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CLINICAL REVIEW

The role of prescribed napping in sleep medicine

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KEYWORDS
nap, sleep, alertness, health, safety, shiftwork, aging

Summary Napping, when its timing and duration are designed properly, has the potential to improve our daily lives. Laboratory findings indicate that scheduled napping promotes waking function after normal sleep at night, and also counteracts decreased alertness and performance under conditions of sleep deprivation. Since these effects are evident even with naps shorter than 30 min, shiftwork problems may be alleviated by the short nap at the workplace. Multiple short naps are effective in managing excessive daytime sleepiness in narcoleptic patients under medication. The therapeutic usefulness of napping in other sleep disorders, however, remains to be established. Epidemiological studies suggest a decrease in the risk of cardiovascular and cognitive dysfunction by the practice of taking short naps several times a week. Sleep inertia occurs immediately after napping, but its severity can be minimized by avoiding long naps that may result in awakening from deep non-rapid eye movement sleep. Activities during the post-nap period should also be undertaken carefully. To allow the maximum advantage to be gained from napping, more efforts are needed to identify the strategies of napping that are compatible with individual cases including aging, work schedules, and sleep disorders, and to examine their efficacy in real-life settings.

INTRODUCTION

Napping has recently received wide attention, and reliable information about napping is available in plain language [1, 2]. The first reason for this interest relates to the so-called 24-h society, in which sleep deprivation and disruption are commonplace [3, 4]. The lack of good sleep causes considerable expense in terms of impaired health, decreased alertness, frequent errors and accidents, decreased productivity, and poor quality of life [3]. We thus need effective, but practical, measures to counteract these effects. Another reason for the increased attention to napping is the recent rapid progress in nap research. Indeed, experts in sleep medicine have produced evidence showing the invigorating effects of short, i.e. less than a half hour, naps [5–15]. However, there are also factors that limit the usefulness of napping, such as sleep inertia [16].

This article reviews the current status of our knowledge on napping, in particular, short naps, to facilitate a practical approach to the use of napping based on reports in the field of sleep medicine.

WHO WOULD BENEFIT FROM NAPPING?

Previous research has examined the effects of napping in various populations. The target populations may be divided into four groups: young adults, elderly people, shiftworkers, and patients with sleep disorders.

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Young adults

Young adults, 20–30 years old, sleep less during the night (average duration, 6.8 h on weekdays) than individuals in other age groups [4]. Also, 33% of people younger than 30 years of age report that daytime sleepiness interferes with their daily activities, as compared with approximately 15% of people older than 30 [4]. It would therefore appear that young adults are candidates for advocating napping. Indeed, 40% of them would consider napping at work if their employers would permit it, and 62% of those who are allowed to take a nap at work actually do so [4].

Laboratory experiments have indicated that brief naps have favorable effects in young adults [5–11]. These findings can be summarized in terms of the duration of sleep on the preceding night and the timing of the naps.

Prior sleep

The effects of napping depend on the recent history of sleep and wakefulness. When the duration of sleep on the preceding night has been sufficient, a daytime nap shorter than 30 min improves alertness and performance [6, 8, 9]. A previous study on young subjects who slept for an average of 7.4 h the preceding night, found a shorter latency of P300 event-related potentials after a 15-min nap scheduled during the post-lunch period than after no nap, or a 45-min nap [6]. Since shortened P300 latency represents increased alertness, this finding indicates an improvement of objective alertness with napping. Subjective alertness on a Visual Analogue Scale (VAS) was maintained for 3 h after either a 15-min or a 45-min nap than after no nap. The number of errors in transcription typing was also reduced after a 15-min nap. Even after a restricted sleep of 4 h during the previous night, a 15-min nap after lunch, compared with no nap, improved alertness as assessed by the P300 and VAS, and decreased errors in logical reasoning [5]. Such advantages were observed clearly during the midafternoon (13:00–15:00), a time when human errors and accidents appear to be the most likely to occur [17]. These findings are consistent with those reported from a more recent study, which indicated that both alertness, as judged by sleep onset latency, and cognitive performance (symbol-digit substitution and letter cancellation) increased after a 10-min nap taken at 15:00 h following a sleep duration of 4.7 h on the preceding night [7]. This study also found a 10-min nap superior to a 30-min nap in improving alertness and performance.

