

Mood changes after sleep deprivation in morningness–eveningness chronotypes in healthy individuals

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SUMMARY Inconsistent results have been found in the studies evaluating the effect of both total and partial sleep deprivation (SD) on mood in healthy subjects and a few variables have been analyzed as possible predictors. In the present study, we examined whether circadian preference modifies the effect of SD on mood changes in healthy subjects. Sample consisted of 60 healthy volunteers (including 30 morningness and 30 eveningness subjects). Then, the two groups were again divided into two groups for two SD procedures. Fifteen morningness and 15 eveningness chronotypes were total sleep deprived and 15 morningness and 15 eveningness subjects were partial sleep deprived. The mood changes were evaluated before and after SD using Profile of Mood States. Two main results were obtained from our study: a significant increase in depression subscale in morningness chronotypes and a significant decrease in depression subscale score after total SD (TSD) in eveningness chronotypes. The changes in depression-dejection scores of eveningness chronotypes after total ($P < 0.01$) and partial SD ($P < 0.01$) were significantly different from changes in morningness chronotypes after TSD. Our results suggest that the effect of SD on mood in normal subjects is related to their circadian preferences. The morningness or eveningness characteristics of the shift workers have significant impact on their mood states. Therefore, adjusting the work schedule with the morningness and eveningness characteristics of the workers may improve their mood alterations.

KEYWORDS circadian, mood, shift work, sleep deprivation

INTRODUCTION

Historically, sleep deprivation (SD) has been used as a major tool in understanding the function of sleep (Bonnet, 2000). SD was introduced as a therapeutic agent for depressive syndromes by Schulte (1966) and has been used for nearly 30 years (see review in Wirz-Justice and van den Hoofdakker, 1999). Mood changes occur rapidly, but relapses after rebound sleep have limited its use in everyday clinical practice. Patients with positive diurnal variation (the patients feeling better in the evening) in the course of the day before SD tend to respond more favorably than those with negative diurnal variation (worse in the evening) or no

diurnal variation (Haug, 1992; Reinink *et al.*, 1990). Both total (TSD) and partial SD (PSD) in the second half of the night are efficacious.

Healthy individuals display distinct differences in the timing of biological and behavioral rhythms. Individuals having a marked preference, i.e., morningness-type (M) or eveningness-type (E), differ on a number of psychological and biological variables, including usual meal times, performance, body temperature, cortisol and melatonin secretion (Kerkhof, 1985; Natale and Adan, 1999; Tankova *et al.*, 1994). M types rise earlier in the day, retire earlier at night and show less variable sleep duration compared with E types. E types show a preference for sleeping later hours and often find it difficult to get up in the morning.

The purpose of this study was to investigate the relationship between circadian preference and the effects of both TSD and PSD on mood in healthy individuals.

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METHODS

Subjects

Participants were recruited from undergraduate students at the University of Yuzuncu Yil. Subjects were asked to read and to sign a consent form that provided detailed information about the nature of the study. A questionnaire from developed research studies was used to explore the various inclusion and exclusion criteria. Subjects reported disturbed sleep–wake cycles (i.e., a history of insomnia or hypersomnia, irregular sleep pattern and excessively advanced or delayed sleep, experienced night work or transmeridian travel) within the past 4 months were excluded from the study. All the subjects were medication-free and they had no sleep complaints for at least 1 year. They had no history of psychiatric, neurological and serious medical disorders or alcohol/substance abuse. Whether the subjects met the inclusion criteria was confirmed with a clinical interview (SCID-I) by two experienced physicians. Their circadian preferences were documented through the Morningness–Eveningness Questionnaire (MEQ), designed by Horne and Ostberg (1976). Thirty M (20 men and 10 women) and 30 E (20 men and 10 women) chronotypes were selected by means of a randomized procedure. Participants' age ranged from 18 to 30 years (25.4 ± 4.9).

All were healthy and normally slept 7–8 h at night, with the bedtime hour between 22:30 and 02:30 hours and the wake-time hour between 06:30 and 10:30 hours.

The Ethics Committee of the Faculty of Medicine, University of Yuzuncu Yil approved the study protocol. Written informed consent was obtained from all subjects after they had received a complete description of the study protocol. They were not paid for their participation.

Materials

Morningness–Eveningness Questionnaire

MEQ consists of 19 items pertaining to habitual rising and bed times, preferred times of physical and mental performance and subjective alertness after rising and before going to bed. MEQ yields scores ranging from 16 to 86. Higher scores show greater morningness. Lower scores indicate eveningness. MEQ classifies participants who score between 59 and 86 as M type, those scoring 16–41 as E type. The psychometric properties of the Turkish version of MEQ were tested by Agargun *et al.* (2003a). Its validity and reliability were found as high as the original version.

