Restorative Effects of a Short Afternoon Nap (<30 Min) in the Elderly on Subjective Mood, Performance and EEG Activity

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This study investigated the effects of a short afternoon nap (<30 min) in the elderly on subjective mood, performance, and electroencephalograms (EEG). Ten healthy elderly persons who habitually napped in the afternoon three or more times a week participated in the present study. They participated in two experimental conditions with an interval of more than five days. In the nap condition, the participants went to bed at 13:00 hours and slept for 30 min, whereas they just had a rest while watching television in the no-nap condition. In both conditions, subjective sleepiness, fatigue, performance and EEG activities with eyes opened and closed were repeatedly measured before and after the nap or rest. The nap significantly reduced subjective sleepiness and fatigue in the afternoon. It also improved performance levels and EEG theta, alpha 1 or alpha 2 band activities with eyes opened and closed. These findings suggest that a short afternoon nap is useful for the elderly in maintaining their daytime psychological, behavioral and physiological arousal at an adequate level.

CURRENT CLAIM: This study showed that a short afternoon nap in the elderly improved subjective sleepiness, fatigue, performance and physiological arousal levels in the afternoon.

It is well known that sleepiness occurs in the afternoon in people of all ages (Carskadon, 1989). In general, this sleepiness is considered to be a part of the biological rhythm, such as a circadian rhythm (Broughton, 1989). Since the risk of single vehicle accidents or mistakes at work is increased with increasing sleepiness (Mitler et al., 1988), it is probable that sleepiness in the afternoon also causes poor alertness and consequently misfortune in normal life. A solution to countermeasure against this sleepiness might be to take a nap in the afternoon.

It has been documented by many laboratory studies that napping has positive effects on alertness in various settings (Lumley et al., 1986; Bonnet, 1991; Dingess, 1992; Bonnet et al., 1995; Gillberg et al., 1996; Horne and Reyner, 1996; Reyner and Horne, 1997; Hayashi et al., 1999a, 1999b). In particular, some studies have reported that an afternoon nap after normal nocturnal sleep improved sleepiness in the afternoon (Hayashi et al., 1999a, 1999b). The vast majority of such data studying the effects of napping, however, examined younger to middle-aged adults. The effects of a nap in the elderly are not well understood.

As humans enter the later decades of life, daytime napping appears to increase in frequency, with more of the elderly napping with greater frequency (Dingess, 1989). It has been considered that napping occurrence is the result of poor nocturnal sleep in the elderly, that is, the elderly take naps frequently in an attempt to compensate for an increase in nocturnal waking and a decrease in slow wave sleep (SWS) as a result of aging (Miles and Dement, 1980; Bliwise, 1993). Also, napping in the elderly might cause poor nocturnal sleep or an increase in daytime sleepiness (Bliwise, 1993). Thus, several studies have supported the curtailment of napping to improve nocturnal sleep or excessive daytime sleepiness in elderly insomniacs (Spiegel et al., 1987; Morin and Azrin, 1988; Rubinstein et al., 1990). However, one survey showed that the incidence of napping was scarcely related to poor sleep at night in the elderly (Metz and Bunnell, 1990). Another study reported that napping was common in the elderly who had a good night sleep (Asplund, 1996). These findings could lead to the conclusion that daytime napping in some elderly people is not necessarily a reflection of sleep problems such as poor nocturnal sleep or excessive daytime sleepiness.

According to several studies (Evans et al., 1977; Dingess, 1992), naps are taken for the following two reasons: 1) replacement naps, taken in response to a sleep debt, and 2) appetitive naps, taken without regard to the sleep debt, as a result of an endogenous biphasic sleep-wake cycle. When naps occur in association with poor nocturnal sleep in the elderly, these naps can be regarded as replacement naps. However, it is highly probable that appetitive naps are more frequent in the elderly. Metz and Bunnell (1990), have suggested that napping in the elderly may reflect a desire for the benefits of naps, rather than contributing to disrupted nocturnal sleep. Our objective with this study was to study the effects of an afternoon nap in the elderly taken for reasons unrelated to sleep debt.

