Fatigue Resource Packet for Shipping
Naval Safety Center
Updated 8/6/13
Ms. Kelsey Leo

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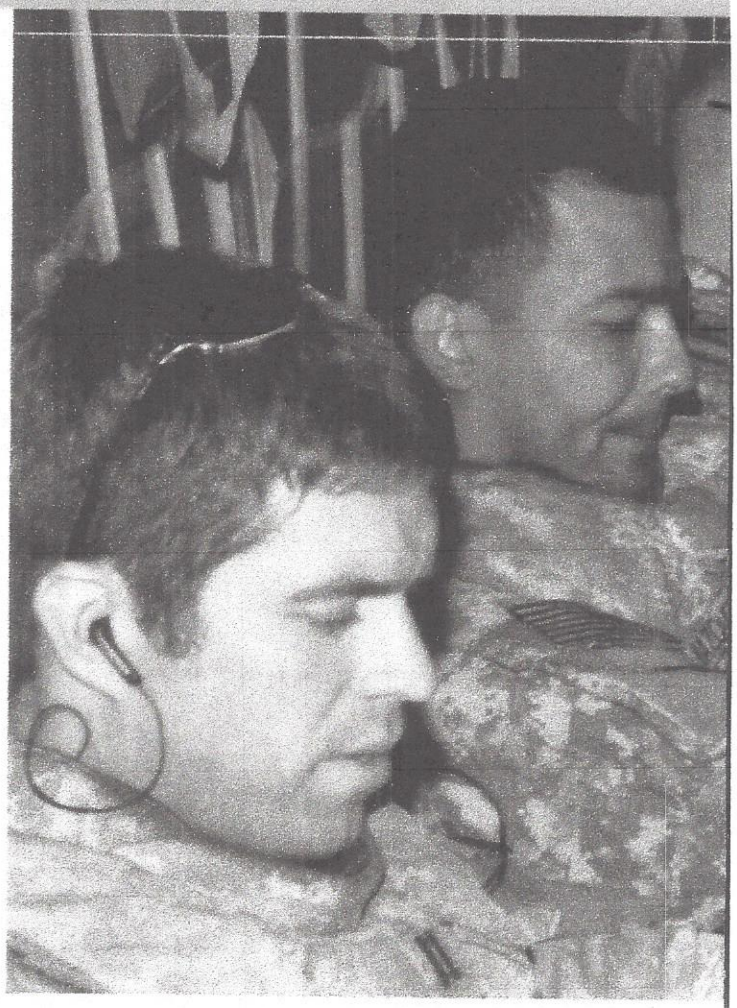
AIRCREW MEMBER FATIGUE AND CREW REST



By Lt Col Al "Jedi" Larkins, AMC/SEF

Note: While this article discusses aircrew fatigue, the principles discussed apply to everyone.

I recently overheard a conversation about crew rest, and the individuals did not understand why aviators are authorized pre-mission down time. Crew rest is required in accordance with *Air Force Instruction 11-202V3, General Flight Rules*. The instruction prescribes crew rest and maximum flight duty periods (FDP) for aircrew members in U.S. Air Force aircraft, and it applies to all personnel who operate those aircraft. The crew rest period is normally a minimum 12-hour non-duty period before the FDP to ensure the aircrew member is adequately rested before performing flight or flight-related duties.

Why is this important for optimum mental and physical performance? Statistics show that fatigue and distractions generally have a detrimental impact on physical and cognitive performance regardless of the tasks involved. While all human beings experience fatigue in day-to-day activities, aircrew

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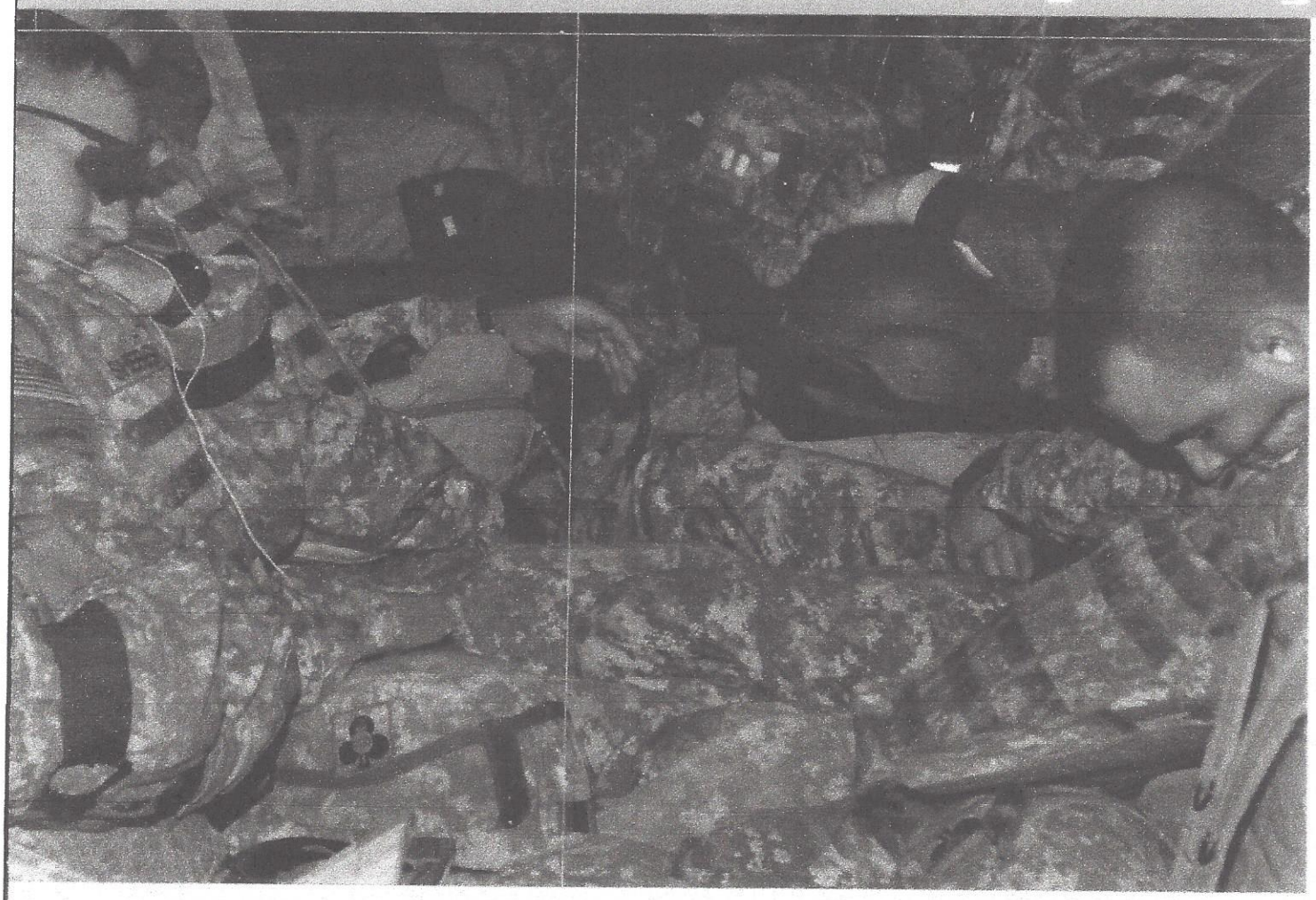

Passengers rest and relax during a C-130 Hercules airlift mission over Iraq. This C-130 aircraft is with the 777th Expeditionary Airlift Squadron from Little Rock AFB, AR.

USAF PHOTO BY TSGT ERIK GUDMUNDSON

members often experience it more severely due to constantly shifting flight times. When they do, it increases the risk to their lives and the lives of those with whom they are flying. For example, one of the most commonly cited causes of aviation mishaps is human error—things such as lack of attention to detail, cockpit/crew resource management issues, training deficiencies, or complacency—and fatigue can amplify any mistake.

Fatigue can be difficult to define, but one relatively accurate definition is, "a condition characterized by increased discomfort with lessened capacity for work, reduced efficiency of accomplishment, loss of power or capacity to respond to stimulation, usually accompanied by a feeling of weariness and tiredness." It is generally described as "tiredness from bodily or mental exertion" and is often characterized by deterioration in the quality of work, lack of enthusiasm, and inaccuracy.

In aviation, sleep loss and circadian disruption are two principal sources of fatigue. Sleep loss simply refers to insufficient sleep, causing a buildup of "sleep debt" that can result in uncontrolled sleep episodes, i.e. dozing off, once the sleep debt becomes high enough.

Aircrew members also experience circadian disruption—where the individual's internal clock is attempting to resynchronize to the external environment when moving to a new time zone or constantly shifting a person's natural body clock. The effects of work/rest cycle shifts parallel the effects of what is commonly referred to as "jet lag." When an individual shifts from a typical day-work/night sleep schedule to a day-sleep/night-work routine, the

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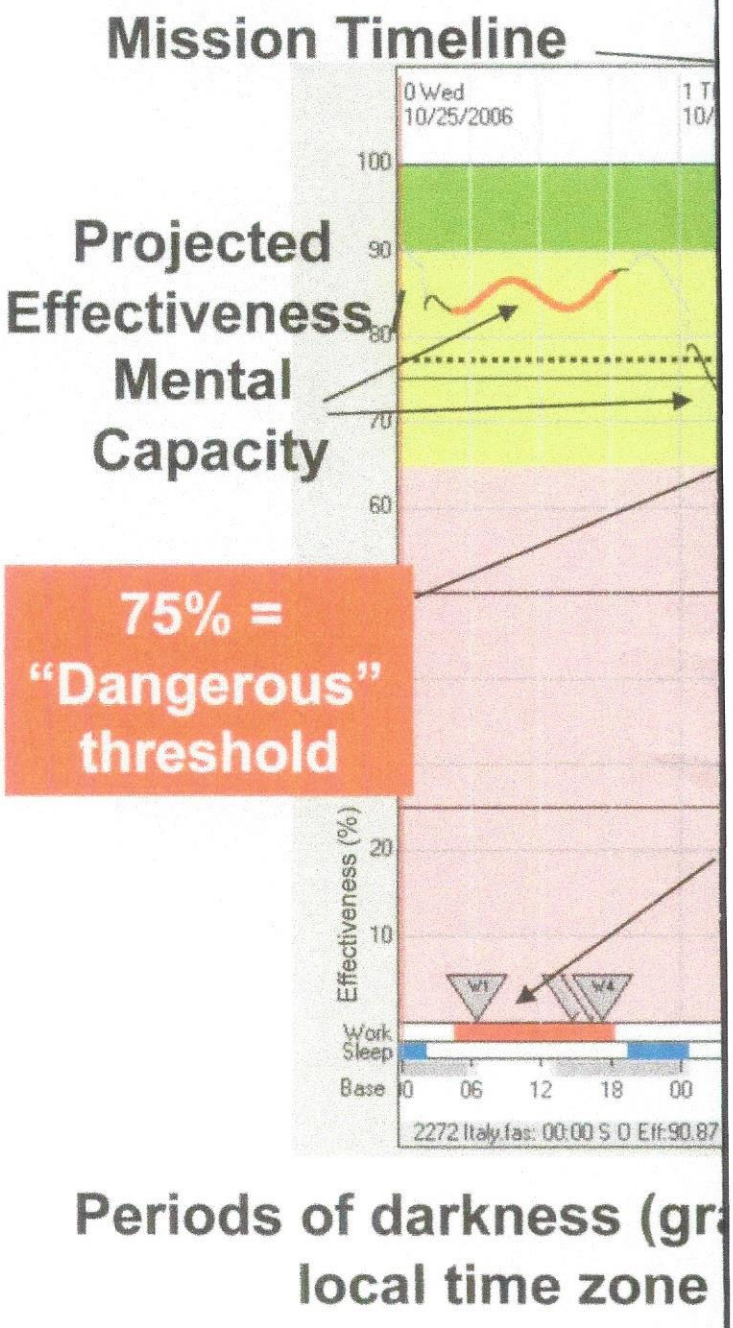
body is forced to alter its normal schedule of melatonin production gradually. Since most work place environments are typically well lit at night, the effect is moderate. A worker who can find a dark place to rest during the day only has to endure gradually decreasing effects of a shift in their sleep cycle.

However, when aircrew members fly at night, they typically keep the flight deck/cockpit at fairly low light levels to better maintain night vision. This practice, while operationally sound, can magnify the effects of the work cycle shift, as the body is still experiencing periods—sometimes extended periods—of darkness or semi-darkness. This increases melatonin production while the individual is performing duties. So, crews moving from a day schedule to a night schedule not only have to endure the effects of the sudden shift in sleep cycle, but their bodies are more resistant to the change, extending the effect over a longer time period.

When the proper amount of sleep is not attained, the body's performance ability begins to suffer. A recent study examined the comparison between lack of sleep and blood alcohol content. After 17 hours of wakefulness, the body's performance and effectiveness began to decrease drastically to the point where, at 22 hours of wakefulness, the body had an equivalent blood alcohol content of .08%. In many states, this makes an individual too drunk to legally drive a vehicle.

There are many ways of avoiding or alleviating aircrew fatigue. Proper scheduling, for example, is crucial to ensuring crew rest. The U.S. Department of Defense has sponsored and licensed a scheduling software program called Fatigue Avoidance Scheduling Tool (FAST) for military use. Based on a mathematical model, FAST uses graphical visualizations of predicted performance that allow units to schedule aviation and ground crews for maximum effectiveness in terms of day/night cycles and fatigue management. FAST is becoming more widespread in U.S. Naval aviation and is starting to make inroads in the U.S. Air Force as well.

The most important thing anyone can do to prevent fatigue is obvious: get whatever sleep you can, when you can. The average person requires approximately eight hours of sleep each night, and anything less will result in a "sleep debt" that must



be paid off eventually. When an individual sleeps less than his or her physiologically required duration or experiences poor quality sleep over successive periods, cumulative fatigue develops. Cumulative fatigue persists and results in worsening physical and mental performance until restorative sleep occurs.

Most individuals require two consecutive nights' sleep to fully recover from a significant sleep debt.

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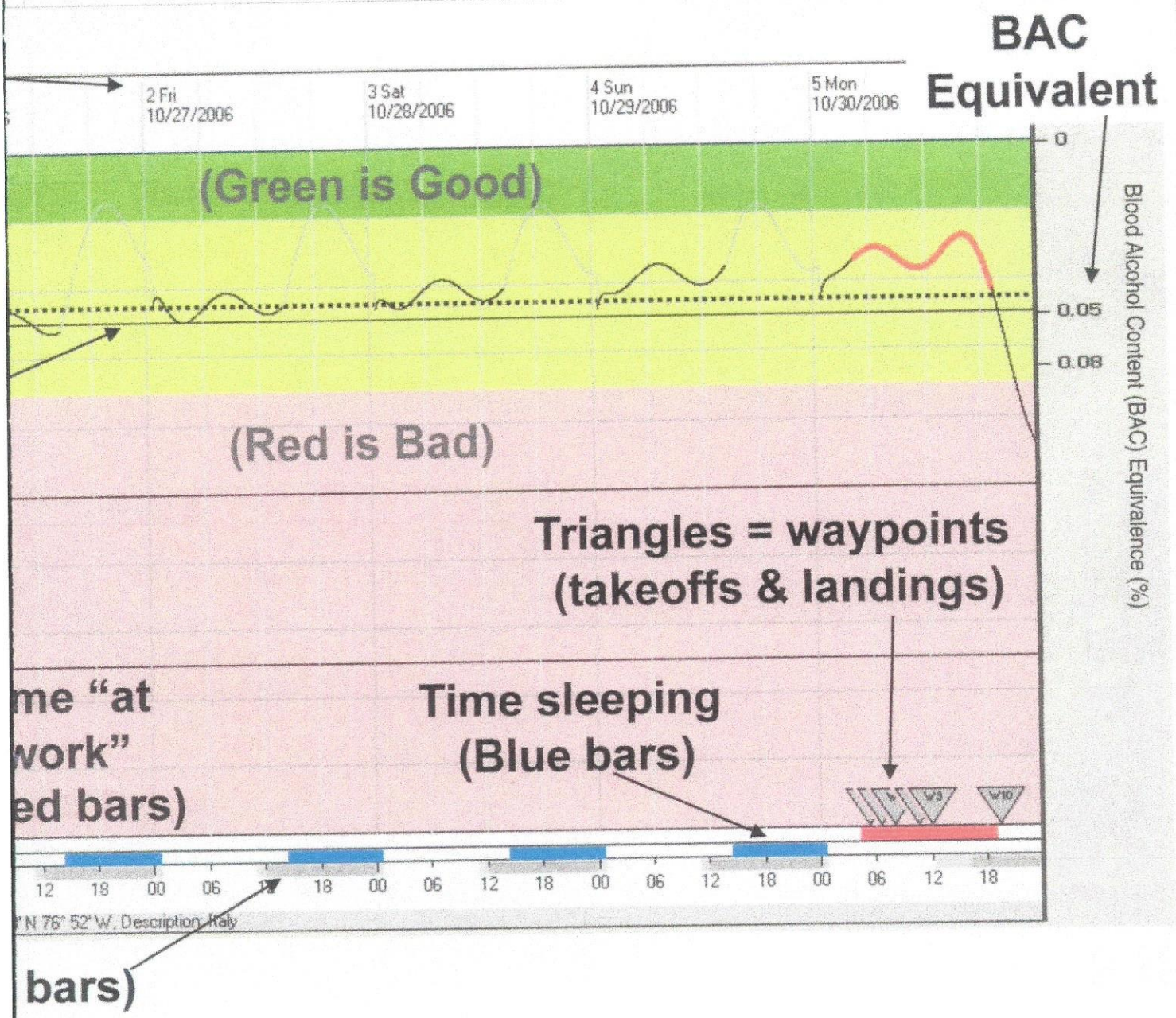

In essence, individuals with chronic sleep debt appear to cognitively shut down. The research seems to suggest that fatigue overloads the mind, leading the individual to abbreviate activities, ignore relatively unimportant information, and not perform redundant tasks.

Fatigue is a major, ever-present danger in civilian and military aviation resulting from physiological and external factors, as well as personal habits. It affects the human body and an individual's performance and ability to perform a job. The key to fatigue management, however, as with many aviation-related hazards, is awareness. With proper scheduling, adjustment of personal habits, and mandated pre-mission rest, aircrew members can minimize fatigue.

Medscape REFERENCE Drugs, Diseases & Procedures

Chronic Fatigue Syndrome

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Updated: Jul 13, 2012

Background

Chronic fatigue syndrome (CFS) is a disorder characterized by a state of chronic fatigue that persists for more than 6 months, has no clear cause, and is accompanied by cognitive difficulties. It was initially termed encephalomyalgia (or myalgic encephalomyelitis) because British clinicians noted that the essential clinical features of CFS included both an encephalitic component (manifesting as cognitive difficulties) and a skeletal muscle component (manifesting as chronic fatigue).

Various unrelated infectious diseases (eg, pneumonia, Epstein-Barr virus [EBV] infection, diarrhea, upper respiratory tract infections) appear to lead to a state of prolonged fatigue in some persons. Generally, if this condition is accompanied by cognitive difficulties, it is referred to as CFS.

The cause of CFS is unknown, but the disorder is probably an infectious disease with immunologic manifestations. EBV has been excluded as a cause of CFS, even though EBV infection is one of the many causes that may lead to a state of chronic fatigue. CFS is not synonymous with chronic EBV infection or chronic infectious mononucleosis.

Because no direct tests aid in the diagnosis of CFS, the diagnosis is one of exclusion but that meets certain clinical criteria, which are further supported by certain nonspecific tests. The diagnosis of CFS also rests on historical criteria (ie, otherwise unexplained fatigue for more than 6 months accompanied by cognitive dysfunction). The absence of cognitive dysfunction should exclude CFS as a potential diagnosis.

Because no cause of CFS has been determined, no effective therapy exists for CFS.

For patient education resources, see the Back, Ribs, Neck, and Head Center, as well as Chronic Fatigue Syndrome, Fibromyalgia, and Fatigue.

Diagnostic criteria

According to the Centers for Disease Control and Prevention (CDC),[1] in order to receive a diagnosis of CFS, a patient must (1) have severe chronic fatigue of at least 6 months' duration, with other known medical conditions excluded by clinical diagnosis, and (2) concurrently have 4 or more of the following symptoms:

- Substantial impairment in short-term memory or concentration
- Sore throat
- Tender lymph nodes
- Muscle pain
- Multijoint pain without swelling or redness

- Headaches of a new type, pattern or severity
- Unrefreshing sleep
- Postexertional malaise lasting more than 24 hours

The symptoms must have persisted or recurred during 6 or more consecutive months of illness and must not have predated the fatigue.

The CDC case definition also states that any unexplained abnormality detected on examination or other testing that strongly suggests an exclusionary condition must be resolved before further classification is attempted. Conditions that do not exclude CFS include the following:

- Any condition defined primarily by symptoms that cannot be confirmed by diagnostic laboratory tests, including fibromyalgia, anxiety disorders, somatoform disorders, nonpsychotic or melancholic depression, neurasthenia, and multiple chemical sensitivity disorder
- Any condition under specific treatment sufficient to alleviate all symptoms related to that condition and for which the adequacy of treatment has been documented, including hypothyroidism for which the adequacy of replacement hormone has been verified by normal thyroid-stimulating hormone levels, or asthma in which the adequacy of treatment has been determined by pulmonary function and other testing
- Any condition, such as Lyme disease or syphilis, that was treated with definitive therapy before development of chronic symptoms
- Any isolated and unexplained physical examination finding, or laboratory or imaging test abnormality that is insufficient to strongly suggest the existence of an exclusionary condition, including an elevated antinuclear antibody titer that is inadequate, without additional laboratory or clinical evidence, to strongly support a diagnosis of a discrete connective tissue disorder

In children, CFS is poorly defined. Most studies of CFS in the pediatric age range have followed the CDC criteria. However, whether the adult CDC case definition can be applied to children and adolescents is debatable.

Children have typically been referred to specialty clinics after extensive screening by their primary care physician has yielded negative or nonspecific test results. Therefore, common short-lived causes of fatigue are effectively excluded. The length of fatigue (6 months) also effectively excludes many common illnesses and probably should be retained in any forthcoming pediatric case definition.

