The Effects of Short Daytime Naps for Five Consecutive Days

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The aim of the present study was to examine the effects of short naps (less than 20 min) at noon for five consecutive days. Seven young adults (21-24 yrs) who had normal sleep-wake habits without habitual daytime napping participated in both the Nap and the No-nap conditions. During the Nap week between Monday and Friday, the subjects went to bed at 12:40 and were awakened at 13:00. During the No-nap week, they read a newspaper, sitting on a semi-reclining chair during that time. Subjective sleepiness and fatigue were evaluated immediately before and after napping and twice in the mid-afternoon (14:40 and 16:30). A visual detection task was also performed in the mid-afternoon. The subjects took a nap for approximately 12 min every five days. Sleep inertia occurred even after such a short nap. However, it was reduced as a function of days and became similar to the No-nap week on the fourth day. In the mid-afternoon, sleepiness was suppressed by not only taking a nap, but also taking it continuously for three days or more. These findings suggest that even a short nap of less than 20 min would cause sleep inertia, however, it would have positive effects upon mid-afternoon sleepiness. Furthermore, the effects of a short nap are enhanced by taking it for more than three consecutive days.

CURRENT CLAIM: A short daytime nap of less than 20 min is more effective when taking it for more than three consecutive days.

Daytime arousal levels decline in the afternoon (Carskadon, 1989). Sleepiness-related accidents often occur at that time (Mitler et al., 1988). One of the countermeasures for preventing declines in the arousal level during the afternoon is napping. However, the effects of napping depend on the duration and the timing of the nap (Naitoh, 1981).

Commonly, sleep duration and the amount of slow wave sleep (SWS) in major nocturnal sleep reflect sleep quality (Åkerstedt et al., 1997) and daytime function (Devoto et al., 1999). However, the occurrence of SWS during the daytime nap is not always beneficial. Although habitual nappers would be refreshed by relatively long naps ranging from 40 to 70 min (Dinges, 1989, 1992), it was not the case for non-nappers (Spiegel, 1981). This is because long daytime naps containing SWS increase sleep inertia, i.e., temporarily deteriorate the performance level or mood immediately after waking (Stampi et al., 1990). Moreover, when 2-h daytime naps containing SWS are taken, SWS in the subsequent major nocturnal sleep decreases (Feinberg et al., 1992), suggesting that the quality of the subsequent nocturnal sleep declines. In contrast, short naps, which were composed of Stages 1 and 2 sleep and did not contain SWS, had restorative effects on the afternoon sleepiness for non-habitual nappers (Hayashi et al., 1999a, 1999b).

Recently, it was observed that short naps of less than 30 min had positive effects for maintaining daytime arousal levels. These effects were observed after normal night sleep in young adults (Hayashi et al., 1999a, 1999b) and in elderly subjects (Tamaki et al., 1999, 2000). This was also confirmed after restricted night sleep (Gillberg et al., 1996; Horne and Reyner, 1996; Reyner and Horne, 1997; Stampi et al., 1990; Takahashi and Arito, 2000), during night shifts (Sallinen et al., 1998), and prolonged, sustained performance (Naitoh et al., 1992; Stampi, 1989). In addition, it was reported that short daytime naps had positive effects on emotions (Luo and Inoué, 2000).

Except for Naitoh et al. (1992) and Stampi (1989), who examined the effects of short naps during prolonged, sustained performance, the previous studies examined those for only one day. The positive effects of napping have been observed for habitual nappers (Dinges, 1989, 1992; Spiegel, 1981; Tamaki et al., 1999, 2000). Therefore, the habit of taking short naps might cause additional prophylactic effects for arousal levels in the afternoon.

In the present study, the participants who were non-habitual nappers took 20 naps at noon for five consecutive days. The effects of the short naps among the days were studied. For practical purposes, the daily activities of the subjects were not controlled, as much as possible, except for the sleep-wake schedule including night sleep and daytime naps, and two 4-min tasks during the mid-afternoon. In addition, they were also free from the recordings of the polysomnogram because the measurement of EEG activities would restrict the time and behavior of the subjects. Actigraphical recordings were used as a substitute for EEG recordings. Although those are apt to overestimate sleep duration in comparison with the polysomnogram or subjective estimates (Hauri and Wisbey, 1992; Lockley et al., 1999), it has often been used in longitudinal field studies because of convenience and the reduced influences on their daily activities.

