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Brief communication

Sleepiness/alertness among healthy evening and morning type individuals☆

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Abstract

Objective: The aim of this study was to determine the level of sleepiness/alertness among different chronotypes.

Background: The Horne–Ostberg Morningness–Eveningness Questionnaire (MEQ) has allowed the characterization of chronotypes that are associated with a number of biological factors including: body temperature, cortisol rhythm, sleep patterns, and architecture.

Methods: Fifty-six consecutive normal volunteers underwent an 8-h polysomnogram followed by a multiple sleep latency test (MSLT). Each subject also completed the MEQ and the Sleep/Wake Activity Inventory.

Results: Evening types (ET) reported significantly later bedtimes and risetimes than both morning types (MT) and neither types (NT, $P < 0.05$). On nocturnal polysomnography, the ET documented significantly longer latencies to stage 1 and persistent sleep when compared to both the NT and MT ($P < 0.01$). There were no significant differences in the level of sleepiness on the MSLT across the different chronotypes. However, the pattern of sleepiness differed among them. While ET and NT showed differential sleep latencies across nap opportunities, MT showed no evidence of circadian variation on their level of sleepiness.

Conclusions: There were no overall differences in daytime sleepiness/alertness across chronotypes. However, a differential pattern of sleep latencies was noted on the MSLT.

Keywords: Morningness–Eveningness Questionnaire; Chronotype; Multiple sleep latency test; Sleepiness; Polysomnography

1. Introduction

The Horne–Ostberg Morningness–Eveningness Questionnaire (MEQ) is predictive of individual preferred bedtimes and risetimes (chronotypes) [1]. A number of biological factors are associated with the morningness/eveningness chronotypes as defined by the MEQ. For example, a relationship between preferred sleep patterns and peak body temperature times has been demonstrated [1–4]. Also, individual preference of sleep/wake schedule has been associated with differences in cortisol rhythms [5,6].

Polysomnographic differences based on MEQ scores have also been documented. Increased levels of morningness are associated with decreased nocturnal sleep latency, decreased latency to rapid eye

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movement (REM) sleep, more stage 1 sleep, decreased REM activity, more awakenings in the last 2 h of sleep, and less total sleep time [3,7,8].

To date, it is not known whether the nocturnal polysomnographic differences that have been observed in the various chronotypes result in differential levels of daytime sleepiness. Therefore, the purpose of this study was to assess the sleepiness/alertness of normal volunteers in relation to their scores on the MEQ.

2. Materials and methods

2.1. Subjects

Fifty-six consecutive individuals (32 males; 24 females, mean age 27 ± 7 years) recruited for various research protocols served as subjects. Subjects were required to have normal sleep schedules (i.e. 6.5–8.5 h of sleep time/night) without habitual napping. All subjects had a non-revelatory physical and psychiatric examination, no evidence of a sleep disorder, and a negative urine toxicology screen. Subjects signed a written informed consent form which explained the voluntary nature of their participation.

2.2. Procedures

Subjects participated in an 8-h nocturnal polysomnogram (PSG) followed by a four nap multiple sleep latency test (MSLT) the next day. The procedures used for the polysomnogram (PSG) recording have been described in a previous report [9]. Subjects were asked to refrain from consuming caffeine and alcohol for at least 5 h prior to the nocturnal PSG.

The nocturnal PSG began at 23:00 h and was terminated at 07:00 h. The daytime naps for the MSLT were at 09:30, 11:30, 13:30 and 15:30 h. The standard pre-nap MSLT protocol was followed for each nap [10]. For each nap, subjects were asked to lie down and to attempt to fall asleep. If subjects did not fall asleep within 20 min they were instructed to get out of bed and remain awake until the next nap. These subjects were also included in a study examining the rate of sleep detection as a function of sleep length [9]. If subjects fell asleep, they were allowed to sleep for 1, 5, 10 or 20 min. Subjects were exposed to the same nap duration across the MSLT. A Latin square design was used to assign the order in which the duration of naps were administered. After the first nap, each subject was asked to fill out a MEQ [1], and the Sleep/Wake Activity Inventory (SWAI).

The SWAI is a self-report multidimensional questionnaire which includes the excessive daytime sleepiness scale (SWAI-EDS). The SWAI-EDS scale has been used extensively across various populations [11–16]. The currently validated SWAI-EDS scale consists of nine statements each followed by a 1–9 semi-continuous scale. For each item, subjects are asked to circle the number which most accurately describes them over the previous 7 days. Clinical experience indicates that lower scores (i.e. ≤ 50) on the SWAI-EDS are indicative of a clinically significant propensity to fall asleep [17].

