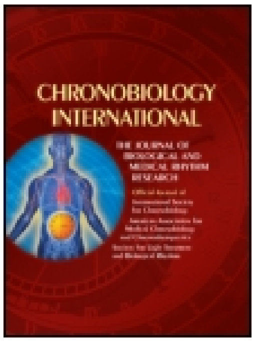

Chronobiology International

The Journal of Biological and Medical Rhythm Research

ISSN: 0742-0528 (Print) 1525-6073 (Online) Journal homepage: http://www.tandfonline.com/loi/icbi20

Daily activities and sleep quality in college students

Colleen E. Carney, Jack D. Edinger, Björn Meyer, Linda Lindman & Tai Istre

To cite this article: Colleen E. Carney, Jack D. Edinger, Björn Meyer, Linda Lindman & Tai Istre (2006) Daily activities and sleep quality in college students, Chronobiology International, 23:3, 623-637, DOI: 10.1080/07420520600650695

To link to this article: https://doi.org/10.1080/07420520600650695

Published online: 07 Jul 2009.

Chronobiology International, 23(3): 623–637, (2006)

ISSN 0742-0528 print/1525-6073 online
DOI: 10.1080/07420520600650695

DAILY ACTIVITIES AND SLEEP QUALITY IN COLLEGE STUDENTS

Colleen E. Carney,[1] Jack D. Edinger,[1,2] Björn Meyer,[3] Linda Lindman,[4] and Tai Istre[5]

[1]*Duke University Medical Center, Durham, NC, USA*
[2]*Veteran's Affairs Medical Center, Durham, NC, USA*
[3]*City University, London, UK*
[4]*University of South Alabama, Mobile, AL, USA*
[5]*Louisiana State University, Baton Rouge, LA, USA*

There is growing evidence that social rhythms (*e.g.*, daily activities such as getting into or out of bed, eating, and adhering to a work schedule) have important implications for sleep. The present study used a prospective measure of daily activities to assess the relation between sleep and social rhythms. College students ($n = 243$) 18 to 39 yrs of age, completed the Social Rhythm Metric (SRM) each day for 14 d and then completed the Pittsburgh Sleep Quality Index (PSQI). The sample was divided into groups of good or poor sleepers, according to a PSQI cut-off score of 5 points and was compared on the regularity, frequency, timing, and extent of social engagement during activities. There was a lower frequency and less regularity of social rhythms in poor sleepers relative to good sleepers. Good sleepers engaged more regularly in activities with active social engagement. Earlier rise time, first consumption of a beverage, going outdoors for the first time, and bedtime were associated with better sleep. Greater variability in rise time, consuming a morning beverage, returning home for the last time, and bedtime were associated with more disturbed sleep. The results are consistent with previous findings of reduced regularity in bedtime and rise time schedules in undergraduates, other age groups, and in clinical populations. Results augment the current thought that regulating behavioral zeitgebers may be important in influencing bed and rise times, and suggest that engaging in activities with other people may increase regularity.

Keywords Daily activity schedules, Social rhythms, Sleep quality, Circadian rhythm, Social rhythm metric

Submitted November 24, 2005, Accepted January 9, 2006
Address correspondence to Colleen E. Carney, Ph.D., Duke Insomnia and Sleep Research Program, Duke University Medical Center Box 2908, Durham, NC 27710, USA. E-mail: colleen.carney@duke.edu

INTRODUCTION

It has long been recognized that consistent and qualitatively satisfying sleep is largely dependent on a robust and well entrained endogenous circadian rhythm (Monk et al., 2003; Reid and Zee, 2005). In recent years, much attention has been devoted to the roles of both physical/environmental (*e.g.*, daylight *vs.* darkness) and endogenous (*e.g.*, 24 h melatonin rhythm) zeitgebers or time markers in circadian regulation and entrainment (Czeisler et al., 2005; Monk et al., 1990; Scheer et al., 2005). However, daily routines associated with bed and rise times, exercise, attendance of school or work, recreation, and engagement in social activities may also act as important zeitgebers (Monk et al., 1990, 2003; Wever, 1979). Under optimal conditions, these so-called "social rhythms" act in synchrony with physical/environmental and physiologic zeitgebers to assure proper circadian entrainment and consequent satisfying sleep. In contrast, under less than optimal conditions, some aspects of these social rhythms may conflict with and disrupt normal circadian entrainment and consequently disturb sleep. Because of their potential positive and negative effects on sleep quality, the daily routines comprising social rhythms warrant research scrutiny in their own right.

