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# Sleepiness/Alertness on a Simulated Night Shift Schedule and Morningness–Eveningness Tendency

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**Summary:** This study examined the influence of morningness–eveningness on night shift sleepiness in 15 subjects. Sleepiness was assessed during a five-night protocol involving the multiple sleep latency test (MSLT), repeated test of sustained wakefulness (RTSW) and the Stanford Sleepiness Scale (SSS). Daytime sleep was estimated by sleep diaries and wrist actigraphy. The sample was divided by median score on the Horne and Ostberg Morningness-Eveningness Questionnaire. Physiological sleep tendency was significantly worse between 0030 and 0430 hours for the Morning Tendency group than for the Non-Morning Tendency group. The Morning Tendency group reported obtaining less daytime sleep than the Non-Morning Tendency group; however, there was no difference between groups in total daytime sleep estimated by actigraphy. This preliminary study suggests that morning types are sleepier during night shift hours than non-morning types. **Key Words:** Morningness–eveningness—Shift work—Sleepiness.

Approximately 6.8 million people in the United States work a night or rotating shift schedule (unpublished data from the May 1991 Supplement Current Population Survey, U.S. Bureau of Labor and Statistics). For most shiftworkers, nocturnal wakefulness and perfomance followed by daytime sleep conflicts with their circadian rhythms. Consequently, three-fourths of night shift workers are sleepy every night shift and at least one-fifth fall asleep on the job (1).

People differ in their preferred time of day for mental and physical activity. Those who experience peak alertness and activity early in the day are called "morning types". Others, who feel best later in the day, are known as "evening types" (2). This morningness–eveningness tendency has been hypothesized as a tolerance factor in night work (3).

Studies have shown that the alertness acrophase is nearly three hours earlier for morning types than for evening types (4). When bedtimes were delayed in one study, evening types adapted by maintaining habitual sleep length, but morning types were unable to obtain their normal amount of sleep and became sleep deprived (5).

To our knowledge, the relationship between physiological sleepiness/alertness during night shift hours and morningness–eveningness has not been studied. Also, changes in physiological sleepiness/alertness in night shift workers over several nights have not been examined in these groups. Finally, the daytime sleep of circadian types has not been objectively studied. The purpose of this study was to examine these factors as a function of morningness–eveningness.

## METHODS

### Subjects

Fifteen volunteers were recruited through advertisement. Four males and 11 females (mean age = 41 years; range 32–53 years) were screened for medical disorders, psychopathology, and central nervous system-active medications by physical examination, medical history, and laboratory tests. No volunteer had worked rotating or night shifts during the past year. Volunteers were screened for sleep disorders by nocturnal polysomnography and sleep history. Subjects gave written informed consent and were paid for participation.

### Procedures

The Horne and Ostberg Morningness–Eveningness Questionnaire (6) (HOMEQ) was given to subjects participating in a counterbalanced, cross-over, double-blind study to examine the effect of triazolam on sleep and alertness during a simulated night shift schedule

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(7). Subjects underwent two tours of five nighttime test periods and four daytime sleep periods. During one tour, the subjects received placebo and during the other, they received triazolam. Tours were separated by a minimum of seven days of normally timed sleep. Only the placebo tour data are reported here.

On five consecutive nights, subjects arrived at the lab at 2130 hours. Sleepiness/alertness was measured at two-hour intervals between 2230 and 0700 hours with the multiple sleep latency test (MSLT) and the repeated test of sustained wakefulness (RTSW) (8). The Stanford Sleepiness Scale (SSS) was given at two-hour intervals, starting at 2225 hours.

Sleep latency for each MSLT and RTSW subtest was scored as the first epoch of any sleep stage. Each subtest was terminated after three consective epochs of stage 1, the appearance of stage 2 or REM, or after 20 minutes if no sleep occurred.