Profile of Mood States

POMS (McNair *et al.*, 1981) was developed to assess transient distinct mood states. The original form of the instrument consists of 65 adjectives rated on a 5-point scale from *not at all* to *extremely*. Six subscales were derived: Tension-anxiety, depression-dejection, anger-hostility, fatigue-inertia, vigor-activity and confusion-bewilderment. A seventh score of total

mood disturbance is also calculated by subtracting the score on the one positively scored subscale, vigor-activity, from the sum of the other five subscales. The validity and reliability of the Turkish version of POMS were performed by Agargun *et al.* (2003b).

Procedure

The subjects were divided into the M and E types on the basis of their ratings on the MEQ. We excluded all of intermediate types. The sample consisted of 60 subjects (30 M and 30 E subjects). Then, the two groups were randomly subdivided into two groups for distinct SD procedures. Thus, four groups were constituted as seen in Table 1. We evaluated the changes of mood states before (22:00 hours) and after (08:00 hours) SD using the POMS.

In this study, TSD was defined as an acute SD, which means not sleeping for 24 h. The subjects were instructed about SD procedure. SD was initiated at 08:00 hours and ended at 08:00 hours next day. The individuals were not allowed to sleep between 08:00 and 22:00 hours. All the participants were recruited to the clinic at 22:00 hours and they kept awake until the next morning at 08:00 hours. For the late PSD, subjects went to bed at their usual bedtime, and they were woken up at 01:30 hours. Participants were monitored by two investigators throughout the deprivation period to make sure they did not fall asleep.

The experiment was conducted in groups of five subjects in our clinic and participants were supervised throughout the whole period. They had no special activities during the SD. During SD, participants remained in a large lounge, watched TV, read, and played board games. Non-caffeinated beverages and snacks were available.

All analyses were performed using the SPSS software package (ver. 10.0; SPSS Inc., Chicago, IL, USA). Mean difference scores between baseline and follow-up POMS scores of four groups (group I: M chronotypes with TSD; group II: E chronotypes with TSD; group III: M chronotypes with PSD and group IV: E chronotypes with PSD) were compared with one-way ANOVA followed by *post-hoc* Tukey tests (using Bonferroni's corrections where appropriate). The Wilcoxon test was used to evaluate the POMS differences before and after the SD. The *P* level was set at 0.05 for statistical significance.

RESULTS

We found significant differences regarding mean scores changing from baseline to follow-up in tension-anxiety ($F = 4.41$, $P < 0.05$) and depression-dejection ($F = 7.06$, $P < 0.01$) subscales of four groups. The *post-hoc* testing using Bonferroni correction did not reveal any significant difference between groups regarding tension-anxiety subscale. The changes in depression-dejection scores of E chronotypes after TSD ($P < 0.01$) and PSD ($P < 0.01$) were significantly different from changes in M chronotypes after TSD.

Table 1 The mood changes of subjects after SD procedures

	<i>Tension-anxiety</i>	<i>Depression-dejection</i>	<i>Anger-hostility</i>	<i>Vigor-activity</i>	<i>Fatigue-inertia</i>	<i>Confusion-bewilderment</i>	<i>Total score</i>
Group I							
Before SD	15.3 ± 2.0	15.6 ± 1.3	15.4 ± 2.0	17.2 ± 3.9	8.8 ± 1.5	9.4 ± 2.1	47.4 ± 5.1
After SD	14.2 ± 1.7	19.1 ± 4.9	13.1 ± 2.1	13.5 ± 1.5	13.0 ± 2.5	11.0 ± 2.8	55.7 ± 6.2
Z value	-0.70	-1.82	-1.16	-3.18	-2.56	-1.08	-1.60
P	NS	0.047	NS	0.001	0.01	NS	NS
Group II							
Before SD	16.2 ± 1.3	20.0 ± 3.0	16.8 ± 4.4	15.6 ± 3.2	10.9 ± 2.7	11.5 ± 2.0	60.0 ± 6.8
After SD	12.6 ± 3.1	13.5 ± 1.7	11.4 ± 2.2	11.0 ± 1.2	10.1 ± 2.2	9.5 ± 1.4	46.2 ± 6.1
Z value	-1.12	-2.50	-2.33	-2.77	-0.37	-1.51	-1.90
P	NS	0.012	0.02	0.006	NS	NS	NS
Group III							
Before SD	11.1 ± 1.9	16.2 ± 5.3	12.6 ± 2.4	15.2 ± 5.2	10.0 ± 2.9	8.8 ± 1.5	43.9 ± 6.3
After SD	12.2 ± 3.9	10.4 ± 3.1	7.8 ± 2.1	16.0 ± 4.9	6.5 ± 2.1	7.5 ± 1.9	28.5 ± 4.1
Z value	-0.69	-1.73	-1.12	-0.09	-1.54	-0.75	-1.68
P	NS	NS	NS	NS	NS	NS	NS
Group IV							
Before SD	18.4 ± 2.2	22.6 ± 5.4	19.7 ± 4.5	15.2 ± 3.3	9.1 ± 1.7	7.3 ± 2.1	61.9 ± 6.6
After SD	13.2 ± 3.8	15.7 ± 2.8	14.2 ± 2.6	11.3 ± 3.7	13.8 ± 2.2	11.7 ± 3.1	57.4 ± 8.1
Z value	-2.59	-1.92	-2.29	-1.81	-2.05	-2.17	-1.14
P	0.01	0.046	0.02	NS	0.04	0.03	NS

