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Polysomnographic, Performance, and Personality Differences of Sleepy and Alert Normals

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Summary: The nocturnal sleep, performance, and personality of healthy, asymptomatic, normal young men, 18 who had unusually short sleep latencies on the Multiple Sleep Latency Test (average latency, ≤6 min) and 20 with unusually long latencies (average latency, ≥16 min) were compared. On the nocturnal sleep recording, sleepy subjects had a shorter sleep latency, less waking time, and overall greater sleep efficiency than alert subjects. During the day, sleepy subjects performed more poorly than alert subjects on divided attention and vigilance performance tasks. The sleepy and alert subjects did not differ appreciably on the Minnesota Multiphasic Personality Inventory and Jenkins Activity measures of personality. On the Institute of Personality and Ability Testing Anxiety Scale, the sleepy subjects showed higher levels of anxiety than the alert subjects. The data were interpreted as indicating that the sleepy subjects had a sleep debt due to chronic sleep restriction. **Key Words:** MSLT—Daytime sleepiness—Personality—Performance.

A percentage of healthy, normal, asymptomatic young adults, when assessed with the Multiple Sleep Latency Test (MSLT), are objectively sleepy during the day following 8 h of sleep the previous night (1). Sixteen percent of 129 normal subjects had average daily sleep latencies of ≤6 min, although all reported sleeping normally and none complained of excessive daytime sleepiness or reported napping during the day. Average daily sleep latencies of 6 min or less are consistently seen in patients with disorders of excessive daytime sleepiness (2). Conversely, a percentage of subjects also showed unusually long latencies; 16% of the 129 young adults had average daily sleep latencies of ≥16 min.

It can be hypothesized that the different daytime sleep latencies of these healthy normal individuals is the expression of a differential fulfillment of sleep need. Webb and Agnew were the first to propose that many healthy adults have accumulated a sleep debt that results from chronically insufficient sleep relative to sleep need (3). Alterna-

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tively, one could argue that the differences in daytime sleep latency merely reflect individual differences in ability to fall asleep and are not associated with nocturnal sleep time.

If the group differences in daytime sleep latency arise from a differential fulfillment of sleep need, previous studies suggest there should be predictable differences in the nocturnal sleep of the groups. It has been previously reported that restriction and extension of bedtime in healthy normal subjects systematically affects nocturnal sleep efficiency, with restriction increasing sleep efficiency and extension reducing efficiency (4). Another study has shown that patients with a diagnosis of excessive daytime sleepiness associated with chronic insufficient sleep have short sleep latencies on the MSLT and normal nocturnal sleep with no identifiable sleep pathologic characteristics, but unusually high (i.e., consistently >90%) sleep efficiencies (5). Thus, it is of interest to compare the nocturnal sleep of sleepy asymptomatic normal subjects to that of their alert counterparts.

Further, if these individuals are differentially meeting their sleep needs, either in quality or quantity, one would expect that there should be some daytime consequence associated with the insufficient sleep. Studies have shown that restriction of nocturnal sleep time by 1–2 h or fragmentation of sleep without reducing the total amount of sleep produces deficits in various measures of performance, specifically psychomotor and vigilance skills (6,7). Thus, a comparative assessment of performance efficiency between the unusually sleepy and alert normal subjects was also included in this study.

Finally, personality differences between these sleepy and alert normal subjects would be of interest for several reasons. First, studies have found that self-reported long and short sleepers differ in personality variables. In studies comparing short and long sleepers, long sleepers scored higher on the social introversion scale of the Minnesota Multiphasic Personality Inventory (MMPI) and short sleepers scored higher on the sociability and flexibility scales of the California Personality Inventory (8,9). Given that the personality profile of the short sleepers resembled that of the coronary-prone type A personality, subsequent studies compared short and long sleepers on the Jenkins Activity Scale (10,11). These studies found that short and variable sleepers had greater levels of type A behavior than long sleepers.

A second reason that the personality profiles of sleepy and alert normal subjects is of interest was mentioned earlier. One could argue that personality variables relate not to sleep habits or needs, but rather to the ability to relax and fall asleep quickly during the MSLT. Thus, this study also assessed the personality profiles of unusually sleepy and alert healthy normal young adults.

METHODS

Subjects

Thirty-eight healthy young men aged 21–35 years (18 sleepy and 20 alert subjects as defined later, see Table 1) participated in this study. All subjects had self-described normal sleep, no complaints of daytime sleepiness, and no habitual napping. They were healthy and drug free based on the screening described later. Each signed an informed consent and was paid for his participation.

