

Characteristics of Insomniacs with Self-Reported Morning and Evening Chronotypes

Jason C. Ong, Ph.D.; Jennifer S. Huang, B.S.; Tracy F. Kuo, Ph.D.; Rachel Manber, Ph.D.

Department of Psychiatry and Behavioral Sciences, Stanford University, Stanford, CA

Study Objectives: This study examines the relevance of self-reported morning and evening chronotypes in treatment-seeking insomniacs presenting to a tertiary sleep clinic setting.

Design: Using a cross-sectional design, patients were categorized as morning, intermediate, and evening chronotypes based upon scores on the Morningness-Eveningness Composite Scale (MECS). Group comparisons were made on self-report measures of nocturnal sleep, sleep period variability, and waking correlates and consequences of insomnia. **Setting:** Sleep disorders clinic

Patients: The sample consisted of 312 patients who presented to a group cognitive-behavior therapy for insomnia (CBT-I) at the sleep clinic.

Measurements and Results: Participants completed the MECS, Beck Depression Inventory (BDI), Dysfunctional Beliefs and Attitudes about Sleep Scale (DBAS), and one week of sleep diary prior to treatment. Even after adjusting for total wake time as an index of insomnia sever-

ity, differences between the three chronotypes were present on several measures. Compared to the morning and intermediate types, evening types reported more total sleep time, more time in bed, greater variability in the time out of bed, and higher levels of distress on the DBAS and BDI.

Conclusions: These results indicate that insomniacs presenting to a sleep specialist who endorse an evening chronotype report sleep/wake irregularities and waking distress greater than expected in association with the level of insomnia severity. These factors may serve to perpetuate the insomnia disorder and might be particularly important to consider when treating this subgroup of insomniacs.

Keywords: Insomnia, chronotype, morningness, eveningness

Citations: Ong J; Huang J; Kuo T et al. Characteristics of insomniacs with self-reported morning and evening chronotypes. *J Clin Sleep Med* 2007;3(3):289-294

Variations in diurnal preferences for activity and sleep have long been classified as morning and evening chronotypes.¹ In healthy adults the timing of the sleep/wake cycle appears to be influenced by both endogenous (e.g., circadian pacemaker) and exogenous factors (e.g., work schedules, social commitments).² Scores on self-report questionnaires measuring morning and evening chronotypes have been shown to correlate with differences in markers of the circadian pacemaker.^{3,4} These differences include the peak,³ trough, amplitude,⁵ and period⁶ of the core-body temperature curve, as well as the melatonin⁷ and cortisol curves.⁸ Despite differences in the preferred timing of the sleep period, morning and evening types do not differ in sleep architecture.⁹ Instead, differences between chronotypes have been found in the variability of the sleep schedule, with evening types showing more variability in bed times and rising times compared to morning types.^{2,10} In addition, evening types appear capable of extending total sleep time during the weekend and may have a greater sleep need.¹⁰

Disclosure Statement

This is not an industry supported study. Drs. Ong, Huang, Kuo, and Manber have indicated no financial conflicts of interests.

Submitted for publication June, 2006

Accepted for publication December, 2006

Address correspondence to: Jason C. Ong, Ph.D., Department of Psychiatry and Behavioral Sciences, Stanford University Medical Center, 401 Quarry Road, Suite 3301, Stanford, CA, 94305-5730, Telephone: 650-725-5716, Email: jcong@stanford.edu

Morningness and eveningness scores are differentially related to several behavioral and psychological factors. Morning types appear to have more regular social rhythms compared to evening types, leading to the suggestion that this chronotype might have a more robust behavioral circadian amplitude.¹¹ In contrast, evening types report higher levels of daytime sleepiness^{12,13} and more maladaptive beliefs about sleep compared to morning types.¹⁴ Both groups are also sensitive to the time of day influence on performance tasks, with the morning group performing better during the morning and the evening group performing better during the afternoon.¹⁵ Eveningness has also been associated with several psychiatric illnesses including substance abuse,¹⁶ schizophrenia,¹⁷ and mood disorders.¹⁸⁻²¹ In particular, studies on chronotypes and mood disorders have found that eveningness is associated with depression symptom severity,^{19,20} Bipolar I Disorder,²¹ and seasonal affective disorder.¹⁸ Collectively, these findings indicate that eveningness is associated with a greater degree of irregularity and more psychiatric distress.

