

Effects of Sleep Deprivation with Reference to Military Operations

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Abstract

This review discusses the need for sleep, effects of sleep deprivation on behaviour and performance in the military, and sleep management recommendations to optimise combat effectiveness. Most people, regardless of sex or race, prefer 7 to 8 hours of sleep each night. Sleeping during the day is less recuperative. Continuous sleep is more effective than multiple short naps-even when the total hours for naps is more. Ten to 20 minute naps are useful when continuous sleep is not possible. Sleep inertia is the 5 to 30 minute period of sluggishness after awakening and important military tasks should be avoided.

Previously, continuous work episodes (CWEs) duration was restricted by limited night vision, unreliable equipment and reduced endurance of military personnel. With improved technology, CWEs are now restricted primarily by endurance which is affected by sleep deprivation. This was one of the experiences noted in recent conflicts (e.g. Desert Storm) by personnel in the air force, army and navy. Since there will be changes in operational requirements, several work-rest-sleep plans must be prepared. Sleeping the preferred 7 to 8 hours per 24 hours the week before an operation may help prepare for optimal performance. Personnel should be familiarised with conditions under which they may sleep. During combat, sleep management should ideally avoid situations where all personnel are exhausted at the same time.

As sleep debt accumulates, a person's mood, motivation, attention, alertness, short-term memory, ability to complete routines, task performance (errors of omission more than errors of commission) and physical performance will become more negatively affected. Counter measures must then be taken (e.g. time for sleep or naps, changing routines or rotating jobs).

Drugs like caffeine and amphetamine can help personnel stay awake. However, they may also keep them awake when they need to sleep-and on awakening, they could suffer from "hang-overs" and are less efficient.

Sleep lost need not be replaced hour-for-hour. Therefore, after operations, personnel need continuous sleep for only 10 to 12 hours as longer sleep increases sleep inertia and delays getting back to normal schedules.

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Introduction

Military personnel are often subjected to stressful, prolonged and irregular work schedules and requirements during military operations. With improved night vision technology, troops are now able to continue fighting when it is still dark and the changing nature of modern warfare frequently requires them to do so. Inadequate management of optimal sleep requirements may result in sleep deprivation which will significantly affect their combat or training capabilities and effectiveness.¹⁻¹¹ Behavioural problems associated with sleep deprivation during operations are also well documented^{1-3,5,7,8,10-13} These include disorientation, overwhelming sleepiness, poor memory and inability to give and receive orders due to uncontrollable lapses in attention^{1-3,6-8,12}

Circadian Rhythm

Human beings are diurnal creatures, programmed to

be awake and active during the day and to sleep continuously for seven to eight hours each night.¹⁻⁴ Physical and mental performance, mood, body temperature, blood pressure and pulse, show a characteristic 24 to 25-hour variation cycle called the circadian rhythm.¹⁻⁴ The time of least effective work and alertness-the circadian low or trough-is 0200 to 0600 hours.^{1-4,10} The circadian high or peak is 1400 and 2000 hours.^{1-4,10} Even when the circadian peak for mental work and memory processes is reported to be much earlier (0800 to 1200 hours), the circadian peak for physical performance often remains in the afternoon or early evening (personal communication).

Sleep Deprivation

Sleep deprivation can be total (defined as no sleep for at least 24 hours¹⁴) or partial (anything short of the "usual" amount). What is "usual" varies from person to person-and there appears to be no significant differ-

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ence between the sexes or between different ethnic origins.^{1,2,4,10} While most people indicate their preference for continuous sleep of seven to eight hours each night,¹⁻⁴ younger persons generally require more sleep.^{3,4} Physically active people (such as those in the military) also require more rest and sleep in order to recover more completely from their additional physical stresses.^{2,4,10}

Some individuals can make do with only four to five hours of sleep per night for weeks (or even months) without major effects on their cognitive, physical and motor performance—although their mood and motivation may suffer.^{1,3,4,11-13} As sleep is further reduced, performance in all areas is inevitably affected (Fig. 1).^{1-4,6,7,8,10-12}

With special and prolonged training, some individuals can learn to tolerate about three hours of sleep per 24 hours, for short periods, without major deleterious effects.⁷ For the majority, however, sleep deprivation is cumulative. A little deprivation over many days adds up. It has been observed that the higher-ranking military personnel are more prone to being sleep deprived during military operations, combat or training exercises.⁷ This is because they tend to feel that their duties are more critical, that they are more indispensable or that they should not be sleeping when their subordinates are still awake. Paradoxically, because of this sense of responsibility, they often suffer significant performance impairment and may even compromise the very goals they seek to achieve.

