Psycho-Physiological Effects of Naps during Night Shifts on Morning Types and Evening Types

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Abstract: Psycho-Physiological Effects of Naps during Night Shifts on Morning Types and Evening Types: Hidemaro TAKEYAMA, et al. — An experimental study was carried out under simulated shift-work schedules to examine the effects of a nighttime nap on task performances and psycho-physiological functions on morningness (M-types) and eveningness (E-types) subjects. Sixty male students, classified as M-types or E-types by the Japanese version morningness-eveningness questionnaire, were recruited for this study. Five moderate M-types and eight moderate E-types were selected. Their MEQ scores were 32-41 (average 36.9) in E-types and 60–64 (average 62.4) in M-types, respectively. Experiment periods were simulated shift schedules of 9 consecutive days consisting of 2 d shifts (working 8:00–16:00), 3 night shifts (working 22:00–8:00) and 3 d shifts. They carried out two series of experiments. In one series the subjects took a nap from 2:00 to 4:00. In the other series they did not take a nap during the night shift. In order to minimize the effect of the previous experiments, a rest period of more than one week was inserted between the nap-condition and the no-nap condition experiments. During the shifts, the subjects repeatedly performed two kinds of tasks: typing figures listed randomly on sheets into a computer for 20 min; and after a 5 min break performing mental arithmetic with two adjacent figures, listed randomly on the sheets, for 15 min. During the breaks, psycho-physiological functions and questionnaires on subjective feelings of fatigue and index of the state of anxiety were examined. Throughout the experiments, heart rate variability was also recorded with a portable recorder to evaluate autonomic nerve activity. Task performances decreased and subjective feelings of fatigue and anxiety scores increased in proportion to the length of time worked in both M-types and E-types who had no nap. In M-types, these changes were significantly suppressed by the nap on the first night of duty. Parasympathetic nerve activity for M-types estimated from heart rate variability between 4:00 and 6:00 under nap conditions decreased significantly compared with that under no-nap conditions. Overall changes for E-types, however, were smaller than those for M-types in terms of task performance and psycho-physiological parameters. The present study suggested that taking a nighttime nap was an effective way to reduce adverse effects due to first nocturnal work, especially for M-types.

Key words: Night shift, Morningness, Eveningness, Nap, Task performance, Psycho-physiological effect

Shift workers tend to produce accumulations of lack of sleep and fatigue as a result of being compelled to invert a wake-sleep cycle against the biological rhythm1, 2. Some shift workers quit shift work due to medical problems caused by shift work workloads, whereas others engage themselves in shift work longer3. Previously, several studies have tried to explain the difference in individual adaptability to shift work4–7. Morningness-eveningness representing the diurnal types of individuals is a well-known dimension of “personality” used to predict adaptability to shift work3. Morning types (M-types) display a phase advance in the peak of body temperature and alertness rhythm as well as earlier sleeping and rising times compared with Evening types (E-types)8, 9. M-types have less daytime sleep after night duty than E-types. Generally it is known that M-types have poorer adaptability to shift work than E-types10. This finding can be explained by examining the differences between M-types and E-types in circadian rhythms such as wake-sleep and body temperature5, 10, although contradictory reports also exist11.

Recently, new shift systems in which workers can get extra holidays in return for working longer hours per shift have been introduced11, 12. The number of elderly shift workers is increasing in Japan and other industrial
countries, and it is assumed that the elderly workers generally have difficulty adapting to the shift work system. It is therefore increasingly important to take measures against fatigue and other adverse effects due to shift work, especially night shift work. Previous studies have indicated that taking naps is one of the effective countermeasures against the adverse effects. Some researchers have reported the effects of naps as prophylactic sleep. These studies focus on the quality, timing, and length of daytime naps prior to night work, but studies that examine the effects of nighttime naps are limited. In order to study the effect of a nap in reducing fatigue or other complaints relating to the load from shift work in the actual workplace, it is important to accumulate data regarding the effects of the nap. Nevertheless, researches have yet to report the effects of nighttime naps, while taking into account individual differences in adaptability to shift work.

In this study, the effects of a nighttime nap on task performances and psycho-physiological functions during night work in M-types and E-types under simulated shift work schedules were examined.