In a simulated driving study conducted on subjects who had slept for 5 h the previous night, either a 15-min nap or ingestion of caffeine (150 mg) was effective in enhancing alertness and driving performance during the next hour [10]. Furthermore, a 15-min nap together with caffeine (200 mg) was the most reliable way of ensuring that sleepy subjects drove safely during the next 2 h [11]. Other measures, e.g. exposure of the face to cold air and listening to the radio or tape, have been reported as being ineffective in enhancing alertness while driving [18].

Nap timing

The timing of a nap determines its effects. Given the feasibility for most daytime workers, napping during the post-lunch rest period is the most likely to be complied with [5, 6]. However, one could argue that midafternoon is a good time for napping because this period corresponds to the peak of daytime sleepiness [19]. This view is supported by recent findings from two well-designed studies [8, 9]. A 25-min nap that commenced at 12:20 h increased alertness by both subjective and objective criteria as compared with no nap, but did not increase the cognitive performance, whereas a 27-min nap that commenced at 14:00 h was effective in improving both alertness and cognitive performance during the next 2.5 h [8, 9]. Despite these merits, people at work or at school are typically not permitted to nap in the midafternoon.

Elderly people

Sleep and circadian rhythms change dramatically with age [20]. Sleep problems are very common in elderly people, affecting their quality of life. As in young adults, a brief nap is believed to improve alertness and performance in the elderly, too. Indeed, according to a study by Tamaki and colleagues (2000) [12], elderly subjects (mean age, 73 years) showed reduced sleepiness and fatigue and improvement in performance in a visual detection task after a 34-min nap commencing at 13:00 h (polysomnographically defined sleep of 24 min). These effects of napping were observed for the subsequent 2 h. Actigraphic monitoring of these elderly subjects over a 1-week period also revealed that they took 4.6 naps per week, and that each nap starting at 13:51 h, on average, lasted for 38 min. Notably, there were no significant differences in nocturnal sleep variables between nap days and no-nap days, which suggests the absence of any interference with the following night's sleep.

The findings mentioned above, however, are contrary to those reported from a controlled study by Monk *et al.* (2001), which tested if a 90-min nap scheduled between 13:00 and 15:00 h would affect the following night's sleep, the core body temperature, alertness, and performance among the elderly (mean age, 79 years) [21]. Two-week home recording in a sleep diary showed 58 min of napping, and shorter nocturnal sleep time (20 min, not significant), and a later bedtime (24 min, $P < 0.1$) under the nap condition than under the no-nap condition. Sleep efficiency did not differ between the two conditions. In contrast, polysomnographic recordings in a time isolation unit revealed significantly shorter nocturnal sleep (48 min, $P < 0.01$), lower sleep efficiency (2%, $P < 0.01$), and earlier waketime (36 min, $P < 0.01$) after a 90-min nap (nap duration = 57 min) than under the no-nap condition. However, neither sleep latency nor deep non-rapid eye movement (NREM) sleep variables under the nap condition differed from that under the no-nap condition. These data are regarded as indicative of deterioration in the following night's sleep as a result of the daytime napping. Regarding the temperature data, a 15% reduction in the temperature amplitude was observed (not significant), with no associated changes in the temperature rhythm phase (the time of the temperature minimum). No reliable effects of the nap were found on alertness and performance, except for improved alertness at 19:30 h in nappers, as measured by a single trial of the Multiple Sleep Latency Test (MSLT).

A principal difference between the two aforementioned studies is in the duration of the nap. Thus, the time in bed and the nap duration were shorter in Tamaki *et al.*'s study (24 min) than in Monk *et al.*'s study (57 min). As such, a nap of up to 30 min that is taken by 15:00 h may make napping desirable for improved alertness and performance without disrupting the following night's sleep and the circadian rhythms among elderly people. Such a brief nap can scarcely reduce the homeostatic drive for sleep [22, 23], and therefore has been used in association with sleep restriction therapy to manage daytime sleepiness for insomnia in the elderly. Sleep restriction therapy is a behavioral treatment for insomnia aimed at an enhancement of sleep quality through curtailing time in bed to just the actual sleep time [24, 25].