Recently, several laboratory studies have focused on the effects of a short nap (<30 min) on alertness (Stampi, 1992; Gillberg et al., 1996; Horne and Reyner, 1996; Reyner and Horne, 1997; Hayashi et al., 1999a, 1999b). A short nap could...
be useful to attenuate the following two potential negative effects of naps (Rosekind et al., 1995). One, sleep inertia, is the confusion, disorientation and impairment of performance usually experienced upon waking (Dinges, 1992). Sleep inertia is most enhanced when one is awakened from the deepest levels of sleep (SWS) (Stampi, 1992; Dinges, 1992). The other is the influence on subsequent sleep periods. Several studies have suggested that a longer nap, at certain times of the day, could disrupt the quantity and quality of later sleep periods (Karacan et al., 1970; Åkerstedt et al., 1989; Dinges, 1989). Karacan et al. (1970), observed, that a longer afternoon nap (2 h) reduced the amount of SWS during the following nights sleep. These findings would imply that the effects of a nap on subsequent sleep periods, as well as sleep inertia, depend on the depth of sleep in the nap. SWS occurs when a certain time has elapsed from the onset of sleep, suggesting the above negative effects could arise when one sleeps long enough to cause SWS. A short nap could prevent the occurrence of the SWS.

Regardless of its short duration, the restorative effects of a short nap were observed after a normal night's sleep (Hayashi et al., 1999a, 1999b), after a restricted night's sleep (Gillberg et al., 1996; Horne and Reyner, 1996; Reyner and Horne, 1997), and during 64 hours of continuous work (Naitoh et al., 1992) in young adults. However, there is no study that evaluated the effects of a short nap in the elderly.

Applying a short afternoon nap to the elderly could possibly prevent poor nocturnal sleep from occurring, as compared to taking a longer afternoon nap. Williams et al. (1974), showed that SWS latency for night sleep averaged more than 30 min in the elderly (>60 years old). The elderly are more likely to wake before the occurrence of SWS when taking an afternoon nap of less than 30 min, because sleep pressure is more enhanced during nighttime than during daytime.

Although sleepiness in the afternoon occurs in the elderly as well in younger adults, sleepiness in the elderly occurs earlier (12:00-15:00 h) than in younger adults (14:00-17:00 h) (Carskadon, 1989; Dinges, 1993). Thus, an afternoon nap in the elderly is more likely to occur between 12:00 and 15:00 h if it is taken as a result of the biphasic sleep cycle.

The purpose of this study was to evaluate the effects of an afternoon nap of less than 30 min from 13:00 h, after a normal night's sleep in the elderly, on subjective sleepiness, fatigue, performance and EEG activity. In this study, participants were those who habitually took an afternoon nap and had a positive attitude toward napping. However, it is possible that these habitual nappers take daytime naps as a result of insufficient nocturnal sleep. Thus, in the study, the relationship between daytime naps and nocturnal sleep was also examined.

**METHODS**

**Participants**

Ten healthy elderly individuals participated in this study (5 women and 5 men; mean age 73.0 ± SD 3.62 years; all were over 65 years). Each participant was initially screened by the modified version of Okawa’s sleep questionnaire (1994). The participants were required to fulfill the following criteria: 1) total sleep time at night was more than 6.5 hours; 2) an afternoon nap was habitually taken three or more times in a week; 3) there were no complaints about sleep; 4) no sleep disorders such as sleep apnea and restless legs syndrome; 5) no history of psychiatric disorders; and 6) not using sedatives. Next, the participants were interviewed at their homes. They reported having a positive attitude toward napping (e.g., they felt refreshed after taking a nap). They also thought that an afternoon nap was not taken in order to compensate for a lack of the previous night’s sleep and did not influence subsequent night's sleep. The participants signed an informed consent, after they were instructed, as to the purpose and contents of the experiment and they were paid for their participation.

**Design**

The laboratory experiment was comprised of nap and no-nap conditions. In the nap condition, the participant was allowed to sleep for 30 min in the afternoon. In the no-nap condition, they rested while watching a television program instead of taking a nap. The participant underwent both conditions with an interval of more than five days between the two. The order of the conditions was counterbalanced across the participants. A wrist actigraph (Mini-Motionlogger Actigraph, Inc., Ardsley, NY) was worn by the participants on their non-dominant wrist for about two consecutive weeks (12-15 days), in which two laboratory days were included. Their home sleep-wake patterns were monitored by the wrist actigraph. The participants were instructed to maintain their normal life during the study periods except for two laboratory days.

