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Efficacy of Napping Strategies to Counter the Effects of Sleep Deprivation

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INTRODUCTION

There is an abundance of evidence indicating that a nap taken during long periods of otherwise continuous wakefulness is extremely beneficial for improving alertness and performance (Bonnet, 1990; 1991; Dinges, Whitehouse, Orne, and Orne, 1988; Lorizio, Terzano, Parrino, Cesana, and Priore, 1990; Matsumoto and Harada, 1994; Rogers, Spencer, Stone, and Nicholson, 1989; Rosa, 1993; Webb, 1987). However, scheduling naps is not a simple matter. Several factors are important to consider before implementing a napping regime into a continuous operations scenario.

Nap timing

One important factor in scheduling naps is placing them at optimal times with regard to the amount of sleep loss. A nap taken during the day before an all-night work shift (a prophylactic nap), with no sleep loss prior to the shift, will result in improved performance over the night compared to performance without the nap. Although naps taken later in the sleep-deprivation period also are beneficial, these naps probably should be longer than prophylactic naps in order to derive the same performance benefit. Schweitzer, Muehlback, and Walsh (1992) measured performance and alertness in subjects who received a 2- to 3-hour nap before a night work shift (with concurrent sleep loss). Although the usual circadian trough was seen in the early morning, the nap attenuated the decline in performance compared to a night where no nap was taken prior to the shift.

In a study conducted by Bonnet (1991), a nap before a 52-hour continuous performance period was beneficial in keeping performance and alertness from decreasing for up to 24 hours compared to the no-nap condition. However, by the second night of sleep loss, the benefit of the naps could not be reliably measured. In a study by Naitoh and colleagues (Naitoh, Englund, and Ryman, 1982), subjects were given a 3-hour nap after being awake for approximately 24 hours, but then were required to stay awake an additional 20 hours.

Results indicated that this 3-hour nap reduced the decline in performance during the additional work period. Naps taken prior to extended periods of sleep loss, "prophylactic naps," do not totally eliminate the circadian dip seen in the early morning (around 0500); however, the degradation in both cognitive performance and alertness is attenuated compared to no napping conditions (Bonnet, 1990; Carskadon and Dement, 1982; Gillberg, 1984; Haslam, 1985; Nicholson et al., 1985).

Nap length

Another factor to consider when scheduling naps during continuous operations is nap length. Most studies indicate that naps from 1 hour to 8 hours will improve performance and alertness during continuous operations. A relationship between nap length and performance was reported by Bonnet (1991) based on a study in which subjects were allowed either a 2, 4, or 8-hour nap before 52 hours of continuous operations. The results indicated a dose-response relationship between the length of the nap and performance during the first 24 hours of sleep deprivation. Bonnet concluded that the nap before an all-night shift should be as long as possible to produce maximum performance benefits, and that prophylactic naps were better than naps designed to replace sleep that was already lost due to requirements for continuous wakefulness.

An investigation by Lumley and colleagues (Lumley, Roehrs, Zorick, Lamphere, and Roth, 1986) in which subjects were deprived of sleep for 24 hours and then permitted naps of either 15, 30, 60, or 120 minutes, indicated that alertness increased as a function of increased nap length, with the highest level of alertness occurring after the 60-minute nap. There was, however, no difference between the 60-minute nap and the 120-minute nap, possibly due to sleep fragmentation in the longer period.

Nap placement and the circadian phase

Another factor to consider when planning a napping strategy for use during continuous operations

is where the nap should be placed in the circadian phase. Nap timing should take into account the ease of falling asleep at various times, the quality of sleep as a function of the body's internal clock, and the effects on performance both immediately after awakening and later in the work period. Sleep tendency is highest when core body temperature is in its trough (in the early morning hours) and lowest when core body temperature is in its peak (in the early evening hours) (Dinges, 1986). Thus, there may be significant problems initiating and/or maintaining a nap during times when core temperature is high, termed the forbidden zone for sleep (Lavie, 1986).

Naps which are placed during the circadian troughs are the easiest to maintain, and they show beneficial effects on later performance. When naps placed in the circadian trough are compared to naps placed in the circadian peak, the effects on performance are different. Gillberg (1984) examined the effects of a 1-hour nap placed either at 2100 or 0430 after 24 hours of sleep deprivation. Both naps improved performance the following morning when compared to a no-nap group, but the nap taken at 0430 (in the circadian trough) showed the most benefit. While a nap taken anywhere in the circadian cycle before sleep deprivation is beneficial in maintaining performance across the sleep loss period, there is a high cost to napping during the early morning (during the circadian trough). Although naps during the circadian trough may be more effective for performance sustainment (and they are easier to initiate and maintain), they also are the more difficult naps from which to awaken. Generally, studies have shown that post-nap sleepiness, termed "sleep inertia," is higher and performance is lower immediately upon awakening from a nap taken during the circadian trough as compared to naps taken during the circadian peak (Dinges, Orne, and Orne, 1985).