Pathophysiology

Because the immune system is upregulated in CFS, the levels of antibodies to various previously encountered antigens are increased. Although increased titers do not indicate a causal relationship in CFS, the titers are nonetheless useful as laboratory clues, which, when taken together, are common in patients with CFS.

Because so many patients with a possible diagnosis of CFS are found to have elevated levels of immunoglobulin G (IgG) viral capsid antigen (VCA) EBV, this determination should be considered as an incidental finding in CFS. Most patients with CFS demonstrate elevated IgG, coxsackievirus B, human herpesvirus 6 (HHV-6), and/or *C pneumoniae* titers. Patients with CFS also commonly have a decreased percentage of natural killer (NK) cells. Most patients with CFS have 2 of the 3 above-mentioned immunological abnormalities.

Etiology

Many viruses have been studied as potential causal agents, including EBV, HHV-6, coxsackievirus B, spumaviruses, and even human T-cell leukemia virus strains; however, no definitive causal relation has been determined. A role for xenotropic murine leukemia virus–related virus (XMRV) and other murine retroviruses was posited,[2, 3] but XMRV has been ruled out as a cause of CFS.[4, 5, 6, 7]

Patients with CFS are often referred to an infectious disease specialist because of elevated levels of immunoglobulin G (IgG) to the viral capsid antigen (VCA) of EBV. Increased IgG titers to the VCA of EBV are common in the general population, regardless of whether the patient is fatigued. An increased IgG VCA EBV titer indicates past exposure to EBV but does not indicate acute disease or explain the patient's chronic fatigue state. EBV infection is often the precipitating event that has triggered the patient's chronic fatigue.

Some have suggested that the infectious agent responsible for CFS is *Chlamydia pneumoniae*, which may become activated after contact with another infectious agent. In hospitals or commercial laboratories, immunoglobulin M (IgM)

tests and IgG enzyme-linked immunosorbent assay (ELISA) are used to test for *C pneumoniae*. As with elevated EBV IgG VCA titers, many individuals in the healthy population have elevated IgG titers to *C pneumoniae*.

Some patients with CFS are found to have elevated IgM *C pneumoniae* titers, indicating a recent *C pneumoniae* infection, and these patients are the most likely to respond to antichlamydial therapy. However, definitive proof supporting causality is lacking.[8, 9]

Some investigators studying the potential role of *C pneumoniae* in CFS believe that serum tests are insensitive and that a more sensitive test (eg, polymerase chain reaction [PCR]) should be used for evaluation. PCR for *C pneumoniae* is a very sensitive technique but, unfortunately, is available only in research centers.

Candida albicans and other yeast infections do not cause CFS.

Epidemiology

CFS is common in the United States, but the data are difficult to interpret because the various studies define CFS in different ways. Outside the United States, CFS appears to be less common, but it probably exists worldwide. Overall, CFS is more common in females than in males.[10] It occurs most commonly in young to middle-aged adults.

Prognosis

As suggested by the term chronic, the clinical course of CFS is punctuated by remissions and relapses, often triggered by intercurrent infection, stress, exercise, or lack of sleep. The course in adolescents is similar to that in adults.

Most cases improve to some degree over time.

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Fatigue

Fatigue is when a person feels a strong need to rest and has so little energy that starting and sustaining activity is difficult. Fatigue is normal after physical exertion, prolonged stress, and sleep deprivation. However, fatigue that increases and develops after activities that previously did not cause it may be one of the symptoms, or occasionally, the first symptom of a disorder.

Causes

Most serious and many minor illnesses cause fatigue. However, most of these disorders have other more prominent symptoms (for example, pain, cough, fever, or jaundice) that are likely to bring the person to the doctor. This discussion focuses on disorders in which fatigue is the first or most severe symptom.

Common causes: There is no firm dividing line between causes based on duration of fatigue. However, doctors find that certain causes tend to be more common depending on how long people have had fatigue before they seek medical care.

Recent fatigue (lasting less than 1 month) has many causes but the most common are the following:

- Drug adverse effects
- Anemia
- Stress and/or depression

For **prolonged fatigue** (lasting 1 to 6 months), the most common causes are the following:

- Diabetes
- An underactive thyroid gland (hypothyroidism)
- Sleep disturbances (such as sleep apnea)
- Cancer

For **chronic fatigue** (lasting longer than 6 months), the most common causes are the following:

- Chronic fatigue syndrome
- Mental health disorder (such as depression)
- Drug adverse effects

Chronic fatigue syndrome (see Disorders of Unknown Cause: Chronic Fatigue Syndrome) is a disorder of unknown cause that results in fatigue and certain other symptoms. Not everyone who has fatigue for no apparent reason has chronic fatigue syndrome.

Less common causes: Stopping cocaine can cause severe recent fatigue. Less common causes of prolonged or chronic fatigue include adrenal gland underactivity and pituitary gland underactivity.

Evaluation

Fatigue can be highly subjective. People vary in what they consider to be fatigue and how they describe it. There are also few ways to objectively confirm fatigue or tell how severe it is. Doctors usually start an evaluation by trying to distinguish true fatigue from other symptoms that people may refer to as fatigue.

- Weakness: Weakness (see Symptoms and Diagnosis of Brain, Spinal Cord, and Nerve Disorders: Weakness) is lack of

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muscle strength that makes it difficult for people to move the affected muscles. Weakness is typically a symptom of a nervous system or muscle disorder. Disorders such as myasthenia gravis and Eaton-Lambert syndrome can cause weakness that worsens with activity, which may be confused with fatigue.

- Shortness of breath: People, such as those with certain heart and lung disorders, become short of breath with activity but do not feel fatigued at rest.
- Drowsiness: Excessive sleepiness (see Sleep Disorders: Insomnia and Excessive Daytime Sleepiness) is a symptom of sleep deprivation (for example, caused by lifestyle or by disorders such as allergic rhinitis, esophageal reflux, painful musculoskeletal disorders, sleep apnea, and severe long-lasting disorders). Yawning and lapsing into sleep during daytime hours are common. However, many people with fatigue have disturbed sleep, so symptoms of sleep deprivation and fatigue can overlap.

Warning signs: In people with fatigue, certain symptoms and characteristics are cause for concern. They include

- Persistent, unintentional weight loss
- Chronic fever or night sweats
- Swollen lymph nodes throughout the body
- Muscle weakness and/or pain
- Serious accompanying symptoms (for example, coughing up or vomiting blood, bloody or black stools, shortness of breath, swelling in the abdomen, confusion, or suicidal thoughts)
- Involvement of more than one organ system (for example, rash plus joint pain and stiffness)
- Headache or loss of vision, particularly with muscle pains, in an older adult
- Older age (for example, older than about 65 years)

When to see a doctor: All people feel fatigue occasionally, and not every case of fatigue requires evaluation by a doctor, particularly those that accompany an acute illness (such as an acute infection) or that go away after a week or so. However, fatigue that seems to last longer or has no obvious explanation should be evaluated.

Older adults with a new or different headache or loss of vision and people who have serious accompanying symptoms should see a doctor immediately. Even if they have no other symptoms, older adults with fatigue should see their doctor as soon as possible. Other people who have other warning signs should see a doctor in a few days. People who have no warning signs should call their doctor. The doctor can decide how quickly they need to be seen. Typically a delay of a week or so is not harmful.

What the doctor does: Doctors first ask questions about the person's symptoms and medical history. Doctors then do a physical examination. What they find during the history and physical examination often suggests a cause of the fatigue and the tests that may need to be done (see Nonspecific Symptoms: Some Common Causes and Features of Prolonged or Chronic Fatigue).

Doctors ask the person

- To describe what is meant by fatigue as precisely a possible
- How long fatigue has lasted
- When fatigue occurs in relation to rest and activity
- What other symptoms occur (such as fever, night sweats, or shortness of breath)
- What measures relieve or worsen fatigue
- How fatigue affects the person's work and social activities

Women are asked about their menstrual history. All people are asked about diet, anxiety, depression, and alcohol and drug use (including use of over-the-counter and recreational drugs).

Doctors then do a physical examination. Because many disorders can cause fatigue, the physical examination is very thorough, particularly in people with chronic fatigue. In particular, doctors also do a neurologic examination to evaluate the person's muscle strength and tone, reflexes, gait, mood, and mental status. The history and physical examination are more likely to reveal the cause of fatigue of more recent onset. A cause is also more likely to be found when fatigue is one of many symptoms than when fatigue is the only symptom. Fatigue that worsens with

activity and lessens with rest suggests a physical disorder.

Some Common Causes and Features of Prolonged or Chronic Fatigue

Cause	Common Features*	Tests
Blood disorders or cancers		
Anemia	Decreased exercise tolerance with shortness of breath during activity greater than expected for the activity Sometimes paleness	CBC
Cancers (such as digestive tract cancer, lung cancer, leukemia, lymphoma, multiple myeloma)	Widespread lymph node swelling, weight loss, and night sweats With multiple myeloma, low back or other bone pain, often severe at night	CBC
Infections		
Chronic hepatitis	Sometimes jaundice, loss of appetite, and fluid in the abdomen	Blood tests to determine how well the liver is functioning and to identify the hepatitis virus Sometimes liver biopsy
Cytomegalovirus infection	Enlarged spleen and lymph nodes, fever, and night sweats	Sometimes blood tests for antibodies to cytomegalovirus
Heart valve infection (endocarditis)	Fever and night sweats Sometimes joint pains Usually in people who have heart murmurs or inject drugs intravenously	Cultures of blood samples and echocardiography
HIV/AIDS	Fever, night sweats, and frequent infections Sometimes difficulty breathing, cough, diarrhea, and/or	HIV blood test

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	rash	
Mononucleosis	Recent sore throat and lymph node swelling	Mononucleosis blood test
Other infections (for example, fungal pneumonias such as histoplasmosis, parasitic infections, or tuberculosis)	Fever, night sweats, and weight loss Sometimes cough, difficulty breathing, and coughing up blood	Tests based on which type of infection seems likely
Other disorders and causes		
Chronic kidney disease	Shortness of breath, difficulty breathing when lying down that is relieved when upright (orthopnea), and/or swelling	Blood tests of kidney function
Connective tissue disorder (for example, rheumatoid arthritis or systemic lupus erythematosus [lupus])	Fever, night sweats, weight loss, joint pain, rash, and/or other organ involvement (for example, effects on the heart or lungs)	Blood tests for abnormal antibodies
Deconditioning	A history of lack of exercise or being bedbound or hospitalized	Only a doctor's examination
Diabetes (sometimes, other symptoms often more prominent)	Excessive thirst, excessive urination, increased appetite, and unexplained weight gain or loss	Measurement of sugar (glucose) level in the blood after the person fasts overnight and sometimes glucose tolerance testing
Drugs: Antidepressants, older antihistamines, antihypertensives, diuretics that cause low potassium levels in the blood, muscle relaxants, recreational drugs, and sedatives	History of taking a drug known to cause fatigue	Only a doctor's examination
Giant cell arteritis	Headache, pain in the jaw when chewing, pain	ESR and temporal artery biopsy

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	when combing hair, loss of vision, and/or muscle pains in a person over 50	
Mental health disorders: Anxiety, depression, drug addiction, panic disorder, or somatization disorder (physical symptoms caused mainly by anxiety)	Anxiety, sadness, loss of appetite, and unexplained sleep disturbance With somatization disorder, an excessive preoccupation with physical symptoms	Only a doctor's examination
Multiple sclerosis	Fatigue worse with exposure to heat Past symptoms of nervous system malfunction (such as, numbness, loss of coordination, and weakness), particularly if people had more than one episode of symptoms	Brain and/or spinal cord MRI
Pregnancy	Cessation of menstrual periods, breast tenderness, morning sickness, and abdominal swelling	Pregnancy test
Sleep disorders	Excessive daytime sleepiness, frequent awakenings, breathing interruptions during sleep, difficulty falling asleep, unrefreshing sleep	Sleep laboratory testing (polysomnography)
Underactive thyroid gland (hypothyroidism)	Inability to tolerate cold, weight gain, constipation, and coarse skin	Blood tests of thyroid function
Undernutrition	Weight loss Sometimes loss of appetite, foul-smelling stool, abdominal pain, or a combination	A doctor's examination Sometimes other tests

Disorders of unknown cause		
Chronic fatigue syndrome	Sore throat, sleep that is not refreshing, difficulty with concentration or short-term memory, muscle aches, joint pain, headaches, and/or tender lymph nodes in the neck or under the arms	Only a doctor's examination
Fibromyalgia	Long-standing and widespread muscle and bone pain in areas outside the joints, trigger points, lower abdominal pain, gas, bloating, constipation or diarrhea, migraines, and anxiety	Only a doctor's examination

*Features include symptoms and the results of the doctor's examination. Features mentioned are typical but not always present.

CBC = complete blood count; ESR = erythrocyte sedimentation rate; HIV = human immunodeficiency virus; MRI = magnetic resonance imaging.

Testing: The need for tests depends on what doctors find during the history and physical examination. For example, doctors test for human immunodeficiency virus infection and tuberculosis if people have risk factors. Testing for other infections or cancer is usually done only when people's findings suggest these causes. In general, people who have had fatigue for a long time and those who have warning signs are more likely to require testing.

If people do not have any other findings besides fatigue, many doctors do a few common blood tests. For example, they may do a complete blood count, blood tests to measure liver, thyroid gland, and kidney function, and a blood test called the erythrocyte sedimentation rate that suggests the presence of inflammation. However, such blood testing often does not reveal the cause.

Treatment

Treatment is directed at the cause. People with chronic fatigue syndrome or fatigue with no clear cause may be helped with physical therapy that includes increasing degrees of exercise and by psychologic support (for example, cognitive behavioral therapy).

Essentials for Older People

Although it is normal for people to slow down as they age, fatigue is not normal. Fatigue is more often the first symptom of a disorder in older people. For example, the first symptom of a urinary tract infection in an older woman may be fatigue, rather than any urinary symptoms (such as burning during urination, frequent urination, or blood in the urine). Older people with pneumonia may have fatigue before they have a cough or fever. In older people, the first symptom of other disorders, such as giant cell arteritis, may also be fatigue. Because serious illness may become apparent soon after sudden fatigue in older people, it is important to determine the cause as quickly as

possible.

Key Points

- Fatigue is a common symptom.
- Fatigue caused primarily by a physical disorder increases with activity and lessens with rest.
- If a doctor uncovers no findings suggesting a cause of fatigue, tests are often not helpful in identifying the cause.
- Successful treatment of chronic fatigue may take work and persistence.
- Fatigue in older people is not a normal part of aging.

Last full review/revision March 2013 by Michael R. Wasserman, MD

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Record: 1

Are We Driving the Ship Drunk? By: Armstrong, Benjamin. U.S. Naval Institute Proceedings. Feb2010, Vol. 136 Issue 2, p79-81. 3p. 1 Color Photograph. Abstract: The article focuses on the issue regarding naval ship maneuvering in the U.S. Navy. It mentions that several sailors have experienced fatigue, affecting the work performances, while maneuvering the vessel. Research shows that sleep deprivation can alter the sailors' function, in terms of psychomotor skills, than alcohol intoxication. Moreover, the sleep adequacy for naval officers is also suggested. (*AN: 48168562*)

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Section: PROFESSIONAL NOTES

Are We Driving the Ship Drunk?

Are you a Sailor who brags, "My record is 72 hours!" How many times have we heard phrases such as these: "Sleep is a crutch for the weak" or "There'll be plenty of time to sleep when I'm dead"? Long watches combined with shipboard routines that require normal working hours are common in today's surface Navy. But a culture that values hours logged over sound decision-making, efficiency, and safety places not only us but our shipmates — and the nation's security — at risk.

Fatigue and its hazards to our service have recently become part of the discussion in professional circles.[1] The importance of rest is frequently covered at safety stand-downs, and fatigue is cited as a part of operational risk management. And yet the connection between these talks and actual changes in the watchbill or working hours is tenuous at best. Stories of drastic measures remain common; for example, removing the doors from junior-officer staterooms so that daytime sleep is impossible, regardless of when their last watch was. Several medical and academic studies have investigated the effects of fatigue. Their conclusions demonstrate beyond any doubt that it is past time to take this problem seriously and make changes to account for it.

Needlessly Hazardous Duty

In 1997, Australian researchers Drew Dawson and Kathryn Reid compared the effects of fatigue and alcohol in a study published in the journal Nature. Their findings,

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consistent with those of several other studies, show a remarkable similarity between the effects of fatigue and those of drinking.

Dawson and Reid kept one group awake for 28 hours and had another drink a prescribed amount of alcohol. At half-hour intervals, subjects were given a computerized psychomotor test designed to check their hand-eye coordination. Results were stark. After 17 to 20 waking hours, psychomotor abilities of the sleep-deprived group were the same as those of a drinker with a blood alcohol content of .08 percent, the legal limit. Dawson and Reid concluded: "Relatively moderate levels of fatigue impair performance to an extent equivalent to or greater than is currently acceptable for alcohol intoxication."[2]

Reaction time and psychomotor skills are key to many tasks that our watch-standers perform. However, these are not the only areas that fatigue affects. In the British Journal of Psychiatry, J. A. Home wrote in 1993 about the effect of sleep on the prefrontal cortex (PFC) of the brain. The PFC controls a number of functions, including wakefulness, arousal, planning, and decision-making. Sailors with a slowed PFC are likely, Horne found, to feel indifferent and have reduced motor skills. According to his study, sleep deprivation negatively impacts the PFC, which then affects the ability to plan actions and make appropriate decisions.3

More recently, Lieutenant Colonel Daniel Miller's 2005 study at the U.S. Military Academy found that "sleep-deprived individuals often do not realize that they are operating with decreased cognitive and physical capacities."4 This means that our Sailors, officers, and even captains could be on the bridge of a national asset with reduced eye-hand coordination, poor planning ability, and negative decision-making ability. Are we driving the ship drunk and don't even know it? What can be done?

Countermeasures Research

Studies of other shift-work public servants have yielded potential solutions. In the 1980s, Harvard University professor Charles Czeisler began a study of sleep patterns and shift work of the Philadelphia Police Department. The department had an erratic schedule, with long shifts that anecdotally left officers fatigued. Czeisler convinced them to implement a new schedule with greater regularity and predictability. The results were impressive. Officers reported a 29 percent decline in sleeping on the job. More important, the department realized a nearly 40 percent reduction in on-duty police-motor vehicle accidents. Officers also reported a decline in alcohol consumption, use of sleep medication, and greater quality of life when off duty.5

Extensive studies have documented the value of napping as a fatigue countermeasure. When Japanese nurses on a 16-hour night shift were allowed 2-hour naps, self-reported fatigue and mistakes decreased significantly. A French study of industrial workers gave those on night shifts a short nap — resulting in greater vigilance and productivity in the early morning hours.[6]

Tired Navy Policy

The tradition of standing watch on a naval vessel is a long and storied one. Even on our modern ships, the boatswain's mate of the watch still sounds the bells, and we "live by the bell, die by the bell," just as our forefathers did on fast frigates two centuries ago. But naval warfare has changed in revolutionary ways since Decatur and Perry stood the watch. Today it is a 24-hour enterprise. Unlike during the Age of Sail, modern weapons and sensors continue the fight well into the night or start it in the early morning hours. The demands of 21st-century operations, our custody of national assets and personnel, and the security of the world's oceans preclude a traditional response to fatigue.

Several senior and experienced surface warriors warn against a Navy-wide policy mandating sleep management. They argue that the captain's role and authority are paramount, and that operational requirements can only be assessed in-theater. A good captain, they contend, considers the crew and their fatigue and uses the sound judgment gained throughout a career to make the right decision. But this argument for the status quo is disingenuous.

Naval aviators receive thorough training in the limits of fatigue. Squadrons are governed by written crew rest requirements in OPNAV Instruction 3710.7 (NATOPS General Flight and Operating Instructions). The implication that a squadron commanding officer is somehow inferior to a surface warrior and requires guidance in writing is not only unfair but also insulting. The crew-rest requirements in 3710.7 are prefaced with the word should, not shall. This gives the CO leeway during periods of high operational tempo or special requirements. Operational necessity dictates adherence to aviation's crew-rest rules and is easily transferable to the surface fleet.

Getting Our Rest

The Navy needs to make two significant changes to the sleep policy for the surface fleet. First, a new training plan on the hazards of fatigue should be developed for the pre-CO/XO training pipeline, department head training, and the safety officer afloat course. Officers are generally aware of the hazard, but they need education in the

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science and available countermeasures, not just for themselves but, more important, for their crews.

This training, developed with the Naval Operational Medicine Institute to incorporate the latest research, would include discussion of the concepts of circadian rhythm, sleep debt, sleep inertia, and performance degradation. Leaders and safety officers who better understand the science will be better prepared for the decision-making process.

Second, all commands should have a sleep policy. OPNAV 3710.7 provides the policy for naval aviation. Some squadrons institute even greater requirements. Helicopter Anti-Submarine (Light) Squadron 43 has a crew-rest policy for maintenance personnel. In the surface fleet, OPNAV Instruction 5100.19 (Navy Safety and Occupational Health Program Manual for Forces Afloat) should require that all commands have a fatigue policy. This could be fulfilled in many ways.

On some ships, the commanding officer's standing orders may require all watch-standers to have a certain amount of sleep before assuming the watch. Other commands could add language to their command safety instructions or other standard operating procedures. The content of the policy need not be dictated, giving captains the proper authority over their crews. A formal policy, nonetheless, should be thought out and put in writing.

Three Mile Island, Chernoybl, and the Space Shuttle Challenger disaster were all caused partly by sleep deprivation. How many groundings, collisions, and fires have had the same causal factor? To keep our officers and crews from operating our nation's warships in a drunken state, we must proactively combat fatigue. Increased training for decision-makers and the introduction of command-specific policies are two key elements to implement. Without a serious and coordinated effort, one of your Sailors may end up dead tired or simply dead.

PHOTO (COLOR): Sleepless nights create additional hazards. Here, Sailors stand watch in the combat information center of the USS Nimitz (CVN-68) on New Year's Day, 1 January 2010, in the North Arabian Sea.

1. *J. Washington, "Sleep Matters!" U.S. Naval Institute blog, 5 March 2009, http://blog.usni.org/?p=1561.*

2. *D. Dawson and K. Reid K. "Fatigue, Alcohol and Performance Impairment," Nature 288 (1997): p. 235.*

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3. J. A. Home, "Human Sleep, Sleep Loss, and Behavior: Implications for the Prefrontal Cortex and Psychiatric Disorder," British Journal of Psychiatry 162 (1993): pp. 413-19.