Not only do brief naps have immediate favorable effects in the elderly, but also, long-term health benefits may be expected from life styles that incorporate napping. A survey conducted in Okinawa, where people are the longest-lived in the world, found that elderly Okinawans (mean age, 71 years) who had good sleep health took naps (<1 h) more frequently (59%) than those who had poor sleep health (38%) [26]. Yet, the results reported so far regarding the relationship between napping and health have been conflicting, as will be discussed later.

Shiftworkers

Due to misalignment between the circadian phase and work schedules, shiftwork is demanding. Shiftworkers experience numerous problems relating to sleep-wakefulness, health, safety, and well-being [27]. Ideally, shiftwork schedules should be re-designed to prevent or alleviate these problems, but it is not always possible to change existing schedules. In this regard, napping plays an important role in managing shiftwork problems. According to a report from a shiftwork consulting firm, 15% of US and Canadian companies permit their employees to take a nap during breaktime, and 32% of the companies permit breaktime napping if it is taken discreetly [28]. Survey data in Japan show that 20% of companies in the manufacturing industry, and 36% of companies in the non-manufacturing industry permit their workers to take naps [29].

A nap of a few hours' duration during a night shift is known to be important for maintenance of the health and safety of shiftworkers. This type of napping results in the alleviation of fatigue and sleepiness [30, 31], compensation for sleep loss [31], and decreases in the blood pressure and heart rate [30]. From a circadian perspective, a 4-hour nap taken at the same time each day, referred to as "anchor sleep", has been shown to stabilize the circadian system [32], although it remains to be determined whether a shorter than 4 h nap would have similar stabilizing effects.

A field study conducted on house staff physicians working extremely long ($\sim$40 h) shifts examined the effects of a 4-h nap, with and without coverage by a resident (night-float system), on sleep, alertness, and performance [33]. The night-float system significantly increased sleep efficiency by 17% and slow-wave sleep by 14 min during the 4-h nap, as compared with the observations in the group which received no such coverage by a resident. However, no significant differences were noted in the electroencephalogram (EEG)-based assessment of sleepiness and attention-task performance between the two systems. The no-nap condition was not designed to be investigated in this study, and the effects of the 4-h nap could therefore not be assessed precisely. The findings, however, suggest the importance of napping sometime during the extended shift. This notion is supported by previous studies that show improved alertness and performance in subjects who take naps during sustained wakefulness of 50–90 h, as compared with the observations in the no-nap condition [34, 35].

Napping for a few hours has a critical implication for shiftworkers working under two-shift system, which has become increasingly popular as an alternative to the usual three-shift system. The two-shift system requires extension of a night shift to 12 h or longer, raising serious health and safety concerns [36]. A previous report indicated, however, that sleepiness, fatigue, and dullness were decreased after a 2-h nap taken during a 16-h night shift, although these parameters actually became transiently worse immediately after the nap, as a result of sleep inertia [37]. Moreover, similar or lower levels of sleepiness, difficulty in concentration, and fatigue were noted in nurses on 16-h night shifts even when they practiced napping, as compared with the results in nurses on 8-h evening/night shifts without napping [38]. These data indicate that the 2-h nap helped to prevent the nurses' workload from building up excessively, despite the shift being longer than 8 h.

If a short nap is as effective as a long nap, napping strategies may be implemented relatively easily in shiftwork settings. Employers are unlikely to agree to introduction of any shiftwork measures that appear to disturb jobs. Break time, a possible opportunity for a nap, is also quite limited during a shift. Research on cockpit napping by the U.S. National Aeronautics and Space Administration (NASA) has triggered further research to determine the effects of a short nap on alertness and performance [13]. In the NASA study, one group of airline pilots was asked to take a 40-min nap in their cockpit seat during cruise over water, while another group was asked not to. The results indicated that the pilots who took naps had significantly shorter response times on the Psychomotor Vigilance Task (a decrease of 20%), and also significantly fewer lapses (responses >0.5 s) (a decrease of 30%) than did the pilots who did not nap. Microevents, which are a parameter of objective sleepiness as defined by EEG and electrooculography (EOG), were reduced dramatically during the last 90 min of the flights among the pilots who napped, as compared with those in the pilots who did not. Importantly, no microevents occurred during the last 30 min of the flights among the pilots who took naps. Subjective alertness, however, was not significantly different between the two groups.