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METHODS

Subjects
Eight university students with good health participated in the study. They previously answered the sleep-wake habit inventory (Miyasita, 1994) and Morning-Evening questionnaire (Horne and Östberg, 1976). The subjects reported that they had normal sleep-wake habits and did not complain of sleep-wake problems. They took naps less than once per week, and were good, non-irregular sleepers with normal sleep lengths (Hayashi et al., 1999a, 1999b) as follows: their subjective sleep latencies were less than 10 min, they never awakened during the night, and did not complain of difficulty in falling asleep or remaining asleep. The subjects reported that retiring and waking times and sleep duration varied by less than 2 h over one month. They slept 6 to 8 h nightly. Moreover, they were not excessive morning types, nor evening types (Horne and Östberg, 1976). All were non-smokers, and did not consume excessive caffeinated beverages.

The sleep log and wrist activity during the experimental period revealed that one of the subjects showed an irregular sleep-wake pattern during the experimental period, so that the findings of the seven other subjects (3 female and 4 male, 21-24 yrs) were analyzed.

Procedure
The subjects were instructed to follow their normal sleep-wake schedule during the experimental weeks. They kept a sleep log from one week before to the termination of the experimental period. In addition, wrist activity was recorded throughout the experimental period (Mini-motion logger actigraph, Ambulatory Monitoring Inc., USA). Sleep/wake identification from the wrist activity was performed using the algorithm of Cole et al. (1992). The sleep log and the sleep/wake pattern, identified by wrist activity, confirmed that the seven subjects showed a normal sleep-wake schedule during the experimental period.

The subjects attended the experiment for two weeks during the semester. One week was the Nap condition and the other was the No-nap condition. The order of the weeks was counterbalanced across the subjects. For each week, they engaged in the same conditions for five consecutive days between Monday and Friday.

Naps were taken during the lunch break (12:20 to 13:10). The subjects reported to the laboratory at 12:25 and took lunch. During the Nap week, lights were turned off at 12:40, and they napped until 13:00 in a soundproof and air-conditioned isolation unit. During the No-nap week, subjects read a newspaper, sitting on a semi-reclining chair in the unit, from 12:40 to 13:00. Immediately before and after, subjective sleepiness and fatigue were evaluated using the 100 mm long visual analog scale (Monk, 1989). The values ranged from 0 (very alert or very vigorous) to 100 (very sleepy or very tired).

Almost all subjects attended classes at 13:10 to 14:40 and 15:00 to 16:30. They came back to the laboratory twice during the breaks at 14:40 to 15:00 and 16:30 to 16:50 and performed approximately 4-min tasks. They performed a modified version of the visual detection task (Englund et al., 1985) as displayed on a personal computer (PC-386V, Epson). An alphanumeric sequence was displayed for 50 msec at intervals of 2 sec. Eighty trials were presented. Each subject was instructed to press the “correct” button as quickly and as accurately as possible if “A” or “3” was presented. After the task, they estimated sleepiness and fatigue via a visual analog scale.

Except for the above procedure, the subjects were engaged in daily activities as usual during the experimental weeks.

Statistical Analysis
Two-way [2 (Nap or No-nap week) x 5 (Days)] analyses of variance (ANOVAs) with repeated measures were performed for nocturnal sleep, mood (sleepiness and fatigue), and performance (reaction time and percent correct of the detection task). In addition, to examine the time-course of napping effects in the afternoon, three-way [2 (Nap or No-nap week) x 4 (Time of day) x 5 (Days)] ANOVA with repeated measures was performed for sleepiness and fatigue. The degrees of freedom were adjusted by Huynh and Feldt's epsilon (Winer et al., 1991). The post hoc comparisons were performed using the Newman-Keuls procedure.