4. D. Miller, "Sleep and Predicted Cognitive Performance of New Cadets during Cadet Basic Training at the United States Military Academy," master's thesis in Modeling, Virtual Environments, and Simulation, Naval Postgraduate School (2005), p. 2.

5. E. Eckholm, "Exploring the Forces of Sleep," New York Times, 17 July 1988.

6. Both studies cited in Miller, "Sleep and Predicted Cognitive Performance," p. 34.

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By Benjamin Armstrong, U.S. Navy

Lieutenant Commander Armstrong is the safety officer on board the USS Wasp (LHD-1). He is a naval aviator who has contributed previously to Proceedings.
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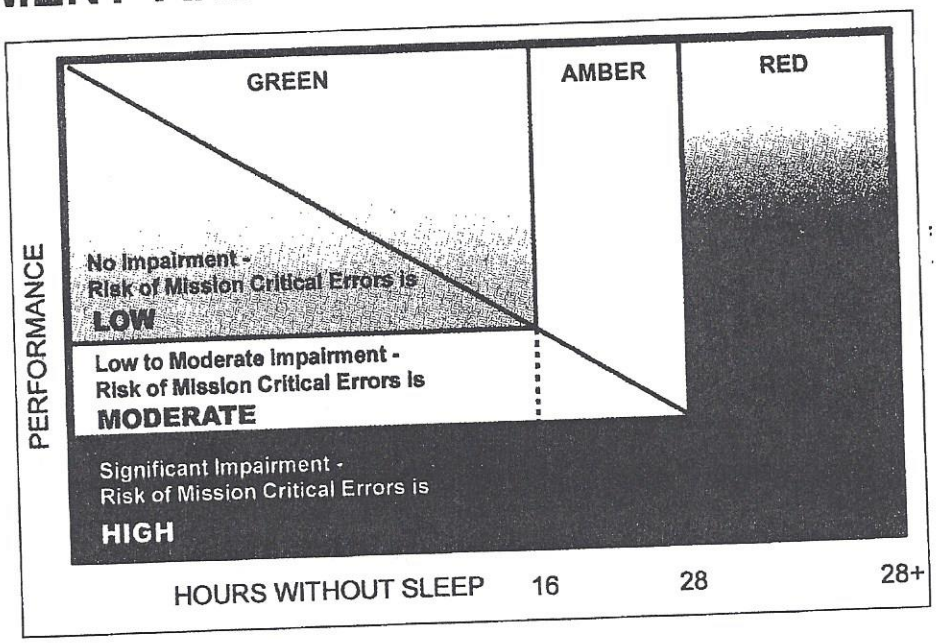
Sleep Management and Soldier Readiness:

A Guide for Leaders and Soldiers

CAPTAIN JUSTIN CURRY



Like food, water, and air — sleep is a necessity. When Soldiers don't get enough sleep, performance suffers and everyone is put at risk. The effects of sleep deprivation sneak up on us. When Soldiers don't get enough sleep, the ability to judge the impact that sleep deprivation has on their abilities is diminished and performance decreases. Sleep deprivations may lead to:

- ☐ Falling asleep at the wheel causing a vehicle roll-over;
- ☐ Administering the wrong medicine or the wrong dose;
- ☐ Failing to recognize a threat or reacting too slowly to it; or
- ☐ Transposing digits while entering coordinates into a fire-control system.

A sleep deprived Soldier may make bad tactical decisions. The bottom line is that sleep deprivation can get Soldiers killed!

Sleep Deprivation and Performance

The longer Soldiers go without sleep, the poorer their performance on any number of tasks. In general, a person can sustain normal performance without noticeable impairment for about 16 hours after waking up. After 16 hours without sleep, there is a noticeable decrease in performance. After being awake for 24 hours, the reaction time is worse than being legally intoxicated. After 28 hours without sleep, performance becomes significantly impaired with the likelihood of critical errors rising to an unacceptable level.

Sleep Management

To sustain performance over the long haul, Soldiers need at least six and preferably seven to eight hours of sleep out of every 24. Soldier performance will degrade over time with less sleep than six hours. Getting four to six hours of sleep every 24 hours will keep Soldiers in the Amber zone (where the risk for mission critical errors is increased but still at acceptable levels) for periods of up to several weeks. Getting less than four hours of sleep will keep Soldiers in the Red Zone (where the risk for mission critical errors is unacceptably high).

Sleep doesn't have to be continuous. It is preferred that Soldiers have uninterrupted sleep time; however, several shorter sleep periods that add up to six to eight hours will likely be adequate.

Tips for Sleep Management

Tips for Soldiers:

- ✓ Don't sleep in areas where there is regular activity.
- ✓ When sleeping, minimize exposure to noise and light — wear ear plugs and use blackout shades.
- ✓ Avoid over-the-counter "sleep aids," which cause grogginess not actual sleep.
- ✓ Sleep whenever possible — even a little sleep is better than none. Several "catnaps" can add up quickly.

Tips for Leaders:

- ☐ Develop a unit sleep management program that gives Soldiers at least six and preferably seven to eight hours to sleep out of every 24.
- ☐ Soldiers trying to sleep during the day require longer (or more frequent) opportunities to sleep to compensate for the body's normal reaction to sleep cycle disruption.
- ☐ Never put Soldiers in a position where they must choose between sleep and something else they would enjoy.
- ☐ Arrange sleep schedules that give Soldiers opportunities to sleep at a consistent time.

If Sleep Loss Can't be Avoided:

- ✓ Use caffeine – drink the equivalent of two cups of coffee (~200 mg of caffeine) every two to four hours. Caffeine use as described above will help maintain performance even in the face of moderate sleep loss.
- ✓ Remember … sleep is a necessity.
- ✓ Your performance begins to suffer as soon as you start losing sleep.
- ✓ If you are struggling to stay awake, then your ability to function is already impaired.

Captain Justin Curry is a psychologist with the U.S. Army Center for Health Promotion and Preventive Medicine.

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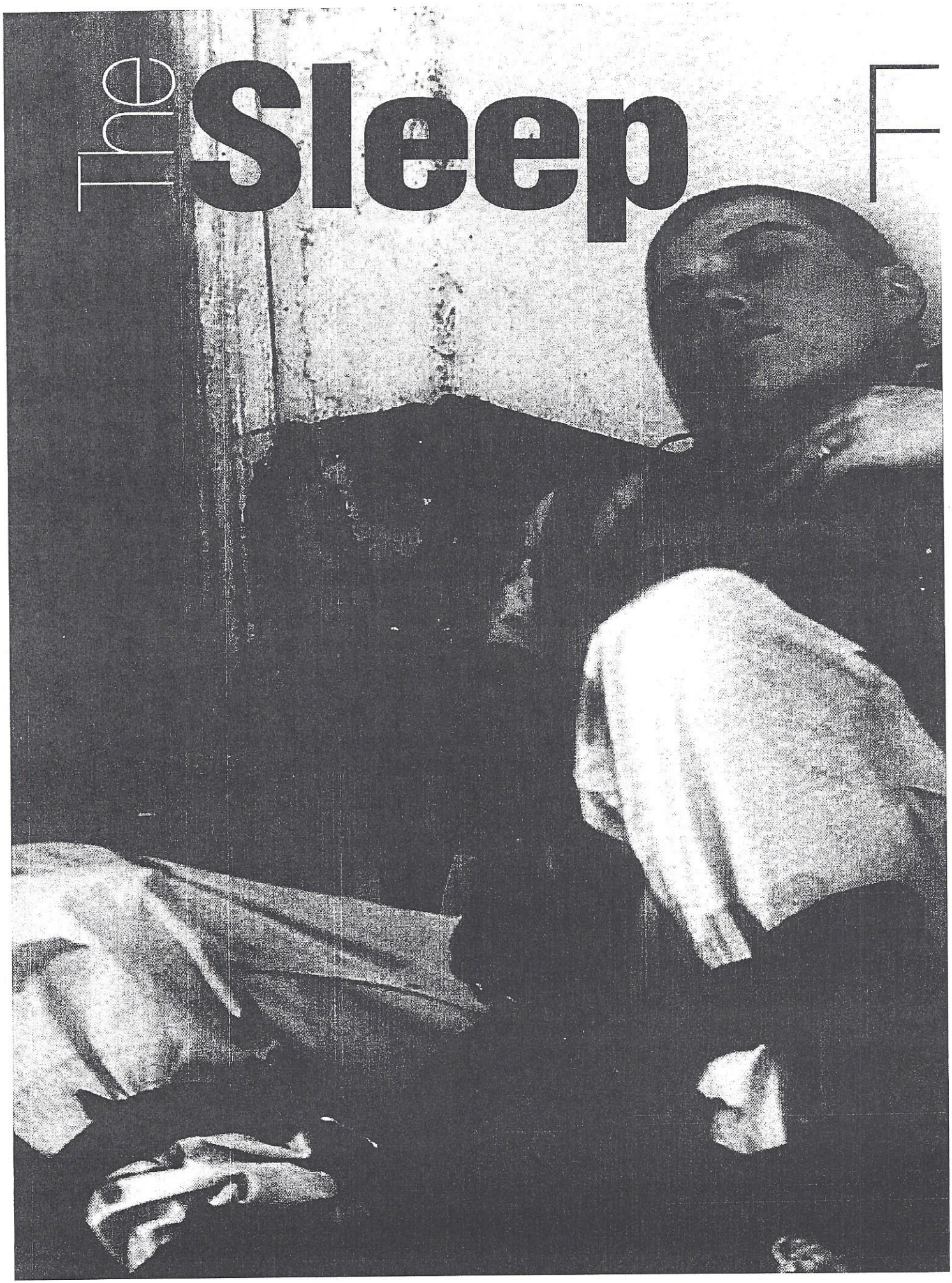
The Sleep F



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Story by Karen Fleming-Michael

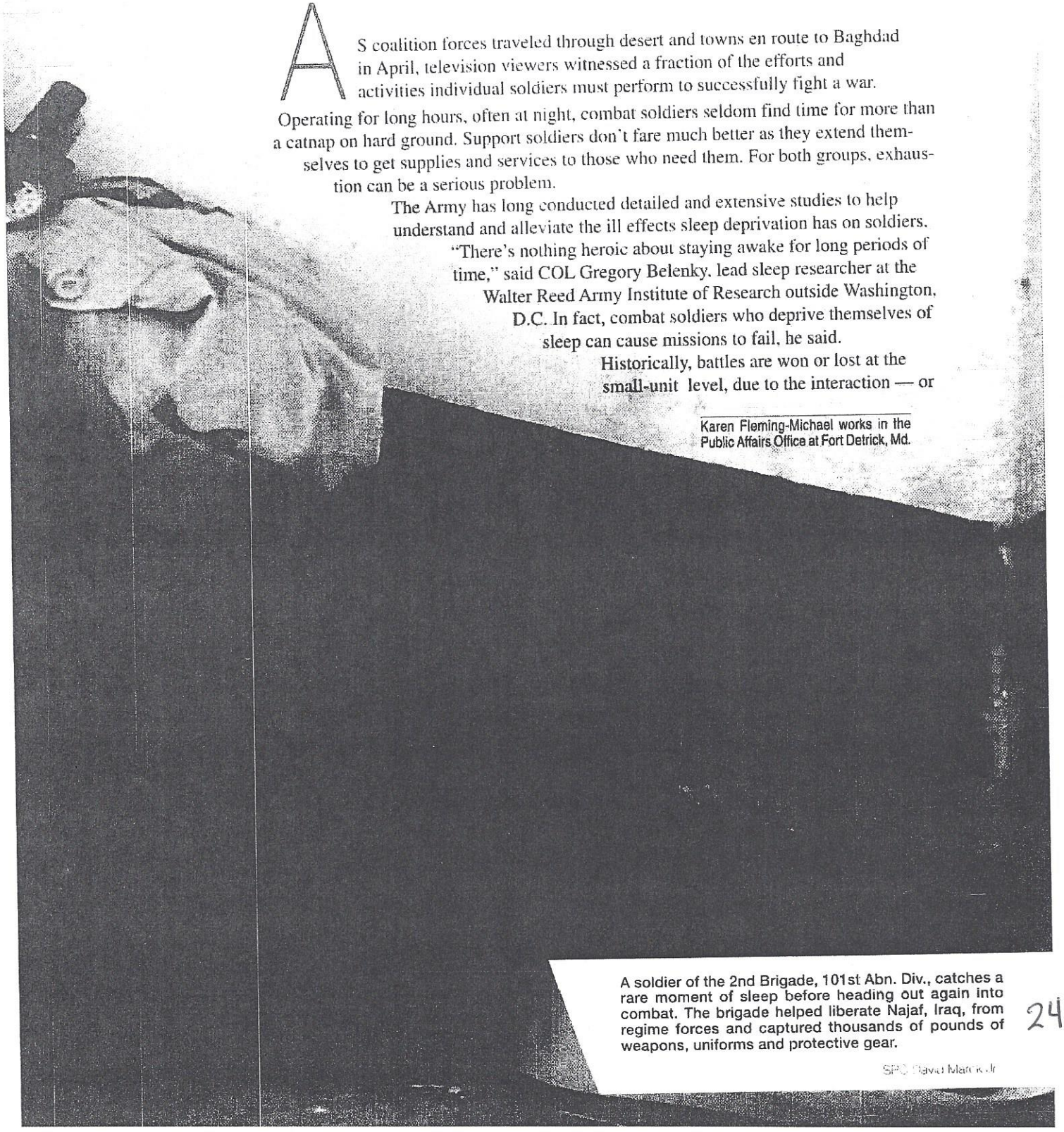
AS coalition forces traveled through desert and towns en route to Baghdad in April, television viewers witnessed a fraction of the efforts and activities individual soldiers must perform to successfully fight a war. Operating for long hours, often at night, combat soldiers seldom find time for more than a catnap on hard ground. Support soldiers don't fare much better as they extend themselves to get supplies and services to those who need them. For both groups, exhaustion can be a serious problem.

The Army has long conducted detailed and extensive studies to help understand and alleviate the ill effects sleep deprivation has on soldiers.

"There's nothing heroic about staying awake for long periods of time," said COL Gregory Belenky, lead sleep researcher at the Walter Reed Army Institute of Research outside Washington, D.C. In fact, combat soldiers who deprive themselves of sleep can cause missions to fail, he said.

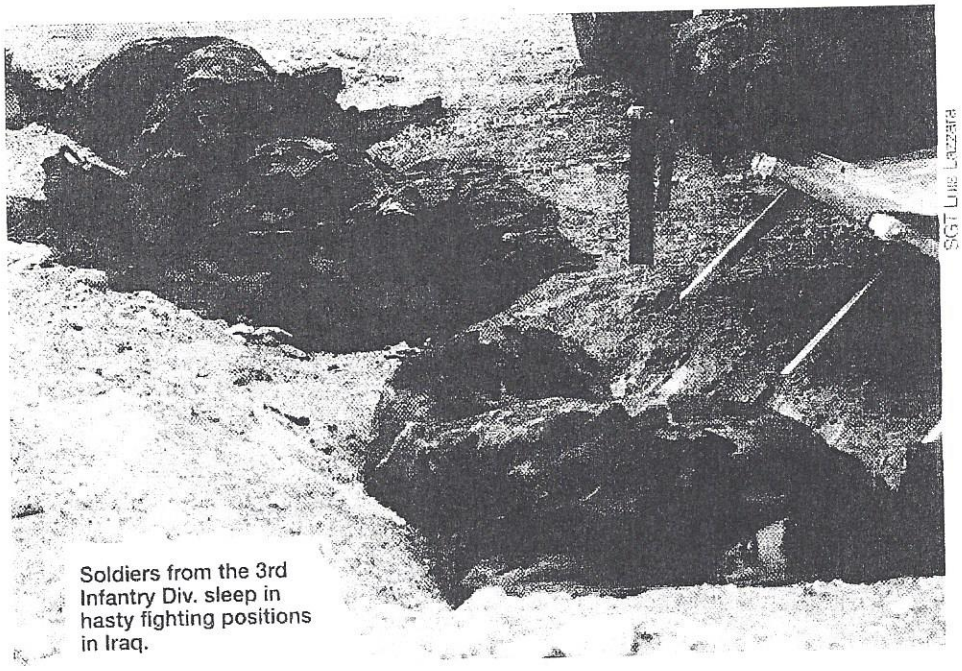
Historically, battles are won or lost at the small-unit level, due to the interaction — or

Karen Fleming-Michael works in the Public Affairs Office at Fort Detrick, Md.



A soldier of the 2nd Brigade, 101st Abn. Div., catches a rare moment of sleep before heading out again into combat. The brigade helped liberate Najaf, Iraq, from regime forces and captured thousands of pounds of weapons, uniforms and protective gear.

SPC David Marck Jr



SGT Luis Lazzara

Soldiers from the 3rd Infantry Div. sleep in hasty fighting positions in Iraq.

lack of it — between individuals in squads and platoons, said Belenky, a psychiatrist who has studied sleep for the Army since 1984. "If you're sleep deprived, you're not going to make good decisions," he said.

Sleep-deprived battle planners, too, can make poor decisions, said LTC Robert Noback, who studies aircrew health and performance at the U.S. Army Aeromedical Research Laboratory at Fort Rucker, Ala. Members of battle staffs frequently get less sleep than the soldiers in combat, so they're equally at risk of making bad decisions, Noback said. One bad decision leads to others; tired soldiers will make bad decisions based on poor plans passed to them by tired planners.

The military studies sleep as it pertains to both sustained and continuous operations. During sustained operations, combat soldiers get less than four hours sleep each night for days at a time, which is considered severe sleep deprivation. During continuous operations, soldiers get less than seven hours sleep each night, Noback said.

Both sustained and continuous operations take their toll, but what complicates deprivation is that sustained operations can occur simultaneously with continuous operations. "So the mixed-up sleep patterns of already sleep-deprived soldiers get even more mixed up," Noback said.

The regions of the brain best able to process information, judge situations and make logical decisions are also those most affected by lack of sleep, Belenky said. "Degraded activity in these regions of the brain can pose great peril to future combat units," he said

More and more, combat soldiers will continue to receive an overwhelming amount of information, and they'll need to be able to process it to make decisions, Belenky said. "You can have a brilliant plan, but unless you have intelligent execution at the lowest level, it won't work."

To mitigate some of the effects of sleep deprivation during operations, WRAIR has a team of physicians, physiologists and experimental psychologists who study sleep for the Department of Defense. Findings are included in peer-reviewed literature, such as the "Journal of Sleep Research," as well as Army field manuals, including FM 6-22.5, "Combat Stress," and FM 22-51, "Leader's Manual for Combat Stress Control."

In experiments done at WRAIR's sleep lab, the team learned that people who functioned on minimal amounts of sleep for more than a week required more than three days to recover — that is, to function to their "standard" capacity, Belenky said.

To help commanders determine the consequences of sleep deprivation, WRAIR researchers developed a sleep watch that measures how much sleep a study subject gets and indicates how well the individual is performing and will perform in the future.

Because the amount of sleep needed varies from one individual to another, Army researchers are exploring ways to alter the watch's current one-size-fits-all presentation.

The sleep watch will be included in the Objective Force Warrior's "Scorpion" ensemble as part of the Warfighter Physiological Status Monitoring System being developed by the U.S. Army Research Institute of Environmental Medicine in Natick, Mass.

The system will give commanders and medics aggregate information on soldiers' physical readiness, such as thermal stress, hydration status and cognitive state.

Army researchers have also looked at stimulants to see if they are effective in keeping soldiers awake and able to make sound decisions.

"Stimulants can be very effective, but there's no set standard for who

NAPPIN' IS GOOD FOR YOU... GETTIN' ENOUGH SLEEP HELPS YOU MAKE SOUND DECISIONS.

During sustained operations, combat soldiers get less than four hours sleep each night for days at a time, which is considered severe sleep deprivation. The Army is working on the problem.

should take a stimulant," Belenky said. He'd like to see stimulant use and dosage targeted toward individuals, not groups, so a person gets just what he needs to perform — no more and no less.

When looking at different stimulants, it's not surprising that studies have shown caffeine is an effective aid, Noback said. For caffeine to be most effective, however, regular users need to minimize their caffeine use so that when they need it, caffeine will give them a boost.

In upcoming studies, WRAIR researchers will test caffeine, d-amphetamine and modafinil to see which of the three stimulants produces the best results. The bottom line with stimulants, Belenky said, is that they are "short-term fixes at best. The real answer is to get adequate amounts of sleep and efficiently managed sleep."

Army researchers also study sleep-inducing compounds to help circumvent the body's natural rhythm.

Though highly addictive, drugs called hypnotics do increase sleep length. However, if the user is awakened an hour or two after some drugs' peak effects, his or her judgment is impaired. If the user is a soldier, that means readiness is impaired.

The aviation community at the U.S. Army Aeromedical Research Laboratory has begun testing zaleplon, a new sleep-inducing compound, to see if its hangover effect is less than the effect of previously tested hypnotics.

"Aviators may fly strictly day missions for long periods and then suddenly be switched to night flying," Belenky said. They've reported they then have difficulty staying awake, said researcher Dr. Pat Le Duc of USAARL. "Finding a safe hypnotic is one way we can mitigate the effects of interfering with normal sleep patterns.