Subsequent studies have tested whether a 30-min nap taken during a shift would affect the alertness and performance of shiftworkers. Under a simulated morning shift, a 30-min nap at 10:45 h improved the performance in a vigilance task of partially sleep-deprived subjects, yielding levels of performance similar to those of subjects who had slept normally the previous night [14]. The same was also true for subjective sleepiness, however, objective sleepiness as measured by EEG and EOG was not affected by napping. In a study simulating a night shift, both the effects of nap length (30 versus 50 min) and nap timing (1:00 versus 4:00 h) were examined among real shiftworkers who worked at an oil refinery [15]. In a reaction time task, the percentage of lapses (responses >1.5 s) was 50% less after a 30-min or a 50-min nap than after no nap, regardless of the nap timing. The Repeated Test of Sustained Wakefulness, which measures the duration for which a subject remains awake while lying in a bed with his or her eyes closed, showed a reduction in objective sleepiness after napping at 1:00 h as compared with the observation under the no-nap condition (1.6 times greater after the 30-min nap; 2.8 times greater after the 50-min nap). Subjective sleepiness was lower at the end of the night shift among those who had napped than among those who had not.

Some companies already allow brief naps to boost the alertness and performance of workers [28]. Drivers in an oilfield service company are not only permitted to nap when they are tired, but are also educated on when and how they should nap [39]. Specifically, the drivers are advised to take a nap in a safe area for 15–25 min, the instructions being individualized for each driver. Importantly, the number of vehicular accidents caused by these drivers decreased by 30% with institution of the comprehensive program for fatigue reduction, including appropriate napping strategies.

A recent work by the US Federal Aviation Administration Civil Aeromedical Institute (CAMI) was noteworthy in terms of the research rationale [40]. This study focused on the effects of napping during a night shift in counteracting impaired alertness and performance among air traffic control specialists (ATCSs) who were scheduled to work only one or two night shifts in a row. Exposure to bright light at night and darkness/sleep in the daytime has been shown to be highly effective for treating night shift problems [41]. The CAMI investigators, however, considered that photic intervention was incompatible for use in rapidly rotating shiftworkers, such as ATCSs, because it takes a few days for the circadian system to shift to the night shift schedule and then to shift again to the day shift schedule. The results showed that a 45-min nap taken at 3:00 h during a simulated night shift produced 20% faster response times, as compared with the results in the no-nap condition, in a simulated task of air traffic control. The faster responses were not associated with any decrease in the accuracy of performance of the simulated task. Performance on a vigilance task was also better after the 45-min nap than after no nap. Subjective alertness was maintained after napping, while it decreased during the shift under the no-nap condition.

Shiftworkers who are not permitted to take a nap during a night shift are often advised to take a nap before the shift, the so-called prophylactic nap [42, 43]. In the US, 33% of shiftworkers have been shown to take a nap before going to work [4]. The prophylactic nap reduces sleep pressure resulting from being awake for an extended period of time before going to work, thereby attenuating potential decrements in alertness and performance during the shift. But it is sometimes difficult for shiftworkers to take the prophylactic naps that are scheduled in the evening, because of social/family activities, in addition to the evening wake-maintenance zone, during which people find it difficult to fall asleep [19]. Instead, naps taken during the midafternoon may help to be alert in the subsequent night shift [42, 44].

Although napping is advantageous for shiftworkers, the appropriate timing and duration depend on a given shift schedule. It is possible, for example, that a long daytime nap after the final night shift interferes with the following night's (main) sleep [45]. This is relevant to rapidly rotating shiftworkers whose circadian phases should be kept day-oriented. Clearly, napping strategies for shiftworkers need to be designed with particular attention given to each cycle of their work schedules.

Patients with sleep disorders

Among the variety of symptoms of sleep disorders, excessive daytime sleepiness (EDS) is presumed to be amendable to control by prescribed napping. EDS may occur in people with sleep disorders, such as narcolepsy, idiopathic hypersomnia, sleep breathing disorders, insomnia, or circadian rhythm sleep disorders.