To date, the relationship between sleep quality and several aspects of social rhythms (*i.e.*, the nature and number of activities they include, their regularity, their timing during the day, and the degree to which they entail social engagement) have been scrutinized. Several studies (Morgan, 2003; Ohayon et al., 2001; Sherrill et al., 1998) have shown that sleep quality is related to daily activity level, such that poor sleep quality arises from inactivity or proneness toward sedentary lifestyles. Studies also suggest that irregular daily routines are associated with poor sleep quality; whereas, strategies that regularize daily events, such as bed and rise times, serve to improve sleep in clinical patients, such as those complaining of insomnia (Bootzin, 1972; Edinger et al., 1992, 1998, 2001; Edinger and Sampson, 2003; Espie et al., 2001; Monk et al., 1994, 2003; Morin et al., 1993, 1999). The timing of social rhythms also likely has at least indirect sleep effects, inasmuch as those who start activities earlier in the day (*e.g.*, those exhibiting increased morningness) have more active lifestyles and more regular social rhythms than do those with late-day activity patterns (Monk et al., 1994). Finally, social engagement also appears important to sleep quality, in that studies across various age groups have shown that sleep complaints are relatively prevalent among those who are socially alienated or otherwise dissatisfied with their social relations (Edinger et al., 1988; Marchini et al., 1983; Ohayon et al., 2001).

Whereas overall activity levels, as well as the regularity, timing, and social nature of daily social rhythms, all may relate to sleep quality, their relative importance to the sleep process has yet to be examined. To date, no study has examined the relationship between each of these measures of daily social rhythms and sleep quality within the same study population or sample. Therefore, we designed this study to examine the relationship between sleep quality and overall activity levels, the timing and regularity of social rhythms, and the degree to which daily routines entail social engagement within a college student sample. A college sample was selected because of the well documented sleep difficulties observed in this group (Coren, 1994; Lack, 1986). In addition, the college setting is characterized by significant adjustment and affords individuals their first opportunity to establish their own schedules and to develop independent social rhythms. As such, a college sample provides a sufficiently large range of variability in daytime behaviors and sleep quality. Based on previous studies (*e.g.*, Monk et al., 2003), we hypothesized that self-reported good sleepers would report more daily activities, show earlier daily scheduling of their social rhythms, have social rhythms characterized by greater regularity, and be involved in more activities with active social engagement than would poor sleepers.

METHODS

Design

This study used a between-groups, cross-sectional research design. Participants were required to provide written informed consent prior to enrolling in the research and undergoing study-related procedures. Approval was obtained from the Louisiana State University Institutional Review Board before recruiting students from an online psychology experiment message board. The research protocol met the ethical standards of the journal (Touitou et al., 2004). Upon completion of study procedures, participants were granted extra course credit for participating.

Participants

Participants ($n = 243$) were between 18 and 39 yrs of age (mean = 20.7 yrs, SD = 2.9). The sample was predominantly female (87%) and Caucasian (79%). There were 34 African Americans (14%), 2 Asian Americans (<1%), and 20 participants of unspecified ethnicity (6%). The Sleep Quality Index score on the Pittsburgh Sleep Quality Index (PSQI) ranged from 0 to 19 points, and the mean (mean = 5.6, SD = 3.4) suggested that overall this sample had poor perceived sleep quality. The sample was in the non-clinical range for depression (Beck et al., 1996), as measured by the total score on the Beck Depression

Inventory, Second Edition (BDI-II) without sleep item #16 (mean = 11.32, SD = 8.89).

Measures

Social Rhythm Metric (SRM)

The SRM (Monk et al., 1990) is a daily monitoring diary designed to assess social rhythms. The diary lists 17 activities, 15 of which are fixed and assumed to be common zeitgebers. Included among these 15 activities are: 1) out of bed; 2) first contact with a person; 3) first beverage; 4) breakfast; 5) first time outside; 6) start work/school; 7) lunch; 8) afternoon nap; 9) dinner; 10) exercise 11) evening snack/beverage; 12) watch news program; 13) watch television; 14) return home; and 15) get into bed. The remaining 2 activities are idiosyncratic, or "write-in" activities not included in the other 15 activities. The "write-in" activities (*e.g.*, Activity A and B) are created during a training session during which participants are asked to write down 2 activities they tend to do on a regular basis, such as caring for a pet or using the internet/email. They are then asked to monitor these write-in activities along with the other 15 activities throughout the observation period.

Several indices can be calculated from the SRM, including the number of overall activities (ALI index) and the number of activities performed with either active social engagement (ALI-A) or minimal to no social engagement (ALI-N) activities. The ALI indices are frequency counts of the total number of activities (ALI)—the total number of activities wherein the social interaction was rated as a 2 to connote active social engagement (ALI-A) and the total number of activities wherein social interaction was rated as a 1 or 0 to connote minimal to no social engagement. The range for possible weekly ALI scores is 0 to 119 points ($7\,\mathrm{d} \times 17$ activities = 119). Diary entries wherein the degree of social interaction was not coded were excluded from the ALI-A and ALI-N index calculations.

The regularity of activities (SRM) is calculated using a validated algorithm (Monk et al., 1990, 1991). Presenting the algorithm and the evidence for the algorithm is beyond the scope of this paper; but briefly, the SRM is calculated by determining a habitual time for each activity. Observations that fall outside 1.5 SD of the mean time for the respondent are removed, and a new habitual time is calculated that omits outlier data. Next, all the observations including the outliers are combined to calculate the number of "hits." Hits are defined as the number of activities that occur within 45 min of the habitual time. Finally, the total number of hits for activities that occur three or more times per week is divided by the number of activities occurring three or more times per week. This provides an index between 0 (*i.e.*, no apparent regularly) and 7 (*i.e.*, perfectly regular). Hence, in simple terms, this index reflects the average number of times per week that an activity occurs within the habitual time. The regularity of activities with active social engagement (SRM-A) is calculated by selecting only those activities wherein social interaction was rated as a 2, and then entering those events into the SRM algorithm. The regularity of activities with no or minimal social engagement (SRM-N) is calculated by selecting activities wherein social interaction was minimal (rating = 1) or the activity was performed alone (rating = 0), and only those activities are entered into the SRM algorithm.