In sleep medicine, chronotypes have typically received attention in the context of circadian rhythm sleep disorders (CRSD) such as advanced sleep phase syndrome (ASPS) and delayed sleep phase syndrome (DSPS). Core symptoms of DSPS include a prolonged latency to sleep onset with difficulty waking up spontaneously at the desired time of awakening, while core symptoms of ASPS include a short latency to sleep onset with an earlier awakening than desired.²² In both cases, there is a mismatch between the endogenous circadian timing of sleep and the social or environmental demands, and sleep is normal in the absence of these exogenous constraints. Similar to CRSD, psychophysiological insomnia is an intrinsic sleep disorder with symptoms

including difficulty with sleep onset or sleep maintenance. However, in psychophysiological insomnia, somatic tension or conditioned arousal is also present and there is no evidence of phase misalignment.²² Although CRSD and psychophysiological insomnia have been conceptualized as distinct problems with different etiological mechanisms, recent models have suggested that circadian rhythm factors may be involved in the development of psychophysiological insomnia.²³

In a series of studies, Lack and colleagues examined the circadian rhythms of insomniacs recruited through advertisements. These researchers found evidence that insomniacs with sleep-onset difficulty exhibit a phase delay pattern in body temperature rhythm, while insomniacs with early morning awakenings exhibit a phase advance in the temperature rhythm.^{24,25} Another study found that insomniacs with an earlier temperature phase reported shorter and more restless sleep compared to those with a later temperature phase.²⁶ These studies indicate that the endogenous circadian rhythms might be relevant to the pattern of nocturnal insomnia complaints (i.e., sleep-onset versus sleep maintenance), although the direction of the relationship remains unclear.

It is not known if circadian preferences affect nocturnal symptoms and the waking correlates and consequences of poor sleep reported by insomnia patients above and beyond insomnia severity. To the best of our knowledge, no study has examined the relevance of circadian preferences to patients seeking treatment for insomnia. Therefore, the goal of this study was to explore differences between chronotypes on self-reported sleep/wake patterns and the waking correlates and consequences of insomnia after adjusting for total wake time as an index of insomnia severity. It was hypothesized that even after adjusting for total wake time, the evening chronotypes would exhibit a pattern of greater sleep/wake irregularity and greater psychological distress than other chronotypes.

METHOD

Participants

The present study examined data collected as part of routine care from a series of patients who attended group cognitive-behavior therapy for insomnia (CBT-I) between March 1999 and May 2004 at the Stanford Sleep Disorders Clinic. The CBT-I group is an outpatient service offered by the sleep clinic for the nonpharmacological treatment of insomnia. All patients who presented to the sleep clinic received an initial evaluation by a sleep specialist and were subsequently referred to the group CBT-I²⁷ if the evaluation revealed evidence of insomnia symptoms and the sleep specialist determined that the patient could benefit from nonpharmacological treatment of these symptoms. Given the tertiary clinic setting, patients with coexisting sleep disorders (e.g., sleep apnea, restless legs syndrome, periodic limb movement disorder), psychiatric disorders (e.g., depression), and medical conditions were allowed to attend the CBT-I group, resulting in a heterogeneous patient sample. During this time period, a total of 595 patients provided written informed consent to participate in the study or were exempt by a waiver obtained from the Institutional Review Board. Patients were included for analyses in this study if they provided valid data on the Morningness-Eveningness Composite Scale⁴ and completed at least 6 nights of valid baseline sleep diary data with at least 3 nights of sleep onset latency >30 minutes or

wake time after sleep onset >30 minutes.²⁸ As a result, a sample size of 312 patients was used for the present study. The study was approved by the Institutional Review Board at Stanford University Medical Center.

Procedures

Patients were asked to complete a questionnaire packet containing self-report measures, including a one-week sleep diary, when they enrolled in the group CBT-I. The completed packets were collected at the first or second treatment session. During the first session, patients were oriented to the treatment program, introduced to other members of the group, and presented their sleep complaints to the therapist and the group. No specific therapeutic elements were discussed during this session. Therefore, data completed between the first and second sessions were used for those participants who failed to complete the sleep diary or the initial packet prior to the first session.