**Procedure for Laboratory Experiments**

For both the nap and no-nap conditions, the participants arrived at the laboratory at 09:00 h and electrodes were attached for a continuous recording of their electroencephalograms (EEG) and left eye vertical electrooculogram (EOG) during the experimental period. The experiment started at 10:00 h and the tests were repeated every 30 min from 10:00 to 12:00 h and from 14:00 to 16:00 h. The task of tests was displayed on a personal computer (EPSON PC-486 HX). Each test battery included the following: 1) EEG recordings of relaxed wakefulness with eyes opened and closed—the participants were first instructed to relax and close their eyes for 1 min, then look at a circle for 1 min; 2) self-estimation—subjective sleepiness and fatigue were estimated via a visual analog scale (Monk, 1987). The scale was 150 mm long and was composed of 100 dots on a screen, as the participant could easily use the scale; 3) performance task—a 4 min visual detection test (Englund et al., 1985) was conducted. The content of the task is explained below; and 4) a 10 min break—during the break the participants could read magazines, drink non-caffeinated beverages and use the toilet facilities. However, participants were prohibited from exercising, lying on a bed or sleeping. During the test periods participants stayed in a soundproof and air-conditioned isolation unit containing a
bed, a semi-reclining chair and a portable toilet. They sat on the semi-reclining chair except for using the toilet facilities.

Lunch was served at 12:00 h in the anteroom of the isolation unit and participants entered the unit again at 13:00 h, which was preceded by application of electrodes for monitoring horizontal EOG and electromyogram (EMG) (only in the nap condition), in accordance with the standard techniques of Rechtschaffen and Kales (1968).

The differences between the nap and no-nap conditions were scheduled from 13:00 to 14:00 h. In the nap condition, participants went to bed at 13:00 h and were awakened by an intercom when 30 min had elapsed from the onset of Stage 1 sleep (Rechtschaffen and Kales, 1968). The participants were asked to estimate their mood just after awakening and about 3 min after rising, based on a 7-point scale (from 1-very bad to 7-very good). In the no-nap condition, participants rested without sleeping while watching a television program on a semi-reclining chair from 13:00 to 13:45 h. The television program was selected according to the participant’s preference.

Measurements

1) Subjective Sleepiness and Fatigue

Visual analog scales for sleepiness and fatigue ranged from "very sleepy" or "very fatigued" to "very alert" or "not fatigued at all." Measurements were scored with 100 as full marks, by the number of dots on the screen with one end of the scale being "very alert" or "not fatigued at all."

2) Performance

To obtain performance measures, a 4 min visual detection task was conducted. Englund et al. (1985), revealed that a visual detection task was effective in increasing sleepiness. We modified their task so as to maintain the participant’s confidence and motivation for the task. Ten digits (0, 1, 2...9) were randomly displayed on the screen (duration 100 ms, ISI=2-4 sec). The participants were required to press a button with the thumb of their preferred hand as quickly and as accurately as possible whenever they detected "3" (15% of 10 digits were "3"). Simple reaction time and percentage of correct responses were used as performance measures.

3) EEG Activity

EEG(s) were recorded from Fz, Cz and Pz according to the standard techniques used with a polygraph (model 1A97, NEC-Sanei, Tokyo). EEG data with eyes opened and closed during each test period were digitized at 100 Hz and subjected to a spectral analyzer (model 7T18A, NEC-Sanei) by the Fast Fourier routine. Power spectra were computed for consecutive 4-sec epochs and 0.25 Hz frequency bins by applying a Hamming window. The 20-40 sec long spectra were obtained by averaging 4-sec epochs with the exception of epochs that contained artifacts. It has been documented that EEG theta and alpha activities are more enhanced with increasing sleepiness (Torsvall and Åkerstedt, 1988). Thus, the power spectra were integrated for the theta (3.5-7.25 Hz), alpha 1 (7.5-9.5 Hz), alpha 2 (9.75-11.5 Hz) and alpha 3 (11.75-13.25 Hz) band frequencies and transformed into magnitude values in microvolts.

4) Sleep Structure of the Laboratory Nap

The EEG recording (Cz) when napping was scored for sleep stages and sleep latency according to Rechtschaffen and Kales’ criteria (1968).

5) Identification of Daytime Naps and Night Sleeps from Wrist Actigraph Data

The wrist actigraph was set to run in a zero-crossing mode with a data storage epoch length of 1 min. Activity data were scored every 1-min epoch for sleep and wake according to the algorithm by Cole et al. (1992). As sleep during the daytime assessed from activity may be underestimated (Levine et al., 1986), a daytime nap was defined as such when more than 5 min of consecutive sleep occurred from 12:00 to 17:00 h (there were hardly any sleep periods during the morning and evening for the participants). Also, bedtime and rising-time of a night’s sleep were identified using mean activity (69 counts) during watching television (relaxing), as reported by Shapiro and Goldstein (1998). In other words, bedtime was referred to be the first epoch when activities were less than 69 counts during 5 consecutive epochs, and time of rising was referred to be the first epoch when activities were more than 68 counts during 5 consecutive epochs.