Previous studies have documented the reliability and validity of the SRM for daily activity monitoring (Monk et al., 1990, 1991, 1994, 2003). Validation research also has shown that the reported bed and rise times on the SRM are typically within 10 to 20 min of the objective, actigraphic estimates of bed and rise time (Monk et al., 1994). Moreover, comparisons have shown that the SRM index relates to the endogenous circadian temperature rhythm, such that greater SRM regularity is associated with a greater nocturnal dip (*i.e.*, a deeper trough) in core body temperature (Monk et al., 1994).

Pittsburgh Sleep Quality Index (PSQI)

The PSQI (Buysse et al., 1989) is a retrospective (*i.e.*, past month) measure of perceived sleep quality. Participants rate nine aspects of their sleep so that six specific component scores (*e.g.*, sleep onset latency), as well as a summary global Sleep Quality Index (SQI), can be calculated. The sample was divided into good or poor sleepers according to the SQI of the PSQI (scores > 5 points were categorized as poor). Previous studies have documented the reliability and validity of the PSQI for detecting sleep disturbances (Backhaus et al., 2002; Buysse et al., 1989). Although not a specific diagnostic tool for insomnia, the PSQI has a sensitivity of 89.6% and a specificity is 86.5% for detecting this form of sleep difficulty (Buysse et al., 1989).

Beck Depression Inventory—Second Edition (BDI-II)

The BDI-II (Beck et al., 1996) was used as a covariate for the study participants' levels of dysphoric mood. This instrument contains 21 items listing symptoms of Major Depressive Disorder (MDD), including depressed mood and cognitive symptoms such as hopelessness, suicidal ideation, sleep disturbance, reduced appetite, and poor libido. The BDI-II has well documented psychometric properties (Beck et al., 1996; Richter et al., 1998) and correlates highly with other well validated measures such as the Hamilton Rating Scale for Depression (r = 0.71) (Beck et al., 1996).

Procedures

On the first day of the study, participants received 20 min of group training on completing the SRM. During the training, each activity was reviewed, operational definitions for each activity were provided, and participants were given the opportunity to ask questions. Participants were given 14 d worth of SRMs and were told to return with the completed diary exactly 15 d later. A 2 wk period of monitoring was selected inasmuch as previous research has shown that healthy control subjects require 2 wks of data collection to achieve stability of SRM scores (Monk et al., 1991). Once they completed their 14 d monitoring period, participants surrendered their SRM data and completed the PSQI, BDI-II, and a 30 min psychometric battery relating to a different study.

RESULTS

Demographic Analyses

The sample was dichotomized into good or poor sleepers, with those having PSQI scores > 5 classified as poor sleepers. There were 139 good sleepers and 104 poor sleepers. The rate of self-reported sleep pathology (*i.e.*, PSQI greater than the clinical cut-off of 5) for these undergraduate students was 42%. An analysis of variance (ANOVA) confirmed that there were no differences between the good and poor sleepers in regard to their mean ages. Likewise χ^2 analyses verified that there were no group differences in the distribution of gender or race. There were 121 females (87%) in the good sleeper group (mean age $\pm$SD, 21.47 $\pm$ 3.74 yr) and 93 females (89%) in the poor sleeper group (mean age $\pm$SD, 20.33 $\pm$ 2.40 yr).

Group Differences on Social Rhythm Metric Indices

A multivariate analysis of variance (MANOVA) tested whether good sleepers differed from poor sleepers on the three regularity-dependent (total SRM, SRM-A, and SRM-N) and three activity level-dependent measures (total ALI, ALI-A, and ALI-N) derived from the SRM diaries. This MANOVA revealed a main effect for group [$F(5,237) = 3.12$, $p = 0.009$]. Follow-up ANOVAs revealed significantly lower total ALI [$F(1, 241]) = 5.88$, $p = 0.016$] and total SRM scores [$F(1, 241) = 4.91$, $p = 0.028$] in poor sleepers relative to good sleepers. Similarly, follow-up ANOVAs revealed significant group effects for ALI-A, [$F(1, 241) = 6$, $p = .015$] and SRM-A [$F(1, 241) = 8.59, p = 0.004$]. More specifically, poor

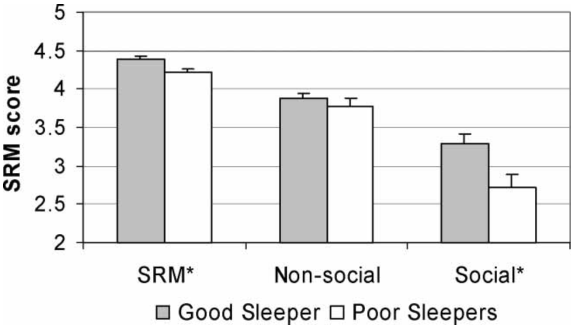

FIGURE 1 Group comparisons on the mean weekly regularity of activities (SRM indices) for good and poor sleepers. $^*p < 0.05$.