The clinical symptoms of narcolepsy include EDS, cataplexy (an abrupt and reversible decrease in, or loss of muscle tone that is typically triggered by emotion), sleep paralysis, and hypnagogic hallucinations [46]. A core treatment is appropriate administration of central nervous system stimulants, including methylphenidate, amphetamines, and modafinil. Nevertheless, narcolepsy experts have emphasized the usefulness of scheduled napping [46, 47]. Indeed, the scores on the Maintenance of Wakefulness Test (MWT), a test used to measure the ability of a subject to remain awake while sitting in a darkened room for 20 min, were improved after a 4-week period during which three 15-minute naps were taken each day [48]. A 2-h nap increased alertness even more than a 15-min nap, as assessed by the MSLT [49]. In regard to cognitive performance, a 129-min nap at around 15:00 h improved reaction time, but not logical reasoning, as compared with the no-nap condition, although five 26-min naps per day also improved these parameters slightly [50]. More recently, the combination of two 15-min naps per day and regular bedtimes has found to be effective in reducing daytime sleepiness and narcoleptic symptoms, particularly in patients having greater sleepiness [51]. Taken together, it seems clear that napping is useful for managing EDS in narcolepsy. Since multiple short naps appear to help workers with narcolepsy to be alert, employers are encouraged to allow them to nap at the workplace sometime during the workday. In this regard, occupational safety and health staff, in collaboration with sleep specialists, should be responsible for explaining to employers the manageable aspects of sleepiness in workers with narcolepsy, and proposing feasible schedules for napping.

Apart from narcolepsy, however, previous work has not determined whether scheduling of naps could be a therapeutic modality or option for the other sleep disorders listed above. Patients with idiopathic hypersomnia often sleep longer and deeper in the daytime, and experience unrefreshed and sleep drunkenness after the naps [47, 52]. It seems thus unlikely that taking short naps would relieve their EDS. Given that EDS is due to fragmented sleep caused by frequent episodes of sleep apnea, some recuperative effects of napping may be expected to occur among patients with sleep breathing disorders. Yet, this possibility has not been evaluated in controlled studies. Insomnia patients, who show a higher level of arousal even in the daytime [53], might be unable to fall asleep within the given opportunity for a nap, even if it were available. With respect to circadian rhythm sleep disorders, in particular the intrinsic types, little attention has been paid to naps as a treatment option [54]. In contrast, it is quite possible that napping is effective in alleviating the symptoms of the extrinsic types of the circadian rhythm sleep disorders, such as jet lag and shift work sleep disorders, as reviewed in the preceding section.

POSSIBLE OBSTACLES TO THE PRACTICE OF NAPPING

Although napping has been reported to produce desirable consequences, there are also obstacles and potential drawbacks to napping. The present review addresses sleep inertia, the lack of an appropriate place to nap, and epidemiological findings suggesting that napping may be associated with health risks.

Sleep inertia

The groggy feeling immediately after awakening from napping, resulting in impaired alertness and performance, is known as sleep inertia [16]. Sleep inertia is caused by the physiological delay associated with switching of the brain from a state of sleep to one of full alertness. The effects of sleep inertia usually dissipate in 30 min. Sleep inertia slows the speed of cognitive tasks, but has few effects on the accuracy of task performance [16]. As such, the impact of sleep inertia is not necessarily regarded as the basis for not advocating napping. Rather, it is essential to actively cope with sleep inertia. Since awakening from deep NREM sleep makes sleep inertia more severe, a nap should be either shorter than 20 min (to avoid the likelihood of deep NREM sleep) or approximately 90 min (to allow sufficient time for one NREM-REM cycle and waking from REM sleep). It is also important to learn how to resume activities after waking up from a nap. We need to pause before returning to work and avoid tasks that require a quick response or critical judgments immediately after awakening.

Places for napping

Finding an appropriate place to take a nap is difficult, particularly at the workplace. Based on a recent report, the most popular places for napping are the cafeteria and the break room [28]. At a small-sized factory in Japan, the president constructed a resting facility in the factory and permitted his employees to use it for napping, expecting reductions in the levels of fatigue and sleepiness and increased productivity [55]. If his expectations are fulfilled, the construction of such a place could be a worthwhile investment.