Procedure

The subjects were recruited through newspaper advertisements and announcements posted at local universities and hospitals. The subjects were being recruited for various

studies being conducted at the time. In a telephone interview, the subjects reported their usual nocturnal bedtime, arising time, and total sleep time. All subjects were required to report spending between 6.5–8 h in bed nightly. However, subjects with highly irregular bedtimes and arising times (i.e., variations of >2 h nightly) were excluded. Also excluded were subjects who had difficulty sleeping at night, reported sleepiness during the daytime, or routinely napped. Subjects reported no history of alcohol or drug abuse and no current drug use.

Each subject then came to the sleep center and underwent a medical history, drug use history, and physical examination, and blood and urine samples were collected. Standard laboratory analyses of the blood and urine samples were used to verify normal health and the absence of recent drug use.

Subjects were scheduled for a standard 8-h polysomnogram and MSLT the following day. They reported to the sleep laboratory 1.5 h before their usual bedtime, with 2230 h being the latest arrival time to assure a 0000-h bedtime and 0800-h arising time. These limits were established to maintain a minimum of 2 h of wakefulness before the first latency test of the MSLT. For the polysomnogram, subjects had electrodes attached at standard placements for the continuous recording of bilateral electro-oculograms (EOGs), submental and tibialis electromyograms (EMGs), central (C3/C4) and occipital (Oz) electroencephalograms (EEGs), and electrocardiograms (ECGs) (V5) according to standard procedures (12). Naso-oral thermistors were used to monitor breathing during sleep (13).

In the morning, subjects arose, bathed, and were allowed to eat a light breakfast with the instruction to avoid beverages with caffeine. Electrodes were checked and replaced if necessary to prepare for the MSLT. The MSLT was conducted at 1000, 1200, 1400, and 1600 h according to standard procedures (14). Subjects went to bed in a darkened room and were instructed to try to fall asleep, while EOGs, submental EMG, and EEGs, always including an Oz placement, were recorded. The recording was terminated after 1 min of unambiguous stage 1 sleep, the first signs of stage 2 or rapid-eye-movement (REM) sleep, or 20 min of continuous waking according to standard sleep stage criteria (12). Sleep latency was defined as minutes to the first 30-s epoch of nonwaking recording. Results of the screening MSLT defined the two study groups (see Table 1). Sleepy subjects had average daily sleep latencies on the MSLT of ≤6 min, and alert subjects had latencies of ≥16 min. The first 20 consecutive subjects meeting the "sleepy" criteria and the first 18 meeting the "alert" criteria were included in this study.

During the day between latency tests, each subject completed an MMPI, the Jenkins Activity Survey, and the Institute of Personality and Ability Testing (IPAT) Anxiety Scale. The MMPIs were scored on the standard nine clinical scales. The IPAT Anxiety

TABLE 1. *Study groups*

	Alert subjects	Sleepy subjects
Inclusion criteria	MSLT ≥16 min	MSLT ≤6 min
No. per group	18	20
Mean age, yr	24 (2.9)[a]	26 (5.3)
Mean MSLT[b] result, min	18.0 (1.5)	3.8 (1.2)
Reported sleep time, h	7.7 (0.9)	7.5 (0.8)

[a] Data are means (±SD).
[b] MSLT, Multiple Sleep Latency Test.

Scale provides scales on overt and covert anxiety, apprehensiveness, suspicion, tension, low self-control, and total anxiety (15). The Jenkins Activity Survey yields a type A behavior score and additionally scores for impatience, job involvement, and competitiveness (16).

All subjects of each of the groups also underwent a performance battery. A 20-min divided attention task required tracking, with a joystick, a moving target appearing on a video monitor, while responding on a key to the appearance of a target stimulus (a bright circle) in the center or the periphery of the monitor. A 40-min auditory vigilance required detection of long 1,000-Hz tones (450 ms) against the background of short 1,000-Hz tones (250 ms). Divided attention was assessed at 1030 h and auditory vigilance at 1430 h. These tests have been used in a number of previous studies and have proven to be sensitive to the sedating and alerting effects of various manipulations of sleep and drugs (17–19).