sleepers engaged in approximately three fewer mean activities (ALI) and approximately five less mean activities with social engagement (ALI-A) per week than did good sleepers. Likewise, the average regularity (SRM) and the average regularity of activities with active social engagement (SRM-A) were lower in poor sleepers relative to good sleepers. According to Cohen's (1977) classification of effect sizes, the effect sizes for SRM and SRM-A were small (0.20 and 0.34, respectively), and the effect sizes for ALI and ALI-A were large (0.84 and 0.89, respectively). The groups did not statistically differ on SRM-N or ALI-N indices. Figure 1 depicts the group differences on mean SRM and Figure 2 depicts mean differences on ALI indices.

Group Differences on Social Rhythm Metric Indices after Controlling for Depression

To determine if mood accounted for the above results, ANCOVAs that used the BDI-II total score (with item #16, sleep disturbance, removed) as

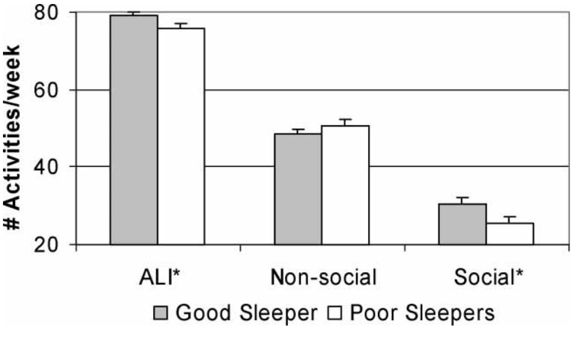

FIGURE 2 Group comparisons on the mean number of activities (ALI indices) for good and poor sleepers. $^*p < 0.05l$.

a covariate tested for a group difference on the four variables with significant group effects (SRM, SRM-A, ALI, and ALI-A). The only variable that remained statistically significant after adjusting for dysphoric mood was SRM-A [$F(1, 235) = 4.42$, $p = 0.037$].

Group Differences on the Mean Variability in the Timing of Daily Activities

To determine whether the variability in the timing of social rhythms was important for SRM activities, intra-subject SD for the time of day that each activity was performed over the 2 wk period were calculated. However, because there were three planned analyses for each of 17 activities (*i.e.*, 51 tests), we made some *a priori* decisions to reduce the number of statistical tests, so as to control the experiment-wise error rate. Since it seemed unlikely that infrequently occurring activities would have a pronounced effect on sleep, we excluded those activities that were reported by less than two-thirds of the participants. This resulted in the exclusion of "Afternoon nap" (done at least once per week by only 55% of participants), "Exercise" (done at least once per week by only 55% of participants), and "Watch news program" (done at least once per week by only 64% of participants). We also excluded Activities A and B, because these were idiosyncratic activities that varied for each participant. For example, Activity A for one person could be "Shopping;" whereas, Activity A for another participant could be "Internet use." These exclusions resulted in five fewer statistical tests per hypothesis tested. Given that the variables for this analysis were SD values, an additional consideration was whether the variables were normally distributed. Thus, visual inspections of the distribution histograms and Shapiro-Wilk tests were used to determine whether the distributions for the various activities approximated normality. These procedures showed that the distributions for several activities (*i.e.*, Breakfast; First contact; Outside; Work; Lunch; Snack; Dinner; and Watch TV) departed markedly from normality. SRM data for these eight activities were subjected to a square root transformation, which was successful in normalizing their distributions.

The eight transformed variables and the remaining four activities with normal distributions were analyzed by MANOVA. Results of this analysis showed a significant group effect [$F(12, 154) = 2.15$, $p = 0.017$]. Follow-up ANOVAs revealed a statistically significant group effect for "Out of bed," "Morning beverage," "Return Home," and "Into bed." An examination of the means revealed that good sleepers were less variable than poor sleepers in regard to the times when they consumed the first beverage of the day, their rise times, and their bed times, and the times when they returned home for the last time. Table 1 depicts group means, SD, and ANOVA results for the mean variability of activities.

TABLE 1 Group Comparisons on Intra-Subject Variability of Activities

Activity	Good Sleeper		Poor Sleeper		*F* statistic	*p* value
	Mean	SD	Mean	SD		
Out of bed	1.46	0.54	1.78	0.62	11.95	0.001*
First contact	1.57	0.64	1.82	0.75	1.85	0.175
Morning beverage	1.36	0.64	1.52	0.74	5.13	0.025*
Breakfast	1.38	0.72	1.48	0.83	0.24	0.622
Start work	1.67	1.07	1.80	1.18	0.93	0.336
Outside first time	2.08	0.88	2.26	0.79	2.11	0.149
Lunch	1.09	0.53	1.20	0.56	0.64	0.462
Snack	2.79	3.04	3.72	4.10	1.26	0.263
Watch TV	2.93	2.52	3.20	2.78	0.02	0.902
Dinner	1.20	0.56	1.42	0.61	2.55	0.112
Return home	2.98	1.05	3.29	1.05	4.57	0.034*
Bedtime	1.36	0.55	1.55	0.56	4.00	0.047*

SD = standard deviation; means are the mean intra-subject standard deviations, and the standard deviation is the standard deviation of the mean values.
*$p < 0.05$.