Rests and Naps

Sleep, when taken during the day, is less effective and recuperative than the same amount taken during the

night.^{1,2} It is more beneficial when taken as a single continuous period of four to eight hours than when broken up into many short naps¹⁻⁴—even when the total hours of sleep from the naps is more. However, multiple naps (of at least 20 to 40 minutes) can be invaluable in reducing the detrimental effects of sleep deprivation when the situation does not permit sleep^{1-4,7,9} as in combat and long-duration military operations. Multiple naps, by reducing total sleep deprivation to partial sleep deprivation, increase the likelihood of improved performance and minimise operational errors.^{1-4,7,9}

There is evidence that effective napping can be learnt with practice.¹ Resting (i.e. lying down in a relaxed state with eyes closed or open) is not the same as napping or sleeping and cannot replace the body's need for sleep nor can it reverse the detrimental effects.^{1,3,4}

Sleep Inertia

Most people are accustomed to awakening slowly and then easing gradually into the required activities.^{1,3,4} Immediately upon awakening, there is typically a period of variable confusion, sluggishness and lack of co-ordination called sleep inertia. During combat, military personnel may be called upon to react immediately to an enemy attack during this sleep inertia phase and may not perform at their optimum. This post-sleep state usually lasts about five minutes^{1,3} although some researchers believe that it could be as long as 10 to 30 minutes.^{10,14}

A 1985 study¹⁵ suggested that sleep inertia is worse during the circadian low although a more recent study in 1992¹ suggested that it is the same throughout the circadian cycle. Sleep-deprived individuals tend to show more severe or prolonged sleep inertia.* Furthermore,

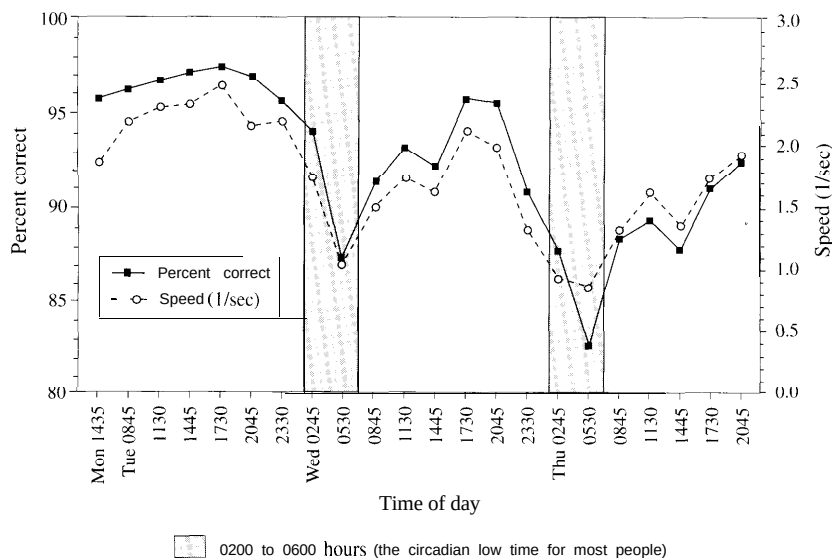


Fig. 1. Speed and accuracy on a four-choice task over two days of sleep deprivation (Naitoh P, Kelly T L. Sleep management user's guide for special operations personnel. San Diego, California: US Naval Health Research Center, 1992).

unusually long continuous sleep (e.g. more than 10 to 12 hours) may be followed by increased sleep inertia.^{1,3} Therefore, sleep inertia must be taken into consideration when assigning critical activities to personnel who have just been recently awakened.