RESULTS

Nocturnal Sleep and Daytime Naps
The ANOVA showed that significant differences between the Nap and the No-nap weeks during nocturnal sleep could not be observed for the time in bed (mean time ±SE was 459.4±14.5 min during the Nap week and 455.4±20.5 min during the No-nap week), total sleep time (Nap week: 431.0±13.8 min; No-nap week: 406.3±18.5 min), sleep efficiency (Nap week: 93.8±1.5%; No-nap week: 89.2±1.8%), or sleep latency (Nap week: 13.8±4.6 min; No-nap week: 13.6±3.1 min). However, waking time after sleep onset during the Nap week (14.6±3.5 min) was significantly shorter than that during the No-nap week (35.5±9.0 min) [F (1,6)=7.13, p<0.05].

The mean nap time (±SE) was 11.4±0.3 min, which was longer than the self-estimated time (6.3±0.5 min) [F (1,6)=8.69, p<0.05]. Mean sleep latency (±SE) was 8.2±0.3 min, which was not significantly different from self-estimated time (11.5±0.4 min). The main effects of the days were not observed for both nap time (mean ±SE for each day was 12.5±0.2, 12.3±0.3, 10.6±1.0, 10.7±0.4 and 11.0±0.4 min, respectively) and sleep latency (mean latency for each day was 7.2±0.2, 7.7±0.3, 9.3±1.0, 8.6±0.3 and 8.3±0.2 min, respectively).

Performance
The percent correct of the detection task for both 14:40 and 16:30 was above 99%. For the reaction time, no main effects or interactions were observed at 14:40, however, it shortened as a function of days at 16:30 [F (4,24)=8.44, ε=0.38, p<0.05] (Figure 1). Reaction time at 16:30 on the fourth to fifth day was lowered compared with that on the first to second day (p<0.05). However, there were no significant differences between the Nap and No-nap weeks.
Sleepiness

Figure 2 shows the mean sleepiness scores, among five consecutive days, immediately before (12:40) and after (13:00) napping or resting, and at mid-afternoon (14:40 and 16:30). Sleepiness changed as a function of time of days during both the Nap $[F (3,18)=3.48, \varepsilon=1.00, p<0.05]$ and the No-nap weeks $[F (3,18)=3.71, \varepsilon=0.99, p<0.05]$. Sleepiness significantly increased from before (12:20) to after (13:00) napping or resting for both weeks ($p<0.05$). However, it significantly decreased in the mid-afternoon (14:40 and 16:30) during the Nap week ($p<0.05$), but did not significantly change during the No-nap week. In Figure 2, sleepiness at 14:40 was lower during the Nap week than during the No-nap week, however, the difference between the weeks was not significant $[F (1,6)=4.68, p<0.08]$.

In Figure 3, sleepiness fluctuations among the days immediately after napping or resting (13:00) and in the mid-afternoon (14:40) are shown. The main effect of days was significant at these times [13:00: $F (4,24)=4.96, \varepsilon=0.53, p<0.05$; 14:40: $F (4,24)=6.61, \varepsilon=0.37, p<0.05$]. During the Nap week, sleepiness on the fourth to fifth day at 13:00 was significantly lowered compared with the first to third day, and on the third to fifth day, at 14:40, sleepiness was significantly lowered compared with the first to second day ($p<0.05$). During the No-nap week, however, there was no significant change among the days at both 13:00 and 14:40.

Fatigue

Figure 4 shows the mean fatigue scores among five consecutive days immediately before (12:40) and after (13:00) napping or resting, and at mid-afternoon (14:40 and 16:30). Fatigue changed as a function of time of day during the No-nap week $[F (3,18)=6.90, \varepsilon=0.86, p<0.01]$ but not during the Nap week $[F (3,18)=1.77, \varepsilon=1.00, ns]$. Fatigue during the No-nap week significantly increased in the mid-afternoon (14:40 and 16:30) compared with the early afternoon (12:40 and 13:00; $p<0.05$). Furthermore, fatigue was significantly higher during the No-nap week than during the Nap week in the mid-afternoon (14:40 and 16:30; $p<0.01$).

In Figure 5, the fluctuations of fatigue among the days at 14:40 and 16:30 are shown. Fatigue was lower during the Nap week than during the No-nap week on all days (14:40: $F (1,6)=10.87, p<0.05$; 16:30: $F (1,6)=12.79, p<0.05$).