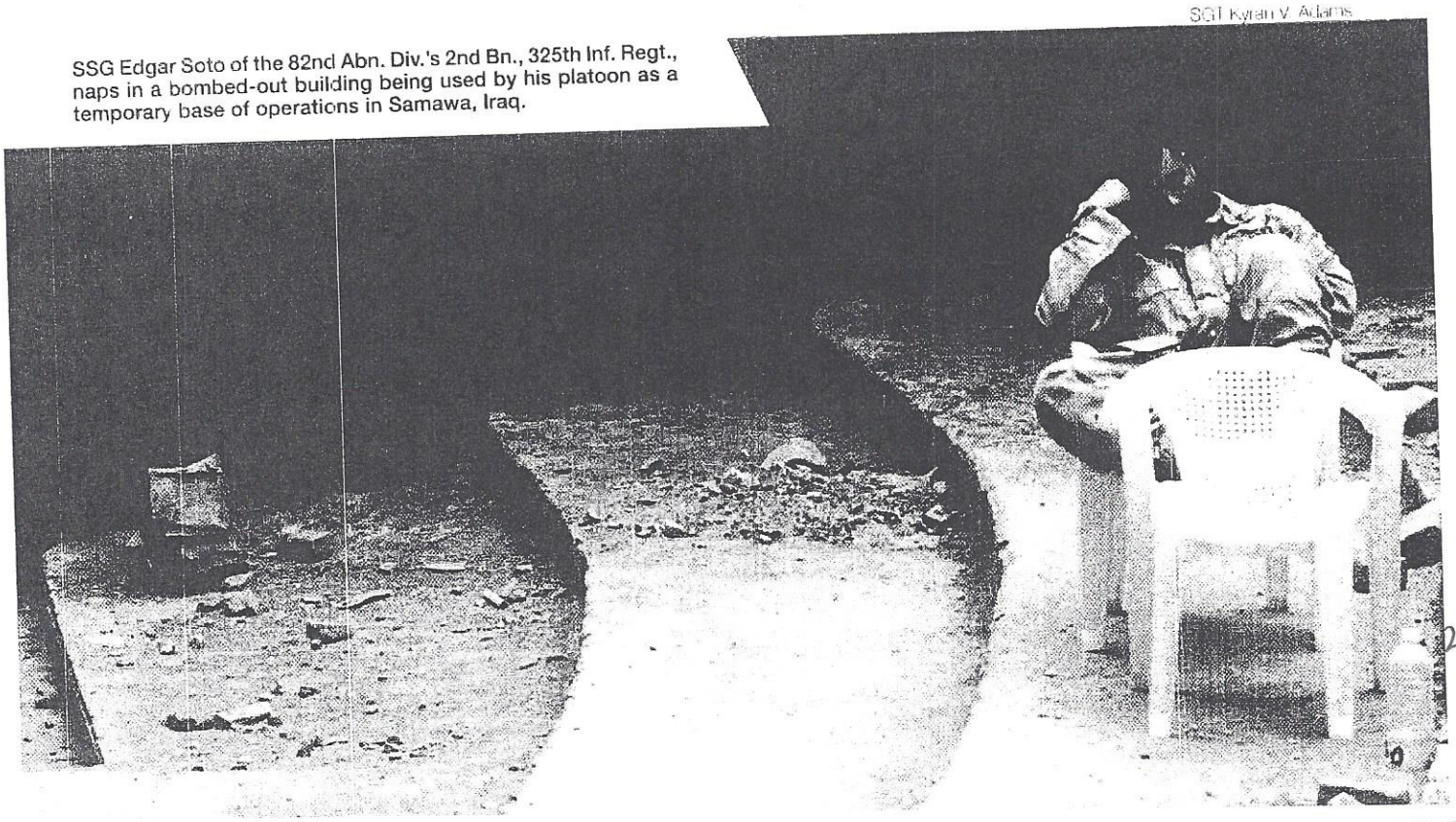
Le Duc and other researchers hope an upcoming eight-day, seven-night study of 12 aviators will provide answers as to whether a 10-milligram dose taken before an early bedtime will allow subjects to fall asleep faster and get better sleep. The team also hopes to learn if more sleep will increase alertness, lessen fatigue and offset the common declines in performance that typically occur when work begins early in the morning.

The aviators will complete cognitive tests, fly the lab's simulator, undergo sleepiness and electrophysiological evaluations, and complete questionnaires about their mood.

While waiting for answers to help determine the best stimulant or hypnotic for soldiers in combat, Belenky's advice on catching Zs is clear-cut. "Take the opportunity to sleep. Naps are wonderful," he said. He advises commanders to organize their areas so sleep can occur. "I've tried to sleep in a big tent, where every 20 minutes someone shook me awake, asking me if I was 'Smith.' It got so bad, we ended up sleeping with big signs that had our names on them so we'd be left alone," he said.

SGT Kyran V. Adams

SSG Edgar Soto of the 82nd Abn. Div.'s 2nd Bn., 325th Inf. Regt., naps in a bombed-out building being used by his platoon as a temporary base of operations in Samawa, Iraq.



A SEA CHANGE in STANDING WATCH

By Captain John Cordle, U.S. Navy, with Dr. Nita Shattuck

A new approach to shipboard routine, as seen through two distinct lenses—science and naval operations—could increase readiness with no additional investment of time or money.

Mission readiness has many components, one of which is the resilience of the human body. As a career surface warfare officer (SWO), I have spent much of my working life in a state of fatigue. Long workdays, traditional three-section watch rotations, and special evolutions often result in 18-hour days and 4 hours or less of sleep for our deployed sailors.

The Naval Safety Center cites fatigue as a contributing factor in nearly 80 percent of mishaps, and yet—unlike the aviation community, where concepts like "crew rest" are embraced—the surface warfare community has remained locked in a "sleep is a luxury" mentality, and the number of hours awake is worn as a badge of honor.

In each command tour, I committed errors on the bridge directly attributable to my own failure to recognize that I was personally fatigued to the point of impaired judgment; two memorable instances caused damage and in one case, personal injury. Both situations came very close to being career enders. But it does not have to be that way.

Here, we examine the issue of resilience, sleep, and operational readiness. To the SWOs reading this, set aside your preconceived notions and read on, because these concepts could change your life.

'Ready Around the Clock'

In a 2000 *Proceedings* article titled "Ready Around the Clock," Captain Lenny Capello told an interesting story of a guided-missile cruiser employing a "Blue and Gold" watch concept in which the crew was split in two. The day was divided into two 12-hour blocks: one block dedicated to working and standing watch, and the other for physical training (PT), sleep, and personal time. Capello's contention was that, because his crew followed a 24-hour circadian rhythm and had time to work and sleep, the ship was battle-ready around the clock, with a focused, well-rested crew.

Thinking back to my engineering and department-head tours, standing "five and dimes"—five hours on followed by ten off in a rotating sequence, and always tired—I resolved to give it a try if I got the chance. While in command of the guided-missile destroyer USS *Oscar Austin* (DDG-79), I set out to see if this concept could work on a DDG. With almost 300 sailors, a two-month deployment to the Mediterranean seemed like a perfect opportunity to try out the Blue and Gold concept. With a skeptical but supportive executive officer and some rapid planning, we set up two teams and steamed across the Atlantic.

I would love to report it was a success, but the watchbill proved very unpopular with a large portion of the crew. Those whose duties were limited to watch standing and administrative duties were actually quite pleased with it, but for the specialized technicians, especially those who stood watch, it had many negatives. They had a full workday, and if their gear broke, no one else was there to fix it. As a result, they lost sleep and became fatigued very quickly. We also failed—despite some focused efforts—to follow one of Capello's tenets of leaving the "off" crew's time inviolate. The experiment failed—in retrospect because of a lack of "depth on the bench" and failure to embrace a few out-of-the-box ideas. When we deployed a year later, it was in a more standard three- and four-section watchbill. I made a mental note that if some day I was fortunate enough to command a cruiser, I would try again with the larger crew.

Fast-Forward One Decade

Ten years later, while in command of the USS *San Jacinto* (CG-56), I did get another shot at it. With more than a year to prepare, there was time to set up a watchbill to support maximum battle readiness over an extended deployment. However, several initiatives had reduced the crew size on board to less than the one on my DDG. I had relegated the Blue and Gold idea to the back burner when my navi-

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gator, Lieutenant Ben Mattes, came back from a shipboard safety course with a slightly different idea employed by the German navy: 3 hours on, 3 off, 3 on, and 15 off. This was very unorthodox but provided the 24-hour circadian rhythm I was after. So we set up a plan to implement it during our month under way for integrated training.

One key requirement was to qualify four watch sections, since this would be needed for any stable rotation. Another was to craft a workday that accommodated this rather novel plan. Thus armed with a new ship's instruction and a plan, we embarked on our cruise. After just a few weeks, and despite an aggressive strategic-communications program, it appeared we had another failure on our hands. Although the crew liked the 15 hours off work to eat, sleep, and PT, the 3/3/3 rotation resulted in a lot of churn at turnover, and the 3-hour interim was nearly always wasted with barely enough time to eat and perhaps PT. And it was not really enough time for any restful sleep. Then it was back on watch.

In a wardroom/chief petty officer session one chief suggested we try 3 on and 9 off. We made the shift, and suddenly a few good things happened. Everyone was in a stable 24-hour day, standing the same watch every day, and 9 hours off proved to be long enough to eat, sleep, and PT during one break and work during the other. The shorter watches also allowed for better focus and less fatigue. We were on our way.

Not Business as Usual

Deployment came, and thanks to a dedicated effort, we established most of the crew in a four-section rotation with 3 on, 9 off. Some divisions, notably deck, could not support this rotation and were split into two parts, watch standers with a 6/6 rotation and day workers. The

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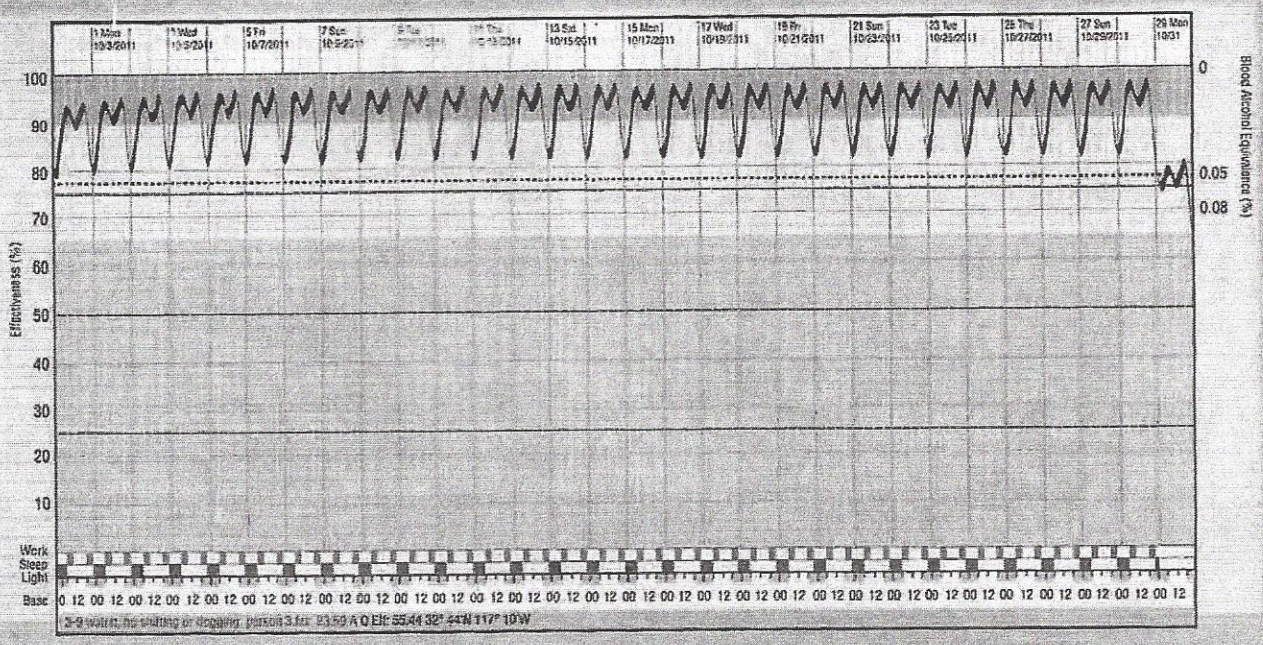
Comparing Effectiveness: 3/9 rotation vs. 4/12 rotation



This graph shows the effectiveness of watch standers on a 4-section rotation using the 3/9 schedule. Watch standers on this watch have a mean 92.56 percent predicted effectiveness while on watch. Only 5.8 percent of the time, an individual's predicted effectiveness falls below 80 percent.

6/6 watch standers still rotated with the 3/9 teams, and swapped duties every week to even out the good and bad deals for all. This was not just a watchbill but a comprehensive plan. Some allowances had to be made (some very difficult to swallow for the "old salts") for the plan to work. A few examples:

- Sleeping Hours: Those watch standers with the 00-03 and 03-06 watches were allowed to sleep in, with berthings dark from 1800 to 0900. Quarters were delayed until 1100 each day.
- Meal Hours: An early breakfast was required to support the 0600 watch relief, and a later supper to support the 15-18 watch being able to eat a warm meal
- Meetings: Collateral-duty meetings and other administrative events were restricted to the hours between 0900 and 1500. Ops/Intel and Navigation briefs were moved to the 1530 time slot to allow evening watches to sleep after supper and before watch.
- Evening Prayer: Announcements were restricted to operational issues outside of 0900 to 1500, and the chaplain provided an afternoon prayer to avoid waking up the watch standers at Taps. I even seem to recall that Reveille and Taps were no longer passed (gasp!). As stated previously, it is hard to let go of some traditions.

Tangible Benefits from Day One

So, did it work? Certainly, acceptance was not unanimous, but for the majority of watch standers, the answer was yes. First and foremost, the ability to preserve a circadian rhythm—working and sleeping the same hours each day—paid huge dividends in reducing fatigue. As the commanding officer, observing watch teams on the bridge and the combat information center (CIC) throughout the day, I noticed that my watch standers were alert and awake, even when I sat in my chair long after Taps. A few other tangible benefits came to light over time and contributed to the positive effects of this rotation.

Three-hour watches allow for better focus and eliminate the low points in a traditional 5-hour watch. This, combined with a stable rotation, resulted in significantly less fatigue. Since the teams rotate together, command and control is stable from the bridge to CIC to engineering. The ability to build stable teams and combine key personnel based on skill level and experience and have them remain the same was a tremendous tool for training junior personnel.

One of the junior sailors in engineering gave me an epiphany when he expressed satisfaction that he was no longer experiencing heat stress. The short watch in the hot spaces (the Persian Gulf in summer, for example) and triple the time outside the hot area virtually eliminated the need for "stay time" limitations and mitigated the effects of heat and humidity on engineering watch standers. After reviewing the program, the commanding officer of the Surface Warfare Officer School wrote that he had just heard a presentation on heat stress in which the instructor told the class that a watch stander had to get at least six hours of sleep at night and twice as long out of the hot space as he had spent in it to recover fully. In the email, he wrote, "I stood up [in the class] and said that this was physically impossible on a Navy warship . . . today you have proved me wrong." In fact, it is now passed on to

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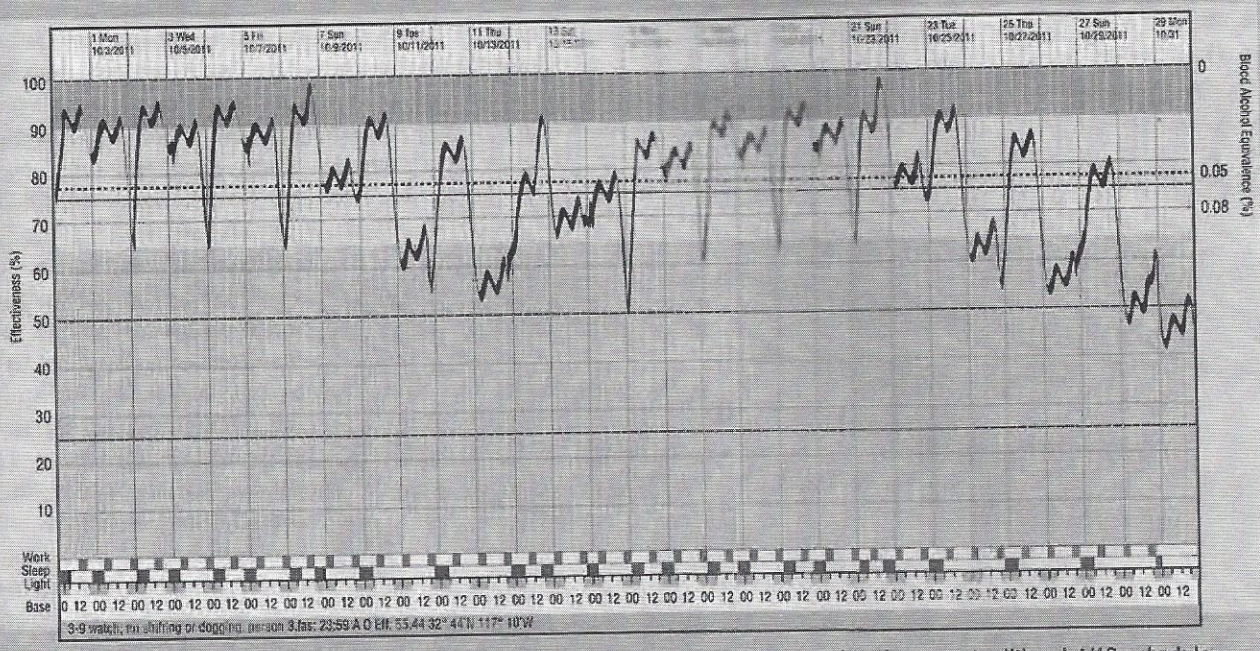


This graph shows the effectiveness of watch standers on a 4-section rotation using the more traditional 4/12 schedule. Watch standers on this watch have a mean 82.7 percent predicted effectiveness while on watch. 33.3 percent of the time, an individual's predicted effectiveness falls below 80 percent.

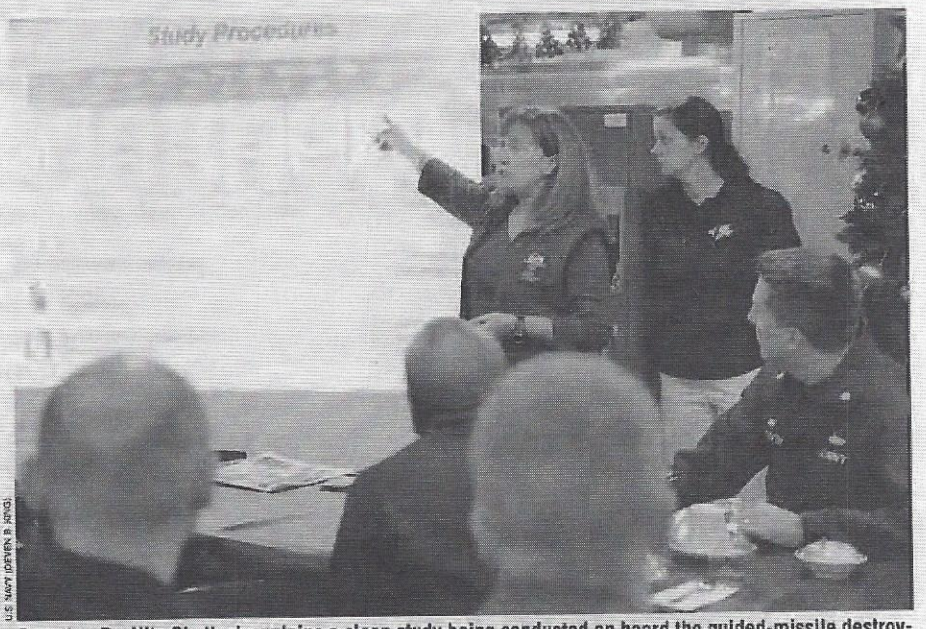
every prospective commanding officer as a best practice for consideration.

Where to Go from Here

Based on feedback from some of the crew, the safety officer submitted a message input for the annual shipboard safety award. That led to the ship's selection to receive the Secretary of the Navy award for the class. The Naval Safety Center then took the watchbill one step further and conducted an initial fatigue analysis. In a message to the Fleet, it recommended to all ships that this watchbill be considered since "initial indications are that fatigue levels are much lower than all other watch rotations."

A follow-on came when the Naval Postgraduate School studied this watchbill under the supervision of this article's coauthor, Dr. Nita Shattuck. An additional area of interest came through the Combat and Operations Stress Control (COSC) program, headed by retired Commander Leanne Braddock. Studies have shown that fatigue is a significant contributor to stress, and the COSC programs are looking for any areas that could reduce stress on the crew.

What is the bottom line? First, this approach is not just a watchbill. It is a sea change in shipboard daily routine. Some ships have adopted it in various forms. One destroyer and one cruiser report using a five-section watch-



U.S. NAVY (DEVEN R. JEYO)

Coauthor Dr. Nita Shattuck explains a sleep study being conducted on board the guided-missile destroyer USS *Jason Dunham* on 3 December 2012 in the Arabian Sea. Shattuck supervised a study of the watchbill implemented by Captain Cordle on board the USS *San Jacinto*, and together with Commander Leanne Braddock, head of the Combat and Operations Stress Control (COSC) program, concluded that because "fatigue is a significant contributor to stress," such programs "are looking for any areas that could reduce stress on the crew."

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bill, rotated once a week, that also maintains a circadian rhythm.

This concept does not come without cost. It requires "breaking some china" (rethinking when you conduct quarters, evening prayer, messing and berthing, meetings, etc.). And not everyone will like it. Not all divisions on all ships will be able to achieve a four-section watch rotation. It requires time and dedicated planning. More frequent watch turnover could create inefficiencies if this process is not refined a bit. But the core benefits to a shipboard routine that acknowledges the needs of the human body to maintain a circadian rhythm and a command climate that recognizes the benefits of stress mitigation should not be ignored. Dr. Shattuck advances the following thoughts.

U.S. NAVY (Jennifer B. Kitson)

Gas Turbine System Technician (Electrical) Second Class Jannet Cain checks out a smart phone as part of the Naval Postgraduate School sleep study on board the *Jason Dunham*. The study is being conducted by school researchers on approximately 120 sailors working various watch-standing schedules in an operational environment. The 24-hour circadian watchbill promises large mental-health dividends, a payoff that costs—nothing.

The Importance of Sleep

For hundreds of years, sleep was a mysterious process that was poorly understood and often undervalued. However, over the past three to four decades, scientists have made great strides in uncovering the vital role of sleep in our everyday lives, including its impact on our health, ability to learn and retain information, alertness, judgment, mood, and performance on even the most mundane tasks such as driving a car. The civilian world has acknowledged the critical importance of sleep in safe driving, going so far as to equate hours of wakefulness with alcohol intoxication. In 2003, Maggie's Law was passed in New Jersey, criminalizing accidents resulting in death because of "drowsy driving" and making it equivalent to drunk driving. Drowsy-driving bills are being considered by several other states in an attempt to address this all-too-common cause of deadly accidents.