The following sleep variables were calculated: night sleep comprised of 1) bedtime; 2) rising-time; 3) time of sleep onset; 4) time of final awakening; 5) sleep latency; 6) time in bed; 7) total sleep time; 8) sleep efficiency; 9) number of intermittent awakenings; and 10) duration of an intermittent awakening.

Daytime naps were comprised of 1) time of sleep onset; 2) time of final awakening; 3) duration of a daytime nap episode; 4) total sleep time during daytime; and 5) number of daytime nap episodes. The night sleep data, except for the laboratory days, were combined as follows: 1) total nights; 2) nights before taking daytime naps; 3) nights after taking daytime naps; 4) nights before taking no daytime naps; and 5) nights after taking no daytime naps.

Statistical Analysis

The purpose of the present study was to reveal, more plainly, the effects of an afternoon nap on subjective sleepiness and fatigue, performance and EEG activity rather than the detailed time course of them. To reduce error variance, these measurements on each condition were weighted respectively with 3-point smoothing (1/4 + 1/2 + 1/4). After a 3-point smoothing, two-way analyses of variance (ANOVA) [2 conditions x 8 test periods] with repeated measures was performed on each of the measures. The degree of freedom was adjusted by Greenhouse and Geisser’s epsilon when appropriate. Pairwise comparisons were performed with the Neuman-Keuls test. To evaluate whether night sleeps were different between before or after taking daytime naps and no-daytime naps, the two-tailed paired t-test was also performed. A 5% significance level was adopted. All results were expressed as mean ± SE.
RESULTS

Sleep Structure of the Laboratory Nap and Mood Measurements after Waking

Sleep structure of the laboratory nap and mood measurements after waking are shown in Table 1. All participants took a nap for more than 15.5 min; the mean for total sleep time was 24.2 min. The naps mainly consisted of Stage 1 and Stage 2 sleep. No Stage 4 and REM sleep occurred. Stage 3 sleep occurred in three participants. However, Stage 3 sleep was very short. The participants slept after 4.5 min from lights off and awakened from a light sleep stage.

Their moods just after waking from sleep were relatively good (5.2 mean score), and 3 min after rising (6.3 mean score) was significantly better ($t_{9}=4.71; p<.05$).

Subjective Sleepiness and Fatigue

The time courses of subjective sleepiness and fatigue are illustrated in Figure 1. The ANOVA for sleepiness and fatigue revealed significant interaction between conditions and time (test periods), respectively (Sleepiness: $F_{3,23}=15.59$, $\varepsilon=.37$, $p<.05$; Fatigue: $F_{2,17}=10.95$, $\varepsilon=.28$, $p<.05$). Tests of simple main effects of conditions showed sleepiness and fatigue were significantly decreased after the nap compared with the rest ($p<.05$). Also, as for each measure, there was significantly simple main effect of time ($p<.05$). Pairwise comparisons showed that in the nap condition, sleepiness significantly decreased after a nap (10:00 vs. 14:30; 10:30 vs. 14:00 and 14:30; 11:00 vs. 14:00 to 15:30; 11:30 vs. 14:00 and 14:30; $p<.05$), while in the no-nap condition, sleepiness and fatigue were increased in the afternoon, respectively (sleepiness: 10:00 and 10:30 vs. 11:30 to 15:30; 11:00 vs. 14:30; fatigue: 10:00 and 10:30 vs. 14:00 to 15:30; 11:00 vs. 14:30 to 15:30; 11:30 vs. 15:00; $p<.05$). On the other hand, sleepiness and fatigue seem to be more enhanced before the nap, compared to the corresponding before the rest, as shown in Figure 1. These may contribute to the above significant interactions. Thus, a separate ANOVA comparing the two conditions in the morning is conducted for each measurement. However, as for each measure, there was no significant difference between conditions.