Measures

MORNINGNESS-EVENINGNESS COMPOSITE SCALE (MECS)

The MECS⁴ is a 13-item scale used to determine an individual's preference for various activities and ease of rising in the morning (e.g., times to get up and to go to sleep, how easy to rise at 06:00). The scale includes 9 items from the Horne-Östberg Morningness-Eveningness scale³ and 4 items from the Torsvall and Åkerstedt scales.²⁹ The MECS has excellent internal consistency ($\alpha = 0.87$) and demonstrated psychometric properties that are comparable or better than the Horne-Östberg and Torsvall and Åkerstedt scales.⁴ Since its development, the MECS has been used in several studies on self-reported chronotypes.^{11,30}

Based on the MECS scores in this patient sample, participants were classified into morning (larks), intermediate (neither), and evening (owls) chronotypes. Given the absence of normative data for an insomnia population, classification of patients into chronotypes was based on quartiles: the top quartile (scores above 43) comprised the morning group, the middle 50% (scores between 30 and 43) comprised the intermediate group, and the lower quartile (scores below 30) comprised the evening group. The distribution of scores in the present sample is similar to that found in other studies using middle-aged adults^{11,31,32} and is slightly skewed towards morningness compared to a younger sample of undergraduate students, where the extreme 10% (morning type raw MECS score ≥ 44 ; evening type, ≤ 22) and the middle 80% (raw scores 23-43) were used for categorization.⁴

SLEEP/WAKE DIARIES

Patients completed prospective sleep/wake diaries every morning for one week at baseline before receiving any specific treatment instructions for improving sleep. Sleep diaries are routinely used for clinical and research purposes and are considered the standard of practice for measuring sleep in insomnia populations.³³ In the present study, nighttime diary items included the time of lights out (LO), number of awakenings (NWA), time out of bed (TOB), total sleep time (TST), and ratings of sleep quality (SQ; 1-10 Likert scale with higher numbers reflecting higher sleep quality). From these items, time in bed (TIB) was extracted as the

time between LO and TOB and total wake time (TWT) was calculated as TIB – TST. The average across all nights of the diary was calculated for TIB, TST, NWAK, and SQ. Together, this group of dependent variables was used in the analysis on nighttime sleep. To assess night-to-night variability in sleep habits, the standard deviation across the baseline week was calculated for each patient on the time of lights out and the time getting out of bed. To assess daytime sleep across the week, the sum of all napping time during the week was calculated. For descriptive purposes, patients were asked to report any medication used to facilitate sleep for each night on the sleep/wake diary (see Table 1).

DYSFUNCTIONAL BELIEFS AND ATTITUDES ABOUT SLEEP (DBAS)

The DBAS was originally developed as a 30-item scale by Morin and colleagues³⁴ and subsequently reduced to a 10-item version (DBAS-10) by Espie and colleagues.³⁵ The DBAS-10 is highly correlated with the original DBAS ($r = 0.83$) and has satisfactory internal consistency (Coefficient alpha = 0.69).³⁵ The total score from the DBAS-10 was used in the present study as a measure of sleep-related cognitions.

BECK DEPRESSION INVENTORY (BDI)

The BDI is a 21-item self-report scale used to assess symptoms of depression.³⁶ The scale has high internal consistency (Coefficient alpha = 0.87), strong evidence of validity, and appears to have one underlying factor.³⁷ In the present study, the total score on the BDI was used as a measure of depression symptom severity.

Table 1—Sleep medications

Type of Medication	Morning	Intermediate	Evening	Total
	n	n	n	n
No sleep medication				
Total	26	44	26	96
Hypnotics				
Benzodiazepines	5	12	6	23
Zolpidem	23	29	24	76
Zaleplon	2	1	1	4
Multiple Hypnotics	8	12	3	23
Total	38	54	34	126
Over-the-Counter				
Diphenhydramine	6	9	1	16
Melatonin	0	0	1	1
Herbal Remedy	2	1	0	3
Total	8	10	2	20
Antidepressant				
Total	4	14	8	26
Combinations				
Hypnotics + antidepressants	2	12	8	22
OTC + antidepressants	0	1	0	1
Zolpidem + Buspirone	0	1	0	1
Hypnotics + others	5	6	2	13
Total	7	20	10	37

Note. Data for 7 participants were uninterpretable and are not reported here. Chi-square analyses were conducted on the total number per group for each category.