While scientific research continues to reveal our crucial requirement for sleep to live healthy lives, opposing forces push us to sleep less. Pressure to stay connected through social media and omnipresent technology runs counter to our need for getting adequate amounts of sleep. Add to that the pressures of top-down requirements to be "more efficient" and "do more with less" and you create the environment in which the military currently operates. Despite the strides made in our understanding of the effects of sleep on performance, the U.S. military has continued to ignore problems related to sleep and fatigue.

For the past 12 years, Naval Postgraduate School's Operations Research Department has studied sleep and fatigue in operational environments. Together with our active-duty graduate students, we have collected data on the sleep and work patterns of military service members in a wide variety of contexts—including a detailed look at crew members on board various surface ships and submarines. The results present a compelling and concerning picture. U.S. Navy sailors are chronically sleep-deprived, often working in dangerously fatigued states to accomplish missions that demand the highest levels of vigilance and are critical to our nation's defense.

We use the officially sanctioned Department of Defense model for fatigue avoidance, the Sleep, Activity, Fatigue, and Task Effectiveness (SAFTE) model and the Fatigue Avoidance Scheduling Tool (FAST) to predict fatigue and alertness levels based on sleep patterns. By analyzing various watch rotations from Navy ships using the FAST program, individual watch-stander performance can be predicted. Wrist-worn activity monitors, or "sleep watches," are used to record actual sleep and work patterns of warfighters.

These methods have been combined with the results from a survey of Captain Cordle's *San Jacinto* crew following their implementation of a 3/9 watchstanding schedule. The result was an alternative 3/9 watchstanding schedule that helps maintain alertness and reduce fatigue in Navy crews. We continue to evaluate these circadian-based (24-

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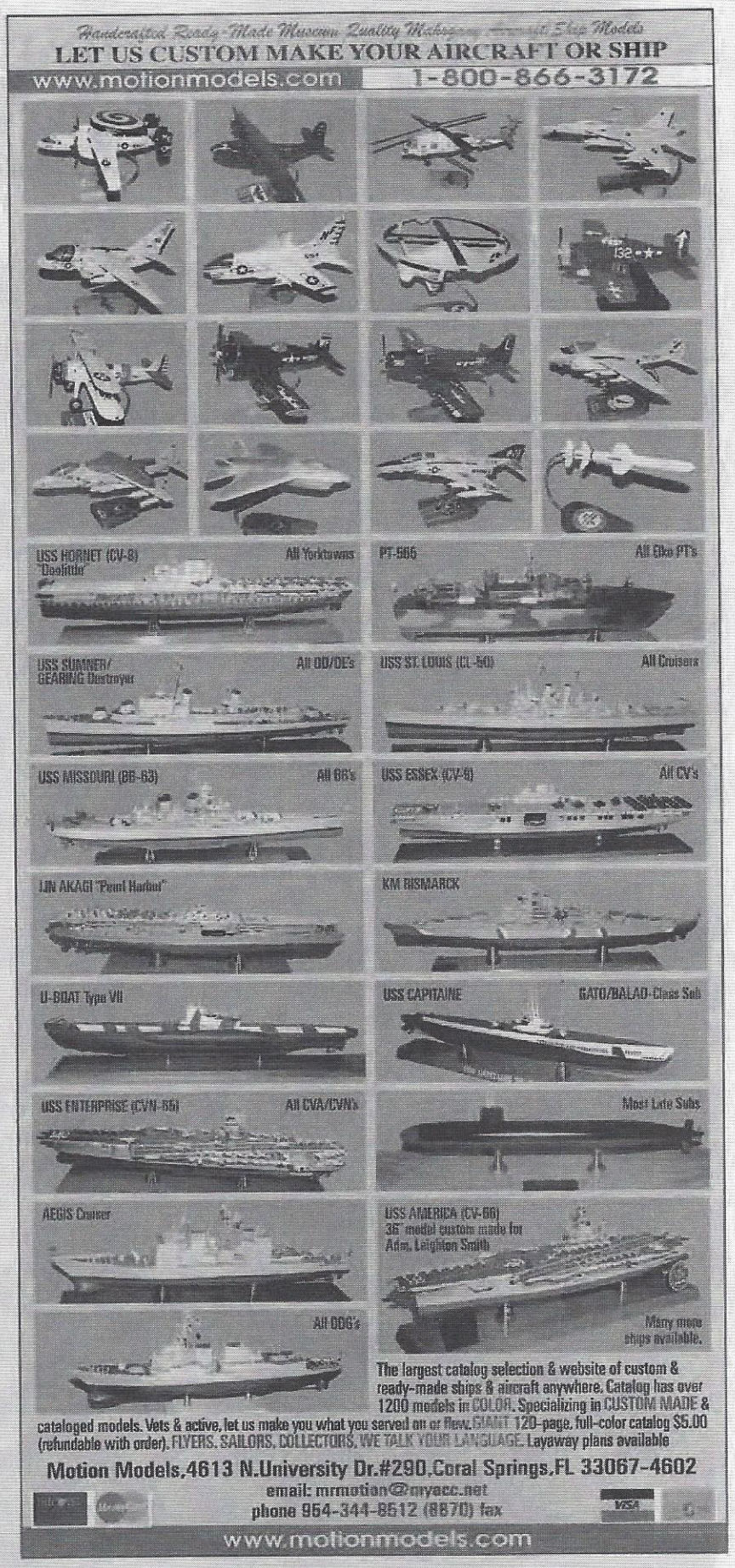
hour) watchbills to determine their operational feasibility and effectiveness in addressing fatigue-management issues. A recent postgraduate study by Lieutenant Donald Roberts contains a detailed analysis of the watch rotation and a Commander's Guide for implementation, which can be accessed at http://hdl.handle.net/10945/6861. Follow-on studies on the USS *Jason Dunham* (DDG-109) are currently being conducted by postgraduate school researchers on approximately 120 sailors working various watch standing schedules in an operational environment.

A typical Navy ship may lose approximately 5 percent of her crew each year to some version of a stress-related issue, often associated with—or exacerbated by—fatigue. The Navy has only recently started to embrace the Operational Stress Control Program, implementing it across all commands and into the training pipeline. The Navy website (www.navynavstress.com) has many tools that can be used by leaders to improve resilience, the sailor's ability to prepare for and deal with stressful situations and perform his duties. Though not expensive, this process is a significant investment in time and effort, but I am convinced that it will benefit our sailors significantly, and it is clearly within the authority of the commanding officer to decide whether to use all or part of the idea. But the facts speak for themselves: The circadian watchbill has the potential for a large and immediate return with no initial investment. How many programs can boast that?

Captain Cordle is chief of staff for Commander, Naval Surface Forces Atlantic. He was the recipient of the 2010 Navy League John Paul Jones Award for Innovative Leadership and the 2010 Bureau of Medicine Epictetus Award for Innovative Leadership, recognizing his efforts in reducing shipboard fatigue.

Dr. Shattuck is a member of the Operations Research Department at the Naval Postgraduate School in Monterey, California, where she teaches human factors and human-systems integration. She has studied human performance and fatigue in operational environments for much of her career with the Department of Defense.



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CHAPTER 20

The Role of Sleep in the Military

Implications for Training and Operational Effectiveness

Nita Lewis Miller, Panagiotis Matsangas, *and* Aileen Kenney

Abstract

This chapter addresses the role of sleep in a variety of military settings, ranging from military education and training regimes and extending to military missions and combat operations. It begins with a broad overview of the scientific literature related to sleep and performance. It then describes a ten-year series of studies conducted at the Naval Postgraduate School that addresses fatigue and sleep restriction in military settings. These studies include a series of efforts examining sleep patterns of sailors aboard U.S. Navy warships and submarines; studies that focus on shifting the timing of sleep during training and educational programs for Navy recruits at Great Lakes, Illinois and Army basic combat trainees at Fort Leonard Wood, Missouri; a four-year longitudinal study describing the sleep in cadets at the United States Military Academy in West Point, New York; and studies of sleep in operational environments, including surveys of warfighters while deployed and recently returned from combat in Southwest Asia. Many of these studies are reviewed in the chapter, which concludes with recommendations advocating the inclusion of sleep as a factor when calculating military effectiveness.

Keywords: Sleep restriction, sleep deprivation, human performance, fatigue, military operations, military training, military education

Military operations span a wide spectrum ranging from basic military training and education, through military operations other than war (MOOTW), to war itself. By their very nature, military operations are conducted under tremendously stressful conditions. Individuals in military settings are under pressure to continue to conduct operations when quality sleep may be a rare commodity—and sometimes, they are asked to perform without any sleep at all. Their duties expose them to life-and-death situations in environmentally hostile conditions that may even include facing enemy combatants. While the impact of fatigue is not restricted to the military, the combined effects of a multitude of acute and chronic stressors—including severe sleep restriction—make the military population both unique and relevant to study when exploring the range and limits of human performance.

An Overview of Sleep

This first section of the chapter provides the rationale and scientific justification for the entirety of the program of research that follows. It begins with a discussion of circadian rhythms and the requirement for sleep in humans. It then provides a short tutorial on sleep architecture that describes the function and purpose of various stages of sleep. This introductory sleep overview concludes with a summary of the effects of restricted sleep on various kinds of human performance.

Circadian Rhythms and Requirements for Sleep in Humans

Human alertness waxes and wanes in a highly predictable manner over the course of a 24-hour day. Known as the circadian cycle (*circa* = about, *dies* = day), this pattern occurs naturally and is

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represented in a diurnal pattern of sleep and wakefulness. Many other physiological parameters are aligned with this same circadian rhythm. For example, core body temperature and hormones such as melatonin, cortisol, human growth hormone (HGH), and the more recently discovered hormones leptin and ghrelin, are known to have circadian patterns of release and action. Together, these hormones have a huge impact on human performance, mediating sleep and wakefulness as well as growth and cellular repair, hunger, and satiation. Although science discovers more every day about the contributions of these hormones, it is evident from our current knowledge that they are vital to our physical and mental health and well-being.

In his autobiographical account of the first nonstop, trans-Atlantic flight, Charles Lindbergh (1953) wrote:

> My mind clicks on and off. . . . I try letting one eyelid close at a time while I prop the other open with my will, but the effort is too much. Sleep is winning. My whole body argues dully that nothing—nothing that life can attain, is quite so desirable as sleep. My mind is losing resolution and control.

Despite efforts to refrain from sleeping, our bodies require it just as we require food and water. As humans, approximately a third of our life is spent asleep. For the most part, humans have adapted to the standard 24-hour day, although research conducted in temporal isolation facilities shows that without light or other cues such as exposure to light, mealtimes, and daytime sounds, many humans have an innate 24.5 to 25.0 hours clock (Horne, 1988). Horne (1988) defines sleep as "the rest and recovery from the wear and tear of wakefulness." Sleep and sleep deprivation have been studied for decades—yet sleep remains a mysterious, but vital, requirement for life to be sustained. If deprived of sleep for longer than 14 days, humans will die (Coren, 1997).

There is almost universal acknowledgement that healthy adult humans require approximately eight hours of sleep each night for full cognitive functioning (Anch et al., 1988). However, it is also recognized that there is considerable variability among individuals, with some requiring more and some less than eight hours of sleep per night (Van Dongen & Dinges, 2000). Not only are there differences between individuals in sleep requirements, but there are also fairly predictable changes in sleep patterns that occur within an individual over the course of a lifetime. Figure 20.1 illustrates the changes in sleep patterns that are seen over a typical lifespan.

As can be seen, newborn infants have highly disrupted sleep patterns and generally get little contiguous sleep. To the great relief of their parents, most infants are sleeping through the night by the time they reach one year of age. Napping, a practice common in babies and young children, tends to disappear as children reach elementary school age. In adolescents and young adults through the

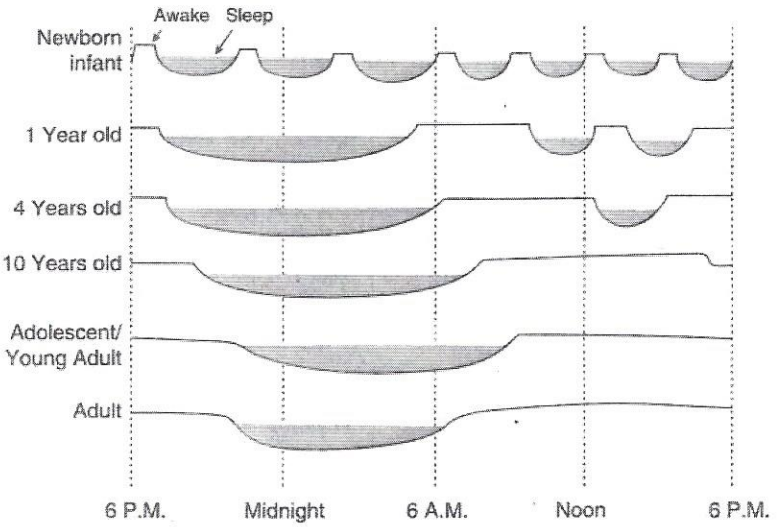

Fig. 20.1. Sleep patterns over a typical lifespan (Miller, Matsangas, & Shattuck, 2008).

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mid-20s, there is another interesting shift in sleep patterns. This age group actually requires approximately 0.50 to 1.25 hours more sleep per night than do their adult counterparts. Coinciding with the pattern of melatonin release in this age group, bedtime is delayed, with even later awakenings (Carskadon, 2002; Carskadon et al., 1995; Wolfson & Carskadon, 1998, 2003). This change is important for the discussion of sleep in the military since many military service members, especially junior enlisted and junior officer personnel, are still in this adolescent and young adult sleep category and consequently require from 8.50 to 9.25 hours of sleep per night (Miller & Shattuck, 2005). By the time individuals reach their mid-20s—and continuing through their middle-age years—sleep requirements are fairly stable, at around eight hours per night.

Sleep Architecture in Humans

At one time, it was thought that nothing happened in the brain during sleep. However, it is now known that there are times in which the sleeping brain is more active than during its waking state. While asleep, it is impossible to monitor our own behavior. Consequently, over the years, scientists have developed various techniques (e.g., polysomnography, or PSG) to gain insight into the activities of the sleeping brain. This technique includes measuring the electrical activity at the surface of the brain using electroencephalographic (EEG) electrodes placed on the scalp (Kryger, Roth, & Dement, 2000). During PSG procedures, electrodes also capture the respiratory patterns and muscle activity that occur during sleep.

Recordings show that over the course of a typical eight-hour sleep period, the human brain experiences two broad categories of sleep: non-rapid eye movement (NREM) and rapid eye movement (REM). These two sleep categories have different functions and are characterized by distinctive behaviors. NREM sleep can be further divided into five sleep stages: Stage 0 (the awake state) and four progressively deeper sleep stages (Stage 1 through Stage 4). Typical sleep stages over the course of a night's sleep are illustrated in Figure 20.2.

As shown in Figure 20.2, all of these sleep stages are generally experienced over a single sleep cycle that lasts approximately 90 minutes. Research has demonstrated that much of the first half of an eight-hour, contiguous night of sleep is spent in deeper sleep (Stages 3 and 4), while Stages 1 and 2 and REM sleep are more prevalent in the latter half of an eight-hour sleep period.

Both REM and NREM sleep are necessary for normal functioning in humans. In a sleep laboratory, humans can be deprived of a single stage of sleep, known as partial sleep deprivation or PSD. When the sleep-deprived individual is allowed to sleep following PSD, the body tends to rebound into the sleep stage from which it was deprived, in an attempt to make up for the lost sleep. Total sleep deprivation, or TSD, is when the research participant is not allowed to sleep at all. When allowed to sleep after experiencing TSD, the body rebounds by rapidly entering deep stages of sleep that render the brain almost unconscious, reminiscent of brain activity under anesthesia. When sleepers are awakened from deep sleep stages, they frequently

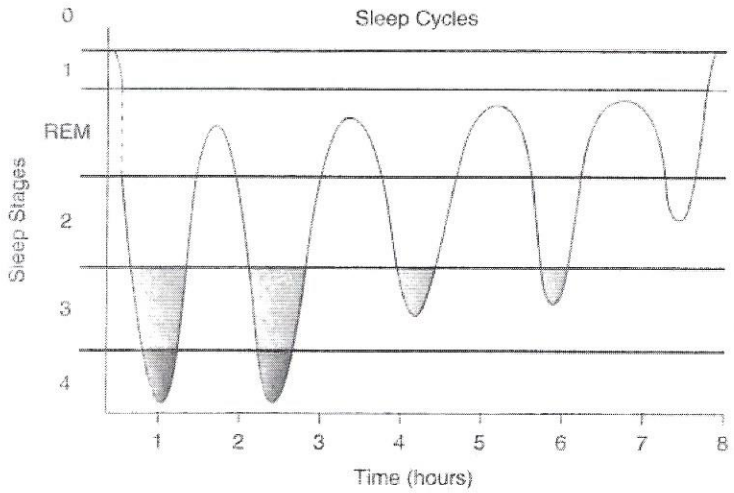

Fig. 20.2 Sleep stages over a typical eight-hour sleep period (Miller et al., 2008).

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experience sleep inertia, characterized by reduced alertness and cognitive functioning. While sleep inertia is a normal occurrence upon awakening from a normal night's sleep, it may last much longer when a sleeper is awakened from deep stages of sleep. In operational environments where humans are deprived of adequate amounts of deep sleep, both conditions—the rebound into deeper sleep stages and the resultant sleep inertia when awakened from deep sleep—pose significant risks to the military members and those who rely on them to make good decisions and perform effectively under time pressure.

The Effects of Sleep Deprivation on Human Performance

The scientific literature clearly shows that sleep has a dramatic effect on human performance in laboratory settings. Countless studies have identified the deleterious effect of sleep deprivation on a wide range of human cognitive functions such as attention, memory, mood, and decision making (Broughton & Ogilvie, 1992; Dinges & Kribbs, 1991; Dinges et al., 1997). These studies are well-controlled trials that provide convincing results of changes that occur with sleep restriction—in the laboratory. However, in the military and other related professions, there is often a reluctance to accept such laboratory findings, coupled with the assertion that motivation and determination will allow individuals to perform in real-world environments despite fatigue and lack of sleep (Shay, 1998). Sleep debt seems ubiquitous in the military, despite policies that emphasize the importance of sleep and fatigue-management for the operational readiness of units deployed to combat environments (Department of the Army, 2009; Department of the Navy, 2007). As history has taught us, lapses in attention and poor decisions made by members of our armed forces can have serious and far-reaching consequences. It is for these reasons that research must extend into naturalistic environments to observe the consequences of chronic and acute sleep deprivation during actual operations and to challenge the notion that these individuals are immune from performance decrements due to sleep loss.

Sleep Studies in Operational Environments at the Naval Postgraduate School

The United States military has long been interested in human performance in operational environments. It is not surprising that many studies conducted in the Operations Research Department at the Naval Postgraduate School (NPS) focus on such issues. Over the past decade beginning in 2002, a group of NPS faculty and graduate students has been actively studying human performance as it relates to sleep in operational settings. Tables 20.1 through 20.3 list many of these operational studies and thesis efforts, the name of the primary investigator (often an NPS graduate student), the date the thesis or report was published, the focus of the investigation, and a summary of its findings with respect to sleep. The remainder of this chapter is divided into three sections according to these tables: "Sleep in Naval Operations," "Sleep in Training and Educational Environments," and "Sleep in Combat and Operational Environments." Many of the findings from these studies are reviewed in the three sections that follow. The chapter then concludes with a discussion of the overall findings from these studies of sleep in military settings.

Studies on U.S. Navy Submarines

This program of operational research began with two studies that examined self-reported sleep patterns of U.S. Navy submariners by Blassingame and Gamboa. In her thesis, Blassingame (2001) evaluated whether differences existed in the self-reported sleep of U.S. Navy submariners in four different operational environments: (1) at sea, (2) in port, (3) on shore duty, and (4) on leave. The analysis was based on survey data of U.S. Navy enlisted submariners ($n = 143$) with at least one year of experience on Fleet Ballistic Missile Submarine (SSBN) or on Fast Attack Submarine (SSN) platforms. Surveys were administered either to sailors assigned to the USS *Providence* ($n = 93$) or a convenience sample of submariners receiving care at the Naval Ambulatory Care Center (NACC) in Groton, Connecticut ($n = 74$) who had served aboard SSBN or SSN platforms. Survey respondents were asked to indicate the number of hours they slept and the longest uninterrupted sleep they received in a typical 24-hour period for each of the four operational conditions. The results of the study (see Figure 20.3) showed that there are significant differences in the reported quality and quantity of sleep between the four operational conditions. Submariners reported getting less sleep (about six hours per night) while "at sea" than in any of the other three conditions.