Regardless of the time of the nap, sleep inertia will occur, and work requirements should be delayed accordingly. Performance generally will be lowest during the first 5 minutes after awakening, but it usually recovers after 15 to 30 minutes (Dinges et al., 1985). Generally, sleep inertia will be extended in situations where the timing of the nap is misplaced and/or the amount of sleep deprivation is extensive before the nap occurs. Thus, Dinges et al. (1985) suggest that during continuous operations, naps in the circadian trough should be avoided, and naps should be taken before a person's sleep loss extends beyond 36 hours. However, it should be possible to take advantage of the improved quality of naps in the circadian trough while avoiding the sleep-inertia effects if napping personnel can be awakened about 1 hour prior to their work shifts.

SUMMARY

In summary, naps are beneficial for reducing sleepiness and performance decrements during sleep-deprivation periods. However, before scheduling naps during continuous operations, several factors should be taken into account. A nap is most beneficial if taken before significant sleep loss occurs, if it is as long as possible, and if it is placed in the circadian trough (provided there is time to recover from sleep inertia).

Unfortunately, work demands and staff shortages make scheduling naps in the real world problematic. It may not be possible to schedule naps during times when personnel will find it easy to sleep (during circadian troughs). In addition, the anxiety, noise, heat, and environmental lighting present in operational scenarios may impair the ability of personnel to initiate and maintain effective sleep. Thus, in order to provide a way for personnel to obtain needed sleep whenever the opportunity to sleep occurs, a short-acting sleeping aid such as zolpidem tartrate may be useful.

Zolpidem tartrate, a non-benzodiazepine hypnotic of the imidazopyridine class, is supplied in 5 and 10 mg tablets for oral administration (Physician Desk Reference, 1998). It has a mean elimination half-life of 1.7 hours (se=0.1) (Thenot et al., 1988) and few daytime residual effects (Blois, Gaillard, Attali, and Coquelin, 1993). The recommended dose is 10 mg given immediately before bedtime. Most studies indicate that next-day performance is not affected by nighttime administration of 5 or 10 mg of zolpidem tartrate (Quera-Salva et al., 1994; Richens, Mercer, Jones, Griffiths, and Marshall, 1993; Sanger et al., 1987; Sicard, Troucherie, Moreau, Vielillefond, and Court, 1993). Higher dosages (20 mg) have been found to mildly affect next-day performance (Balkan, O'Donnell, Wesensten, McCann, and Balance, 1992), but even at this dosage, there have been few residual effects (Bensimon et al., 1990).

STUDY QUESTIONS

Since research indicates that taking a nap prior to sleep loss can help offset performance decrements seen during extended work schedules, napping should be beneficial in sustained operations. However, if people are unable to place naps at optimal times or if they are unable to sleep because of situational factors (i.e., heat, noise, light), zolpidem tartrate may be useful.

The first question addressed by this experiment was whether a 2-hour nap, placed late in the evening (during the "forbidden sleep zone"), would affect the performance, mood, and sleepiness of aviators during a continuous operations scenario. The

second question was whether zolpidem tartrate could be effectively used to promote naps (and thus enhance the performance-sustaining effects of naps) during times when sleep was not expected to come readily.

METHOD

Subjects

Eighteen male aviators between the ages of 22 and 31 (mean of 24.4) and weighing between 145 and 205 pounds (mean of 177.6) participated after medical pre-screening.

Procedure

During three sleep deprivation periods, subjects completed cognitive tests, electrophysiological evaluations, and questionnaires. Subjects were tested following a 2-hour nap induced with zolpidem (Znap), a 2-hour nap without zolpidem (Pnap), and a 2-hour forced-rest period (Nonap). The study was fully counterbalanced and double-blind.

Testing schedule. Subjects were tested in pairs and were housed in the U.S. Army Aeromedical Research Laboratory (USAARL) throughout the 9-day testing period. Subjects reported to USAARL on Sunday for electrode attachment, initial training on the cognitive task, and an adaptation sleep night. On Monday, training began at 0900 after 10 hours of sleep and lasted until 2010 (bedtime was at 2200). On Tuesday, Thursday, and Saturday (the control/intervention days), testing was conducted at the same times as on Monday following 10-hours of sleep; however, rather than receiving a full night's sleep on each of these nights, subjects received one of the interventions--either Pnap, Znap, or Nonap, beginning at 2100 and ending at 2300. All subjects received all three interventions, with subjects being randomly assigned to one of the six possible orders of interventions with the constraint that the orders be fully counterbalanced. On Wednesday, Friday, and Sunday (the test days following interventions), subjects began testing at 0100 and continued until 2010. On the last Monday (following the last sleep-deprivation period), testing was conducted throughout the day. On Tuesday, subjects were released after 10 hours of recovery sleep. Control days (Tuesday, Thursday, and Saturday) were placed between each test day to allow complete drug clearance and recovery from sleep deprivation prior to the next intervention. Subjects were supervised at all times. The schedule is shown in figure 1.