Group Differences on Mean Variability of the Timing of Daily Activities after Controlling for Depression

To determine if depressed mood could account for the differences in the mean variability of the timing of activities, we conducted a MANCOVA on the variables with a significant group effect (*e.g.*, "Out of bed," "Morning beverage," "Return Home", and "Into bed") using total BDI-II score (minus sleep item #16) as a covariate. The MANCOVA showed a statistically significant group effect [$F(4, 216) = 2.47$, $p = 0.046$]. Follow-up ANCOVAs revealed a significant group effect only for "Out of bed" [$F(1, 219) = 3.09, p = 0.002$]. Thus, poor sleepers continued to have greater variability than good sleepers on their rise times, even after factoring out the variance attributable to dysphoric mood.

Group Differences on the Mean Timing for Daily Activities

The last set of analyses was conducted to determine if the mean timing of particular daily activities differentiated the good from poor sleepers. In consideration of reducing the experiment-wise error rate, we excluded five activities (*i.e.*, "Afternoon nap," "Exercise," "Watch news program," "Activity A," and Activity B) that occurred infrequently or were idiosyncratic in nature. Shapiro-Wilk tests revealed that the mean times for several of the remaining activities departed from a normal distribution (*i.e.*, Breakfast; Morning beverage; First contact; Outside; Work; Lunch; Snack; Dinner; Watch TV.; Return Home; and Bedtime). These ten activities were subject to a square root transformation, which was successful in

TABLE 2 Group Comparisons on Mean Time for Activities

	Good Sleeper		Poor Sleeper		F statistic	*p* value
Activity	Mean	SD	Mean	SD		
Out of bed	8.65	1.37	9.09	1.18	5.99	0.015*
First contact	9.17	1.41	9.55	1.23	2.12	0.147
Morning beverage	9.20	1.36	9.63	1.23	4.30	0.039*
Breakfast	9.68	1.55	9.81	1.44	0.39	0.532
Start work	10.13	1.49	10.36	1.48	0.63	0.429
Outside first time	10.00	1.46	10.42	1.37	4.99	0.027*
Lunch	13.05	1.01	13.21	1.23	0.79	0.373
Snack	19.54	2.33	19.02	3.19	1.91	0.169
Watch TV	18.21	3.48	18.43	2.64	0.86	0.355
Dinner	18.95	0.95	19.05	0.85	0.31	0.578
Return home	20.87	1.97	21.39	2.20	0.34	0.561
Bedtime	24.28	1.22	24.86	1.10	8.22	0.005*

Means are the mean time the activity was performed over 14 d; SD = standard deviation; times are decimalized; untransformed means are depicted.

*$p < 0.05$.

normalizing their distributions. The ten transformed variables and the remaining two activities with a normal distribution were analyzed by MANOVA. There was a significant group effect on this MANOVA [$F(12, 188) = 1.82, p = 0.049$]. Follow-up ANOVAs revealed a statistically significant group effect for "Out of bed," "Outside for first time," and "Into bed." On average, good sleepers got out of bed earlier, consumed their morning beverage earlier, went outside for the first time earlier, and went to bed earlier than did the poor sleepers. Table 2 depicts the group means, SD, and ANOVA results for the mean activities.

Group Differences on the Mean Timing for Daily Activities after Controlling for Depression

To determine if depressed mood might account for the differences in the mean timing of activities, we conducted a MANCOVA on the four activities found to have significant group effects in the previous analysis (*i.e.*, "Out of bed," "Morning beverage," "Outside for first time," and "Into bed"). As in the previous MANCOVA, this analysis used total BDI-II score minus sleep item #16 pound as a covariate. Results of this analysis showed a statistically significant group effect [$F(4, 227) = 2.71, p = 0.031$]. Follow-up ANCOVAs revealed a significant group effect for all four activities: "Out of bed" [$F(1, 230) = 3.09$, $p = 0.002$], "Morning beverage" [$F(1, 230) = 5.66$, $p = 0.018$], "Outside for first time" [$F(1, 230) = 4.15$, $p = 0.043$], and "Into bed" [$F(1, 230) = 10.21$, $p = 0.002$]. Thus, good sleepers went outside earlier in the day, consumed the first drink of the day earlier, and had earlier rise times and bedtimes than did poor sleepers, and these differences were not attributable to differences in the mood status of these two groups.

DISCUSSION

The current study tested a number of hypotheses concerning the relationship between reported sleep quality and the social rhythms of college students. Consistent with study predictions, our results recapitulated previous reports (Monk et al., 1994, 2003) that college students with self-reported poor sleep quality had greater schedule variability in the timing of social rhythms than did self-reported good sleepers. In addition, poor sleepers had greater schedule variability than did good sleepers on activities with active social involvement. A finding of decreased regularity of social and general activity in those with poor sleep has also been reported in other studies with poor sleepers (Monk et al., 1994, 2003; Morgan, 2003; Ohayon et al., 2001; Sherrill et al., 1998) and in those meeting criteria for primary insomnia (Marchini et al.,1983). This study suggests that like older adults, young adults with limited social activities have poor sleep quality. Moreover, the effect of decreased regularity of activities with social engagement remained significant after controlling for depression; thus, it appears that this effect is mood-independent and should be evaluated in future studies for its independent role in sleep disruption.