Nocturnal PSG and MSLT recordings were scored in 30 s epochs according to the rules established by Rechtschaffen and Kales. The sleep parameters and MSLT latencies were subjected to one-way, general, and repeated measures analyses of variance (ANOVAs) including a measure of covariance (age) using SPSS, Version 6.1 for MacIntosh (Chicago, IL; SPSS Inc., 1994).

3. Results

Subjects were split into morningness/eveningness groups according to the criteria set forth by Horne and Ostberg [1]. Nine subjects (16%) had MEQ scores ≤ 41 and were qualified as evening types (ET). Thirty-nine subjects (70%) had MEQ scores between 42 and 58 and were qualified as neither type (NT). Eight subjects (14%) had MEQ scores ≥ 59 and were qualified as morning types (MT). A main effect of group was documented for age ($P < 0.05$). The MT (32 ± 9 years) were significantly older than both the NT (26 ± 6 years) and the ET (26 ± 7 years). The NT and ET were comparable in age. The ratio of males to females in the ET, NT, and MT groups was comparable.

3.1. Subjective sleep schedules and subjective levels of sleepiness-alertness

Using a one way repeated measures (bedtimes weekdays, bedtimes weekends) ANOVA, a main effect of group was revealed ($P < 0.05$). The ET had later bedtimes than the NT and the MT

($P < 0.05$, see Table 1). The NT also had later bedtimes when compared to MT ($P < 0.05$). A main effect of time was revealed ($P < 0.05$), with later bedtimes reported on weekends than on the weekdays. There was no significant interaction of group and time. Age was not found to be a significant covariant ($t = -0.75$, ns) with bedtimes.

Risetimes were analyzed using a one-way repeated measures ANOVA. A main effect of group was found ($P < 0.05$). The ET documented later risetimes than the MT and the NT ($P < 0.05$, see Table 1). The MT and NT risetimes were not significantly different from each other. A main effect of time was also documented ($P < 0.05$), where later risetimes were reported on the weekends than on the weekdays ($P < 0.05$). There was no significant interaction of group and time. In addition, age was found to be a significant covariant of risetime ($t = -3.34$, $P < 0.01$).

Differences in subjective total sleep time (TST) were analyzed using a one way repeated measures ANOVA. There was no significant main effect of group (ET = 7.6 ± 1.4 h, NT = 7.7 ± 1.0 h, and MT = 7.4 ± 0.8 h, ns). A main effect of time was detected where the mean TST on the weekends (7.7 ± 1.1 h) was significantly longer than the mean TST on the weekdays, (7.4 ± 1.0 h, $P < 0.05$). There was no significant interaction between group and time. Age, however, was found to be a significant covariant ($t = -2.35$, $P < 0.05$).

SWAI-EDS scores were analyzed using a one way ANOVA. No significant differences were found on the SWAI-EDS scale among the three groups (ET = 62.8 ± 3.6, NT = 59.8 ± 8.8, and MT = 55.1 ± 10.6).

3.2. Nocturnal PSG sleep characteristics

The sleep efficiencies of the three groups were comparable (ET = 85.6 ± 6.4, NT = 87.8 ± 6.5, MT = 87.0 ± 11.9, ns). There were no significant differences in sleep architecture among the three groups. The latency to stage 1 NREM sleep differed among the chronotypes ($P < 0.01$). The ET documented a significantly longer latency to stage 1 (30.3 ± 13.3 min) when compared to the NT (17.0 ± 12.7 min) and the MT (8.8 ± 4.0 min). The latencies to stage 1 in the NT and MT were comparable. The latency to persistent sleep (PS; number of min from lights out to the first 10 min of consolidated sleep) yielded similar results, with the ET documenting a longer latency to PS (47.9 ± 40.9 min) than the NT (21.2 ± 14.9 min) and MT (13.8 ± 8.6 min, $P < 0.01$). The latency to PS in the NT and MT were comparable. The latency to stage REM in the MT (69.5 ± 15.2 min) was significantly shorter than the NT (106.1 ± 40.5 min, $P < 0.05$). The latency to REM in the ET group was intermediate (103.2 ± 45.6 min), and not significantly different from the MT or NT. Age was not a significant covariant for any of the PSG characteristics.

3.3. Daytime sleepiness/alertness (MSLT)

The MSLT latencies were submitted to a two-way, repeated measures (four naps) ANOVA. A main effect of group was not found. A main effect of time of day was demonstrated ($P < 0.05$ see Table 2). The latency at 09:30 h was significantly shorter than the latency at any other time. The remaining naps had comparable latencies. Interestingly, a group by time of day interaction was found ($P < 0.05$). The ET documented a significantly longer latency at 11:30 h when compared to the MT ($P < 0.05$). The NT was intermediate. The ET's latencies at 11:30 and 15:30 h were significantly longer when compared to the 13:30 h latency ($P < 0.05$). In the NT group the latencies at 11:30 and 13:30 h were significantly longer when compared to the 09:30 h nap ($P < 0.05$). No significant differences were found in the MT latencies. Finally, age was not a significant covariant with MSLT latencies ($t = 0.03$, ns).