Data Analysis

Descriptive analyses were conducted using chi-square tests to compare the groups on demographic variables and medication use. The main analyses were conducted across 3 conceptually-derived domains relevant to insomnia: nocturnal sleep, sleep period variability, and waking correlates and consequences. For nocturnal sleep, a multivariate analysis of covariance (MANCOVA) was conducted with chronotype as the between-subjects factor, TWT as the covariate, and NWAK, TIB, TST, and SQ as dependent variables (DV). For sleep period variability, a MANCOVA was conducted with chronotype as the between-subjects factor, TWT as the covariate, and the standard deviation of LO and TOB as the DV. For waking correlates and consequences, separate analyses were conducted on each DV, since they are different constructs. Analysis of covariance (ANCOVAs) with TWT as the covariate were conducted on depression and sleep related cognitions using BDI and DBAS, respectively, and a nonparametric test (Kruskal-Wallis) was conducted on total nap time due to violations of normality on this DV.

Preliminary examination of the data was conducted to test the assumptions of the MANCOVA and ANCOVA. Using stem-and-leaf plots, univariate outliers were identified for NWAK, TIB, standard deviation of LO and TOB, and BDI. Square-root transformations were conducted on these variables and subsequent evaluation for the assumptions of normality, linearity, multivariate outliers, multicollinearity, and homogeneity of variance-covariance matrices were satisfactory. Therefore, the MANCOVA and ANCOVA were conducted using square-root transformation for the variables above with an alpha level of $p < 0.05$. For the MANCOVAs, Bonferroni adjustments were subsequently applied to the univariate comparisons for each DV to adjust for Type I error resulting from multiple post hoc comparisons.

RESULTS

Descriptive Analyses

PATIENT DEMOGRAPHICS

A total of 312 patients met inclusion criteria for the study with 84 patients (60% female) in the morning group, 147 patients (59% female) in the intermediate group, and 81 patients (58% female) in the evening group. No significant sex differences between the groups were found. A one-way ANOVA revealed significant age differences between the 3 groups, $F_{2,306} = 13.13$, $p < 0.001$. The morning group was the oldest ($M = 54.27$ years, $SD = 14.18$), followed by the intermediate group ($M = 49.023$ years, $SD = 14.62$), and the evening group was the youngest ($M = 42.94$ years, $SD = 12.93$). In addition, a chi-square test revealed a significant difference on marital status, $\chi^2(4) = 9.94$, $p < 0.05$. More patients in the morning group (68%) were married compared with the intermediate (48%) or evening group (45%).

BED TIME AND RISE TIME PATTERNS

The overall bed time behaviors were consistent with expectations for each chronotype. The average LO was 22:35 for the morning group, 23:14 for the intermediate group, and 00:13 for the evening group. As expected, a one-way ANOVA revealed that

Table 2—Unadjusted means and standard deviations by chronotype

Variable	Morning			Intermediate			Evening		
	M	SD	n	M	SD	n	M	SD	n
Nocturnal sleep									
TST	5.93 ^a	1.11	79	5.88 ^a	1.32	137	6.44 ^b	1.39	70
TIB	7.94 ^a	.90	79	8.19 ^a	.99	137	8.71 ^b	1.16	70
NWAK	2.39	1.33	79	2.22	1.37	137	2.64	2.03	70
SQ	5.39	1.53	79	5.09	1.76	137	5.00	1.80	70
Variability									
LO	0.55	0.29	84	0.58	0.36	145	0.70	0.43	73
TOB	0.78 ^a	0.43	84	0.76 ^a	0.48	145	0.97 ^b	0.59	73
Waking correlates									
DBAS	56.72 ^a	14.93	84	60.60 ^a	15.83	144	68.59 ^b	12.41	73
BDI	10.38 ^a	6.71	84	13.08 ^b	7.17	144	16.99 ^c	9.93	72
Total Nap Time	64.11	114.14	84	56.30	96.03	147	84.46	176.45	81