Following nighttime testing, subjects were taken home by taxi. They were instructed to go to bed immediately and sleep as long as possible between 0900 and 1700 hours. They were not required to remain in bed if they were unable to sleep for the entire eight hours. Subjects recorded sleep estimates in a diary. For an objective estimate of daytime sleep, each subject wore a wrist actigraph (Ambulatory Monitory, Inc., Ardsley, NY).

Actigraph measurements were taken in one-minute epochs. Actigraphic sleep–wake scoring methodology is described in a previous study (7). Briefly, "sleep" was defined as the first of three successive epochs with accumulated activity level less than or equal to 20 units, and "wake" was defined as any epoch with activity level greater than 20 units and those epochs not meeting criteria for sleep.

## RESULTS

The sample was split by the median HOMEQ score of 52.9, forming a Morning Tendency (MT) group and a Non-Morning Tendency (Non-MT) group. The mean HOMEQ score for the MT group (4 females and 3 males) was 66.1, which is within the Horne and Ostberg criteria range (59–86) for morning types (6). This group contained six morning types and one intermediate type, with individual scores ranging from 57 to 74. The Non-MT group's (7 females, 1 male) mean score was 41.2, which is slightly outside the criteria range for evening types (16–41). Three evening types and five intermediate types formed this group, with scores ranging from 25 to 52. There was no significant age difference between groups. Differences in living conditions, family situations, and bedroom standards were not assessed.

Data were analyzed with repeated measures analysis of variance (night × time × group) using a multivariate general linear hypothesis model (SYSTAT, Inc., Evanston, IL). To control for bias that may be present in this design, conservative Huynh-Feldt probabilities were used. Post hoc comparisons were done when there were significant group effects or group by time of night interactions. Night 1 was excluded from analysis because of the influence of sleep deprivation produced by the change to a night schedule. RTSW, MSLT, and SSS data are presented in Table 1.

**TABLE 1.** *Morning Tendency (MT) and Non-Morning Tendency (Non-MT) groups compared for SSS scores, MSLT, and RTSW means (in minutes) on nights 2 through 5*

| Time of day | SSS score MT | SSS score Non-MT | MSLT mean MT | MSLT mean Non-MT | RTSW mean MT | RTSW mean Non-MT |
|---|---|---|---|---|---|---|
| 2225 | 1.71 | 1.13 | | | | |
| 2230 | | | 14.66 | 14.53 | | |
| 2300 | | | | | 14.96 | 18.95 |
| 0025 | 2.21 | 1.41[a] | | | | |
| 0030 | | | 7.5 | 13.45[a] | | |
| 0100 | | | | | 9.95 | 16.69[a] |
| 0225 | 3.39 | 1.91[a] | | | | |
| 0230 | | | 4.43 | 9.67[a] | | |
| 0300 | | | | | 7.36 | 13.94[a] |
| 0425 | 4.18 | 2.84[a] | | | | |
| 0430 | | | 3.14 | 6.7[a] | | |
| 0500 | | | | | 6.8 | 11.89 |
| 0625 | 4.07 | 3.63 | | | | |
| 0630 | | | 3.86 | 3.56 | | |
| 0700 | | | | | 9.11 | 11.09 |

[a] $p < 0.05$.

### Physiological sleepiness/alertness

MSLT data analysis demonstrated a significant group by time of night interaction ($F = 4.2$; df = 4,52; $p < 0.01$). There was no significant main effect for nights; however, mean sleep latencies for night 2 and night 5 were 5.6 minutes and 7.1 minutes, respectively, for the MT group and 9.0 minutes and 11.9 minutes for the Non-MT group. Post hoc comparisons revealed that the MT group had shorter sleep latencies than the Non-MT group at 0030, 0230, and 0430 hours ($p < 0.05$). Groups demonstrated similar sleep tendency at 2230 and 0630 hours. Sleep latency decreased significantly during the night ($F = 36.6$; df = 4,52; $p < 0.001$). There were no other significant main effects or interactions.