In another survey of U.S. Navy submariners, Gamboa (2002) focused on environmental constraints and time in service as factors related to sleep and fatigue. His analysis was based on survey responses from 258 submariners, which combined the 143 respondents from Blassingame's thesis with

Table 20.1 NPS Sleep studies in naval operation

Naval Vessel	Mission (Length of Study)	Participants	Method of Collecting Sleep Data	Gender	Average Da Sleep in Ho (+stdev)
USS PROVIDENCE and other SSN or SSBN: Blassingame (2001)	NA	167 submariners	Survey	NA	Self-report - (while at sea (NA)
USS PROVIDENCE, USS CONNECTICUT, and other SSN or SSBN: Gamboa (2002)	NA	258 submariners	NA	NA	NA
USS STENNIS (CVN): Nguyen (2002)	Operation Enduring Freedom NAO (3 days)	33 enlisted sailors	Actigraphy and sleep logs (n = 28)	22 males 6 females 5 NA	6.28 (NA)
USS STENNIS (CVN): Sawyer (2004)	Operation Enduring Freedom (7 days)	24 crewmembers	Profile of Mood States (POMS) administration	19 males 5 females	NA
USS HENRY M. JACKSON: Osborn (2004)	At sea trials (32 days)	41 submariners	Actigraphy and sleep logs (n = 29)	Males	6.67 (+2.56)
HSV-2 SWIFT: McCauley, Matsangas, and Miller (2004)	Transiting and conducting sea-keeping trials (13 days)	19 total; 1 officer 16 enlisted 2 civilians	Sleep logs (mainly) and actigraphy	18 males 1 female	7.5 (+2.13)
HSV-2 SWIFT: Archibald (2005)	GOMEX 05–1 MIW (8 days)	21 total; 3 officers 18 enlisted	Actigraphy and sleep logs (n = 21)	19 males 2 females	6.78 (+1.5)
USS CHUNG HOON (DDG): Haynes (2007)	Predeployment training (14 days)	25 total; 2 officers 23 enlisted	Actigraphy (n = 22) and sleep logs (n = 25)	NA	7.27 (+1.03)
USS LAKE ERIE and USS PORT ROYAL (CG): Mason (2008), and unpublished data	RIMPAC Exercise 2008 (24 days)	70	Actigraphy and sleep logs (n = 70)	NA	5.58 (+1.92)
USS RENTZ: Green (2009)	Predeployment workups (24 days)	24 total, 3 officers 21 enlisted	Actigraphy and sleep logs (n = 24)	males	6.71 (NA)
Sleep on Motion-Based Platform: Grow & Sullivan, (2009)	Laboratory experiment (2 nights of sleep)	12 NPS graduate students	Actigraphy and sleep logs (n = 12)	11 males 1 female	NA

additional survey data obtained onboard the USS *Connecticut* (SSN 22), a Seawolf-class attack submarine. The purpose of this research was twofold: (1) to determine whether the shift in working environment from shore duty to sea duty had an effect on enlisted submariner sleep patterns; and (2) to assess whether length of time in service was related self-reported optimal sleep duration. As v Blassingame's study, Gamboa verified that subm ners reported shorter and more disrupted sl patterns while underway. Rank, time in service, time, and self-reported optimal sleep durat

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Table 20.2 NPS Sleep studies in training and educational environments

Unit or Program	Mission (Length of Study)	Participants	Method of Collecting Sleep Data	Gender	Average Daily Sleep in Hours (±stdev)
USN Enlisted training at RTC, Great Lakes: Baldus (2002)	Enlisted training (~63 days)	31 USN recruits	Actigraphy and sleep logs (n = 31)	20 males 11 females	6.1(±1.2)
USN Enlisted training at RTC, Great Lakes: Andrews (2004)	Academic performance (3 years of test scores)	2,597 USN recruits	Test scores retrospective analysis; no sleep data	NA	NA
United States Military Academy, West Point, 4-Year Longitudinal Study of Sleep in Cadets: Kenney and Neverosky, 2003; Miller, 2005; Godfrey, 2006; DeVany, 2008; Miller and Shattuck (2005); Miller et al. (2010)	Military undergraduate university (4 years of data, 2 months per year)	~1,400 (80 cadets selected for actigraphic recording)	Actigraphy and sleep logs (n = 80) Surveys (n = ~1,400)	56 males 24 females	5.60 (+1.49)
USN Officer Candidate School, Newport, RI: O'Connor and Patillo (2003)	Officer training and indoctrination (6 days)	20 faculty and students	Actigraphy and sleep logs (n = 20)	NA	NA
MAWTS-1: Maynard (2008)	Flight training WTI 2–05 (43 days)	13 total, students (n = 6) instructors (n = 7)	Actigraphy and sleep logs (n = 13)	NA	Students: 5.62 Instructors: 6.10
	Flight training school WTI 1–06 (44 days)	20 students	Actigraphy and sleep logs (n = 20)	males	7.05 (±0.74)
Fort Leonard Wood: Miller et al. (2010)	Basic combat training (63 days per unit)	394 recruits and cadre	Actigraphy and sleep logs (n = 94 recruits)	59 males 35 females	Intervention: 5.89 (±1.21) Control: 5.33 (±1.18)

were also associated with the respondents' sleep patterns.

One of the more interesting findings of the Gamboa thesis was that more experienced submariners reported needing *fewer* hours of sleep at sea, compared to the amount they needed while on shore duty. It was as if the more experienced submariners knew that they were not going to be able to get adequate sleep while at sea, so they reported needing less sleep in this condition. One explanation for this finding could be that submariners who are more susceptible to sleep deprivation are more likely to drop out of the service or find other branches of military service more to their liking, and the remaining service members were a self-selected group who required less overall sleep to function. Another possible explanation offered was cognitive-dissonance-reduction theory, which holds that an individual will attempt to remedy a perceived dissonance or disconnection between two or more conflicting beliefs. According to Gamboa, these sleep-deprived submariners reported needing less sleep while at sea to reduce the perceived dissonance between the environment (that of continual sleep deprivation) and the knowledge that they need a certain amount of sleep to function optimally. While the individual's actual sleep requirement did not change between at-sea and in-port conditions,

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Table 20.3 NPS Sleep studies in combat and operational operations

Unit or Context	Mission (Length of Study)	Participants	Method of Collecting Sleep Data	Gender	Average Daily Sleep in Hours (+stdev)
Warfighters in Iraq and Kuwait: Doheney (2004)	Operation Iraqi Freedom (OIF) Phase IV (NA)	273 total: 244 enlisted 22 officers	surveys	237 males 24 females 12 NA	Self-report 6.67 (NA)
USMC Rotary Wing Aviation Battalion in Iraq: (unpublished data, 2006)	Rotary wing flight operations in Iraq (10 days)	20 pilots	actigraphy and sleep logs (n = 20)	NA	6.5 (±1.66)
Naval Aviation MH-53 (Rotary Wing) squadron: Solberg (2006)	Mine hunting operations (14 days)	25 aircrew	actigraphy and sleep logs (n = 25)	20 males 2 females 3 NA	7.47 (±1.65)
Fort Benning Survey: Miller et al. (2010)	Infantry officers returning from Iraq/ Afghanistan (NA)	46 infantry officers	surveys	Males	Self report by OPTEMPO: Low: 7.8 (NA) Moderate: 6.0 (NA) High: 3.9 (NA)

NPS Studies in Fatigue in Naval Operations (from Table 20.1)

experienced submariners reported needing less sleep while at sea because they have learned that it will be impossible to get adequate sleep while at sea.

A third NPS study on U.S. Navy submariners was conducted by Osborn (2004) as part of a project sponsored by the Naval Submarine Medical Research Laboratory (NSMRL) in Groton, Connecticut. The purpose of the study was to evaluate the feasibility of a new watchstanding schedule that would be more in line with naturally occurring circadian

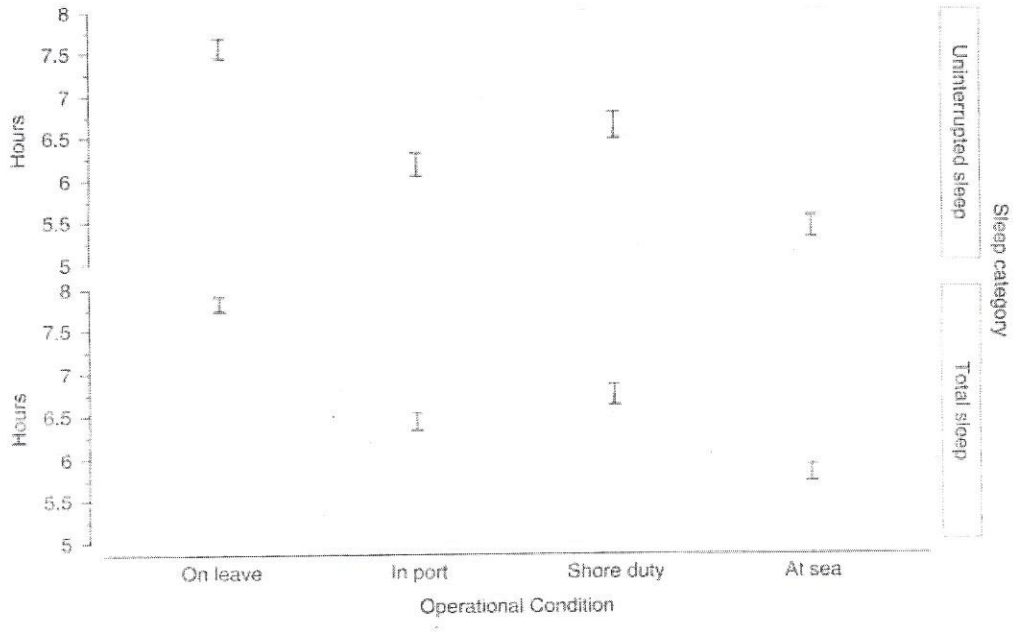

Fig. 20.3 Daily sleep ("Total sleep") and longest uninterrupted sleep episode per 24 hours ("Uninterrupted sleep") (Blasingame, 2001).

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rhythms. The study was conducted between October 29 and December 2, 2003, onboard the USS *Henry M. Jackson* (SSBN 730 GOLD), a nuclear-powered, ballistic missile submarine. Data on 41 male volunteers (average age 25.6 years) were collected for 32 days and included exit surveys to elicit feedback from the crew and objective measures of sleep using wrist-worn activity monitors. Crewmembers were divided into three groups, each one following a different watchstanding schedule (two experimental groups, Schedules 1 and 2, and one control group, Schedule 3). The control group worked the 18-hour, three-section watch schedule currently in use in the U.S. submarine fleet (Stolgitis, 1969). The two experimental (alternative) schedules attempted to more closely simulate a 24-hour cycle (Miller et al., 2003). Results showed that the participants received, on average, 6.67 hours of daily sleep while underway. Analysis showed that Schedule 1 participants received the least amount of sleep. The participants on Schedule 2 received slightly more sleep, while Schedule 3 provided the most sleep in this study. The conclusion: the new schedules failed to provide a significant improvement in daily sleep.

The new schedule attempted to compress watch periods more closely together to extend the opportunity for contiguous sleep. However, since little additional work was completed during the compressed watch periods, unfinished work was carried over into the period set aside for sleep, defeating the intention of the 24-hour schedule. Although laboratory studies had indicated otherwise, when tested in an operational environment, the new schedule was not better than the old 18-hour schedule due to the operational requirements on a submarine. The study did highlight the need for a watchstanding schedule that allows for better sleep hygiene, along with more time to complete required work.

Studies on Surface Ships

Ongoing efforts in support of Operation Enduring Freedom (OEF) gave NPS researchers the opportunity to conduct a study on the effects of shift-work and high operational tempo onboard the aircraft carrier USS *John C. Stennis* (CVN-74) (Miller & Nguyen, 2003; Nguyen, 2002). Before the data collection period, the aircraft carrier had shifted from day to night operations, with the entire crew working the night shift to support nighttime flight operations. Participants in the study were 28 enlisted crew members (22 males and 6 females). Sleep data were collected using wrist-worn activity monitors and sleep logs for 72 hours, while the carrier conducted routine combat operations. The study concluded that significant differences in the quality and quantity of sleep were determined by where the sailors worked. A pattern of sleep deprivation was particularly evident in the individuals who were working topside and were exposed to bright morning sun immediately prior to bedtime. The results, displayed in Figure 20.4, show that individuals who worked belowdecks (and never saw daylight) received 7.35 hours of sleep, while the sailors who worked topside averaged only 4.72 hours of sleep per day ($t = 6.19$, $p < 0.001$).

A follow-on study by Sawyer (2004), also conducted aboard the USS *Stennis*, examined the same participants in the Nguyen (2002) study. This study was a self-reported assessment of the mood state of sailors who were required to abruptly change their work and rest habits. Mood states were assessed using the Profile of Mood States (POMS), a standardized, 65 question five-point adjective rating scale that measures six affective states: Tension-Anxiety, Depression-Dejection, Anger-Hostility, Vigor-Activity, Fatigue-Inertia, and Confusion-Bewilderment (McNair, Lorr, & Droppleman, 1992).

Mood states were monitored at three time points: when sailors had been working the night shift for over 90 days, then 24 hours after shifting from working nights to working the day shift, and again one week following the shift to working during daylight hours. The results showed that younger participants were angrier than older participants while on nightshift work (Figure 20.5). This finding

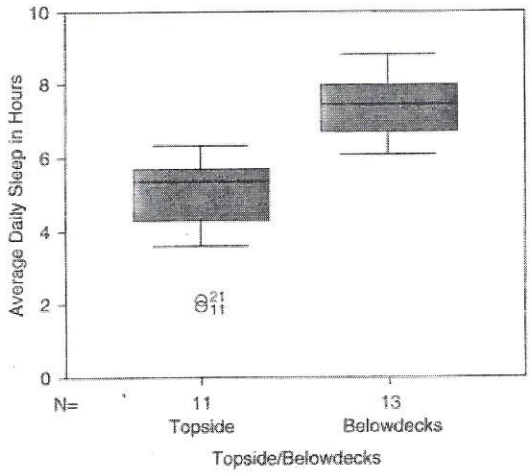

Fig. 20.4 Average daily sleep in hours by working environment on the USS *Stennis*.

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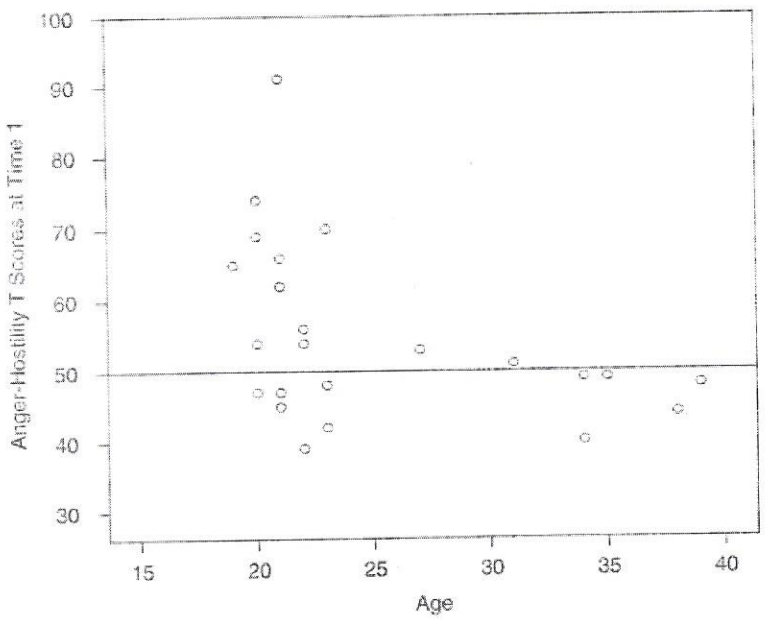

Fig. 20.5 Anger-Hostility T scores versus age while working night shift (Time 1). T scores above 50 indicate greater than normal anger-hostility.

is particularly interesting considering the additional sleep required for adolescent and young adult populations and serves as a possible explanation for the differences observed.

There was also a significant interaction between mood state and sex, with female participants reporting significantly higher scores on total mood disturbance (TMD) than the male participants. The scores for TMD of males dropped one week after shifting to daytime work, indicating an improvement in overall mood; this pattern was reversed in females. This finding was statistically significant, although the sample size of the females was small ($n = 6$). These findings are seen in Figure 20.6, which follows.

In addition, participants working topside received significantly less sleep than those working belowdecks, and their POMS scores reflected their fatigued state (Figure 20.7). The study provided vital information to the U.S. Navy's surface warfare community concerning the operational impact of mood states and performance caused by extended working hours, disruptive sleep, and reversal of sleep and work cycles.

Studies on the High-Speed Vessel HSV-2 Swift

The next pair of NPS operational sleep projects was conducted on the high-speed vessel HSV-2 *Swift*, a 98-meter, wave-piercing catamaran. The main thrust of this research was to address the possible effects on personnel performance when sailors operate aboard high-speed vessels with unconventional hull designs. The first study evaluated the effect of ship motion on sleep amount and quality, sleepiness, and predicted effectiveness (Matsangas & Miller, 2006; McCauley, Matsangas, & Miller, 2005). Data were collected during a 14-day transit while the ship traveled from Norway to Norfolk (May 10–May 23, 2004) and executed sea-keeping trials (May 11–May 17, 2004). Nineteen crewmembers participated in the study, during which sleep was assessed through actigraphy and activity logs. During the data collection period, the ship encountered sea states between 4 and 5.

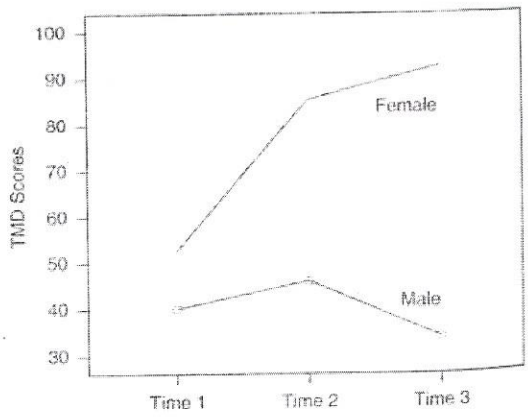

Fig. 20.6 Total Mood Disturbance (TMD) scores of participants working belowdecks, over time, by gender.

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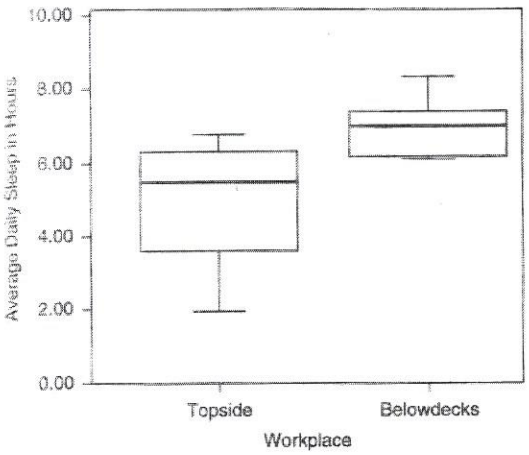

Fig. 20.7 Average daily sleep by work environment (sailors working topside versus those working belowdecks).

Wave heights were significant, generally in the eight- to ten-foot range; average wave period was in the eight- to 12-second range, and the ship's speed varied from 10 to 36 knots, resulting in considerable motion for the sailors onboard. The motion states were quite severe at times, interfering with the wrist-worn activity monitors and resulting in an underestimation of the sleep received by the crew. Because of this complication, sleep amount and quality were determined from activity logs combined with bedtime start and stop times from the actigraphic recordings. This method of calculating sleep gave an overestimation of sleep, but given the severity of the ship's motion, it was the only solution deemed reasonable.

Whether assessed by self-report or by wrist activity monitors (WAMs), it was evident that the crewmembers' sleep was interrupted by ship motion. This finding was echoed in the comments in the underway sleep logs, which indicated increased sleep fragmentation during the rough sea trials period (May 11–17). Thirty percent of the crew noted that sleep disruptions due to ship motion were common on the HSV-2 and identified ship motion as a significant cause of nighttime awakenings.

Building on the previous study on the HSV-2, Archibald (2005) examined the effects of noise, temperature, humidity, motion, and light on the sleep patterns of the crew of HSV-2 *Swift* during Mine Interdiction Warfare (MIW) Gulf of Mexico Exercise (GOMEX) 05–1. The weather during GOMEX 05–1 was mild, and the HSV-2 *Swift* was used as the command flagship, coordinating the movements of the other ships in the exercise. Consequently, the HSV-2 *Swift* was not required to operate at high speeds or maneuver quickly.

The study had 21 participants whose sleep patterns were collected using wrist-worn actigraphy and sleep logs. Results showed that the average daily sleep amount was 6.78 hours, with the average sleep episode length being 5.40 hours. Time spent at sea, which is related to rank, was negatively correlated with sleep while underway ($r = -0.778$, $p = 0.001$). This finding was consistent with that of Belenky (1997), who found that sleep amount is inversely proportional to rank, with higher-ranking soldiers receiving significantly less sleep than those junior to them.

Studies on the Navy Standard Work Week (NSWW)

The most recent U.S. Navy operational studies were conducted on four surface combatants: the USS *Chung Hoon* (Haynes, 2007), the USS *Lake Erie* and USS *Port Royal* (Mason, 2009), and the USS *Rentz* (Green, 2009). In an attempt to accurately calculate the number of sailors required to man each class of ship, the United States Navy has developed a model called the Navy Standard Work Week. The NSWW represents a standardized version of one week of work performed by a single enlisted sailor while at sea (Department of the Navy, 2007). After first determining the amount of work to be performed to operate each class of ship, the NSWW is then used to calculate manning levels, which are a theoretical reflection of the minimum manpower resources necessary to accomplish the ship's mission. The work weeks for sea duty are based on operational requirements under projected wartime conditions with units in Condition III steaming, as described in OPNAV Instruction 1000.16K, page C-1 (Department of the Navy, 2007):

> The Navy's standard workweeks . . . are guidelines for sustained personnel utilization under projected wartime or peacetime conditions. . . . Daily workload intensity is a function of operational requirements; as such, the actual day-to-day management of personnel is the responsibility of the commanding officer. Under certain circumstances it may become necessary to exceed the standard workweek; however, extending working hours on a routine basis could adversely affect such matters as moral, retention, safety, etc., and as policy, such extensions should be avoided.

Using this NSWW model, the 168 hours in one week for any given sailor are divided into two categories: "Available Time" for duty (81 hours) and "Non-Available Time" (87 hours). Available Time is occupied by all required tasks that are performed by

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crewmembers; these include work or maintenance, watchstanding, training, and attending meetings. Non-Available Time comprises all personal time that is allotted to the crew, and includes messing (dining), sleeping (56 hours on a weekly basis; on average, eight hours of sleep per day), and free time.

Three studies have addressed how well the NSWW reflects the daily schedule of sailors: Haynes (2007), Mason (2009), and Green (2009). In his study to assess NSWW issues, Haynes (2007) evaluated sleep patterns onboard the USS *Chung Hoon* (DDG-93), an Arleigh Burke–class Aegis destroyer. Data were collected on 25 crewmembers during a 14-day period in February 2007. Data collected included actigraphy recordings (n = 22), and daily sleep and activity logs (n = 25). During the study period, the ship was conducting predeployment training while in Condition III. (Note: A ship's deployment phase is preceded by a predeployment training cycle. During this phase, the crew conducts exercises involving warfare training and damage control at sea to simulate the operational tempo and conditions that might be experienced during battle.)