Note. TST = Total Sleep Time; TIB = Time in Bed; NWAK = Number of Awakenings; SQ = Sleep Quality; LO = Lights Out; TOB = Time Out of Bed; DBAS = Dysfunctional Beliefs and Attitudes Scale; BDI = Beck Depression Inventory. Units for TST and TIB are in hours. Variability of LO and TOB is measured by the standard deviation across nights. SQ is rated on 1-10 scale with higher numbers representing greater quality. Units for total nap time are in minutes. For post hoc tests, group means across rows that have different subscript differ at $p < 0.05$ (e.g., $b > a$). All analyses were conducted using square root transformation for TIB, NWAK, LO, TOB, and BDI, but raw means are presented in this table to enhance interpretability. The variability in number of subjects reflects the list-wise deletion utilized by each analytic procedure.

the differences in LO between each group was significant, $F_{2,305} = 60.02, p < 0.001$. The average TOB was 06:31 for the morning group, 07:28 for the intermediate group, and 08:58 for the evening group. As expected, a one-way ANOVA revealed that the difference in TOB between the groups was significant, $F_{2,307} = 102.23, p < 0.001$.

MEDICATION

Analyses were conducted to examine medication use based on any medication used for sleep reported on the sleep diary (see Table 1). First, a chi-square test conducted on the use of any medication for sleep during the week revealed no significant differences between the groups. Subsequently, chi-square tests were conducted for each category of medication (hypnotics, over-the-counter sleep aids, antidepressants, combination), revealing no significant difference between groups on any of these categories.

Main Analyses

NOCTURNAL SLEEP.

The results of the MANCOVA conducted on NWAK, TIB, TST, and SQ revealed a significant difference between the chronotype groups on the linear combination of the 4 DVs after adjusting for TWT, $F_{8,558} = 3.05, p < 0.01, \text{Wilks' Lambda} = 0.92, \eta^2 = 0.04$. Univariate comparisons of each dependent variable using Bonferroni adjustments ($\alpha = 0.0125$) revealed significant differences on TIB, $F_{2,282} = 9.85, p < 0.001, \eta^2 = 0.07$, and TST, $F_{2,282} = 10.35, p < 0.001, \eta^2 = 0.07$. Mean comparisons revealed that the evening group reported more TIB compared to the morning and intermediate groups (see Table 2 for means and standard deviations) and more TST compared to the other 2 groups. No significant differences were found on NWAK or SQ ratings.

SLEEP PERIOD VARIABILITY.

The results for the MANCOVA conducted on the standard deviation of LO and TOB revealed a significant difference between the groups on the linear combination of the 2 DVs after adjusting for TWT, $F_{4,594} = 2.70, p < 0.05, \text{Wilks' Lambda} = 0.97, \eta^2 = 0.02$. Univariate comparisons of each dependent variable using Bonferroni adjustments ($\alpha = 0.025$) revealed a significant difference on the standard deviation of TOB, $F_{2,298} = 4.33, p = .014, \eta^2 = 0.03$. Mean comparisons revealed that the evening group exhibited more variability on TOB compared to the morning and intermediate groups (see Table 2 for means and standard deviations).

WAKING CORRELATES AND CONSEQUENCES OF INSOMNIA.

Three separate analyses were conducted for DBAS, BDI, and total nap time (see Table 2 for means and standard deviations). The one-way ANCOVA conducted on DBAS scores revealed a significant group difference after adjusting for TWT, $F_{2,297} = 13.06, p < 0.001, \eta^2 = 0.08$, with the evening group reporting more dysfunctional sleep related cognitions compared to the other 2 groups. The ANCOVA conducted on BDI revealed a significant group difference after adjusting for TWT, $F_{2,296} = 13.68, p < 0.001, \eta^2 = 0.09$, with the evening group reporting the highest levels of depression symptoms, followed by the intermediate group, and then the morning group. The Kruskal-Wallis test conducted on total nap time revealed no significant differences.

DISCUSSION

The goal of this study was to investigate the impact of chronotypes on sleep/wake patterns and the waking correlates of insomnia using a sample of treatment-seeking insomniacs. Even after adjusting for nocturnal total wake time as an index of insomnia severity, differences between the 3 chronotype groups were present in nocturnal sleep patterns, sleep period variability, and the

waking correlates and consequences of insomnia. Compared to the morning and intermediate types, evening types reported more pathological symptoms related to insomnia despite having more total sleep time. These findings suggest that circadian preferences are relevant to the presentation of insomniacs in terms of nocturnal symptoms as well as the associated waking correlates of insomnia.