As indicated earlier, the average daily sleep latency on the MSLT defined the two subject groups. The groups were compared on standard nocturnal polysomnographic parameters, personality measures, and performance parameters. Since the groups were being compared on a large number of dependent measures, many of which are intercorrelated, multivariate analyses (MANOVA) were conducted using the general linear model analysis (SAS Institute). Separate analyses were done on vigilance parameters, divided attention parameters, parameters for each of the personality measures (MMPI, Jenkins, and IPAT), and two groupings of polysomnographic parameters, those reflecting sleep efficiency and those reflecting sleep staging.

RESULTS

Nocturnal sleep

The results of the nocturnal polysomnography for the sleepy and alert groups are presented in Table 2. The overall MANOVA comparing sleepy and alert subjects on polysomnographic variables reflecting sleep efficiency was significant ($F = 18.27$, $df = 7,30$, $p < 0.001$). The subjects were selected for differential daytime sleep latencies on the MSLT and at night, sleepy subjects also had shorter latencies to stage 1 sleep ($F = 16.67$, $df = 1,36$, $p < 0.001$) and stage 2 sleep ($F = 15.47$, $df = 1,36$, $p < 0.001$). Also, sleepy subjects had a higher sleep time per time in bed ($F = 19.13$, $df = 1,36$, $p <$

TABLE 2. *Polysomnographic measures*

	Alert subjects	Sleepy subjects
Sleep efficiency measures		
latency stage 1, min	20.4 (13.3)[a]	7.4 (4.7)
latency stage 2, min	26.4 (14.4)	12.1 (6.8)
sleep time/time in bed, %	86.9 (7.4)	94.6 (3.4)
wake before sleep, min	24.8 (16.9)	9.1 (5.5)
wake during sleep, min	33.5 (26.2)	16.0 (15.2)
entries to stage 1, no.	17.7 (10.3)	26.0 (10.5)
awakenings, no.	16.6 (8.7)	10.8 (6.7)
Sleep stage measures		
stage 1, %	10.2 (4.2)	10.6 (3.3)
stage 2, %	53.6 (5.9)	57.0 (5.3)
stages 3/4, %	16.6 (8.1)	12.8 (6.3)
Rapid eye movement (REM), %	19.6 (5.9)	19.5 (3.4)
latency REM, min	89.9 (28.3)	88.6 (36.7)

[a] Data are means (±SD).

0.001), less waking time before sleep ($F = 17.64$, $df = 1,36$, $p < 0.001$), and less waking time during sleep ($F = 7.33$, $df = 1,36$, $p < 0.01$) than alert subjects. The sleepy subjects had more entries to stage 1 sleep ($F = 6.60$, $df = 1,36$, $p < 0.01$) and fewer awakenings than alert subjects ($F = 5.92$, $df = 1,36$, $p < 0.02$). These differential sleep stage transition data (entries to stage 1 versus number of awakenings) for the two groups is illustrated in Fig. 1. The two groups, however, did not differ in any of the sleep stage percentages or in latency to REM sleep. The MANOVA comparing groups on sleep staging measures was not significant.

Daytime performance

The performance measures for the two groups are presented in Table 3. The MANOVA comparing groups on divided attention performance was significant ($F = 3.03$, $df = 4,33$, $p < 0.01$). On the divided attention task, the sleepy subjects had poorer tracking accuracy ($F = 7.65$, $df = 1,36$, $p < 0.01$) and tracking deviation ($F = 7.93$, $df = 1,36$, $p < 0.01$) performance. The two reaction time measures of the divided attention task did not differ between groups. The Z scores, which combined tracking and reaction time measures for a given subject, showed poorer overall divided attention performance ($F = 4.92$, $df = 1,36$, $p < 0.03$) in the sleepy subjects.

The auditory vigilance reaction time data were submitted to a mixed-design ANOVA, with reaction time on each of four 10-min blocks the within-subject variable and groups the between-subject variable. On the auditory vigilance task, reaction times for both groups slowed in the last two 10-min blocks of the task, a common finding in such a task ($F = 8.44$, $df = 3,109$, $p < 0.001$). However, the slowing of reaction times in the last two 10-min blocks was more marked ($F = 3.19$, $df = 3,109$, $p < 0.03$) in the sleepy subjects compared to the alert subjects.