Also consistent with study predictions, our findings showed that good sleepers reported engagement in a significantly greater number of activities tracked by the SRM than did poor sleepers. Although this finding differs from Monk's previous two studies with young adults (Monk et al., 1994, 2003), the wider range of sleep and mood disturbance and larger sample size in the current study may account for this discrepancy. Our finding of decreased activity levels, particularly those with social involvement, is consistent with other studies in adults with poor sleep (Marchini et al., 1983; Morgan, 2003; Ohayon et al., 2001; Sherrill et al., 1998). However, this group effect was no longer significant after controlling for mood, a finding suggesting that this effect is mood-mediated. The cross-sectional nature of this study precludes clarification of the causal relationships between low mood, disturbed sleep, and decreased activities. Nonetheless, this latter result suggests that the observed relationship between the total number of SRM activities reported and perceived sleep quality is likely an artefact of concurrent mood status.

Results of this study also supported our prediction that consistent timing of activities tracked by the SRM diary is related to sleep quality. In particular, the consistent timing of the daily rise time appeared particularly important, since good sleepers, reported significantly less variability in this activity than did poor sleepers, even after the effects of mood status were statistically controlled. This finding is not particularly surprising, inasmuch as cognitive-behavioral models of insomnia posit that increased variability in the daily rise time exerts deleterious effects on sleep (Bootzin, 1972; Morin, 1993; Spielman et al., 1987). The obvious implication of this finding is that it may be useful to educate college students about the importance of standardizing their rise times to ensure optimal sleep quality. It should be noted, however, that interventions that target this one parameter in college samples (*e.g.*, decreasing rise time variability) have found resultant increased fatigue, because college students tend not to adjust their bedtimes accordingly (Manber and Bootzin, 1991; Manber et al., 1996). Thus, interventions designed to standardize daily rise times among college samples would also likely need to address adherence to coincident bedtime prescriptions.

In addition to the findings discussed thus far, our results supported the prediction that the average timing of many daily activities is related to sleep quality. Specifically, we found that good sleepers got out of bed earlier, consumed their morning beverage earlier, went outside for the first time earlier, and went to bed at an earlier mean time than did poor sleepers. Moreover, the timing of these events was significantly different between the two groups, even after controlling for dysphoric mood. This finding suggests that college students with a relatively delayed sleep-wake cycle are those most prone to suffer poor sleep quality. This finding seems particularly noteworthy, since several studies have noted that delayed sleep-wake schedules are preferred and followed by a sizable proportion of college students (Carskadon and Davis, 1989; Lack, 1986). It is likely that this preference may place many college students at odds with their daily college schedule and thus result in constricted and/or erratic sleep patterns, given that such students vacillate between adhering to their desired (and likely endogenous) sleep-wake patterns, and meeting their daily academic demands. As such, treatments for the sleep problems of these individuals will likely need to consider both their circadian and behavioral tendencies to achieve optimal outcomes. Among the more intriguing findings of this study was the lower rates of social engagement and regularity of social engagement seen in poor sleepers. Apparently, engaging in activities with other people actively involved increases regularity, and is thus protective of sleep. Many activities have times associated with them that are social conventions, *e.g.*, eating lunch around 12:00 h and eating dinner around 18:00 h. If people are to interact, it would be unusual to select a time that is wildly discrepant from the conventional time (*e.g.*, inviting a friend to dinner at 23:00 h). There appears to be greater variability when doing activities alone, and more restrictive variability and earlier mean times when others are involved. People, then, appear to have an effect on regulating social rhythms. The effect that social engagement may have on increased regularity may also anchor bed and rise times. In contrast, poor sleepers with less socially active lifestyles may be more free to violate social conventions, and they may eat, go to bed, or get out bed at later and less conventional times, thus creating more variability. The SRM has been used previously to assess the Social Zeitgeber hypothesis (Ehlers et al., 1988). The Social Zeitgeber hypothesis conceptualizes the regular engagement with people as a zeitgeber, or time cue for the circadian system. Disruptions or general irregularity of social rhythms are postulated to disrupt circadian mechanisms and lead to sleep and mood pathology. In this study, a reduced number of social zeitgebers was associated with poor sleep, lending some support to this theory.