Visual Analog Scale (VAS). The VAS was administered hourly from 0900 to 2000 on control days (and again at 2300 after the nap or forced rest) and from 0100 to 2000 on test days. Subjects rated themselves by marking 100 mm lines centered over the adjectives: "alert/able to concentrate," "anxious," "energetic," "feel confident," "irritable,"

"jittery/nervous," "sleepy," and "talkative" (Penetar et al., 1993) At the ends of each line, "not at all" and "extremely" were printed, respectively. Scores for each adjective consisted of the distance (in millimeters) from the left edge of the line to the mark.

Repeated test of sustained wakefulness (RTSW). The RTSW was performed every 2 hours, beginning at 1010 and ending at 2010 on control days, and from 0210 to 2010 on test days. The subject, who attempted to remain awake while reclined on a bed with eyes closed in a cool, darkened bedroom, was allowed to remain in bed for as long as 20 minutes, but was immediately awakened if he fell asleep. Electroencephalographic (EEG) data were recorded from C3, C4, O1, and O2 referenced to contralateral mastoids (A1 or A2) and scored to determine the time from lights out until the first occurrence of a K complex or sleep spindle. A Nihon Koden electroencephalograph (EEG-4321P) was used with time constants and high filter settings of 0.3 sec. and 35 Hz, respectively.

Sleep architecture of naps. Polysomnograms during naps also were collected with a Nihon Kohden. EEG, electrooculogram (EOG) and electromyogram (EMG) data were recorded throughout the napping periods to assess sleep quality. EEG data were recorded from C3, C4, O1, and O2 referenced to contralateral mastoids; EOG data were recorded from electrodes placed at the outer canthus of the left and right eyes; and EMG data were recorded from electrodes attached submentally. Time constants and high filter settings were the same as the RTSW for the EEG; they were set at 5.0 sec. and 10.0 Hz for the EOG, and 0.003 sec. and 120 Hz for the EMG. Nap records were scored according to standard procedures (Rechtschaffen and Kales, 1968) in terms of sleep latency (lights out until the first full minute of stage 2), percentage of time spent in each stage, movement time, and time awake after sleep onset.

Profile of Mood States (POMS). The POMS was administered every 2 hours, beginning at 0900 and ending at 1900 on control days, and from 0100 to 1900 on test days. The POMS is a 65-adjective scale yielding 6 scores: tension-anxiety, depression-dejection, anger-hostility, vigor-activity, fatigue-inertia, and confusion-bewilderment (McNair, Lorr, and Droppleman, 1981). Subjects were asked to indicate how well each of the mood adjectives described their present feelings. Scores for each of the 6 factors were calculated using template-guided scoring.

Multi-attribute task battery (MATB). The MATB was completed every 4 hours, beginning at 0910 and ending at 1710 on control days, and from 0110 to 1710 on test days. The MATB, a 30-minute, computerized, aviation simulation test, required monitoring simulated aircraft fuel levels (resource management) and warning lights/dials (systems monitoring), while concurrently completing an