The findings on nocturnal sleep patterns indicate that the evening group spent more time in bed and more time asleep relative to the other groups but the groups did not differ in the number of nocturnal awakenings or sleep quality. Compared to the other types, evening types appear more likely to compensate for nocturnal sleeplessness by extending the time in bed, and they are able to gain more total sleep time with the increased time in bed. Thus, the present findings are consistent with the hypothesis that evening types are more capable than morning types of extending their sleep period to compensate for sleep deficits.² Alternatively, the findings could be interpreted as support for the hypothesis that evening types have a greater need for sleep than the other chronotypes¹⁰; evening types may spend more time in bed to satisfy a greater sleep appetite. Future studies should test these hypotheses by investigating different levels of TIB by chronotypes to determine if the implementation of sleep restriction programs should be tailored to chronotypes.

Consistent with expectations, insomniacs with evening chronotypes had the most irregular sleep/wake habits, suggesting poor voluntary control of sleep habits or inadequate circadian entrainment and a greater degree of circadian dysregulation. These findings are consistent with the high level of variability in sleep habits observed among evening types in France¹⁰ as well as the association between morningness and lifestyle regularity.¹¹ Notably, univariate tests found significant differences between the groups on the night-to-night variability of TOB but not LO. Since the average TOB of the evening group was 08:58, a time that is likely to conflict with many daytime work schedules, this indicates that the evening types are likely to vary their TOB based upon social constraints (e.g., work schedule, appointments), which may lead to poor circadian entrainment. This finding is consistent with previous work on the role of the rise time as an important source of circadian entrainment.³⁸

Perhaps the most important finding is that insomniacs with evening chronotypes reported more severe waking correlates and consequences of insomnia in the areas of depression and sleep related cognitions above and beyond the severity of their insomnia. Despite more total sleep time, evening types reported more concern about the consequences of insomnia and the ability to control sleep than the other chronotypes. This suggests that evening types might be more sensitive to the effects of sleep loss or more averse to perceived sleep disruption than other chronotypes. It has also been hypothesized that an evening typology, with maladaptive sleep related cognitions and irregular sleep schedules, might be a risk factor for the perpetuation of insomnia symptoms.¹⁴ In the present study, evening types also reported greater depression symptom severity on the BDI compared with the other groups, a finding consistent with previous reports in samples of noninsomniacs.^{19,20} Together, the higher levels of depression symptomatology combined with greater sleep/wake variability among evening types are intriguing, given recent evidence linking irregularities in social rhythms, including sleep/wake patterns, with affective disorders.^{39,40} The present findings suggest that future research

should seek to clarify the relationship between chronotypes and affective disorders.

Several limitations of this study are acknowledged. First, the cross-sectional design prevents any causal inferences to be drawn regarding the relationships between daytime and nighttime variables in this study. Given the clinical setting, formal diagnostic screening procedures were not performed on these patients. As a result, the sample includes patients with comorbid sleep disorders or medical conditions that may affect their sleep habits, and the possibility that circadian preference is a correlate of a comorbid mood disorder cannot be ruled out. Also, the potential impact of medication cannot be ruled out with the present design. Although no differences were found between the groups on medication use, data were not available to distinguish the potential impact of medication on each chronotype (e.g., dosage and time at which the sleep medication was taken). It was not feasible in this clinical setting to systematically collect objective measures of sleep (e.g., PSG) or endogenous circadian rhythms (e.g., cortisol, melatonin, or core body temperature) that could provide further insights to the relationship between sleep and circadian rhythms. Moreover, data were not available to assess the timing of the awakenings in the present study, thus precluding the comparison of differences in the timing of wakefulness after sleep onset in the 3 chronotypes. Even though the present results revealed no significant differences between the groups on the number of awakenings during the night, previous studies have reported a greater number of awakenings during the early morning period among morning types.^{12,26}

Despite these limitations, the results from this study have potential clinical implications for the evaluation and treatment of insomnia. Although most insomniacs have dysfunctional cognitions and poor sleep habits, these problems are most pronounced in evening chronotypes, and might require additional clinical attention. For example, more time could be spent during sessions discussing these components of treatment. Given the night-to-night variability in bedtime behaviors of evening types, regulating sleep patterns might be a particularly important target in this group of patients, as it has been shown to improve sleep and decrease daytime sleepiness in people with irregular sleep schedules.⁴¹ Since this study employed a cross-sectional design, further research using a longitudinal design is encouraged to investigate the potential effects of chronotype on the course of the illness and response to treatment of insomnia. Overall, the findings from this study extend previous work on the relationship between circadian rhythm factors and insomnia to include both nocturnal symptoms and waking correlates of insomnia. It is hoped that these findings can stimulate future research to help understand the role of circadian factors in the development and treatment of insomnia.