The results of this study were based on the information included in the sleep and activity logs. Analysis showed that participants reported 7.27 hours of daily sleep (standard deviation [stdev] = 1.03 hours, median = 7.08 hours). Departmental analysis shows that participants in the Combat Systems Department reported 7.72 hours of daily sleep, whereas the Engineering Department reported 7.24 hours, and the least sleep was found among the operations personnel (6.15 hours of daily sleep). Crewmembers participating in the study worked longer hours than they were allocated in the NSWW model. Figure 20.8 shows the NSWW and the average time each week sailors spent working during the USS *Chung Hoon* study. In fact, 85% of the sailors in the study exceeded the 81 hours of Available Time allotted by the NSWW; over 50% of the participants reported working more than 95 hours per week (~13.60 hours per day).

On average, the sailors worked 16.95 hours per week more than they were allotted in the NSWW, which equaled 2.40 hours more per day in Available Time. The findings of this study led to a recommendation that revisions of the NSWW be developed for enlisted sailors based on departmental assignment, with a separate version of the NSWW developed for officers. If implemented, this change would more accurately reflect the demands placed on sailors in the Navy and allow for calculation of more realistic manning of U.S. Navy vessels.

Another shipboard study of the NSWW was conducted on the USS *Lake Erie* (CG-70) and the USS *Port Royal* (CG-73), two Ticonderoga-class guided-missile cruisers (Mason, 2009). Like the study on the USS *Chung Hoon*, the purpose of this research was twofold: (1) to determine the amount of work and rest provided to sailors during a typical training exercise, and (2) to determine if the NSWW accurately reflects the actual activities of sailors onboard U.S. Navy cruisers.

Data were collected over an entire 24-day underway period (between July 7 and July 30, 2008) during the Rim of the Pacific (RIMPAC) Exercise 2008 (ship in readiness Condition III). Initially, the study included participants who wore wrist activity monitors and completed daily activity logs. The thesis reported on a total of 39 participants

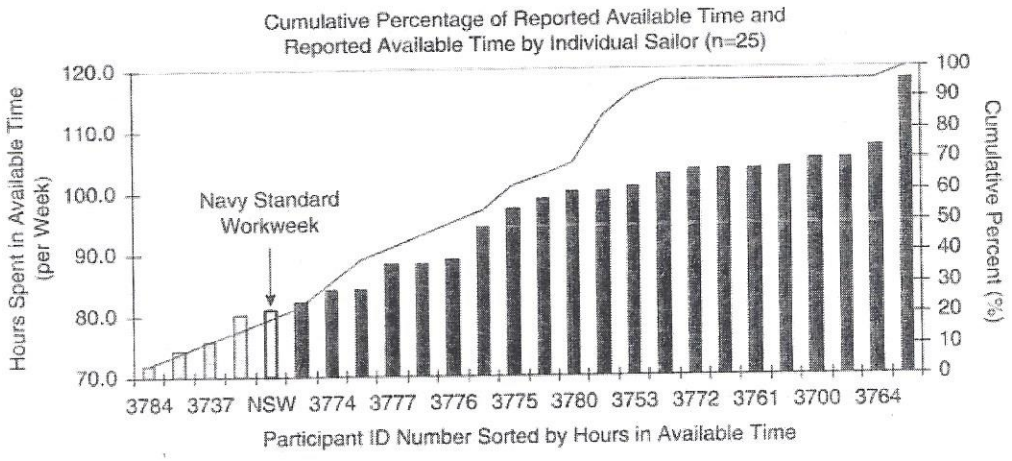

Fig. 20.8 Hours spent working per week on the USS *Chung Hoon* (Haynes, 2007).

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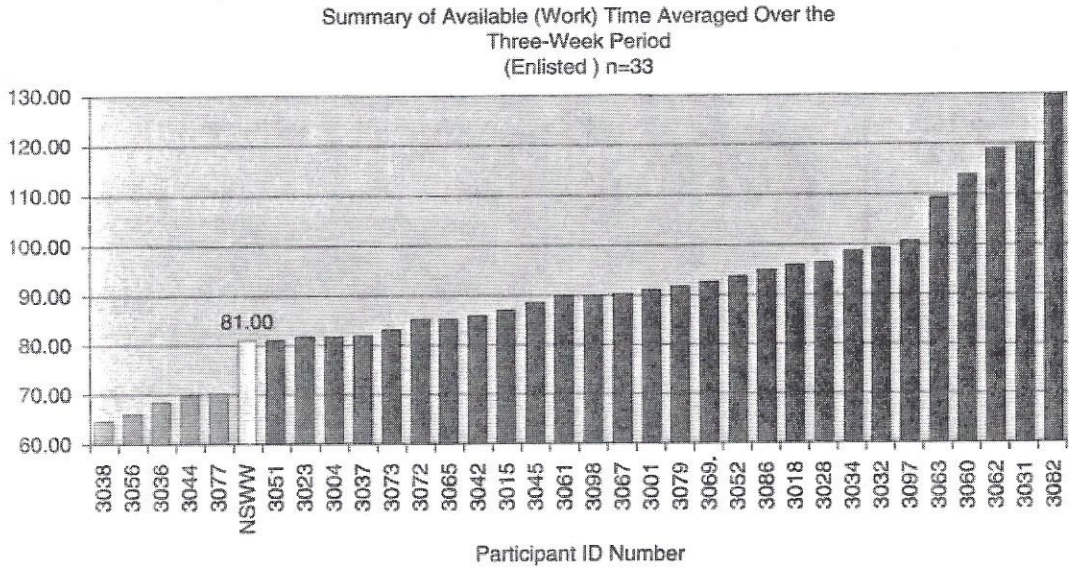
‹ officers and 33 enlisted personnel). The jobs formed by participants varied according to their ing, rank, and Navy Enlisted Classification (NEC) cialty. Pay grades varied from E-1 through O-5. ditionally, the watch-stations manned by the sail- included the engineering, combat systems, oper- ons, supply, and administration departments.

Results show that, on average, senior personnel, h officer and enlisted, slept approximately two urs less than allotted by the NSWW. Senior Chief ty Officers and Chief Petty Officers (both isted-grade E-8/E-7 participants) averaged 6.26 urs of sleep, while senior officers (Lieutenant mmanders [O-4] and above), averaged 6.38 urs of sleep per day. In contrast, junior personnel listed grades E-1 through E-3 and officer grades 2 through O-3) averaged 7.83 and 7.06 hours of p, respectively. Analysis indicated that 85% of participants had more time on duty ("Available ne") than allocated by the NSWW model oughout the entire underway period. In fact, y five participants worked less than the allotted hours (and these individuals were not actively aged in the RIMPAC exercise). The following ure (20.9) depicts these findings.

Departmental analysis showed that sailors in the nbat Systems Department worked the most urs: 15 hours more per week than the "Available" hours of NSWW. Figure 20.10 shows the WW and the departmental breakdown time ors spent sleeping in this study. The Operations partment logged, on average, five hours more sleep than allowed in the NSWW. Final analysis of the data log sheets and Actiwatch indicate that 84% of the participants (excluding officers) were categorized as falling below the NSWW sleep allotment, averaging just over 47 hours versus 56 hours of sleep per week. Finally, as noted by Mason (2009), both ships had similar findings in all categories of the NSWW model.

The sleep data from sailors on these two ships were analyzed again to determine if the patterns of sleep were different between the two ships. This analysis focused on the sleep data of 70 participants—42 from the USS *Lake Erie* and 28 from the USS *Port Royal*. Results showed that the average daily sleep obtained during the three-week underway period was 5.58 hours (stdev = 1.92 hours, median = 5.51), with no significant differences between the two ships. For all sailors on both ships combined, the length of the average sleep episode was 4.11 hours (stdev = 2.12 hours, median = 4.05). However, the length of the average sleep episode differed between the two ships, with sleep episodes being shorter on the USS *Port Royal* (USS *Lake Erie*: mean = 4.34, stdev = 2.11, median = 4.32; USS *Port Royal*: mean = 3.85, stdev = 2.01, median = 3.72; $F[1,1822] = 26.6$, $p < 0.001$, Cohen's $d = 0.239$). Sleep fragmentation was especially evident for sailors on the USS *Port Royal*, who averaged 1.36 sleep episodes per day, which was 11.6% more than seen in sailors on the USS *Lake Erie*. This finding illustrates that napping was a strategy used by many crewmembers to alleviate their sleep debt.



20.9 Weekly average available time (time spent working) for the three-week underway period (Mason, 2009).

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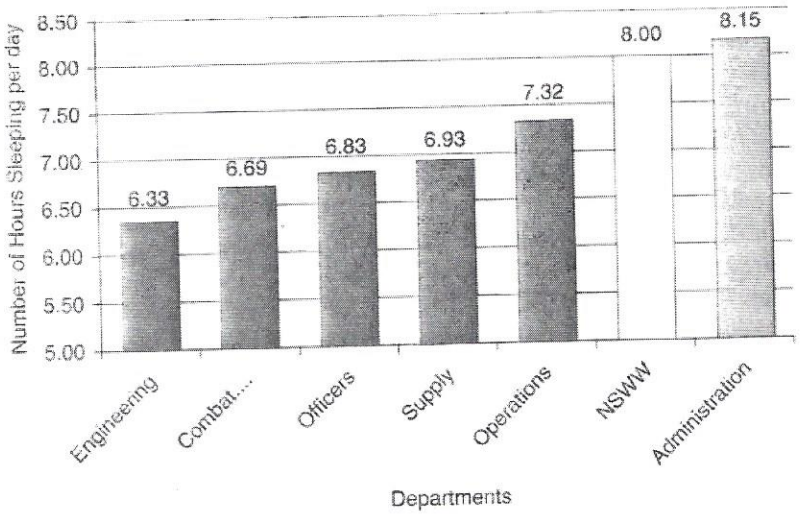

Fig. 20.10 Average hours of sleep per night by ship's department (Mason, 2009).

Since sailors on the USS *Port Royal* had less contiguous sleep, the sleep they did receive was of less benefit than that received by their shipmates on the USS *Lake Erie*. Both crews suffered from significant sleep deprivation, as seen in Figure 20.11.

The most recent NPS study on the NSWW examined work and rest patterns of sailors on the USS *Rentz* (FFG-46), an Oliver Hazard Perry–class guided missile frigate (Green, 2009). In her thesis research, Green examined the sleep of 24 sailors during predeployment underway training periods. Her analysis yielded no surprises; just as in the previous two studies, sailors worked more hours than allocated in the NSWW, and the participants were chronically sleep-deprived.

Studies of Fatigue on the Effectiveness of Training and Education (from Table 20.2)

Studies of Fatigue and Training Effectiveness in U.S. Navy Enlisted Recruits

United States Navy recruits are trained at the Recruit Training Command (RTC) in Great Lakes, Illinois. Basic training, or boot camp, lasts approximately 63 days, during which the recruits are taught basic military knowledge and practice skills that prepare them to serve in the United States Navy. Recruits are under a closely controlled daily schedule, and prior to December 2001, received only six hours of sleep per night. In December 2001, a decision was made to change the amount of sleep allowed by Navy recruits from six to seven hours of sleep per

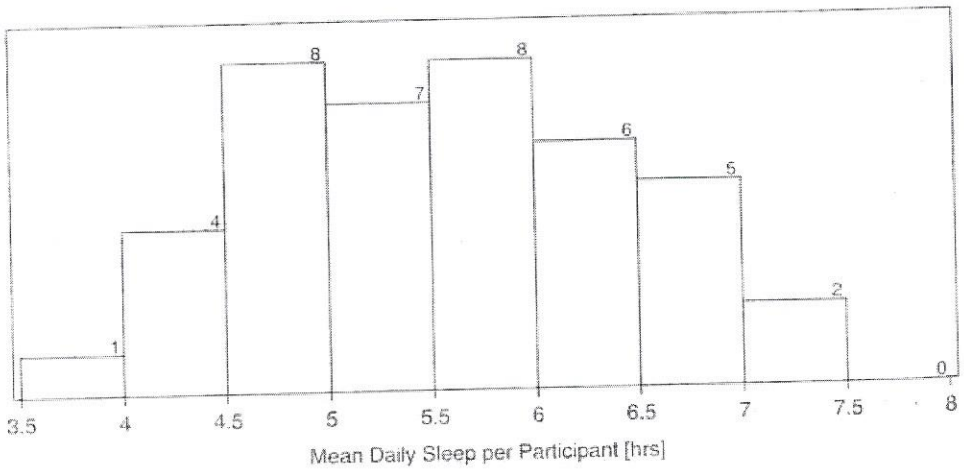

Fig. 20.11 Average daily sleep per sailor on the USS *Lake Erie* and the USS *Port Royal* over the entire three-week data collection period (the number of participants is shown at the top of each bar).

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ıt (i.e., mandatory bedtime was from 2100 to 0 hours). In early 2002, the sleep regimen was ıged once more to give recruits eight hours of ı per night, sleeping from 2100 to 0500 hours. Iay 2002, the Navy recruit sleep regimen was ized at eight hours per night, with bedtime at 0 and wakeup at 0600 hours. This last modifica- was selected to coincide with the recognized ı requirements and naturally occurring circa- rhythms of adolescents and young adults.

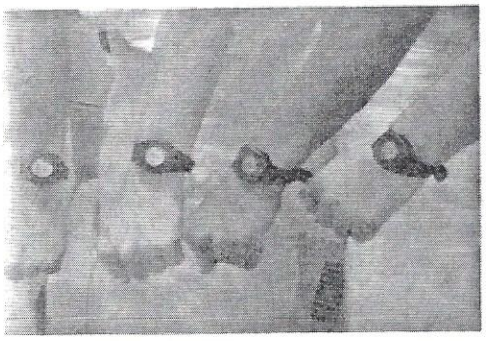
'wo studies of Navy recruits at RTC were lucted by NPS to assess the impact of these sions. The first study (Baldus, 2002) assessed quantity and quality of sleep received by a ple of recruits in two eight-hour sleep condi- s: 2100 to 0500 and 2200 to 0600. The data esent a cohort of boot camp recruits whose bed- s shifted from 2100 to 2200. Sleep data and ity were evaluated using WAMs (see Figure 2) and paper-and-pencil activity logs. Data collected from April to June 2002 and com- d one complete cycle of recruit training. icipants included 31 recruits (20 males and 11 ıles) from five different recruit divisions.

ased on the recruits' sleep patterns, sleep was ıed as *non-disrupted* (an eight-hour contiguous ttime interval) or *disrupted* (any night having at a 30-minute period of wakefulness after sleep t or more than 45 minutes of wakefulness from ime until sleep onset). Standing watch, personal ities such as bathroom visits, or some other ity typically caused these disruptions in night- sleep.

esults from this study showed that although ıits were allotted eight hours of sleep per night, ıverall average sleep for all recruits in this study 6.10 hours (stdev = 1.20 hours) per night lus, 2002). Recruits tended to receive more sleep when following the 2200 to 0600 sleep regimen than when following the 2100 to 0500 sleep regimen. On average, the 2200 bedtime resulted in 22 more minutes of sleep per night per recruit—a finding that mirrored the shift in adolescent and young adult circadian rhythms that favors later bedtimes.

Finally, the study addressed the gender effect in sleep patterns. Although not statistically significant ($p = 0.20$), the results suggest a difference in sleep patterns between males and females. Over the course of the study, female recruits received an average of ten more minutes of sleep per night than did their male counterparts (6.24 hours versus 6.08 hours, respectively; see Figure 20.13). This difference was consistent whether looking at sleep amount in disrupted nights (females = 5.52 hours, males = 5.22 hours) or non-disrupted nights (females = 7.24 hours, males = 7.07 hours). Based on the findings of the study, it was concluded that the change in bedtime from 2100 to 2200 was beneficial and should remain in place.

After this first descriptive study of sleep patterns of recruits, another study was conducted specifically to examine the academic performance associated with the two sleep regimens; that is, six versus eight hours of nightly sleep (Andrews, 2004). One year of data with the eight-hour sleep regimen (calendar year 2003) was compared to two separate years when only six hours of sleep per night were allowed (calendar years 2000 and 2001). Average test scores by division and month were compared across the three years under investigation and included test



0.12 Wrist-worn activity monitors on U.S. Navy recruits ıs, 2002).

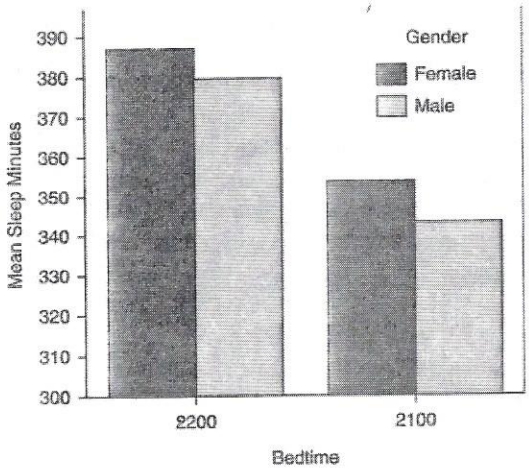


Fig. 20.13 Minutes of sleep received by males and females at two different bedtimes (2100 and 2200). All recruits were allowed eight hours of sleep (Baldus, 2003).

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scores of 2,597 recruits. Standardized test scores for each recruit and the year they were trained were entered into a regression model, adjusting for their Armed Services Vocational Aptitude Battery (ASVAB) score and month of administration. The month of test administration and ASVAB scores were included in the regression equation in an attempt to adjust for seasonal variations and differences in individual recruit aptitude following the two different sleep policies. Results displayed in Figure 20.14 show that recruits who had six hours of sleep per night scored significantly lower than the recruits who had eight hours of sleep per night ($F[2, 33] = 29.97$, $p < 0.0001$).

In short, recruits who received eight hours of sleep per night scored, on average, 11% higher (mean = 4.38, stdev = 0.25, median = 4.38) than their counterparts who received only six hours of sleep (mean = 3.91, stdev = 0.11, median = 3.9), supporting the hypothesis that more sleep was associated with significantly better academic performance. The findings were statistically significant and support the changes made by the Recruit Training Command. It should be noted that other administrative and procedural changes that occurred during this same period (e.g., waterless hand-washing before meals and sleeping in new barracks) may have contributed to the improvements in test scores in 2003.

A Study of Fatigue and Training Effectiveness in U.S. Army Enlisted Recruits

Another study of training effectiveness in military recruits was conducted in late summer and fall of 2009 at Fort Leonard Wood, Missouri, in U.S. Army Basic Combat Training (BCT). This study is described in detail in Chapter VI of an NPS dissertation by Tvaryanas (2010), but is briefly summarized here. The study set out to compare the training effectiveness of Army basic combat trainees in two training regimens. One company of trainees (n = 185) used a conventional training regimen, which allowed eight hours of sleep each night from 2030 to 0430, while another company of trainees (n = 209) used an experimental training regimen that allowed eight hours of sleep each night from 2300 to 0700. The primary question was whether sleep and recruit performance, including marksmanship, would be improved by adjusting the timing of the primary sleep period to be more in alignment with the naturally occurring patterns of sleep in adolescents and young adults.

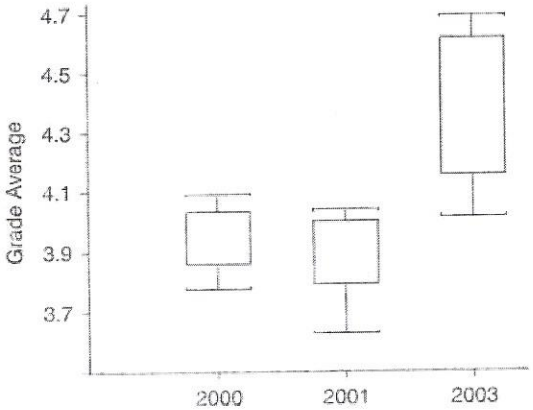

Fig. 20.14 Standardized U.S. Navy grades for recruits receiving six hours of sleep per night (years 2000 and 2001) versus recruits receiving eight hours of sleep per night (Andrews, 2004). The blank line in the shaded box represents the median.

Demographic and psycho-physiological measures were collected at the start of the study using standard survey instruments and methods. A random sample of 95 recruits wore WAMs to record sleep quantity and quality throughout the study period. Weekly assessments of subjective fatigue and mood were collected using the POMS. Results of the actigraphic analysis showed that a 2.5-hour, phase-delayed sleep schedule improved sleep relative to the conventional BCT schedule, resulting in, on average, more than 30 minutes of extra sleep per night. Besides schedule, personal factors such as age and gender also influenced recruits' average total daily sleep: female recruits and recruits who were younger tended to sleep more. The schedule modification was shown to be effective in improving sleep over the entire course of BCT. However, increased nightly sleep during the week in which marksmanship skills were taught (i.e., one week prior to the actual marksmanship tests) resulted in greater improvements in marksmanship.

This finding is in line with other studies that show greater skill-acquisition following adequate amounts of sleep. The study demonstrated that schedule modifications that improve sleep can be expected to result in improved marksmanship performance during BCT. Perhaps most importantly, such benefits may be obtained at no additional cost, since the content and length of training remains the same and there are no requirements for additional investments in new technologies or facilities.

A Study of Sleep in Undergraduate Military Education

In yet another study of sleep in military members, conducted at the United States Military Academy

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USMA) in West Point, New York, the sleep patterns of nearly 1,400 military cadets (the USMA Class of 2007) were followed for four years during their undergraduate education. The results of this study have been described in detail in two publications but are summarized here. Academic performance, class ranking, attrition, race, gender, and "morningness-eveningness" preferences were recorded for the entire class. A sample of the class (n = 80) wore WAMs and completed activity logs for one month in the fall and spring academic semesters for the four-year period.

As seen in Figure 20.15, on average, over the four-year period, cadets slept less than 5.5 hours on school nights. Cadets napped extensively, perhaps in an attempt to compensate for their chronic sleep debt. They slept more during fall than spring semesters. Male and female cadet sleep patterns varied dramatically, with males consistently getting, on average, more than 20 minutes less sleep than females.

The study demonstrated that cadet sleep at USMA is related to academic year, semester, season, gender, day category (school day or weekend), and day of the week. For example, Figure 20.16 shows the pattern of sleep by academic year. Nightly sleep (sleep only in the major nighttime period) is shown by the dotted line. Daily sleep (i.e., total sleep in a 24-hour period, including naps) is indicated by the solid black line. With an increase in naps during the final year at USMA, daily sleep reached a peak in the final year of the study, continuing to rise over the four-year period.

The study showed that military cadets at USMA experience a severe and chronic sleep debt that may have long-term consequences. In addition to developing poor sleep hygiene habits, cadets may have difficulty in taking full advantage of the world-class education and training afforded them at West Point.