Personality measures

Figure 2 presents the MMPI personality profiles of the two subject groups. As is clearly illustrated, no significant differences were found between the groups on any of the nine clinical MMPI scales. The parameters derived from the Jenkins Activity Sur-

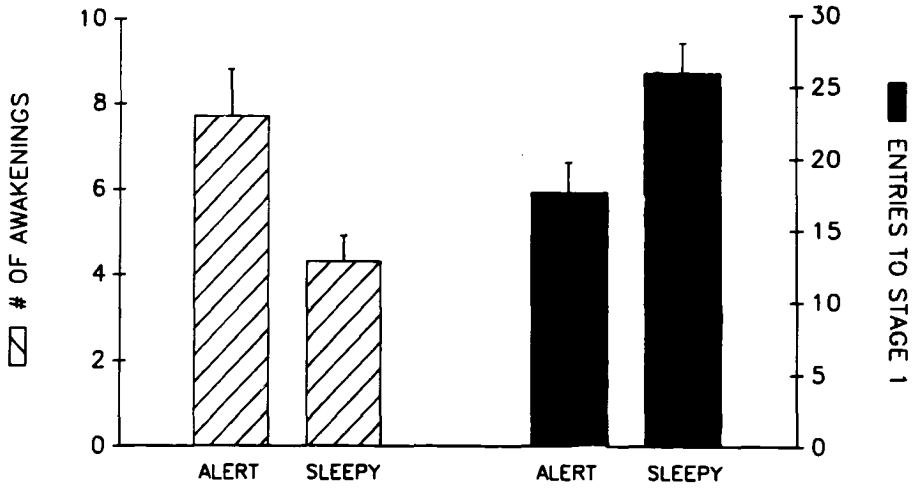

FIG. 1. The number of awakenings and the number of entries to stage 1 sleep in alert and sleepy subjects.

TABLE 3. *Performance measures*

	Alert subjects	Sleepy subjects
Divided attention		
tracking accuracy[a]	81.8 (16.5)[b]	89.4 (19.2)
tracking deviation[a]	124.1 (67.8)	146.0 (59.5)
central reaction time[a]	24.7 (3.1)	25.2 (3.1)
peripheral reaction time[a]	23.6 (3.1)	23.7 (3.7)
Z score	−0.25 (0.6)	0.21 (0.7)
Auditory vigilance		
block 1 reaction time, ms	380.2 (234.5)	361.6 (196.0)
block 2 reaction time, ms	414.7 (298.9)	469.1 (244.6)
block 3 reaction time, ms	452.4 (329.5)	563.4 (345.1)
block 4 reaction time, ms	421.5 (323.7)	503.5 (335.3)

[a] Computer-generated units of measure.
[b] Data are means (±SD).

vey and IPAT Anxiety Scale are presented in Table 4. The Jenkins Activity Survey revealed no group differences. The MANOVA comparing groups on the IPAT Anxiety Scale was significant ($F = 3.83$, $df = 8,29$, $p < 0.005$). The difference between groups was found primarily on the IPATL scale. Sleepy subjects had higher scores on the IPATL scale ($F = 8.00$, $df = 1,36$, $p < 0.01$) than alert subjects did, reflecting greater suspicion. As Table 4 indicates, group differences on other scales, although not significant in univariate comparisons, were also in the direction of sleepy subjects showing greater anxiety.

DISCUSSION

These results support the hypothesis that the daytime sleepiness/alertness of these healthy normal subjects is an expression of a differential fulfillment of sleep need. The groups differed in nocturnal sleep efficiency, but not sleep staging. Sleepy subjects had

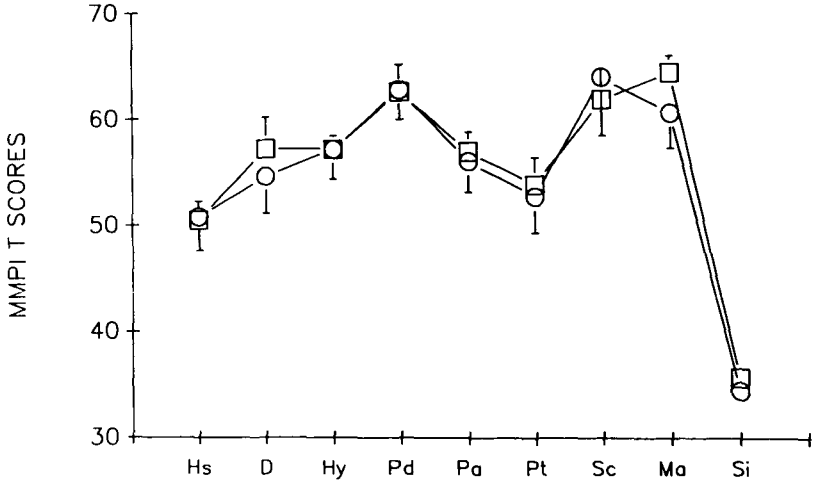

FIG. 2. The *T* scores on the clinical scales of the Minnesota Multiphasic Personality Inventory (MMPI) for alert (○——○) and sleepy (□——□) subjects. Hs, hypochondriasis; D, depression; Hy, hysteria; Pd, psychopathic deviate; Pa, paranoia; Pt, psychasthenia; Sc, schizophrenia; Ma, hypomania; Si, social introversion.