ACKNOWLEDGEMENTS

We are grateful for data assistance provided by Christine Celio, Mary Huang, Sachiko Ito, Anna Packard, and Robin Okada. Portions of the data from this study were presented at the annual meeting of the Associated Professional Sleep Societies, Denver, CO, June 2005 and the annual meeting of the Association for Behavioral and Cognitive Therapies, Chicago, IL, November 2006.

REFERENCES

1. Freeman GL, Hovland CI. Diurnal variations in performance and related physiological processes. *Psychol Bull* 1934;31:777-99.
2. Kerkhof G. Inter-individual differences in the human circadian system: a review. *Biol Psychol* 1985;20:83-112.
3. Horne JA, Ostberg O. A self-assessment questionnaire to determine morningness-eveningness in human circadian rhythms. *Int J Chronobiol* 1976;4:97-110.
4. Smith C, Reilly C, Midkiff K. Evaluation of three circadian rhythm questionnaires with suggestions for an improved measure of morningness. *J Appl Psychol* 1989;74:728-38.
5. Baehr EK, Revelle W, Eastman CI. Individual differences in the phase and amplitude of the human circadian temperature rhythm: with an emphasis on morningness-eveningness. *J Sleep Res* 2000;9:117-27.
6. Duffy JF, Rimmer DW, Czesler CA. Association of intrinsic circadian period with morningness-eveningness, usual wake time, and circadian phase. *Behav Neurosci* 2001;115:895-9.
7. Griefahn B. The validity of the temporal parameters of the daily rhythm of melatonin levels as an indicator of morningness. *Chronobiol Int* 2002;19:561-77.
8. Kudielka BM, Federenko IS, Hellhammer DH, Wust S. Morningness and eveningness: The free cortisol rise after awakening in "early birds" and "night owls". *Biol Psychol* 2006;72:141-6.
9. Mongrain V, Carrier J, Dumont M. Chronotype and sex effects on sleep architecture and quantitative sleep EEG in healthy young adults. *Sleep* 2005;28:819-27.
10. Taillard J, Philip P, Bioulac B. Morningness/eveningness and the need for sleep. *J Sleep Res* 1999;8:291-5.
11. Monk T, Buysse D, Potts J, DeGrazia J, Kupfer D. Morningness-Eveningness and Lifestyle Regularity. *Chronobiol Int* 2004;21:435-43.
12. Carrier J, Monk T, Buysse D, Kupfer D. Sleep and morningness-eveningness in the 'middle' years of life (20-59 y). *J Sleep Res* 1997;6:230-7.
13. National Sleep Foundation. Summary of Findings of the 2005 Sleep in America Poll. Washington, D.C.: National Sleep Foundation; 2005 March 2005.
14. Adan A, Fabbri M, Natale V, Prat G. Sleep Beliefs Scale (SBS) and circadian typology. *J Sleep Res* 2006;15:125-32.
15. Hidalgo MP, Zanette CB, Pedrotti M, Souza CM, Nunes PV, Chaves ML. Performance of chronotypes on memory tests during the morning and the evening shifts. *Psychol Rep* 2004;95:75-85.
16. Adan A. Chronotype and personality factors in the daily consumption of alcohol and psychostimulants. *Addiction* 1994;89:455-62.
17. Hofstetter JR, Mayeda AR, Happel CG, Lysaker PH. Sleep and daily activity preferences in schizophrenia: associations with neurocognition and symptoms. *J Nerv Ment Dis* 2003;191:408-10.
18. Elmore SK, Dahl K, Avery DH, Savage MV, Bregelmann GL. Body temperature and diurnal type in women with seasonal affective disorder. *Health Care Women Int* 1993;14:17-26.
19. Drennan M, Klauber M, Kripke D, Goyette L. The effects of depression and age on the Horne-Ostberg morningness-eveningness score. *J Affect Disord* 1991;23:93-8.
20. Chelminski I, Ferraro F, Petros T, Plaud J. An analysis of the "eveningness-morningness" dimension in "depressive" college students. *J Affect Disord* 1999;52:19-29.