Time	Sunday	Monday Training	Tuesday Baseline	Wednesday Test	Thursday Recovery	Friday Test	Saturday Recovery	Sunday Test	Monday Recovery	Tuesday
0100				VAS/POMS		VAS/POMS		VAS/POMS		
0110				MATB		MATB		MATB		
0200				VAS/RTSW		VAS/RTSW		VAS/RTSW		
0235				EEG/EP		EEG/EP		EEG/EP		
0300				VAS/POMS		VAS/POMS		VAS/POMS		
0330				MiniSim		MiniSim		MiniSim		
0400				VAS/RTSW		VAS/RTSW		VAS/RTSW		
0500				VAS/POMS		VAS/POMS		VAS/POMS		
0510				MATB		MATB		MATB		
0600				VAS/RTSW		VAS/RTSW		VAS/RTSW		
0635				EEG/EP		EEG/EP		EEG/EP		
0700				VAS/POMS		VAS/POMS		VAS/POMS		
0730				MiniSim		MiniSim		MiniSim		
0800		Wakeup	Wakeup	VAS/RTSW	Wakeup	VAS/RTSW	Wakeup	VAS/RTSW	Wakeup	Wakeup
0830		Breakfast	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast	Breakfast
0900 0910		VAS/POMS MATB	VAS/POMS MATB	VAS/POMS MATB	VAS/POMS MATB	VAS/POMS MATB	VAS/POMS MATB	VAS/POMS MATB	VAS/POMS MATB	Debrief
1000		VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	Release
1035		EEG/EP	EEG/EP	EEG/EP	EEG/EP	EEG/EP	EEG/EP	EEG/EP	EEG/EP	
1100		VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	
1130		MiniSim	MiniSim	MiniSim	MiniSim	MiniSim	MiniSim	MiniSim	MiniSim	
1200		VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	
1235		Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	Lunch	
1300		VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	
1310		MATB	MATB	MATB	MATB	MATB	MATB	MATB	MATB	
1400		VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	
1435		EEG/EP	EEG/EP	EEG/EP	EEG/EP	EEG/EP	EEG/EP	EEG/EP	EEG/EP	
1500	Arrive	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	
1530	Inservice	MiniSim	MiniSim	MiniSim	MiniSim	MiniSim	MiniSim	MiniSim	MiniSim	
1600	Medical	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	
1700 1710	Electrode Hook-up	VAS/POMS MATB	VAS/POMS MATB	VAS/POMS MATB	VAS/POMS MATB	VAS/POMS MATB	VAS/POMS MATB	VAS/POMS MATB	VAS/POMS MATB	
1800	Hook-up	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	
1835		EEG/EP	EEG/EP	EEG/EP	EEG/EP	EEG/EP	EEG/EP	EEG/EP	EEG/EP	
1900	Dinner	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	VAS/POMS	
1930	Training	MiniSim	MiniSim	MiniSim	MiniSim	MiniSim	MiniSim	MiniSim	MiniSim	
2000		VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	VAS/RTSW	
2035		Dinner	Dinner	Dinner	Dinner	Dinner	Dinner	Dinner	Dinner	
2100		PT	Drug/nap	PT	Drug/nap	PT	Drug/nap	PT	PT	
2130	Vitals	PT/Shower	OR Rest	PT/Shower	OR Rest	PT/Shower	OR Rest	PT/Shower	PT/Shower	
2205	Lights out	Lights out	Lights out	Lights out	Lights out	Lights out	Lights out	Lights out	Lights out	
2300			Wakeup/VAS		Wakeup/VAS		Wakeup/VAS			
2400			Shower		Shower		Shower			

Figure 1. Testing schedule.
VAS - Visual Analogue Scale; POMS - Profile of Mood States; MATB - Multi-attribute Task Battery; RTSW - Repeated Test of Sustained Wakefulness; EEG - Resting electroencephalogram; EP - evoked potentials; PT - Physical training (exercise)

▨	Nighttime sleep

▨	Nap/rest period
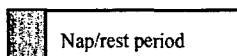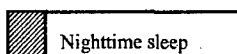
unstable tracking task and a communications task (following auditory instructions to change "radio frequencies"). Subjects were scored in terms of how quickly and accurately they responded. Specifically, the resource management task yielded mean deviation of units of fuel in tanks A and B from the target of 2500; systems monitoring yielded mean reaction time (RT), standard deviation of RT (SDRT), and time-out errors for lights and dials; communications yielded number of time-out errors and mean RT and SDRT for correct responses; and tracking yielded root mean square (RMS) deviations.

Medication administration. Each zolpidem tartrate tablet (10 mg), placed in a white capsule, which matched lactose-filled placebos, was administered at 2230 (30 minutes prior to nap time) with approximately 8 ounces of cold water.

RESULTS

Analysis of variance (ANOVA) with repeated measures on two factors (condition and time) was used to analyze the data (except for the sleep data in which there was only a condition factor). To maintain brevity, only effects which involve the condition factor will be discussed.

Sleep architecture of naps

Nap data were analyzed with a one-way ANOVA for condition (Znap and Pnap). The variables were minutes in bed; minutes until sleep onset; minutes of sleep; percentage of stages 1, 2, 3, 4, and rapid eye movement (REM); percentage of time awake after sleep onset; and movement time. Because one subject was unable to sleep during his zolpidem nap (on the second night of the study) despite being able to sleep during his placebo nap (on the fourth night), his data were excluded from the analysis. The results indicated that there was faster sleep onset, greater minutes of sleep, less stage 1 sleep, and more stage 4 sleep after zolpidem than placebo (see figure 2).