**Subjects and Methods**

**Subjects**

Sixty students volunteered for this study. To select the diurnal types of the subjects, they were requested to fill out the Japanese version of the morningness-eveningness questionnaire (MEQ) and a questionnaire about their sleep habits, including when they go to sleep and when they wake up. According to the results of the MEQ, 5 moderate M-types and 8 moderate E-types were selected. Their MEQ scores were 32–41 (average 36.9) in E-types and 60–64 (average 62.4) in M-types, respectively. All the subjects were healthy males, aged 18–22 years, non-smokers and not on continuous medications. There were no significant differences between the M-types and E-types in sleeping habits. The subjects were given a detailed description of the study, and their informed consent was obtained. Before starting the experiments, the subjects visited the laboratory to get accustomed to various examinations.

**Experimental schedule**

Figure 1 shows the experiment schedule. The experiment periods were for a simulated shift schedule of 9 consecutive d consisting of 2 d shifts (a day shift being 8:00–16:00), 3 night shifts (a night shift being 22:00–6:00) and 3 d shifts. The experiments were carried out in the laboratory, and the subjects spent the time at their home when not “on duty”. Although the subjects were instructed to sleep at least 6 h at their home, there were no restrictions on what time they had to go to sleep or rise. All subjects performed two series of experiments. In one series, the subjects took a nap from 2:00 to 4:00.

In the other series, they did not take a nap during the night. The series were assigned to each subject randomly. In order to minimize the effect of previous experiments, a rest period of more than one wk was inserted between the nap-condition (NAP) and no-nap-condition (N-NAP) experiments. Throughout the experiment period, the subjects were prohibited from drinking beverages containing caffeine or alcohol and from doing vigorous physical activities. While on duty, the subjects were requested to perform sets of tasks repeatedly. The task set was composed of two tasks: typing figures, listed randomly on sheets, into a computer for 20 min, and after a 5 min break, performing mental arithmetic with two adjacent figures, listed randomly on sheets, for 15 min.

Between each set of tasks, a 15-min break was inserted. During the break, critical flicker fusion frequency (CFF), 3-choice reaction time (3CRT), oral temperature, and cortisol levels in saliva were measured. The subjects were also asked to fill out a questionnaire regarding fatigue and anxiety. The subjects spent the break time reading magazines and/or newspapers, or listening to music etc., but taking a nap was prohibited. The set of two tasks was assigned to each subject 7 times during day duty and 8 times during night duty. The subjects were instructed to perform the tasks as quickly and correctly as possible.

This study was carried out in two installments, from February to March and from August to September. The number of subjects was 2 M-types and 3 E-types in one experiment, and 3 M-types and 5 E-types in the other experiment.

**Measurement**

Heart rates and R-R intervals were recorded continuously with Holter type ECG recorders (Active Tracer AC301, GMS Inc., Tokyo, Japan) during the whole experimental period except when subjects were taking baths. The data were transferred into a computer after the measurement, then a frequency analysis of R-R intervals.
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was performed with the Memcalc system 22) (Suwa Trust Co. Ltd., Tokyo, Japan), and high frequency power (HF; 0.15–0.4 Hz) and low frequency power (LF; 0.04–0.15 Hz) were calculated. The HF and LF/HF values were taken as indices of parasympathetic and sympathetic nerve activity levels, respectively 23). The relative values to the mean of all data were calculated at five-min intervals.

To collect saliva samples, SALIBETTE (Sarstat Inc., Rommeldorf, Germany) was used. The collected samples were centrifuged at 3000 rpm for 10 min, then stored at 20°C until analyzed. Salivary cortisol was measured by mean of a Coat-A-Count Cortisol kit (Nippon DPC Co. Ltd., Tokyo, Japan). Because this kit is for measuring serum cortisol, we modified the measurement procedure for salivary cortisol according to Tunn et al. 24).

Oral temperature was measured with a clinical thermometer (TERUMO Co. Ltd., Tokyo, Japan).

To measure 3CRT, we developed a computer program that detects the time between recognition of one to three numbers presented randomly on a display and pressing the corresponding number key with the fingers of the dominant hand. 3CRT was evaluated as the average of 10 trials.