Performance

Since the visual detection task was very easy, the percentage of correct responses was nearly 100% in all of the participants. In this case, the degree which the performance data are a reflection of sleepiness would be very little in appearance. Therefore, taking such deviation of distribution into consideration, the angular transformation was adopted in those data. Figure 2 shows the time course of the percentage of correct responses for the visual detection task. The ANOVA revealed significant interaction between conditions and time ($F_{2,23}=3.45; \varepsilon=.33; p<.05$). Tests of simple main effects of conditions showed the percentage correct was significantly decreased at 14:30 h in the no-nap condition compared with the

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>SE</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sleep Latency (min)</td>
<td>4.5</td>
<td>0.58</td>
<td>2.5–8.0</td>
</tr>
<tr>
<td>Sleep Stages Time (min)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stage W</td>
<td>4.8</td>
<td>0.98</td>
<td>1.0–9.5</td>
</tr>
<tr>
<td>Stage 1</td>
<td>9.4</td>
<td>0.90</td>
<td>6.0–15.0</td>
</tr>
<tr>
<td>Stage 2</td>
<td>14.4</td>
<td>1.78</td>
<td>3.5–20.5</td>
</tr>
<tr>
<td>Stage 3</td>
<td>0.5</td>
<td>0.26</td>
<td>0.0–2.0</td>
</tr>
<tr>
<td>Total Sleep Time (min)</td>
<td>24.2</td>
<td>1.24</td>
<td>15.5–29.0</td>
</tr>
<tr>
<td>Sleep Stage just before Waking (Stage)</td>
<td></td>
<td>1–2</td>
<td></td>
</tr>
<tr>
<td>Mood after a Nap (Score)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>(1 – Bad, 7 – Good )</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Upon Waking</td>
<td>5.2</td>
<td>0.32</td>
<td>4–7</td>
</tr>
<tr>
<td>3 min after Rising</td>
<td>6.3</td>
<td>0.21</td>
<td>5–7</td>
</tr>
</tbody>
</table>

Figure 1. The Time Course of Subjective Sleepiness and Fatigue. The open circles show the nap condition and the black squares the no-nap condition. Data are mean ± SE; *$p<.05$.

Figure 2. The Time Course for the Percentage of Correct Responses in the Visual Detection Task. The open circles show the nap condition and the black squares the no-nap condition. Data are mean ± SE; *$p<.05$. 

Table 1. Sleep Structure of the Laboratory Nap and Mood After Waking
EFFECTS OF A SHORT AFTERNOON NAP IN THE ELDERLY

Data were calculated by wrist activities.

The middle and lower panels show alpha 1 and alpha 2 band activities at Pz area. The open circles show the nap condition and the black squares the no-nap condition. Data are mean ± SE; *p<.05.

Figure 3. The Time Course of EEG Activities with Eyes Closed and Opened. The upper panels show theta band activity at Fz area. The middle and lower panels show alpha 1 and alpha 2 band activities at Pz area. The open circles show the nap condition and the black squares the no-nap condition. Data are mean ± SE; *p<.05.

ELECTROENCEPHALOGRAPHIC ACTIVITY

Activity

The middle and lower panels show alpha 1 and alpha 2 band activities, with eyes both closed and opened, were decreased or maintained after the nap, but they increased after the rest with no nap. Figure 3 shows the time courses of theta band activity at the Fz area and alpha 1 and alpha 2 band activities at Pz area. The ANOVA revealed significant interactions as follows: theta band at Fz (F(2,20)=4.01; ε=0.33; p<.05), Cz (F(2,18)=6.08; ε=0.29; p<.05) and Pz area (F(2,20)=5.43; ε=0.32; p<.05), and alpha 1 band (F(2,14)=6.34; ε=0.23; p<.05) and alpha 3 band (F(2,20)=6.23; ε=0.32; p<.05) at Pz area with eyes closed; theta (F(2,20)=4.71; ε=0.33; p<.05) and alpha 1 band (F(2,20)=5.05; ε=0.38; p<.05) at Cz area and alpha 1 (F(2,20)=3.93; ε=0.33; p<.05), alpha 2 (F(2,20)=4.01; ε=0.31; p<.05), alpha 3 band (F(2,20)=3.87; ε=0.36; p<.05) at Pz area with eyes opened. Tests of simple main effects of conditions showed these amplitudes significantly increased after the rest, compared to after the nap (p<.05) (see Figure 3). There were significantly simple main effects of time for alpha 1 band activity at Pz area with eyes closed in the nap condition (11:00 vs. 14:30 and 15:00, ps<.05) and theta (10:00 vs. 14:30 to 15:30; 10:30 vs. 14:30 and 15:00; 11:00 vs. 14:30, ps<.05) and alpha 1 band (10:00 and 10:30 vs. 14:00 to 15:30; 11:00 and 11:30 vs. 14:30 to 15:30; 14:00 vs. 15:00, ps<.05) at Cz area and alpha 2 and alpha 3 band activity at Pz area (10:00 vs. 14:00 and 14:30; 10:30 vs. 14:30, ps<.05) with eyes opened in the no-nap condition.