Jet Lag

Travelling to a new time zone causes de-synchronisation of the internal clock with the local time.^{1-3,10} Adjustment to jet lag may take 3 to 11 days, depending on the number of time-zones crossed and the direction of the flight. East-West flights are less disrupting than West-East flights. Until recovery is complete, the effects of jet lag will persist and optimal performances and moods cannot be expected.^{1-3,10} During this period, a person may experience low energy, poorer reaction time, sleepiness during the day, irritability and moodiness.^{1-3,5,7,8,11,12} Headaches, intestinal upset and difficulty in sleeping are also likely to occur.^{1,3}

Sustained Military Operations And Sleep

Military operations often result in sleep deprivation. Even short operations may cause sleep deprivation as there is often little recovery time because participants in one operation may have to assist in subsequent operations.^{1,3}

Two terms used when discussing such situations are “continuous work episodes” (CWEs) and “sustained operations” (SUSOPs). A CWE is a time period during which one works without pause for rest or sleep. Sustained operations contain one or more CWEs, and last for more than 24 hours.^{1,3}

Three factors limited the duration of CWEs in the past: a) limited ability to operate at night; b) unreliable equipment; and c) limited endurance. With improved technology, the duration of CWEs is primarily restricted by endurance, which in turn is a function of sleep. Therefore, the duration of SUSOPs is often determined nowadays more by the combat unit's endurance, than by their weapons, target acquisition, weather or darkness. This was one of the experiences noted in recent conflicts such as Operation Desert Storm during the 1991 Gulf War. Such experiences were noted by personnel in the three services-airforce, army and navy.

Even on the front line, there will be relatively quiet periods. Military personnel must then be ready to seize such opportunities to sleep, catch a quick nap or simply rest.

Sleep Management And Sleep Logistics

Sleep management can be defined as the use of scientific techniques for optimising sleep for those who must work under demanding shift work schedules or CWEs.^{1,3} Its purpose is the prevention of and compensation for deteriorating performance, moods and motivation caused by lack of sleep.

Sleep logistics are the application of sleep management to military operations-establishing and requiring compliance to a work-rest-sleep schedule.^{1,3} Sleep logistics include planning the times and places for sleep in operations or closely-spaced missions lasting a total of 24 hours or more. The objective is to ensure that military personnel at all levels have sufficient periods of quality sleep. They must be able to recuperate from the fatigue and stress of CWEs and maintain combat effectiveness, both as individuals and as a fighting unit, during SUSOPs and other stressful schedules.

Sleep Management Recommendations

Periods of available sleep and the total number of possible sleep hours should be planned for-using mission scenarios and operational guidelines. Since there will always be changes in operational requirements, it is recommended that several work-rest-sleep plans be prepared for all phases of an operation so that the best plan can be adopted according to changing requirements.

Predeployment phase: Many people tend to live under conditions of mild sleep deprivation-never getting quite as much sleep as they really need.^{1,3,4,12} Therefore, during the week before a military operation or exercise, late nights-either for work or fun-should be avoided. Instead, longer-than-usual continuous sleep periods would be beneficial although more than 10 to 12 hours of continuous sleep is not normally recommended as it may increase a person's sleep inertia.^{1,4} Sleeping early and waking up early produces better performance than sleeping late and waking up later.¹

Wherever possible, personnel should become familiar with the surroundings and conditions under which they are expected to sleep. For example, there may be an operational requirement to sleep in special attire (e.g. chemical protective garments) or in cramped spaces (e.g. on board ships or in submarines). Sleep management requires that personnel try to practice sleeping under such conditions during the predeployment phase.¹⁻⁴

Good sleep management means trying out expected work-rest-sleep schedules before an operation. For example, if personnel will be working predominantly at night during a mission, it helps to convert to a night-work/day-sleep cycle (relative to the destination time zone) for a period of one to two weeks before deployment.¹⁻⁴

Deployment phase: During the deployment phase, sleep quality may be reduced by an unfamiliar sleep environment, time pressures, travelling in uncomfortable vehicles, and changes in climate and time zone.¹⁻⁴ Pre-planned work-rest-sleep schedules should be followed as closely as possible so that personnel may be fully combat effective.

Pre-combat phase: If military deployment involves rapid transfer across more than two time zones, some degree of jet lag will occur.^{1,2} When there is a week or more delay between combat zone arrival and actual combat, personnel can adjust to the new time zone. Ideally, when there is no delay, it may be best to stay with the work-rest-sleep pattern of the home base.