Critical flicker fusion frequencies were successively determined five times in descending order by using Roken Degital Flicker (modelRDF-1; Shibata Co. Ltd., Tokyo). The questionnaire consisted of 30 questions on subjective feeling of fatigue established by the Industrial Fatigue Research Committee of the Japan Association of Industrial Health 25), and 20 questions on the State-Trait Anxiety Inventory-State scale (STAI-state). STAI-state is defined as a transitory emotional response involving unpleasant feelings of tension and apprehensive thought 26). The subjects were also asked to keep logs of sleep, meals, evacuation and bathing.

Statistical analysis

In this study, the sample sizes in both E-types and M-types were small and different, so that statistical analyses for both M-types and E-types were performed independently under NAP and N-NAP. At first, 2-way repeated ANOVA was used for the evaluation of the effect in regard to time, NAP and N-NAP and their interactions. Paired t-tests were then performed for the NAP and N-NAP at each time point. For the analyses SPSS version 10 was used. Results were considered statistically significant with p<0.05.

Results

The results for oral temperatures and CFF in M-types
and E-types are shown in Fig. 2. The results for CFF are represented by relative values to the mean for the whole experiment. Overall oral temperature increased during the second set of tasks, and gradually decreased with the time of night in both types. For M-types, values at the end of the night duty tended to be high with a nap. With regard to oral temperature, there was a significant difference between N-NAP and NAP at the end of the second night shift. The CFF values tended to decrease as subjects performed the tasks in both types, but no significant effects of a nap on CFF values were observed in either type during the night shifts. The number of figures typed and the percentage of the errors are shown in Fig. 3. The number of figures typed by M-types on NAP gradually increased as the hours grew later during each night shift. There was a significant difference in NAP and N-NAP at the end of the first night shift. The number of figures typed by E-types on NAP also increased after taking a nap, but a decrease in performances of the task was observed just after waking. The number of calculations and percentage of errors are shown in Fig. 4. No clear effects of taking naps on calculation performance were observed.

Figure 5 shows the changes in the number of subjective complaints relating to drowsiness during the three night shifts. The number of the complaints by E-types gradually increased as the hours grew later during night duty on NAP and N-NAP. On the other hand, complaints by M-types on NAP were significantly fewer than those on N-NAP. Significant decreases in subjective complaints after taking a nap were not observed on the second and third night shift among M-types. Changes in STAI-trait scores during the night duty among E-types and M-types are shown in Fig. 6. The normal range is defined as from 32 to 40; moderate high is 41 to 4926). The scores of E-types during the three night shifts were classified in the moderate-high range, but there were no significant differences between NAP and N-NAP. The scores of M-types under N-NAP were also classified in the moderate-high range. The scores of M-types on NAP were significantly lower in the latter half of the first night shift and in the first half of the third night shift compared with N-NAP.

The HF values in both types during the three night shifts are shown in Fig. 7. The HF values for M-types decreased significantly after taking a nap on the first night shift compared with the values at corresponding times under N-NAP. Although HF for E-types tended to be low after taking a nap on the first night shift, there were no significant differences between the values under NAP and N-NAP.

Figure 8 shows the changes in salivary cortisol levels...
Fig. 4. Fluctuations in task performance (amount of calculated figures and error) during the three shifts in E-types and M-types under nap and no nap conditions. Each circle is the mean, and vertical lines are SD. The dotted line is the boundary line before and after a nap and no nap. *P<0.05.

Fig. 5. Changes in number of complaints related to drowsiness during the three shifts in E-types and M-types under nap and no nap conditions. Each circle is the mean, and vertical lines are SD. The dotted line is the boundary line before and after a nap and no nap. *P<0.05.
Fig. 6. Fluctuations in STAI-trait during the three shifts in E-types and M-types under nap and no nap conditions. Each circle is the mean, and vertical lines are SD. The dotted line shows boundary line before and after a nap and no nap. *P<0.05.

Fig. 7. Relative change in HF to the first 2h of work in E-types and M-types every 2 hour during three night shifts. Each bar is the mean, and vertical lines are SD. The dotted line shows boundary line before and after a nap and no nap. *P<0.05.
There were no significant differences between Nap and N-Nap in either type. Table 1 shows the results by the number and rate of subjects whose salivary levels of cortisol at 21:00 exceeded the levels at 8:00.

The increases in percentage with advancing night shifts under both NAP and N-NAP among E-types tended to be larger than those among M-types, but no effects of taking a nap in either type were observed.