EFFECTS OF A SHORT AFTERNOON NAP IN THE ELDERLY

Daytime Naps and Night Sleeps Identified from Wrist Actigraph Data

The frequency of daytime naps in a one week period was, on average, 4.6 ± 0.33 (ranged 2.8 to 5.9) in normal life. The duration of a daytime nap episode was 37.8 ± 5.21 min and the number of daytime nap episodes per day was 1.4 ± 0.09. The time of daytime nap onset was 13:51 ± 00:05 hours and time of waking from a daytime nap was 14:27 ± 00:05 hours. When the time period from 12:00 to 17:00 h was divided into 30 min, the daytime nap onset most frequently occurred from 13:00 to 13:30 h. Of the 115 daytime naps recorded, 28 naps (24%) occurred between 13:00 and 13:30 h and 97 naps (84%) occurred between 12:00 and 15:00 h.

Table 2 shows sleep variables at night in normal life. For the entire night period, total sleep time was 421 min and sleep efficiency was 86%. Sleep latency also was 5.5 min,

| Time of Final Awakening | 6:16 | 0:16 | 6:20 | 0:15 | 6:09 | 0:15 | 2.17 | 0.18 | NS | 0.02 | 0.29 | 0.48 | 0.61 | NS
| Time in Bed | 486.1 | 21.57 | 494.1 | 21.46 | 466.5 | 23.74 | 2.72 | 0.05 | 485.8 | 22.74 | 493.1 | 19.89 | 0.61 | NS
| Total Sleep Time | 421.2 | 25.85 | 426.7 | 25.29 | 406.7 | 29.05 | 1.69 | 0.05 | 421.9 | 27.49 | 431.4 | 21.93 | 0.71 | NS
| Sleep Efficiency | 86.4 | 2.67 | 86.2 | 2.53 | 86.8 | 3.06 | 0.53 | 0.05 | 86.5 | 2.84 | 87.4 | 2.31 | 0.71 | NS
| Number of Awakenings | 10.5 | 1.77 | 10.8 | 1.83 | 9.8 | 2.27 | 0.65 | 0.05 | 10.4 | 1.86 | 9.8 | 1.66 | 0.48 | NS
| Duration of a Awakening | 5.6 | 0.66 | 5.8 | 0.75 | 5.6 | 0.79 | 0.19 | 0.05 | 5.7 | 0.59 | 5.7 | 1.19 | 0.02 | NS

Data were calculated by wrist activities.
suggesting that all participants did not have difficulty falling asleep. Although time in bed was longer before taking daytime naps compared with those before taking no daytime naps, other sleep variables at night were not significantly different. Also, regarding night sleep after daytime naps or no daytime naps, there was no significant difference between the conditions.

Sleep variables at night before laboratory days were not significantly different between the nap and the no-nap conditions (see Table 3). Moreover, night sleep before taking the laboratory nap were not significantly different from those in normal life, suggesting that the participants took their normal sleep pattern.

Table 3. Sleep Variables at Night, Including Before Taking the Laboratory Nap and Before No-Nap

<table>
<thead>
<tr>
<th></th>
<th>Night before the Laboratory Nap</th>
<th>Night before No-Nap</th>
<th>t-value</th>
<th>p&lt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bedtime</td>
<td>22:18 ± 0.24</td>
<td>22:30 ± 0.22</td>
<td>0.56</td>
<td>NS</td>
</tr>
<tr>
<td>Rising Time</td>
<td>6:10 ± 0.14</td>
<td>6:27 ± 0.10</td>
<td>1.69</td>
<td>NS</td>
</tr>
<tr>
<td>Time of Sleep Onset</td>
<td>22:24 ± 0.24</td>
<td>22:36 ± 0.22</td>
<td>0.58</td>
<td>NS</td>
</tr>
<tr>
<td>Time of Final Awakening</td>
<td>6:06 ± 0.15</td>
<td>6:23 ± 0.09</td>
<td>0.65</td>
<td>NS</td>
</tr>
<tr>
<td>Sleep Latency</td>
<td>5.8 ± 0.53</td>
<td>6.2 ± 0.42</td>
<td>1.00</td>
<td>NS</td>
</tr>
<tr>
<td>Time in Bed</td>
<td>472.3 ± 27.94</td>
<td>477.2 ± 22.94</td>
<td>0.20</td>
<td>NS</td>
</tr>
<tr>
<td>Total Sleep Time</td>
<td>409.1 ± 27.96</td>
<td>418.8 ± 26.44</td>
<td>0.66</td>
<td>NS</td>
</tr>
<tr>
<td>Sleep Efficiency</td>
<td>86.8 ± 3.21</td>
<td>87.5 ± 2.40</td>
<td>0.23</td>
<td>NS</td>
</tr>
<tr>
<td>Number of Awakenings</td>
<td>8.8 ± 1.73</td>
<td>9.9 ± 1.68</td>
<td>0.74</td>
<td>NS</td>
</tr>
<tr>
<td>Duration of a Awakening</td>
<td>6.0 ± 1.26</td>
<td>4.8 ± 0.75</td>
<td>0.87</td>
<td>NS</td>
</tr>
</tbody>
</table>