RTSW

The RTSWs, analyzed in a 2-way ANOVA for condition (Znap, Pnap, and Nonap) and time (0210, 0410, 0610, 0810, 1010, 1210, 1410, 1610, 1810, and 2010), indicated a condition-by-time interaction and a condition main effect. The interaction was because differences among the conditions were larger during the first half than the second half of the day (see figure 3). Subjects were better able to remain awake after Znap than after Nonap throughout the testing day; Pnap was better than Nonap except at 1410 and 1610; and Znap was better than Pnap at 0410, 0610, 1210, 1610, and 2010. The condition main effect showed Znap led to improved wakefulness compared to the other

interventions, and Pnap was better than Nonap (means were 11.7, 9.4, and 6.3, respectively).
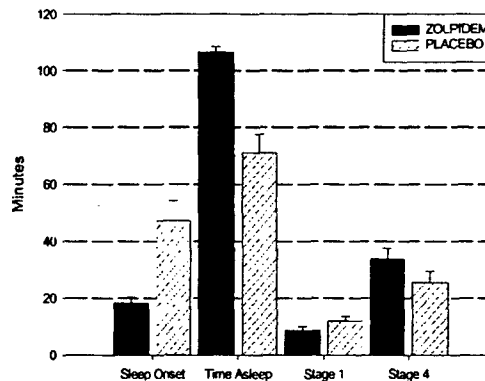

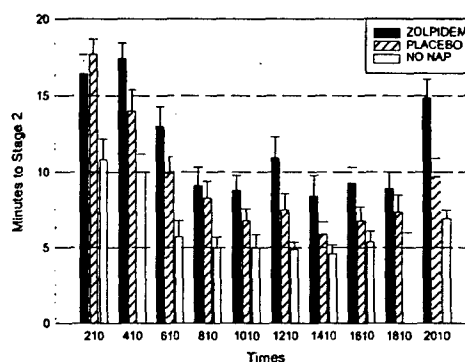Figure 2. Effects of nap condition on sleep parameters.

Figure 3. Latency to sleep onset on the RTSW for each napping condition.

MATB

MATB data were analyzed in a 2-way ANOVA for condition (Znap, Pnap, and Nonap) and time (0110, 0510, 0910, 1310, and 1710). The four tasks were analyzed separately.

Resource management. An examination of the mean deviation of units of fuel in tanks A and B from the target of 2500 revealed no significant main effects or interactions.

Communications. The ANOVA on RT and SDRT for correct responses and number of time-out errors indicated a condition-by-time interaction only on RT because of shorter RTs after both Znap and Nonap than Pnap at 1710 (see figure 4).

Systems monitoring. The ANOVA on RT, SDRT, and time-out errors to lights and dials indicated condition-by-time interactions on the RT for lights and dials and SDRT for lights. In each case, there were differences among the conditions only at 0910; the RTs
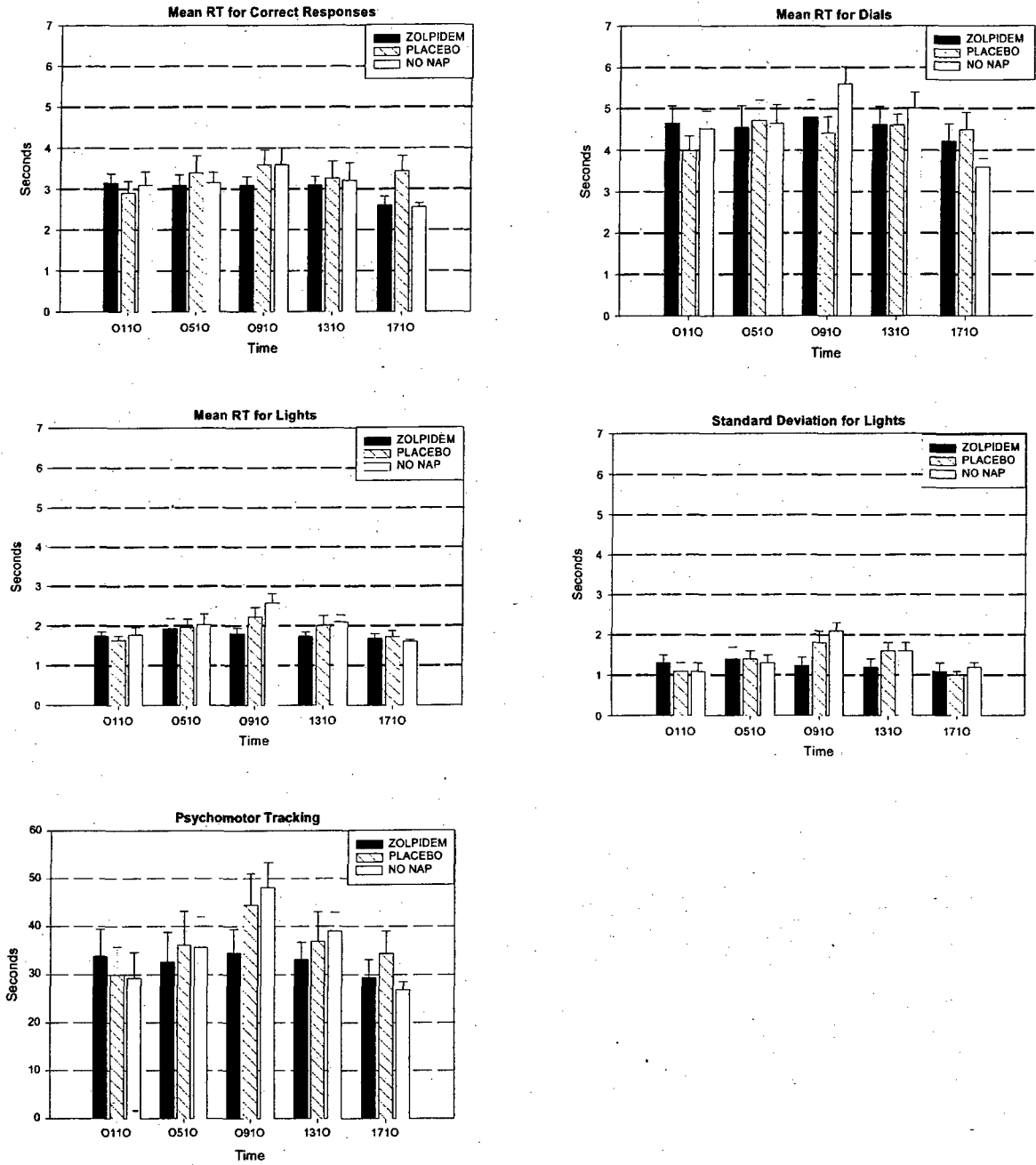
Figure 4. The effects of napping condition on performance of the MATB subtests.