Although this study provides some information about possible mechanisms underlying social rhythms and sleep disruption, one additional implication of this study is that undergraduates are an important group to examine in their own right. The college setting is a unique biopsychosocial crucible. Given the potential for variability and sleep disorders, and the relation between sleep disturbance and other mood or adjustment problems (Jean-Louis et al., 1998; Pilcher and Walter, 1997), our ability to understand and help students navigate their day-to-day adjustment challenges may have enormous health consequences. One interesting research question is whether is increased variability is associated with the transition into college. Specifically, if these college students were followed from high school into their freshman year, would schedule change predict subsequent sleep disturbance, as well as the onset of other co-morbidities like depression? The present study is limited in that the transition into college is not captured; indeed, some participants may have been college seniors. The effects of life transitions on social rhythms and sleep or mood should be assessed in close contiguity with the event (Prigerson et al., 1994), in this case, near the onset of freshman year. Although there are some preliminary longitudinal studies that follow young adults as they make the transition from high school seniors to college freshmen (Carskadon and Davis, 1989), further study is needed to elucidate whether social rhythm changes (*e.g.*, decreased regularity) precipitate sleep disturbance.

Admittedly, this study had a number of limitations that should be mentioned. This sample was composed of college students who were predominantly female and Caucasian. As such, the results may not be generalizable to men, non-college samples, or samples comprising older or younger age groups. In addition, this study focused exclusively on social zeitgebers, without examination of how or if these behavioral phenomena regulate exposure to photic time cues. Since photic zeigebers are thought to exert more powerful control on the circadian system than do social zeigebers, it remains possible that the results noted herein ultimately connote the action of photic rather than the social zeitgebers examined. Given these considerations, future studies of this nature would benefit by the inclusion of more diverse samples and measures to track the relationship among social zeitgebers, photic input, and associated sleep quality. Nonetheless, the current results suggest that social rhythms of college students relate to their sleep quality. Thus, these phenomena merit attention in future studies concerned with the nature and management of sleep difficulties among college student samples.

ACKNOWLEDGMENTS

The authors acknowledge the contributions of Alex Grunfeld and Amanda McCleery for their part in the database design and management. We also thank Dr. Timothy Monk for his generosity in sharing Social Rhythm Metric (SRM) materials and in providing assistance in using the SRM scoring algorithm. Portions of this data were presented at the 2005 meeting of the Associated Professional Sleep Societies, Denver, CO.

REFERENCES

Backhaus, J., Junghanns, K., Broocks, A., Riemann, D., Hohagen, F. (2002). Test-retest reliability of the Pittsburgh Sleep Quality Index in primary insomnia. *J. Psychosom. Res.* 53:737–740.

Beck, A.T., Steer, R.A., Brown, G.K. (1996). *Manual for the Beck Depression Inventory*, 2nd ed.; (BDI-II); The Psychological Association: San Antonio, TX.

Benloucif, S., Orteba, L., Ortiz, R., Janssen, I., Finkel, S.I., Bleiberg, J., Zee, P. (2004). Morning or evening activity improves neuropsychological performance and subjective sleep quality in older adults. *Sleep* 27:1542–1551.

Bootzin, R.R. (1972). Stimulus control treatment for insomnia. *Proc. 80th Ann. Mt, Am. Psychol. Assoc.* 7: 395–396.

Buysse, D.J., Reynolds, C.F., Monk, T.H., Berman, S.R., Kupfer, D.J. (1989). The Pittsburgh sleep quality index: a new instrument for psychiatric practice and research. *Psychiatry Res.* 28:193–213.

Carskadon, M.A., Davis, S.S. (1989). Sleep-wake patterns in the high-school to college transition: preliminary data. *Sleep Res.* 18:113.

Cohen, J. (1977). *Statistical Power for the Behavioral Sciences*; Academic Press: San Diego.

Coren, S. (1994). The prevalence of self-reported sleep disturbances in young adults. *Int. J. Neurosci.* 79:67–73.

Czeisler, C.A., Buxton, O.M., Khalsa, S.B.S. (2005). The human circadian timing system and sleep-wake regulation, In *Principles and Practices of Sleep Medicine*, 4th ed.; Kryger, M.H., Roth, T., Dement, W.C., eds. Elsevier Inc.: Philadelphia, pp. 375–394.

Edinger, J.D., Hoelscher, T.J., Marsh, G.R., Lipper, S., Ionescu-Pioggia, M. (1992). A cognitive-behavioral therapy for sleep-maintenance insomnia in older adults. *Psychol. Aging* 7:282–289.

Edinger, J.D., Sampson, W.S. (2003). A primary care "friendly" cognitive behavioral insomnia therapy. *Sleep* 26:177–182.

Edinger, J.D., Stout, A.L., Hoelscher, T.J. (1988). Cluster analysis of insomniacs' MMPI profiles: Relation of subtypes to sleep history and treatment outcome. *Psychosom. Med.* 50:77–87.

Edinger, J.D., Wohlgemuth, W.K., Radtke, R.A., Marsh, G.R., Quillian, R.E. (2001). Cognitive behavioral therapy for treatment of chronic Primary Insomnia: A randomized controlledtrial. *JAMA* 285:1856–1864.

Ehlers, C.L., Frank, E., Kupfer, D.J. (1988). Social zeitgebers and biological rhythms: A unified approach to understanding the etiology of depression. *Arch. Gen. Psych.* 45:948–952.

Espie, C.A., Inglis, S.J., Tessier, S., Harvey, L. (2001). The clinical effectiveness of cognitive behaviour therapy for chronic insomnia: Implementation and evaluation of a sleep clinic in general medical practice. *Behav. Res. Ther.* 39:45–60.