Data were calculated by wrist activities.

Secondly, to attenuate the negative effects of naps, such as sleep inertia, the duration of the nap was designed to be less than 30 min. Light sleep (Stage 1 and Stage 2) was primarily observed in the naps. Although deep sleep (Stage 3) occurred in three participants, it only accounted for about 2% of total sleep time. All participants were awakened from light sleep. Moreover, their moods just after waking were relatively good and further improved 3 min after rising. These results reveal that a short afternoon nap of less than 30 min in the elderly prevented the occurrence of SWS and kept sleep inertia to a minimum, as was intended.

The most important finding in this study was that a short afternoon nap in the elderly had positive effects on their alertness during the afternoon. Subjective sleepiness and fatigue significantly decreased, the percentage of correct responses on the visual detection task was high and EEG theta and alpha band activities were attenuated after napping compared with after rest. The results also showed that, without napping, subjective sleepiness and fatigue increased, task performance was reduced and EEG theta and alpha band activities were enhanced in the afternoon. In summary, it was revealed that a short afternoon nap in the elderly improved their psychological, behavioral and physiological arousal in the afternoon to adequate levels.

According to the night sleep results identified by wrist actigraph data, night sleep before the two laboratory days were not different between the nap and no-nap conditions. Also, night sleep before the laboratory days was not different from those in normal life, suggesting that the participants took laboratory naps after a normal night sleep. In young adults, Hayashi et al. (1999a, 1999b), confirmed that a short afternoon nap after a normal night sleep improved alertness in the afternoon. The total nap time in these studies was 20 min, which was only 4 min shorter than that of the present study (24.2 min). Also, the afternoon naps consisted mainly of Stage 1 and 2 sleep (Hayashi et al., 1999a, 1999b). Thus, the short afternoon nap in the present study did not differ in either quality and quantity from that reported by Hayashi et al. (1999a, 1999b). Taking these views into consideration, it is suggested that when one has consistent normal night sleep, a short afternoon nap has restorative effects on alertness in the afternoon, regardless of age.

However, normal night sleeps in the elderly may be different from that of younger adults. With respect to night sleep identified by wrist actigraph data, participants typically slept for approximately seven hours, woke several times during the night and stayed awake for an average of 5.6 min each time. The mean sleep efficiency was 86%. These results are consistent with data from previous studies which suggested that frequent nocturnal waking, a somewhat shortened nocturnal sleep period and reduced sleep efficiency are normal changes associated with age (Williams et al., 1974; Miles and Dement, 1980; Bliwise, 1993; Evans and Rogers, 1994; Hume et al., 1998).

DISCUSSION

This study examined the effects of an afternoon nap of less than 30 min in elderly participants on subjective sleepiness, fatigue, performance and EEG activity. In this study, two following assumptions were adopted in the design for napping in the laboratory. First, the napping was scheduled from 13:00 h at which daytime sleepiness normally occurs in the elderly (Carskadon, 1989; Dinges, 1993). From the results of multiple sleep latency tests conducted every two hours from 09:30 h, Carskadon (1989), revealed that sleepiness in the elderly peaked at 13:30 h and sleep latency was approximately 5 min at that time. In this study, all the participants were able to take a nap during the allotted time. Also, their sleep latency averaged 4.6 min, which was comparable to the results of Carskadon (1989). Thus, the timing of napping in the present study was set at the point when daytime sleepiness was at its peak.
Thus, it has been proposed that the incidence of daytime napping in the elderly contributes to disturbed nocturnal sleep, which is compensated for by napping (Miles and Dement, 1980; Bliwise, 1993). In light of this view, night sleep before taking naps would be impaired in the elderly. Several previous studies using younger participants have shown that night sleep before taking a compensatory or replacement nap was shorter in length than that before taking no naps and that the participants felt sleep debt when they took replacement naps (Dinges, 1989, 1992; Rosa, 1993). However, the present participants were satisfied with their normal sleep despite the changes previously mentioned, which are associated with age. Also, night sleep before taking daytime naps was not always impaired in comparison with that before taking no-daytime naps in normal life. Similar results were observed for normal night sleep after daytime naps or no-daytime naps. Moreover, night sleep after the laboratory nap was similar to that of normal night sleep. These results support the argument that participants who took daytime naps did not need to compensate for insufficient sleep and these naps did not negatively influence their subsequent night sleep in normal conditions. Thus, daytime naps, at least those taken by the present participants, could be appetitive naps and not replacement naps.