Association of napping with health risks

Epidemiological research has suggested napping as a risk factor for morbidity and mortality in elderly people [56–58]. In a 4-year prospective cohort study, people over 65 years of age ($n = 3962$) were divided into frequent nappers ($n = 999$) and infrequent nappers ($n = 2963$) on the basis of their answers (most of the time vs. sometimes, rarely, or never) to the question “How often do you get so sleepy during the day or evening that you have to take a nap?” [56]. The 4-year mortality rate was 30% higher among frequent nappers than among infrequent nappers, after adjustment for demographic variables (sex, age, residence, marital status, living arrangements, education, and personal income), cognitive impairment, depressive symptoms, chronic illnesses, activities of daily living, physical activity, gross mobility, body mass index (BMI), smoking, and alcohol use. A 6.5-year prospective study involving 70-year-old Jerusalem residents ($n = 455$) found that taking a nap during the day doubled the risk of dying, which was independent of other factors (sex, blood pressure, smoking, cholesterol level, diabetes, exercise, night sleep duration, cerebrovascular disease, previous myocardial infarction (MI), and financial hardship) [57]. The results of a case-control study among Costa Ricans (mean age, 57 years; case, $n = 548$; control, $n = 589$) indicated an elevated risk of MI as the frequency of naps increased, after controlling for age, sex, area of residence, physical activity, night sleep, smoking, income, education, blood pressure, BMI, lipids, and history of chronic diseases (diabetes, hypertension, and angina) [58]. The risk of MI was 40, 66, and 28% greater among people taking a daily nap lasting a mean of 2.2 h, a daily nap lasting a mean of 1.5 h, and naps five to six times per week lasting 45 min each, respectively, than among people napping once a week. In contrast, taking naps one to four times per week each lasting a mean duration of 19 min tended to be associated with a 23% decrease in risk, as compared with the risk in those taking a nap once a week.

There is nonetheless not enough evidence accounting for the association between napping and health risks. Abrupt increases in heart rate and blood pressure upon awakening from a nap might be responsible for cardiovascular events; however, the epidemiological studies cited in the present review did not look into the actual timing of the events [57, 58]. As to the causes of death in the Jerusalem study, the majority (55%) of the nappers died of non-cardiovascular causes [57]. Moreover, unknown influences of physical and mental diseases may not have been excluded, despite statistical adjustment for medical conditions. Excessive napping or severe daytime sleepiness [59] might be a marker of other pathology, including undiagnosed sleep disorders.

To explain the discrepancies between the epidemiological and experimental findings, it is of prime importance to distinguish planned napping from reactive (unplanned) napping. That is, planned, voluntary naps can exert favorable effects, whereas reactive, involuntary naps may be associated with adverse consequences on health in the elderly. Another relevant factor relates to nap duration. The Costa Rican study showed the advantages of a 19-min nap one to four times per week for cardiovascular health [58]. Likewise, habitual napping (three or more per week) for shorter than 30 min was reported to be associated with an 84% decrease in the risk of Alzheimer's disease [60]. These findings are consistent with those in the Okinawa study described above [26], and indicate that taking short naps several times a week may promote heath in elderly people.

CONCLUSION

Napping is a behavioral technique that may be used to alleviate a number of sleep-related problems, and is capable of promoting waking function and health. Overall, a short nap has the greatest potential for beneficial results. Although there are obstacles to the practice of napping, most of these are manageable. Further studies are warranted to identify appropriate strategies of napping that meet individual needs, and to test their efficacy under real-life situations.

Practice Points

Napping designed properly with respect to its timing and duration is a promising way to:

1. Improve alertness, performance, and health in young adults and elderly population;
2. Deal with shiftwork problems in a reliable and inexpensive manner;
3. Control, along with appropriate medications, excessive daytime sleepiness in patients with narcolepsy;
4. Maximize the advantages of napping while minimizing its unfavorable effects including sleep inertia.

Research Agenda

In future studies, we need to investigate:

1. the role of napping in the family and working life of middle-aged people;
2. the effects of a brief nap in real work settings;
3. sophisticated strategies of napping compatible with individual differences relating to age, occupation, and health status;
4. the efficacy of napping in conjunction with other technologies, such as exposure to bright light for improving waking function;
5. long-term health and safety consequences of napping.

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