for both lights and dials were faster after Znap than Nonap, the RT for dials was shorter after Pnap than Nonap, and the RT for lights was shorter after Znap than Pnap. SDRT for lights was smaller after Znap than either Pnap or Nonap (see figure 4). A condition main effect on RT for lights revealed a reduction in RT after Znap compared to Nonap.

Tracking. A condition-by-time interaction and a time main effect occurred on RMS errors. The interaction was due to differences among conditions only at 0910 where errors were smaller after Znap than Pnap or Nonap (see figure 4).

POMS

The ANOVA for condition (Znap, Pnap, and Nonap) and time (0100, 0300, 0500, 0700, 0900, 1100, 1300, 1500, 1700, and 1900) revealed an interaction only on vigor. Znap increased scores relative to Nonap at 0500 and 0700, while Pnap was better than Nonap only at 0700. At 1900, Pnap was better than both Znap and Nonap (see figure 5).

A condition main effect was found on the fatigue scale due to lower fatigue ratings under Znap than Nonap.
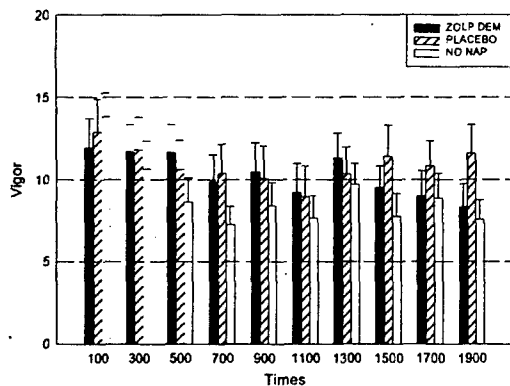

Figure 5. The effects of napping versus forced rest on POMS vigor ratings.

VAS

The VAS scores were analyzed in an ANOVA for condition (Znap, Pnap, and Nonap) and time (2300 and hourly from 0100 to 2000). There were condition-by-time interactions on alertness, energy, confidence, irritability, sleepiness, and talkativeness (see figure 6). Most resulted from inertia-related decrements immediately following the naps, which later gave way to nap-related improvements. VAS ratings were worse at 2300 after both Znap and Pnap compared to Nonap (alertness was also worse at 0100). However, beyond

this time, naps attenuated the declines (except for confidence ratings which were unaffected late in the day). *Alertness* was higher after Znap than Nonap at 0400 and 0500, from 0700 to 1100, and at 2000; higher after Pnap than Nonap at 0400 and from 0700 to 1100; and higher after Znap than Pnap at 0500. *Energy* was higher after Znap than Nonap at 0400, 0500, 0700, and 0800; higher after Pnap than Nonap at 0400, 0700, and 0800; and higher after Znap than Pnap at 0500. *Irritability* was lower after Znap than Nonap from 0400 to 0800, but lower after Pnap only at 0700. Znap was significantly better than Pnap at 0500, 0600, and 0800. *Sleepiness* was reduced by Znap relative to Nonap from 0400 to 0800, at 1500, and from 1700 to 2000; sleepiness was reduced by Pnap relative to Nonap from 0400 to 0800, 1500, 1700, 1900, and 2000; and sleepiness was less after Znap than Pnap only at 2000. *Talkativeness* ratings were higher after both naps at 0500, and higher after Znap compared to Nonap at 0700 as well.