Horne, J.A., Ostberg, O. (1976). A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. *Int.J. Chronobiol.* 4:97–110.

Jean-Louis, G., Von Gizycki, H., Zizi, F., Nunes, J. (1998). Mood states and sleepiness in college students: Influence of age, sex, habitual sleep and substance use. *Percept. Motor Skills* 87:507–512.

Lack, L.C. (1986). Delayed sleep and sleep loss in university students. *J. Am. Coll. Health* 35:105–110.

Manber, R., Bootzin, R.R. (1991). The effects of regular wake-up schedules on daytime sleepiness in college students. *Sleep Res.* 20:284.

Manber, R., Bootzin, R.R., Acebo, C., Carskadon, M.A. (1996). The effects of regularizing sleep-wake schedules on daytime sleepiness. *Sleep* 19:432–441.

Marchini, E.J., Coates, T.J., Magistad, J.G., Waldum, S.J. (1983). What do insomniacs do, think, and feel during the day? A preliminary study. *Sleep* 6:147–155.

Monk, T.H., Flaherty, J.F., Frank, E., Hoskinson, K., Kupfer, D.J. (1990). The social rhythm metric: An instrument to quantify the daily rhythms of life. *J. Nerv. Mental Dis.* 178:120–126.

Monk, T.H., Kupfer, D.J., Frank, E., Ritenour, A.M. (1991). The social rhythm metric (SRM): Measuring daily social rhythms over 12 weeks. *Psychiatry Res.* 36:195–207.

Monk, T.H., Petrie, S.R., Hayes, A.J., Kupfer, D.J. (1994). Regularity of daily life in relation to personality, age, gender, sleep quality and circadian rhythms. *J. Sleep Res.* 3:196–205.

Monk, T.H., Reynolds, C.F., Buysse, D.J., DeGrazia, J.M., Kupfer, D.J. (2003). The relationship between lifestyle regularity and subjective sleep quality. *Chronobiol. Int.* 20:97–107.

Morgan, K. (2003). Daytime activity and risk factors for late life insomnia. *J. Sleep Res.* 12:231.

Morin, C.M. (1993). *Insomnia: Psychological Assessment and Management*; New York: Guilford Press.

Morin, C.M., Colecchi, C., Stone, J., Sood, R., Brink, D. (1999). Behavioral and pharmacological therapies for late-life insomnia: A randomized controlled trial. *JAMA.* 281:991–999.

Morin, C.M., Kowatch, R.A., Barry, T., Walton, E. (1993). Cognitive-behavior therapy for late-life insomnia. *J. Consult. Clin. Psychol.* 61:137–147.

Naylor, E., Penev, P., Orteba, L., Janssen, I., Ortiz, R., Colecchia, E.F., Keng, M., Finkel, S., Zee, P.C. (2000). Daily social and physical activity increases slow wave sleep and daytime neuropsychological performance in the elderly. *Sleep* 23:1–9.

Ohayon, M.M., Zulley, J., Guilleminault, C., Smirne, S., Priest, R.G. (2001). How age and daytime activities are related to insomnia in the general population: Consequences for older people. *J. Am. Geriatri. Soc.* 49:360–366.

Pilcher, J.J., Walter, A.S. (1997). How sleep deprivation affects psychological variables relate to college students' cognitive performance. *J. Am. Coll. Health* 46:121–126.

Prigerson, H.G., Reynolds, C.F., Frank, E., Kupfer, D.J., George, C.J., Houck, P.R. (1994). Stressful life events, social rhythms, and depressive symptoms among the elderly: An examination of hypothesized linkages. *Psychiatry Res.* 51:33–49.

Reid, K.J., Zee, P.C. (2005). Circadian disorders of the sleep-wake cycle; In *Principles and Practices of Sleep Medicine*, 4th ed.; Kryger, M.H., Roth, T., Dement, W.C., eds.; Elsevier Inc.: Philadelphia, pp. 691–701.

Richter, P., Werner, J., Heerlein, A., Kraus, A., Sauer, H. (1998). On the validity of the Beck Depression Inventory: a review. *Psychopathology* 31:160–168.

Scheer, F.A., Cajochen, C., Turek, F.W., Czeisler, C.A. (2005). Melatonin in the regulation of sleep and circadian rhythms; In *Principles and Practices of Sleep Medicine*, 4th ed.; Kryger, M.H., Roth, T., Dement, W.C., eds.; Elsevier Inc.: Philadelphia, pp. 395–404.

Sherrill, D.L., Kotchou, K., Quan, S.F. (1998). Association of physical activity and human sleep disorders. *Arch. Inter. Med.* 158:1894–1898.

Spielman, A.J., Caruso, L.S., Glovinsky, P.B. (1987). A behavioral perspective on insomnia treatment. *Psychiatr. Clin. North Am.* 10:541–553.

Touitou, Y., Portaluppi, Y., Smolensky, M.H., Rensing, L. (2004). Ethical principles and standards for the conduct of human and animal biological rhythm research. *Chronobiol. Int.* 21:161–170.

Wever, R.A. (1979). Influence of physical workload on free-running circadian rhythms. *Pflug Arch.* 381:119–126.