Table 2 shows the sleeping hours under NAP and N-NAP in both types throughout the experiment, and wakeful hours until taking a nap on NAP. On the day before the first night shift and after the third night shift, sleeping hours were longer than those on other days. Wakeful hours before taking a nap on the day before the first night shift were longer among M-types than E-types.

Table 1. Number of subjects whose cortisol level at 22:00 exceed the levels 8:00

<table>
<thead>
<tr>
<th></th>
<th>N1</th>
<th>N2</th>
<th>N3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M-types</td>
<td>E-types</td>
<td>M-types</td>
</tr>
<tr>
<td>Salivary cortisol</td>
<td>No Nap</td>
<td>0/5 (0%)</td>
<td>3/8 (38%)</td>
</tr>
<tr>
<td></td>
<td>Nap</td>
<td>1/5 (20%)</td>
<td>2/8 (25%)</td>
</tr>
</tbody>
</table>

Fig. 8. Fluctuations in salivary cortisol levels during the three shifts in E-types and M-types under nap and no nap conditions. Each circle is the mean, and vertical lines are SD. The dotted line shows boundary line before and after a nap and no nap.

Discussion

Some studies focused on the timing and the lengths of effective nighttime naps. The first cycle of nocturnal sleep in adults usually lasts approximately two h, including the duration of both slow wave sleep and REM sleep. Matsumoto evaluated the effects of nighttime naps taken at different times, by electroencephalogram (EEG). The results of the study suggest that taking naps later at night is more effective with regard to quality of sleep, than when naps are taken earlier at night. According to these results, a 2-h nap taken later at night is expected to be more effective against the adverse effects. Therefore the experiment schedule was designed for taking a nap at 2:00–4:00 during the night shift. The results showed that task performances,
and subjective complaints of drowsiness and anxiety for M-types were improved by taking a nap on the first night of night shifts. On the second and third night shifts, the positive effects of taking a nap on the various parameters were reduced among M-types and E-types. No significant effects of taking a nap during night shifts were observed among E-types.

There are two possibilities to explain why the effects of taking a nap on performance and subjective complaints were observed only among M-types. One possible explanation is the difference between M-types and E-types in wakeful hours before taking a nap. According to the research with an EEG, the length of the wakeful hours before taking a nap affects the sleep efficiency of the nap. Although some of the E-type subjects took a daytime nap before the first night shift, no M-type subject took a daytime nap or rose earlier than E-types under NAP. The length of wakeful hours among M-types before taking a nap on the first night shift tended to be longer than that of E-types. The other possible explanation is the difference between the circadian rhythms of the two types. Recent studies have shown that the minimum phase of the core body temperature is earlier in M-types than in E-types. Gillberg et al. employed a one-hour nap starting either at 21:00 or 4:30. He found that the nap taken at 4:30 was more efficient in improving alertness than one taken at 21:00. Other researchers suggested that the length of time between the onset of naps and the trough of the body temperature rhythm influences the sleep efficiency of naps. The differences between the two groups in the effects of taking a nap might be caused by the relationship between the timing of the onset of a nap and the trough of body temperature, and by wakeful hours until taking a nap. Regarding those points, further consideration is impossible, because the precise trough of body temperature and EEG profile during a nap are not clear in this study.

Analysis of HRV and its spectral components is a non-invasive tool to estimate autonomic nerve activities. The sympathetic activity is prevalent during the day and in the early waking hours, and the parasympathetic component is predominant at night. Huikuri et al. studied the circadian rhythms of HRV in healthy subjects. In their study, it was reported that HF increased late at night before waking, and decreased abruptly after waking. There are few studies estimating autonomic nerve activities during shift work. In this study, HF values later at night on the first night shift increased under N-NAP in both types. The results suggest that the circadian rhythms in autonomic activities remain unchanged in spite of being awake during the night. The HF value for M-types decreased significantly after taking a nap compared with that under N-NAP on the first night of duty. The levels of autonomic nervous activities estimated by HF values could explain the changes in subjective complaints of drowsiness and the task performance.