Activity Level

The activity level of the Nap week, measured by wrist activity, was not significantly different from those of the No-nap week during any hours except for daytime nap hours.

**DISCUSSION**

Based on the actigraphic recordings, the sleep latencies during the nap were 7 to 9 min and they napped for 10 to 13 min daily. Subjective ratings of nap time were shorter than the actigraphical recordings, which were similar to previous findings (Hauri and Wisbey, 1992; Lockley et al., 1999).
Although the contents of the naps, such as sleep stages, were not clear in the present study because the polysomnogram was not recorded, it was clear that the present subjects took 20-min bed rest, including nap time.

In general, daytime sleepiness is maximal and sleep latency is most shortened in the mid-afternoon (Carskadon, 1989). Even before that time, young adults can sleep easily with relatively short sleep latencies of less than 10 min. This is comparable with previous findings in which the subjects could sleep within 1 to 11 min (average 4.4 min) from lights out at noon after normal nocturnal sleep (Hayashi et al., 1999a). Sleep inertia lasts 5 to 15 min immediately after getting up from an approximate 1-hr nap (Dinges, 1989); however, in the present study, it occurred even after taking short naps of less than 15 min (Figure 3).

In the present study, naps taken at noon suppressed sleepiness (Figures 2 and 3) and fatigue (Figures 4 and 5) in the mid-afternoon. These observations agreed with previous findings (Hayashi et al., 1999a, 1999b). Performance levels did not change between the Nap and the No-nap weeks, however, the duration of the tasks may have been too short to detect the effects of napping.

The reaction time at 16:30 declined as a function of days (Figure 1). This may reflect the practice effect because no significant differences were observed between the Nap and No-nap weeks. However, sleepiness immediately after napping, during the Nap week, declined on and after the fourth day, and became similar to those during the No-nap week (Figure 3). Furthermore, sleepiness at mid-afternoon (14:40) could be suppressed by not only taking naps, but also taking them continuously for three or more days. These findings suggest that at least three days might be required to achieve the positive effects of napping. Although the effects of napping were previously examined using a survey, daily sleep log, or laboratory experiments (Dinges, 1989), the effects of the formation of a napping habit for non-nappers had not been studied. Sleep inertia occurred immediately after napping in the present study; however, this was restricted within three days. These findings suggest that the formation of napping habits should further enhance the positive effects of short naps. Because of the small number of the subjects (n=7), the effects of the formation of napping habits by non-nappers should be further explored.

Nocturnal sleep variables, including sleep periods, sleep time, waking time after sleep onset, sleep efficiency and sleep latency, except for the number of times awake, were not significantly different between the Nap and the No-nap weeks. A 2-h nap including slow wave sleep would cause a decline in slow wave activity in the EEG during the subsequent nocturnal sleep (Feinberg et al., 1992). Thus, relatively long naps would be harmful to the subsequent nocturnal sleep for non-habitual nappers. However, the present findings suggest that short daytime naps of less than 20 min do not negatively affect the subsequent nocturnal sleep. The number of times awake during the Nap week decreased in comparison with those during the No-nap week, however, it was not clear whether the short daytime naps had positive effects on subsequent nocturnal sleep, because the polysomnogram was not recorded in the present study. Further studies will be necessary to examine the effects of short daytime naps on nocturnal sleep.

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Daily sleep logs and actigraphic recordings showed that the present subjects had regular sleep-wake habits, and almost all attended classes in the afternoon. Also, daytime activity levels measured by wrist activity did not differ between the Nap and the No-nap weeks. However, the behavior of the subjects was not controlled except for nocturnal sleep and daytime naps. Even if the quantity of the physical activity during the Nap week, indicated by actigraphic recordings, did not differ from those during the No-nap week, the quality and quantity of the mental activity may have differed (Shirota et al., 2001). The relationships between short daytime naps and the contents of the daily activities require further exploration.

In conclusion, the findings of the present study showed that the effects of napping habits were observed even in short daytime naps, which were less than 20 min. It can be expected
that the effects of the short nap are enhanced by taking one for more than three consecutive days.

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REFERENCES