4. Discussion

The results of this study corroborate a number of previously described features among subjects with different chronotypes, mainly, the inter-individual differences in bed and risetimes based on chronotype [1,3,18,19], and the age-related changes in habitual sleep times [3]. The latter is particularly remarkable given the subjects' narrow age range in the present study.

The polysomnographic data further corroborate the inter-individual differences in preferred sleep times. Relevant to the interpretation of these data is the timing of the sleep laboratory studies. Bed and rise-

Table 1
Reported bedtimes and risetimes on weekdays and weekends for the evening types (ET), neither types (NT), and morning types (MT)[a]

	Bedtime weekdays	Bedtime weekends	Bedtime means	Risetime weekdays	Risetime weekends	Risetime means
Evening types ($n = 9$)	01:06 ± 1.4	01:43 ± 1.0	01:24 ± 1.2[b,c]	09:42 ± 2.1	10:10 ± 1.5	09:42 ± 1.8[b,c]
Neither types ($n = 35$)	23:36 ± 1.0	01:00 ± 1.4	00:18 ± 1.0[b]	07:36 ± 1.5	09:10 ± 1.5	00:18 ± 1.0[b]
Morning types ($n = 7$)	22:06 ± 1.5	22:42 ± 1.0	22:24 ± 1.0	06:09 ± 1.0	07:17 ± 0.4	06:42 ± 0.5
Means	23:36 ± 1.4[d]	00:48 ± 1.6		07:42 ± 1.8[d]	09:05 ± 1.6	

[a] Mean time ± standard deviation in h.
[b] Vs. morning types, $P < 0.05$.
[c] Vs. neither types, $P < 0.05$.
[d] Vs. weekend, $P < 0.05$.

Table 2
The sleepiness/alertness of the evening types (ET), neither types (NT), and the morning types (MT) as measure by the MSLT[a]

	09:30 latency	11:30 latency	13:30 latency	15:30 latency	Mean latency
Evening types ($n = 9$)	8.1 ± 5.7	15.3 ± 6.5[b,c,d]	9.1 ± 6.0	14.7 ± 5.9[b,d]	11.8 ± 4.4
Neither types ($n = 39$)	7.2 ± 6.6	9.7 ± 7.3[b]	9.9 ± 6.1[b]	9.4 ± 6.6	9.0 ± 5.0
Morning types ($n = 8$)	6.2 ± 6.0	6.1 ± 6.0	5.7 ± 4.5	8.1 ± 7.7	6.5 ± 5.7
Totals	7.2 ± 6.3	10.1 ± 7.4[b]	9.2 ± 6.0[b]	10.0 ± 6.8[b]	

[a] Mean ± standard deviation in min.
[b] Vs. 09:30 latency, $P < 0.05$.
[c] Vs. morning types, $P < 0.05$.
[d] Vs. 13:30 latency, $P < 0.05$.

times were fixed from 23:00 to 07:00 h, and thus were best suited to the reported weekday sleep schedule of the neither types. The short sleep latency documented for the morning types can easily be explained by their delayed bedtimes vis a vis their reported preference.

The results on the daytime evaluations did not reveal significant differences across the three chronotypes. Our findings may be questionable due to the relatively small sample size available in this study. Only 14% of our sample were classified as morning types. In a recent report on over 2000 individuals, morning types represented over 40% of their population [20]. Interestingly, the results of that study suggest that evening types have greater irregularity in their sleep habits and have an increased sleep debt when compared to the other chronotypes. Subjective reports of sleepiness did not differentiate among chronotypes, but no objective measure of sleepiness was available in that study [2,5].

In the present study, subjective reports of sleepiness were evaluated with the SWAI, and while the sleepiness levels were not significantly different, the morning group reported an overall higher level of sleepiness. Consistent with these results were the MSLT scores. Relevant to these findings is the fact that four of the eight morning type individuals had MSLT scores of ≤5 min. Such a high rate of sleepiness among this group of subjects may explain the lack of a circadian effect on the MSLT.

This study failed to demonstrate differential levels of sleepiness across different chronotypes. However, the confirmation of previously reported differences in the overnight polysomnography, and the suggestion of possible differential patterns of sleepiness clearly indicates the need for more studies in this area.

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