Physical and mental efficiency are influenced by the degree of adjustment to the local day/night cycle. For example, combat unit members working in the afternoon by local time may be working at 0200 to 0600 hours by home base time. Thus, local daytime performance would be poor, since 0200 to 0600 hours is the circadian low point in performance efficiency.⁴

Combat phase: By using a proper work-rest-sleep plan, sleep management can avoid situations where all personnel are physically or mentally exhausted at the same time. Despite this, operational demands may still prevent adoption of optimal work-rest-sleep and shift-work plans. Personnel will then experience significant sleep deprivation and counter measures can help under these circumstances.^{1,3,4}

Personnel should take advantage of any lull in combat to nap. Effective napping means sleeping, not just resting.^{1,3,4,9} Uninterrupted sleep for as little as 10 minutes may partially recover alertness and help maintain job performance.^{1,3,4,9} Sleep management must balance the negative effects of sleep (lost man-hours and sleep inertia) with the positive effects (improved ability to perform a job after sleep).^{1,3,4}

Post-combat phase: Immediately following a military operation, combat personnel should be allowed to sleep continuously for up to about 10 to 12 hours. Longer periods of sleep are not desirable, as they tend to increase sleep inertia and delay getting back to normal schedules.⁴ Sleep lost need not be replaced hour-for-hour. However, sleep inertia lasting longer than five minutes, and increased susceptibility to naps may occur during the week following SUSOPs.^{1,3}

Identifying Signs and Symptoms of Sleep Deprivation

Different people exhibit variable signs and symptoms of sleep deprivation. Their manifestations may also be intermittent. As sleep debt accumulates, signs and symptoms will be more prevalent and persistent.⁴

Mood and motivational changes:^{1-3,5,7,8,11,12} Mood changes and decreased willingness to work are early symptoms. Soldiers may feel less energetic, less alert, less cheerful, more irritable, increasingly negative and sleepy. Those who regard sleepiness and mood changes as signs of weakness often deny negative moods and tiredness, but may admit to decreased positive mood.

Impaired attention and alertness:^{1-3,5,9} With progressive sleep deprivation, attention span becomes shortened.

Sleep-deprived individuals cannot concentrate for long periods of time. Intermittent, dream-like, irrelevant thoughts or even brief "micro-sleeps" cause lapses of attention (Fig. 2).

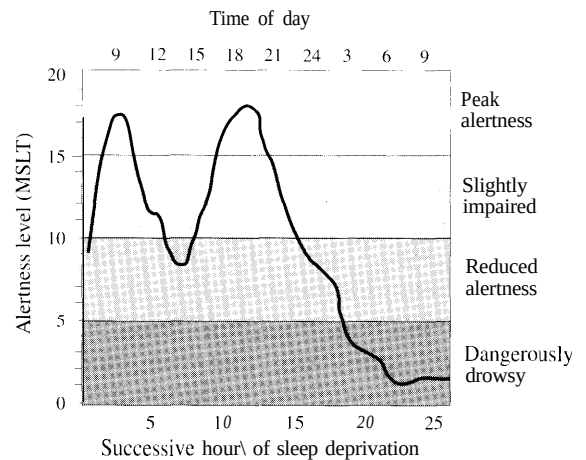


Fig. 2. Time of day and effect of successive hours of sleep deprivation on alertness (Moore-Ede M. *The twenty four hour society*. USA: Addison-Wesley Publishing Co, 1992).

The Multiple Sleep Latency Test (MSLT) developed by the Association of Sleep Disorders Center Task Force on Daytime Sleepiness, was first used in 1976. The MSLT is designed to test sleep-onset and random eye movement (REM) episodes. In this test, a person is placed in a dark room and told to fall asleep. The time taken by the person to fall asleep would indicate how sleepy he is.

Short-term memory loss:^{1-4,5,7,8,12} Memory loss is limited to recent events. A sleep-deprived individual often remains confident about retaining recent messages, events or data, only to find later that these have been forgotten.

Variable and slower responses:^{1,3,4,6,8,12} Some responses remain satisfactory, while others become very slow. The danger of sleep deprivation is the unpredictable failure or slowing down of appropriate responses.