RTSW data analysis showed a trend for a main effect for group ($F = 4.4$; df = 1,13; $p = 0.055$). Sleep latency was shorter for the MT group (9.6 minutes) than for the Non-MT group (14.5 minutes). Sleep latency decreased across the night ($F = 11.7$; df = 4,52; $p < 0.001$). There was no significant main effect for night; however, mean sleep latencies for night 2 and night 5 were, respectively, 8.4 minutes and 9.6 minutes for the MT group and 14.0 minutes and 15.7 minutes for the Non-MT group. There were no significant interactions. Post hoc comparisons revealed that the MT group had significantly shorter sleep latencies than the Non-MT group at 0100 and 0300 hours ($p < 0.05$). There was a trend for the MT group to have a shorter sleep latency at 2300 hours ($p = 0.092$).

### Subjective sleepiness

The SSS results showed that the MT group rated themselves sleepier (3.1) than the Non-MT group (2.2) ($F = 5.3$; df = 1,13; $p < 0.05$). Subjective sleepiness increased during the night ($F = 31.9$; df = 4,52; $p < 0.001$), but did not change across nights. There were no significant interactions. Post hoc comparisons revealed that the MT group rated themselves significantly sleepier than the Non-MT group at 0025, 0225, and 0425 hours ($p < 0.05$).

### Daytime sleep

Groups did not differ on actigraph estimated sleep duration over four days. Mean estimated sleep duration was 312.7 minutes for the MT group and 325.7 minutes for the Non-MT group. Subjective sleep length, however, was estimated to be markedly less by the MT group (255.7 minutes) compared to the Non-MT group (342.5 minutes) ($F = 8.5$; df = 1,13; $p = 0.01$).

## DISCUSSION

These findings suggest that morning types are sleepier than non-morning types for much of a typical night shift. Physiological sleep tendency and subjective sleepiness were significantly greater for the MT group. Further, the degree of physiological sleepiness is severe for morning types. Their mean MSLT latencies were less than 5.0 minutes from 0230 to 0630 hours, whereas mean latencies for the non-morning types did not fall below 5.0 minutes until 0630 hours. The Non-MT group latencies remained above 9.0 minutes until 0430 hours.

Adaptation across nights was not found in either group for physiological or subjective sleepiness. Though not statistically significant, MSLT and RTSW mean latencies were greater for both groups on night 5 than on night 2. In the original study, analysis of the placebo data showed that physiological sleepiness decreased for the sample on nights 2 through 5 (7). This discrepancy may be a result of reduced statistical power as a consequence of splitting the sample.

The MT group reported significantly less daytime sleep than the Non-MT group. On average, the MT group reported sleeping 86.8 minutes less sleep per day. Actigraph estimates, however, did not differ between groups. Thus, it seems unlikely that sleepiness at night for morning types can be attributed solely to sleep quantity. Subjective judgments suggest that sleep quality may be poorer for morning types. Although actigraphy has been demonstrated as a reliable measure of total sleep time in healthy young adults (7), it does not provide data on sleep staging or fragmentation. The misperception of sleep time by morning types may reflect their poor sleep quality. Foret et al. (9) demonstrated that after one night of sleep deprivation, daytime sleep was poorer (e.g. more awakenings, smaller REM percentage) in morning types than in evening types.

Two limitations to this study include the mixed composition of groups and the small sample size. Although 86% of the MT group scored within the morning type range on the HOMEQ, the majority of the Non-MT group received intermediate type scores (63%). These limitations make demonstration of group differences more difficult. The differences between types may be profound under conditions that affect the temporal order of the circadian system (4). Compared to intermediate and evening types, morning types have previously shown the least adaptation to night work (3).

In summary, physiological sleep tendency appears to be greater for morning types than non-morning types during much of the night shift. This study provides objective validation of the poor adaptability to night work reported by morning types. This preliminary study cannot clearly determine if the cause for their severe sleepiness is related to circadian factors. Actigraph measures of sleep time indicate that morning types do not sleep significantly less during the day than non-morning types. This suggests that circadian factors may be a plausible explanation for the increased night shift sleepiness of morning types. Sleep quality, however, is not known and may also contribute to the sleepiness of morning types.

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