Condition main effects occurred on alertness, irritability, sleepiness, and talkativeness. On every scale, Znap was better than Nonap; Pnap was better than Nonap on sleepiness; and Znap was better than Pnap on irritability.

DISCUSSION

This evaluation of two types of 2-hour prophylactic naps (one induced with 10-mg zolpidem tartrate and the other a natural, or placebo, nap) during the final 23 hours of a 38-hour period of continuous wakefulness supported previous findings, which indicated both naps were superior to a forced-rest condition in terms of sustaining alertness. Comparisons between the zolpidem and placebo naps indicated the zolpidem nap was superior in several instances.

Sleep architecture of naps

The more rapid sleep onset and longer sleep duration in the zolpidem nap compared to the natural nap are consistent with other reports (Lorizio, Terzano, Parrino, Cesana, and Priore, 1990; Sanger, Perrault, Morel, Joly, and Zivkovic, 1987). Since subjects were provided with only 2 hours for each nap, zolpidem provided significantly more sleep than placebo. Subjects fell asleep almost twice as fast after zolpidem tartrate (24 minutes) than after placebo (46 minutes), and this no doubt contributed to the mild superiority of the zolpidem nap.
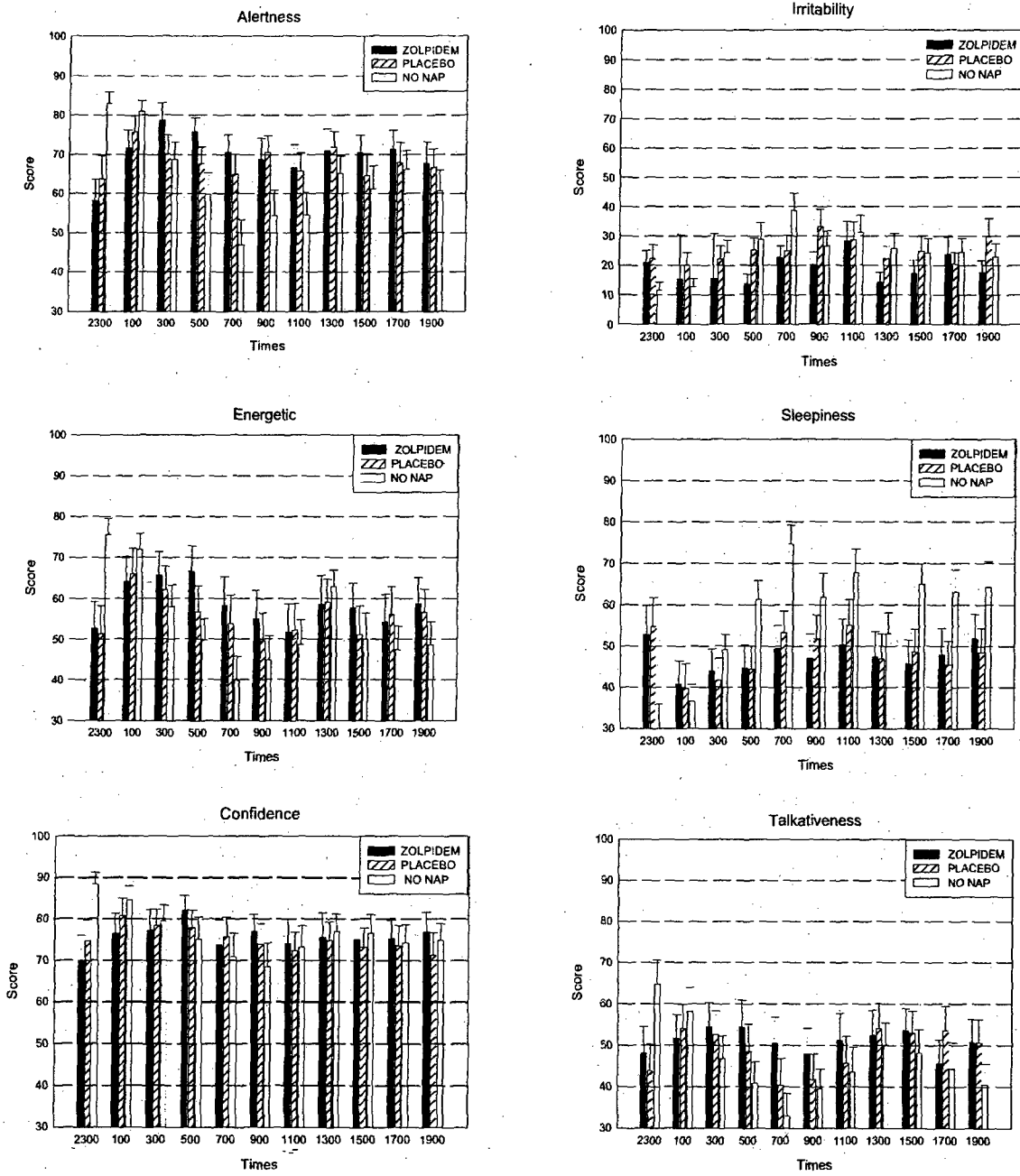
Figure 6. The effects of napping condition on VAS mood scales.