*Visual/auditory hallucination:*¹⁻³ After more than 24 hours without sleep, visual hallucinations may occur. Auditory hallucinations are rare.

Failure to complete routines:^{1,2,11} Sleep deprivation causes carelessness towards military routines such as drying feet, changing socks or filling up water canteens. Confirmation of verbal orders by repeating them aloud becomes ineffective and eventually disappears altogether.

Impaired task performance:^{1,3-5,10,11} Effectiveness in performing tasks is significantly lowered when CWEs exceed 24 hours. After a 36-hour CWE, a combat unit may be able to perform only 50% of the average message coding/decoding work output expected. Similarly, they may be able to detect only 70% of incoming signals. Task performance is degraded due to impaired short-term memory, decreased ability to concentrate, and intrusive, irrelevant, dream-like thoughts.

Performance errors are more frequently due to failure

to respond to task demands (errors of omission) than inaccurate actions (errors of commission). Speed of reading documents slows down. Comprehension is reduced.

Physical exertion:^{1,3,4,6} Physical work performance is accompanied by a subjective feeling of physical exertion ranging from very light to very strenuous. The perception of exertion also follows a circadian pattern. During the circadian low of 0200 to 0600 hours, combat unit members may feel that more effort is required to work at the same physical workload than if it is performed later in the day. Sleep deprivation exaggerates this so that combat unit members may want to stop work because of the increased sensation of physical exertion.

Bickering:^{1-8,12} Bickering is a manifestation of irritability caused by sleep deprivation. However, bickering has one positive aspect—it shows that sleep-deprived individuals are still talking to each other, exchanging orders and messages. The frequency of bickering increases with increased sleep deprivation—up to a point.^{1,3} It decreases when sleep-deprived individuals begin to have difficulty continuing to talk. As long as bickering continues, sleep-loss effects are not severe. A subsequent decline in overall message exchanges and the amount of bickering is a symptom of serious sleep deprivation. When bickering ceases, especially after a period of increased bickering, individuals may be in a state of mental exhaustion.

Recommendations for Sleep Management

When signs of performance degradation begin to appear among members of a combat unit during SUSOPs, several preventive measures can be taken, such as setting aside time for naps, changing routines, or rotating jobs, if personnel are cross-trained.

The most sleep-loss-affected member should be allowed to do a task that can be accomplished at a pace set by the worker, not by the job. Sleep deprivation has less impact on self-paced jobs.^{1,3,4} Everyone should be encouraged to write down work to be done or messages received, and have others check what has been written for clarity and legibility.

It is unlikely that two members of a combat unit will become incapacitated by sleepiness at exactly the same time.^{1,3,10} Teaming up to do a job, or creating the buddy system, is as valid a concept in SUSOPs as in scuba diving.

Drugs To Manage Sleep Deprivation

A detailed discussion of the use of pharmacological agents is outside the scope of this review. Many of the agents used (e.g. caffeine,¹⁷ nicotine,¹⁷ amphetamine,¹⁷ melatonin,¹⁸ methylphenidate^{19,20} and pemoline^{19,20}) have been studied so extensively that it would not do justice

to cover them briefly.

It suffices to mention that some of these drugs (e.g. caffeine, nicotine and amphetamine) have been found to be useful in combating sleep deprivation to some extent. This is achieved by helping the sleep-deprived stay awake. However, the most notable negative effects of these drugs are that when the sleep-deprived person finally has the opportunity to sleep—and wants to sleep—he often has difficulty doing so.^{1-3,14} Furthermore, on awakening, he frequently suffers from a “hang-over” effect and is less efficient.

Conclusion

This review highlights the physiological need for sleep and the consequences to behaviour and mood when that need goes unsatisfied. Additionally, it discusses effects, signs and symptoms of sleep debt and compensating for its ill effects. Judicious sleep management can enhance combat effectiveness while avoiding compromise of mission accomplishment due to sleep deprivation.

The most important steps to be taken for effective sleep management are to: a) factor into operational planning a work-rest-sleep plan to meet sleep needs; and b) understand the physiology of sleep and employ scientific techniques to detect and compensate for the effects of sleep debt.

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