.20	$.36^{**}$
Bedtime change (min)[a]	.19	.08	.08	−.09	$.34^{**}$	$.23^{+}$
Rise-time change (min)[b]	.03	.16	−.03	−.11	.11	$.36^{**}$

$^{+}p < .1$;

$^{*}p < .05$;

$^{**}p < .01$;

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

PSQI = Pittsburgh Sleep Quality Index; SL = sleep-onset latency; WASO = wake after sleep onset; ESS = Epworth Sleepiness Scale; TIB = time in bed; TSA = time spent asleep.

[a]Weekend habitual bedtime–weekday habitual bedtime.

[b] Weekend habitual rise-time–weekend habitual rise-time.

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TABLE 6

Correlations between Composite Scale of Morningness scores with stability variables

Variable	Weekday	Weekend	Overall
Bedtime stability	−.39**	−.42***	−.46***
Rise-time stability	−.28*	−.35**	−.41***

* $p < .05$;

** $p < .01$;

*** $p < .001$.