Salivary cortisol secretion levels show a circadian rhythm. The level is highest in the early morning, decreases through the day, and is lowest around midnight. Fujiwara et al. reported that the peak of cortisol in the early morning was reduced after one night shift. In this study, the comparison of the number of subjects, whose cortisol levels in the evening (21:00) exceeded the levels in the morning (8:00), was made. Henning et al. also examined the response of cortisol levels at 6:00 and 21:00 during night shifts. They reported that cortisol levels in the evening exceeded those in the early morning after fifth night shifts in some of the subjects, although some of them exhibited no change in circadian rhythm. They held that the subjects exhibiting changes in cortisol levels during night shifts tended to be good at adaptation to the night shifts. Although the number of subjects with higher cortisol levels at 21:00 increased with the number of on night shifts among E-types under both NAP and N-NAP compared to M-types, these results showed no significant differences between

### Table 2. Sleeping hours and waking hours until taking a nap during the experiment

<table>
<thead>
<tr>
<th></th>
<th>D2-N1</th>
<th>N1-N2</th>
<th>N2-N3</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>M-types</td>
<td>E-types</td>
<td>M-types</td>
</tr>
<tr>
<td>Sleeping hours</td>
<td>No Nap 633 ± 190</td>
<td>763 ± 185</td>
<td>453 ± 68</td>
</tr>
<tr>
<td>(min) Nap</td>
<td>624 ± 160</td>
<td>780 ± 167</td>
<td>402 ± 56</td>
</tr>
<tr>
<td>Waking hours</td>
<td>No Nap 884 ± 326</td>
<td>594 ± 237</td>
<td>482 ± 129</td>
</tr>
<tr>
<td>until taking a</td>
<td>Nap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nap (min)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N3-D3</td>
<td>No Nap 648 ± 211</td>
<td>720 ± 183</td>
<td>420 ± 102</td>
</tr>
<tr>
<td>(min) Nap</td>
<td>597 ± 34</td>
<td>767 ± 259</td>
<td>435 ± 86</td>
</tr>
<tr>
<td>D3-D4</td>
<td>M-types</td>
<td>E-types</td>
<td>M-types</td>
</tr>
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<tr>
<td>D4-D5</td>
<td>M-types</td>
<td>E-types</td>
<td>M-types</td>
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Mean ± SD.
Matsumoto et al. reported that a two-hour nap at night shortened daytime sleep the following day, but total sleeping hours per day were similar under both nap-taken and no-nap-taken conditions. Nighttime naps may impair the next daytime sleep, which might produce negative effects on alertness during the next night shift. Some studies reported that daytime sleeping hours among M-types were shorter than that among E-types. No significant difference between NAP and N-NAP in either M-types or in E-types in daytime sleeping hours during the night shifts was observed in this study.

It has been reported that complaints of drowsiness increase during night shifts in field studies and of sleep deprivation in laboratory studies. In this study taking a nap had positive effects on subjective complaints as were observed in STAI-states as well as complaints related to drowsiness. Some studies have estimated the effects of nocturnal work on mood by using Profile Mood Scale (POMS) and no-nap-taken conditions. Nighttime naps may impair sleeping hours per day were similar under both nap-taken and no-nap-taken conditions. Nighttime naps may impair sleep-activity scores of night workers are higher than those of day workers, but tension-anxiety and depression-dejection scores are not affected by night work. These researches were designed to study the long-term effects of night work. On the other hand, our study was designed to estimate the immediate effects of night workloads on mood. The average scores of STAI-states were close to the moderate-high range in both types under N-NAP, and remarkable suppression of the score was observed when M-types took a nap on the first night shift. The results suggest the effectiveness of frequent examination on psychological mood and stress for evaluating nocturnal workloads.

The typing performance of E-types showed a decrease just after waking from a nap, although no decrease was observed among M-types. Lubin et al. reported that performances decreased immediately after taking a nap, which is known as “sleep inertia”, and the effect of “sleep inertia” continued for 5–15 min after waking. In this study calculating performance, which followed typing performance showed no decrease after taking a nap in either type. The transient decrease in typing performance for E-types is considered due to “sleep inertia”.

In summary, the effects of a nighttime nap for M-types were greater than for E-types in task performances and psycho-physiological functions in this study. The study suggests that a nighttime nap is an effective way to reduce the adverse effects due to changing from day to night shifts, especially for M-type subjects. The subjects in this study were not extreme types but moderate types in both morningness and eveningness. It is possible that the difference is more apparent in the extreme types. Further research investigating details of the relationship between timing or lengths of naps and individual differences in a large sample and extreme types may help to confirm the effectiveness of taking naps during night shifts.

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