Sleepiness evaluations

Decrements in VAS alertness and energy ratings, coupled with increased irritability and sleepiness, were more pronounced after forced-rest than after one or both napping conditions, and the zolpidem nap often was superior to placebo. Of the 30 significant effects among conditions at various times, 97 percent were because the zolpidem-induced nap was better than forced rest; 63 percent were because the placebo nap was better than forced rest; and 20 percent were a result of better VAS ratings after the zolpidem nap than after the placebo nap.

VAS ratings in the present study were consistent with RTSWs, which indicated subjects could remain awake longer after the zolpidem nap than after the placebo nap or after rest only. It appears that the zolpidem naps were superior to placebo naps; alertness was greater after the zolpidem nap in comparison to forced rest during 100 percent of the RTSWs, greater after the placebo nap than after forced rest in 80 percent, and greater after the zolpidem nap than after the placebo nap in 50 percent of the RTSWs.

Unfortunately, the benefits from napping were not apparent immediately after subjects were awakened. VAS data collected at about 5 minutes after awakening from the 2-hour naps revealed that feelings of alertness, energy, confidence, and talkativeness were lower after both the zolpidem and placebo naps than after the forced-rest condition. In addition, ratings of irritability and sleepiness were higher after both naps than after forced rest. The mood effects disappeared by the time of the next VAS (about 2 hours after awakening from the naps), with the exception of the alertness decrement which persisted until, but not beyond, 0100. If measurements of mood had been obtained more frequently, there may have been increases in mood before 2 hours had lapsed. It is also unclear whether performance suffered along with mood during these times because the first test was not given until 2 hours after the nap; however, it has been suggested that mood disruptions caused by sleep inertia outlast performance decrements (Dinges et al., 1988). Postnap inertia was not more severe after zolpidem than placebo. Initially, there did appear to be a slight hangover effect on the ratings from several scales; however, none of these were statistically significant. The fact that the problems associated with sleep inertia immediately after the naps did not persist for more than 2 hours postnap was evident from an examination of the first RTSW (at 0210), which revealed greater alertness after both naps than after rest only.

Cognitive evaluation

Overall, performance suffered the most from sleep deprivation at the time at which mood and alertness decrements were most severe (in the midmorning hours). Prophylactic napping attenuated many of the problems, especially on tasks requiring vigilance and rapid responding. In addition, the zolpidem-induced nap tended to be superior to a natural nap.

Mood evaluation

Differences in vigor were most pronounced from 0500 to 0900 during the sleep deprivation period since these were the times when alertness suffered most under the no-nap condition. Differences in fatigue ratings occurred between the zolpidem nap and rest, with lower ratings after the zolpidem nap than after forced rest.

CONCLUSIONS

Zolpidem's rapid onset of action can be of significant benefit in situations where there is only a brief period available for sleep. When personnel have only 2 hours for a nap, zolpidem can maximize the effectiveness of that nap by rapidly inducing sleep. Although previous research indicates there are optimal times for napping, in the real world it may not be possible to schedule naps during these times. Work which must continue 24 hours a day with no breaks does not allow perfect scheduling of sleep breaks, so sleep must be taken when circumstances permit. When naps are possible, but the timing is less than optimal, zolpidem decreases the time to sleep onset and leads to more time asleep during a restricted nap period. However, to minimize problems, individuals who plan to use zolpidem should pretest themselves in a safe environment where performance demands are not eminent, and allow enough time from awakening to avoid sleep inertia. In addition, whether zolpidem-induced naps or natural naps are used, care must be taken to avoid the temporary problems associated with postnap sleep inertia by allowing personnel sufficient time to fully awaken from naps prior to returning to work. Research is planned to determine what countermeasures may be used to more quickly alleviate sleep inertia. Also, when zolpidem tartrate is used to initiate a 2-hour prophylactic nap, there may be some minor effects until approximately 5.5 hours postdose, although the practical impact of these effects is probably negligible.

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DISCLAIMER

The opinions, interpretations, conclusions, and recommendations are those of the author and are not necessarily endorsed by the U.S. Army and/or the Department of Defense.

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