TABLE 4. *Personality measures*

	Alert subjects	Sleepy subjects
IPAT scales		
IPATA: covert anxiety	12.5 (5.6)[a]	12.6 (5.0)
IPATB: overt anxiety	9.7 (5.9)	12.1 (5.1)
IPATC: emotional stability	3.1 (2.3)	4.5 (2.6)
IPATL: suspicion	2.2 (1.8)	3.7 (1.7)
IPATO: apprehension	6.9 (3.5)	7.5 (3.9)
IPATQ3: low self-control	5.1 (2.2)	4.0 (2.1)
IPATQ4: tension	5.2 (3.1)	5.1 (3.2)
IPATT: total anxiety	22.2 (10.5)	24.8 (9.2)
Jenkins Activity Scale		
type A	2.7 (13.2)	0.9 (10.7)
factor S: speed, impatience	1.4 (13.3)	0.4 (10.8)
factor J: job involvement	6.4 (10.6)	7.5 (10.1)
factor H: hard driving	−1.3 (11.4)	−2.8 (10.6)

[a] Data are means (±SD).

more efficient sleep, suggestive of the existence of a chronic sleep debt. The nocturnal sleep findings were associated with daytime performance results that also suggested that the sleepy subjects had a chronic sleep debt. Sleepy subjects performed more poorly than the alert subjects.

An important question is whether the sleep debt of the sleepy subjects is due to reduced quantity of sleep (i.e., a voluntary habitual restriction of sleep time) or reduced quality of sleep. Sleep quality has been studied in the laboratory by experimentally disrupting sleep with tones, which produces brief EEG arousals (20). Such a manipulation fragments sleep and produces disruption of daytime alertness. However, the group differences of this study are not a matter of naturally occurring differences in fragmentation of sleep. Sleep fragmentation typically results in an elevated percentage of stage 1 and shifts to stage 1 sleep. The percentage of stage 1 sleep was not elevated in the sleepy subjects, although entries to stage 1 were elevated (see Table 2). The elevated shifts to stage 1 without an elevated percentage of stage 1 probably indicates that, rather than waking completely or remaining in light sleep, sleepy subjects quickly returned to deeper sleep after arousing. Figure 1 illustrates these group differences in the pattern of waking time and entries to stage 1.

It could be argued that the difference in sleepy latency on the MSLT that defined the groups merely reflects individual differences in ability to relax and fall asleep. However, such an explanation does not account for the nocturnal sleep and performance differences between the groups. Furthermore, the one group difference in personality, found in this study, was in the opposite direction than that predicted (i.e., sleepy subjects are relaxed and less anxious). On the anxiety scales of this study, sleepy subjects, not alert subjects, showed greater anxiety. Parenthetically, it should be noted that the anxiety scores of both groups in this study are well below the 50th percentile of population norms for healthy, normal college student males (15).

The most parsimonious explanation for the pattern of results found in this study is that the sleepiness of the sleepy group is the result of a habitual restriction of sleep time relative to sleep need. A direct test of the hypothesis that the sleepiness of these sleepy subjects is due to a chronic sleep restriction is to extend the bedtime of such subjects. One would expect to see an improvement in MSLT scores, performance measures, and a reduction in nocturnal sleep efficiency measures. A recent study extended the bed-

time of a group of sleepy normal subjects for 6 consecutive nights and found an improvement in MSLT scores and performance relative to those of a group of alert normal subjects (19). Additionally, over the 6 nights nocturnal sleep efficiency of the sleepy subjects declined. Such data strengthen the argument that the different levels of sleepiness of this study are associated with different chronic sleep debts.

A final issue is why the two groups of subjects seem to have differential sleep debts given that they report almost comparable time in bed nightly (i.e., about 7.5 h). There are two possibilities: the sleepy subjects are reporting greater time in bed than they actually are achieving, which seems unlikely, or the sleepy group may be biologically long sleepers requiring more than the cultural norm of 7–8 h nightly sleep.

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