21. Mansour HA, Wood J, Chowdari KV, et al. Circadian phase variation in bipolar I disorder. *Chronobiol Int* 2005;22:571-84.
22. American Academy of Sleep Medicine. International classification of sleep disorders: diagnostic and coding manual - revised. Rochester, MN: American Academy of Sleep Medicine; 2000.
23. Lack LC, Bootzin RR. Circadian rhythm factors in insomnia and their treatment. In: Perlis ML, Lichstein KL, eds. *Treating sleep disorders: principles and practice of behavioral sleep medicine*. Hoboken, NJ: John Wiley & Sons; 2003:305-43.
24. Lack L, Wright H. The effect of evening bright light in delaying the circadian rhythms and lengthening the sleep of early morning awakening insomniacs. *Sleep* 1993;16:436-43.
25. Morris M, Lack L, Dawson D. Sleep-onset insomniacs have delayed temperature rhythms. *Sleep* 1990;13:1-14.
26. Kerkhof G, van Vianen B. Circadian phase estimation of chronic insomniacs relates to their sleep characteristics. *Arch Physiol Biochem* 1999:383-92.
27. Manber R, Kuo TF. Cognitive-behavioral therapies for insomnia. In: Lee-Chiong L, Sateia J, Carskadon MA, eds. *Sleep Medicine*. Philadelphia: Hanley & Belfus; 2002:177-85.
28. Lichstein KL, Durrence HH, Taylor DJ, Bush AJ, Riedel BW. Quantitative criteria for insomnia. *Behav Res Ther* 2003;41(4):427-45.
29. Torsvall L, Akerstedt T. A diurnal type scale. Construction, consistency and validation in shift work. *Scand J Work Environ Health* 1980;6:283-90.
30. Klei L, Reitz P, Miller M, et al. Heritability of morningness-eveningness and self-report sleep measures in a family-based sample of 521 hutterites. *Chronobiol Int* 2005;22:1041-54.
31. Paine SJ, Gander PH, Travier N. The epidemiology of morningness/eveningness: influence of age, gender, ethnicity, and socioeconomic factors in adults (30-49 years). *J Biol Rhythms* 2006 21:68-76.
32. Taillard J, Philip P, Chastang JF, Bioulac B. Validation of Horne and Ostberg morningness-eveningness questionnaire in a middle-aged population of French workers. *J Biol Rhythms* 2004;19:76-86.
33. Smith LJ, Nowakowski S, Soeffing JP, Orff HJ, Perlis ML. The measurement of sleep. In: Perlis ML, Lichstein KL, eds. *Treating sleep disorders: principles and practice of behavioral sleep medicine*. Hoboken, NJ: John Wiley & Sons; 2003:29-76.
34. Morin CM, Stone J, Trinkle D, Mercer J, Remsberg S. Dysfunctional beliefs and attitudes about sleep among older adults with and without insomnia complaints. *Psychol Aging* 1993;8:463-7.
35. Espie CA, Inglis SJ, Harvey L, Tessier, S. Insomniacs' attributions: psychometric properties of the Dysfunctional Beliefs and Attitudes about Sleep Scale and the Sleep Disturbance Questionnaire *J Psychosom Res* 2000;48:141-8.
36. Beck AT, Ward CH, Mendelson M, Mock JE, Erbaugh JK. An inventory for measuring depression. *Arch Gen Psychiatry* 1961;4:561-71.
37. Beck AT, Steer RA, Garbin MG. Psychometric properties of the beck depression inventory: twenty-five years of evaluation. *Clin Psychol Rev* 1988;8:77-100.
38. Burgess HJ, Eastman CI. The dim light melatonin onset following fixed and free sleep schedules. *J Sleep Res* 2005;14:229-37.
39. Haynes PL, Ancoli-Israel S, McQuaid J. Illuminating the impact of habitual behaviors in depression. *Chronobiol Int* 2005;22:279-97.
40. Meyer TD, Maier S. Is there evidence for social rhythm instability in people at risk for affective disorders? *Psychiatry Res* 2006;141:103-14.
41. Manber R, Bootzin RR, Acebo C, Carskadon MA. The effects of regularizing sleep-wake schedules on daytime sleepiness. *Sleep* 1996;19:432-41.