Group I: The mood changes of M chronotypes after total sleep deprivation. Group II: The mood changes of E chronotypes after total sleep deprivation. Group III: The mood changes of M chronotypes after partial sleep deprivation. Group IV: The mood changes of E chronotypes after partial sleep deprivation. NS: not significant; SD: sleep deprivation.

Table 1 shows the mean and standard deviation scores of six subscales of POMS before and after PSD and TSD in E and M chronotypes. The results of the M chronotypes' POMS scores before and after TSD: 'Depression-dejection' subscale score showed a significant increase ($z = -1.82$, $P = 0.047$) and 'vigor-activity,' 'fatigue-inertia' subscale scores showed significant decreases after TSD ($z = -3.18$, $P = 0.001$ and $z = -2.56$, $P = 0.01$, respectively). 'Tension-anxiety,' 'anger-hostility,' 'confusion-bewilderment' and total POMS scores showed no significant differences before and after TSD.

The results of the E chronotypes' POMS scores before and after TSD: 'Depression-deject,' 'anger-hostility' and 'vigor-activity' subscales significantly decreased after TSD ($z = -2.50$, $P = 0.012$; $z = -2.33$, $P = 0.02$ and $z = -2.77$, $P = 0.006$, respectively). 'Tension-anxiety,' 'fatigue-inertia,' 'confusion-bewilderment' and total POMS scores showed no significant differences before and after TSD.

The results of the M chronotypes' POMS scores before and after PSD: no significant differences were found in all POMS subscales and total POMS scores. In other words, PSD did not influence the mood states of the M chronotypes.

The results of the E chronotypes' POMS scores before and after PSD: 'Depression-dejection,' 'tension-anxiety' and 'anger-hostility' subscales significantly decreased after PSD ($z = -1.92$, $P = 0.46$; $z = -2.59$, $P = 0.01$ and $z = -2.29$, $P = 0.02$, respectively). Significant increases were found in 'fatigue-inertia' and 'confusion-bewilderment' subscales ($z = -2.05$, $P = 0.04$ and $z = -2.17$, $P = 0.03$) but no significant changes were found in 'vigor-activity' subscale and POMS total scores.

DISCUSSION

Although many studies have investigated the effects of SD on mood in depressive patients, few studies have focused on mood changes in healthy subjects after SD. In the present study, we found that the effect of SD on the depressive mood is influenced by the individual circadian preferences: M chronotypes reported a worsening of their depressed mood, whereas E chronotypes improved. Our results suggest that the differential effects of SD in healthy subjects might be related to their circadian rhythm and sleep-wake habits.

It was interesting to find that TSD and PSD did not have the same effects on mood. PSD was ineffective in modifying mood in M chronotypes, whereas TSD worsened depressive mood and tiredness as well as decreasing activity. E chronotypes improved mood and decreased anger-hostility after both PSD and TSD. Activity was decreased after TSD. PSD in E chronotypes increased fatigue/inertia and confusion – the latter may be after-effects of being awakened from deep sleep (the sleep inertia effect).

The results of our study may be useful when considering shift work. Shift work does not influence every worker equally. It has been estimated that almost one in five workers leave shift work because they cannot tolerate it, about 10% positively enjoy it, and the rest tolerate it to a greater and lesser extent (Harrington, 1978). It seems that women complain of more sleepiness on shift work and exposure to more health problems than men. Women are more often M chronotypes (Adan and Natale, 2002), which may be one reason for this finding. There is an association between neurotic introversion and intolerance to shift work. Young workers tolerate it better than older ones

(Harrington, 2001). Because adjustment to night shift necessitates a phase delay of circadian rhythms, E chronotypes adjust more readily to this system (Costa, 1997). An early study found that extremely morning type workers suffer more from shift work than their evening type counterparts (Hildebrandt and Stratmann, 1979). One study which assessed the quantity and quality of sleep of M & E chronotyped industrial shift workers supports this finding (Khaleque, 1999). The quality of sleep of the E chronotype workers is better than that of the M chronotype workers, and E individuals seem more adapted to shift work than the M group.

In summary, morningness or eveningness characteristics of healthy subjects have significant impact on their mood states when deprived of sleep. This suggests that health, well-being, productivity, and tolerance to shift work could be improved by matching an individual's circadian preference to the appropriately timed shift.

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