The present results showed that such a nap was effective in improving alertness in the elderly, even if it was less than 30 min in length and primarily composed of light sleep stages. However, it has been considered that the amount of time spent in SWS, which is a deeper level of sleep, is more important for restoration (Horne, 1988). The importance of the amount of SWS has been supported by several studies indicating that a nap longer than one hour comprised of SWS, improved sleepiness and performance (Lumley et al., 1986; Dinges et al., 1987), while a short 15 min nap, with little SWS, had shown only minor alerting effects (Lumley et al., 1986). It should be noted, however, that these results were obtained under conditions of sleep deprivation. It is suggested that SWS would be needed to restore alertness when individuals are in sleep debt, which was not the case for the present participants, who had normal night sleep.

On the other hand, it is highly probable that the occurrence of SWS during napping caused negative effects on behavior or mood just after waking, such as sleep inertia (Stampi, 1992; Dinges et al., 1992). Also, several studies revealed that longer naps, which contained SWS, could induce a decrease in SWS and an extension of sleep latency in the subsequent nocturnal sleep (Karacan et al., 1970; Metz and Bunnell, 1990). Moreover, a longer nap may cause an increase in nocturnal waking in association with the continuity of night sleep, which is an important part in the restorative effects of nocturnal sleep (Bonnet, 1986). In this study, the laboratory nap did not show any reduction in the quantity of subsequent nocturnal sleep, as observed from the results of wrist activity. Also, since SWS was minimal in the laboratory nap, it was assumed that it did not result in a decrease in the amount of SWS during the subsequent night, according to the need-fulfillment hypothesis for SWS (Karacan et al., 1970). Thus, we suggest that in the elderly, who take naps regardless of their night sleep, an afternoon nap of less than 30 min can at least attenuate the negative potential effects of napping and they can benefit from its restorative effects.

However, here it is important to note that the night sleep was identified from wrist activity in this study. Several studies have demonstrated the validity of activity in distinguishing between sleep and wakefulness, which have all been based on concomitantly obtained actigraphic and polysomnographic recordings (Sadeh et al., 1995). On the other hand, attempts to identify sleep stages from activity data have been unsuccessful, although different activity levels are associated with sleep stages (Middelkoop et al., 1993). Thus, in this study it was impossible to assess the relationship between daytime naps and quality of night sleep without using a polysomnograph. We would like to emphasize that this discussion on the relationship between daytime naps and night sleep is restricted within the applicable scope in actigraphic assessment of sleep.

In general, naps occur more frequently in the elderly than in younger adults. Metz and Bunnell (1990), showed in their study that 61% of 132 elderly participants took regular naps which occurred 4.8 times per week, compared to the present results which averaged 4.6 naps per week. Numerous studies have also shown that mid-afternoon is the favored time for napping among adults, although the elderly napping phase is slightly advanced (Broughton, 1989; Dinges, 1989, 1993). In the present study, of the 115 daytime naps recorded, 24% of naps occurred between 13:00 and 13:30 h, 84% occurred between 12:00 and 15:00 h, supporting the results of previous studies (Broughton, 1989; Dinges, 1989, 1993). In this study, the duration of a daytime nap averaged 37.8 min. Although data for the duration of a nap in the elderly did not agree with previous studies, the duration of a nap in the elderly is typically less than approximately 60 min (Metz and Bunnell, 1990; Wauquier et al., 1992; Evans and Rogers, 1994). Taking these results into consideration, it is plausible that habitual nappers, such as the participants in this study, are more typical among the elderly and the laboratory nap in this study was representative of afternoon naps in normal life of the elderly. Therefore, napping in the elderly may reflect a desire for the benefits of naps, rather than from the effects of insufficient night sleep, as described by Metz and Bunnell (1990). Further studies are needed to evaluate the significance of daytime naps in the elderly in order to adequately maintain their mental and physical health.

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