Studies of Fatigue in Combat and Operational Environments (from Table 20.3)

Studies of Sleep and Compliance with Sleep Plans in Combat in Southwest Asia

This study assessed the impact of sleep logistics during Phase IV operations of Operation Iraqi Freedom (Doheney, 2004). Survey data were collected from warfighters operating in Iraq and Kuwait from August 25 to October 15, 2003, using a convenience sample of respondents. The study focused on answers to a 96-question survey designed to capture sleep patterns and determine adherence to sleep/rest plans. The survey asked questions relating to unit-level sleep/rest planning, sleep/wake patterns, warfighter fatigue and sleep latency, symptoms of sleep deprivation, and confounding lifestyle factors that impede sleep and rest. The respondent population included 273 participants (237 males and 24 females; average age = 29.80 years, stdev = 8.96 years, median = 27; average time deployed = 178 days, stdev = 68.3 days, median = 174.5 days).

Survey results showed that sleep deprivation was a significant problem for forces deployed to the Southwest Asia region, especially those operating in Iraq ($p = 0.0151$). Between 73% and 83% of the respondents showed moderate symptoms of sleep deprivation, whereas between 14% and 23% showed significant symptoms of sleep deprivation. These findings may be linked with the finding that only 38% of the sample reported that they were briefed on a sleep plan. Considering that the majority of the respondents included warfighters with ranks that have the responsibility to supervise the implementation of a sleep/rest plan, this suggested that units may not have considered the importance of implementing sleep and rest. Respondents reported getting 6.67 hours of sleep per day, most of which was on a cot, and napping occurred approximately every other day for around 45 minutes. Finally, 34% reported falling asleep at least once when they were supposed to be awake.

Another conclusion was that the units with effective sleep/rest plans had a higher probability of maintaining satisfactory performance effectiveness levels than those with no or ineffective sleep/rest plans ($p = 0.004$). Furthermore, units located in Kuwait had a higher probability of maintaining satisfactory performance effectiveness levels than units in Iraq, which supported the decision to rotate units out of Iraq and into Kuwait for rest and recovery ($p = 0.0029$). The data did not suggest, however, that there were differences in the probabilities associated with maintaining satisfactory performance effectiveness levels when other factors were considered (gender, Military Occupational Specialty (MOS) categories, or rank).

The data suggest that the respondents' sleep patterns did not support effective mission accomplishment. Based on the finding that only between 45% and 57% of the sample's sleep/wake patterns satisfactorily supported mission accomplishment, the author concluded that typical standards of operational readiness, requiring 75% of the population to be mission-capable, were not met.

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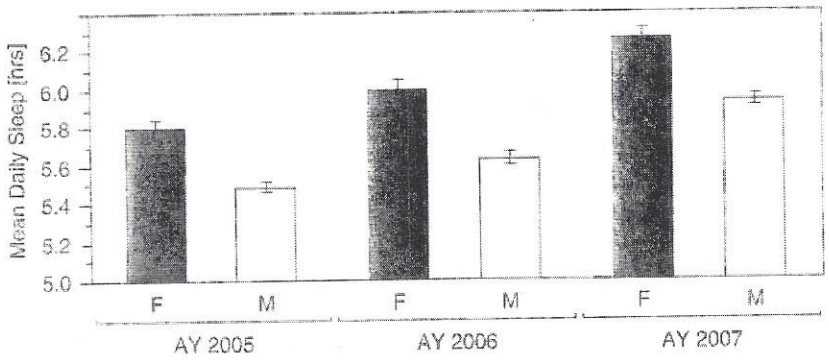

Fig. 20.15 Average daily sleep in hours for females and males for academic years (AY) 2005, 2006, and 2007.

Studies of Sleep in Helicopter Pilots in Iraq (2006)

This study, conducted in Iraq from May 21 to June 1, 2006, assessed sleep quantity and shifting sleep schedules during actual combat flight operations. Participants included 20 active duty pilots from a Marine Corps operational aviation battalion conducting flight operations in Iraq. Ten days of sleep data were collected through actigraphy and sleep logs. The study data included 210 sleep episodes, with durations ranging from 0.62 to 13.65 actual hours of sleep. Depending on sleep duration and the number of major sleep episodes in the course of each day, sleep incidents were categorized as either "sleep" or "nap." In total, 16 naps were reported by eight participants over the ten-day period. All naps occurred during days where the major sleep episodes took place at night. The average sleep duration per "sleep" episode was 6.37 hours (n = 192, stdev = 1.65 hours), while the average "nap" length was 1.55 hours (n = 16, stdev = 1.07 hours). On average, participants in the study got approximately 6.5 hours (stdev = 1.66 hours) of total daily (per 24 hours) sleep. Participant sleep amount varied greatly within the unit, with the average daily (24 hours) sleep ranging from 5.0 to 7.9 hours (median 6 hours), with only 25% of the pilots receivi between 7 and 8 hours of daily sleep.

In order to assess the effect of sleep schedules c the amount of sleep obtained, participants we grouped according to their sleep schedule. Half the participants (n = 10) had a fixed sleep schedul sleeping either during the daytime or at night. Tl other half of the participants' sleep shifted at son time in the data collection period. The participan with fixed schedules who slept only during daytin got their sleep between 08:00 a.m. and 04:00 p.n A second group, night sleepers with fixed schedule slept between 11:00 p.m. and 07:00 a.m. Resul showed that shift schedules were important predi tors of the amount of sleep obtained. Participan with fixed sleep schedules slept more than partic pants whose sleep schedules changed ($F[1,189]$ 3.91, $p = 0.049$). In addition, the quality of sleep night was better than that of sleeping during th daytime. The following table (20.4) shows the findings.

The study results showed that 75% of the pa ticipants received a daily sleep amount significant less than is physiologically acceptable (Horne, 198

Table 20.4 Daily sleep vs. sleep schedule

Sleep Schedule	Number of Participants	Daily Sleep Mean (hrs)	Daily Sleep Standard Deviation (hrs)
Shifting from morning to night sleep	4	6.16	2.01
Shifting from night to morning sleep	6	6.43	1.76
Fixed schedule with daytime sleep only	4	6.53	0.59
Fixed schedule with night sleep only	6	6.79	1.78

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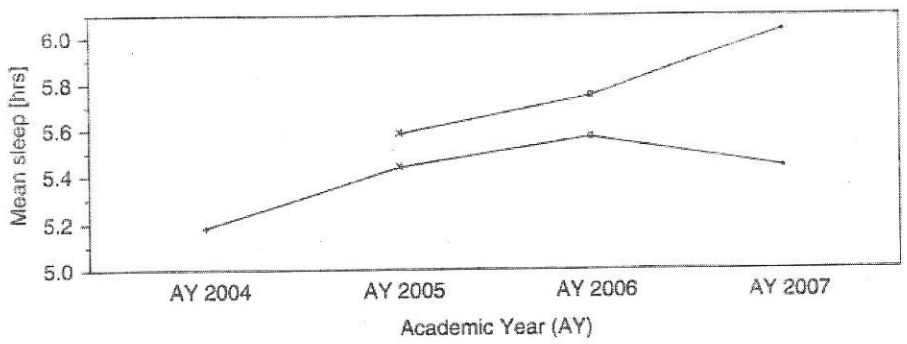

Fig. 20.16 Average daily (solid black line) and night sleep (dotted line) achieved over each of four academic years at USMA.

1988; Van Dongen, Rogers, & Dinges, 2003). Furthermore, a continuously accumulating sleep debt was evident in a large proportion of the participants. Sleep deprivation in this population was exacerbated by the fact that during the data collection period, there were no days that could be considered "weekends" or days off in which catch-up sleep could occur. Therefore, unlike civilians, these combatants did not have the opportunity to ameliorate their sleep deprivation during days off (Akerstedt & Torsvall, 1978; Dahlgren, 1981).

Studies of Reported Sleep Patterns in Army Commanders at Fort Benning, Georgia

This study addressed sleep deprivation issues during military operations from the viewpoint of Army officers newly returned from combat (Miller, Shattuck, & Matsangas, 2010). Forty-nine U.S. Army Officers with recent combat experience were surveyed to assess their units' sleep patterns and to determine the tactics, techniques, and procedures used to counter the effects of sleep deprivation in their units. Results showed that despite Army policy, which requires units to develop and implement sleep management plans (Department of the Army, 2009), nearly 80% of the participants reported they had not been briefed on a sleep management plan during their most recent deployment. Over half of the respondents reported that fatigue was a problem in their units. During high operational tempo (OPTEMPO), which occupied nearly half of their time in combat, participants report receiving only four hours of sleep daily. Finally, the vast majority of respondents (82.6%) reported feeling sleep-deprived at least occasionally while at high OPTEMPO.

Conclusions and Future Directions

This chapter summarizes ten years of sleep research conducted by the Naval Postgraduate School in military settings. A common thread runs through all of these studies: American soldiers, sailors, and Marines worldwide are accumulating a staggering sleep debt. Despite the U.S. Navy's efforts to implement a Navy Standard Work Week, it is clear that its sailors continue to be sleep-deprived—perhaps at an ever-increasing rate. Efforts to promote sleep hygiene in the U.S. military's ground forces have not been successful, as documented by a widespread failure to comply with mandatory sleep management plans. Continuing pressure to "downsize" the military forces has left the same amount of work to be done by an ever-shrinking work force.

Given that U.S. warfighters suffer from chronic sleep deprivation, they will almost certainly experience deleterious effects on their performance. The most egregious example of the consequences of chronic and acute sleep debt is when combat troops fall asleep when they need to be vigilant. While less obvious, other effects of chronic and acute sleep debt such as microsleeps; lapses in attention, memory, and judgment; alterations in mood; and degraded decision-making also have far-reaching consequences for combat effectiveness. Military leaders would never send troops into harm's way without the safety afforded them by armor and other personal protective equipment; yet sending troops on missions when they are sleep deprived is equally dangerous to them and to others in their organization. That said, more research is needed to determine how sleep can be optimized on land, at sea, or in the air. Accommodation of adolescent sleep needs has proven successful in various military training environments (e.g., U.S. Navy's Recruit Training Command at Great Lakes, US Army Basic Combat Training at Fort Leonard Wood and the United States Military Academy at West Point). Other military environments need to be examined to determine if the mitigating strategies used in

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training environments will be effective in operational environments.

Another prevalent and troublesome finding in this ten-year research effort is that senior military personnel report that they do not need more sleep. The inference is that the military has "weeded out" individuals with normal sleep requirements by selecting and promoting the individuals who are less susceptible to sleep deprivation. Is attrition higher for individuals who require more sleep than those who either need less sleep or are less susceptible to sleep deprivation or shift work? Does an individual's sleep propensity constitute such an important characteristic for the U.S. military that this issue should be considered in the military selection process? More importantly, what does this selection process mean for those who do elect to continue in service, and what are the long-term sequelae of chronic sleep deprivation?

In conclusion, ten years of Naval Postgraduate School investigation of sleep in military settings has revealed that when military leaders are bold enough to employ innovative methods to enhance the quality and quantity of sleep, the result is improved effectiveness in training and performance. We conclude this chapter with the sober words of Jonathan Shay (1998):

> Pretending to be superhuman is very dangerous. In a well-led military, the self-maintenance of the commander, the interests of his or her country, and the good of the troops are incommensurable only when the enemy succeeds in making them so. It is time to critically reexamine our love affair with stoic self-denial. . . . If an adversary can turn our commanders into sleepwalking zombies, from a moral point of view the adversary has done nothing fundamentally different than destroying supplies of food, water, or ammunition. Such could be the outcome, despite our best efforts to counter it. But we must stop doing it to ourselves and handing the enemy a dangerous and unearned advantage.

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Sleep and Fatigue Issues in Continuous Operations: A Survey of U.S. Army Officers

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Forty-nine U.S. Army officers with recent combat experience were surveyed to assess their units' sleep patterns and to determine the tactics, techniques, and procedures used to counter the effects of sleep deprivation in their units. Despite Army policy requiring units to develop and implement sleep management plans, nearly 80% of the participants reported they had not been briefed on a sleep management plan during their most recent deployment. Over one half of the respondents reported that fatigue was a problem in their units. During high operational tempo (OPTEMPO), which occupied nearly half of their time in combat, participants report receiving only 4 hr of sleep daily. The vast majority of respondents (82.6%) reported feeling sleep-deprived at least occasionally while at high OPTEMPO. These findings have important implications for the operational readiness of all military units deployed to combat environments.

The demands of modern-day life contribute to work schedules whereby humans chronically fail to get adequate amounts of nightly sleep (Dement & Vaughan, 1999). Over the past century, research indicates that Americans get significantly less sleep than did our forebears: on average, over 2 hr less sleep per night. This alarming trend is even more prevalent among professions requiring around-the-clock operations, such as emergency response teams and members of the military forces. Professionals in these fields are faced with both acute and chronic sleep deprivation, resulting in a sleep debt that undoubtedly affects their performance and safety. Cutbacks in military spending—and the desire to do more with less—have led to increased pressure for military personnel to work longer hours with less time off, and increased operational tempo (OPTEMPO). This term, referring to the pace of military missions (Department of the Army, 1996), can be interpreted as the military equivalent of workload, and it is known to affect soldier and unit performance (Castro & Adler, 1999; Thomas, Adler, & Castro, 2005). Problems from excessive workload are further exacerbated by the dangerous

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combat environments and poor sleeping conditions faced by members of the U.S. military when engaged in combat operations.

The effects of sleep deprivation on performance are well documented in the scientific literature (Belenky et al., 2003; Van Dongen, Maislin, Mullington, & Dinges, 2003). In fact, the performance degradation from sleep deprivation has been likened to that experienced by alcohol intoxication (Dawson & Reid, 1997). In particular, psychomotor vigilance is dramatically altered when sleep is restricted. Vigilance is crucial for many military tasks including watch-standing and tactical operations. When vigilance is degraded, important information is invariably missed, placing both service members and the mission at greater risk of failure.

Harrison and Horne (2000) reviewed the effects of sleep deprivation on a wide range of cognitive activities, including decision making. They pointed out that senior mangement and military leaders are often required to work extended hours during times of crisis, making high-level decisions in complex, dynamic, and dangerous environments. The sleep deprivation experienced by these decision makers may not not affect complex, rule-based, logical task performance—perhaps due to heightened interest and compensatory efforts by participants. However, they concluded that sleep deprivation does affect decisions that involve creative solutions, dynamic replanning, managing competing demands, and complex communications—all critical macrocognitive activities inherent in military environments. Harrison and Horne discussed the critical role of the prefrontal cortex in tasks of this nature, and suggested that sleep deprivation "presents particular difficulties for sleep-deprived decision makers who require these latter skills during emergency situations" (p. 236). Other recent studies have also linked sleep deprivation to altered electrical activity in the prefrontal cortex, adding credence to this argument and offering a physiological rationale to explain macrocognitive changes.

The effects of fatigue are insidious. Humans, especially sleep-deprived ones, are not adept at judging when their performance is impaired. There is an attitude among those in the military that may actually contribute to sleep deprivation by encouraging stoic denial of the need for sleep (Davenport & Lee, 2007; Shay, 1998). A study conducted at the National Training Center found that the amount of sleep received was inversely proportional to rank, indicating that senior leadership received even less sleep than those junior to them (Belenky, 1997). Sleep-deprived leaders appear to have a diminished capacity to recognize their own sleep debt, as well as the sleep debt of their subordinates. Instead, these leaders need strategies for effective fatigue mitigation and fatigue countermeasure guidance that can be implemented easily.

Army regulations address sleep-related issues as part of combat and operational stress and battle fatigue (a military term for combat stress symptoms and reactions; Department of the Army, 2009). Military leaders are required to focus their efforts on their units' operational stress management. The following list of suggested fatigue countermeasures is routinely given to commanders: encourage napping, provide quiet and dark rest areas, and use of stimulants (caffeine). Commanders are advised to be cautious with sleep-inducing agents given the consequent performance impairment that these agents may induce. Appropriate scheduling of shift work is another method to maintain unit performance during operations (Department of the Army, 2009). Before deployment, sleep and fatigue issues are always a concern for the chain of command, and military leaders are advised at staff meetings to enforce sleep management plans for their units.

This article reports the results of a survey of self-reported sleep and napping patterns, OPTEMPO, and stress of U.S. Army officers recently returned from deployments to Iraq or

Afghanistan. The focus of the study is on two areas: the sleep patterns of individual soldiers and military units engaged in continuous operations; and, the tactics, techniques, and procedures used by forward-deployed units to counter fatigue.

METHOD

Participants and Setting

This study focuses on sleep issues during military operations. The study respondents were recruited after consulting with the senior leadership at the Infantry Officer Advanced Course (IOAC) at Fort Benning, Georgia. Study participants were a convenience sample of 49 male returning combat-deployed Army officers enrolled in the IOAC. As reported by the school leadership, the distribution of IOAC attendees is representative of the larger deployed force of U.S. Army officers in terms of age, rank, and experience.

Instrument

The questionnaire was specifically constructed to evaluate the respondent's most recent combat deployment, and was composed of 13 questions. Three questions were open-ended, whereas the other 10 questions included numerical inputs, dichotomized inputs, or ratings on 5-point Likert-type scales. The questionnaire included the following sections:

1. Demographic information: age, rank, gender, Military Occupational Specialty, total years of service, commissioned years of service, and number and total length of all combat deployments.
2. Briefing on sleep management plan (yes or no).
3. Sleep issues related to the participant's unit: "My unit worked in shifts," "My unit encouraged and monitored naps," "My unit designated dark and quite areas for rest," and "My unit tried to enforce sleep schedules."
4. Fatigue and sleep routines management question: "Fatigue was a problem in my unit," and "My unit did a good job managing sleep routines."
5. OPTEMPO occurrence. The participant estimated the percentage of time spent in OPTEMPO level (high, moderate, or low) during last deployment.
6. Daily sleep question: Participant reported the average amount of daily sleep by OPTEMPO level.
7. Napping question: "In addition to one major sleep period, I took naps to get more sleep." Participants estimated the occurrence of napping by OPTEMPO level.
8. Sleep deprivation question: "How often did you experience sleep deprivation symptoms?" Input included frequency of occurrence for each OPTEMPO level.
9. Deployment issues question: Over the course of the deployment, "Sleep deprivation was a serious problem in your unit," "You were exposed to significant sources of stress," "You would characterize your stress level as very high," and "Compared to your normal life, you used more caffeinated drinks (coffee, soft drinks, or tea)."

10. Sleep evaluation question: "When I reflect on my own sleep patterns and the sleep patterns of the soldiers with whom I served throughout the entire deployment, I would characterize that sleep as. . . ." Participants rated sleep quantity (their own, peers, superiors, and subordinates) on a 5-point scale ranging from 1 (*much less than needed*), 2 (*less than needed*), 3 (*about right*), 4 (*more than needed*), to 5 (*much more than needed*).
11. Three open-ended questions: "Indicate other things your unit did to address sleep issues," "Indicate positive factors that affected your unit's rest," and "Indicate negative factors that affected your unit's rest."

Questions 3, 4, and 7 to 9 were rated on a 5-point Likert scale ranging from 1 (*never*), 2 (*rarely*), 3 (*occasionally*), 4 (*sometimes*), to 5 (*all the time*).

Statistical Analysis

Answers to the survey questions were entered into a Microsoft Excel spreadsheet. Statistical analysis was conducted with Excel and JMP Release 7.0. Data normality was assessed with the Shapiro–Wilk W test. Initially, the data were analyzed for outliers. Analyses of variance (ANOVAs), chi-square analyses, and nonparametric tests were used when appropriate to assess the study responses. Statistical significance was indicated for two-tailed p values of $<.05$. The independent variables were OPTEMPO and whether participants had been briefed on a sleep management plan. The main dependent variables examined were self-reported sleep and napping, sleep deprivation symptoms and stress, and assessment of unit sleep issues.

Procedures

Study participants were volunteers who provided their informed consent after being briefed about the study. The survey was administered to the entire group of officers after they were informed of their right to decline participation. The study instrument and research protocol was accepted by the Infantry School leadership, and approved by the Naval Postgraduate School institutional review board. All participants were asked to fill out the study questionnaire.

RESULTS

Demographic Data

Two participants reported that they had never deployed to combat, whereas one participant reported having deployed 10 times in just 6 years of service (Mahalanobis outlier distance = 5.81). These 3 participants were excluded from further analysis. This article focuses on the remaining 46 participants. The average age of the study participants was 29.4 years ($SD = 4.4$, $Mdn = 28$); 6 of the respondents held the rank of first lieutenant, 38 were captains, and 2 were majors. The average length of time in military service was 8.1 years ($SD = 5.0$, $Mdn = 6.5$). The majority of the participants (71.1%) had only one deployment to combat, whereas the

remainder had more than one combat deployment (2 deployments: 20%; 3 deployments: 6.7%; and 4 deployments: 2.2%). On average, respondents reported that the total time they had deployed to combat was 15.5 months ($SD = 11.7$, $Mdn = 12.0$).

Sleep Plan

Approximately 80% of the participants in the study reported that they were not briefed on a sleep management plan during their most recent deployment (not briefed: $n = 37$, or 80.4%; briefed: $n = 9$, or 19.6%). Briefing status was independent of age, rank, length of total time in service, and length of commissioned service.

We also examined the extent to which the participants' units focused on sleep issues and on the use of countermeasures that could mitigate the impact of fatigue on individual and unit performance. We focused on participants' responses to known interventions used in military operations in order to reduce the deleterious effect of sleep deprivation: (a) shift-working, (b) encouraging and monitoring naps, (c) designating dark and quiet areas for rest, and (d) enforcing sleep schedules. The frequency of responses for these four survey items is shown in Figure 1. The percentage of participants is shown by the number at the top of each bar. For example, in Figure 1, 25% of the total number of those responding to this item answered "never" to whether their unit worked in shifts.

Of particular interest and concern is the large proportion of "never" or "rarely" answers in Figure 1. For example, 73.9% of the respondents reported that their unit never or rarely encouraged or monitored naps, whereas 66.7% of respondents reported that their unit never or rarely designated dark or quiet areas for rest. One half of the respondents (50%) answered that they had never, or rarely, tried to enforce sleep schedules, indicating that most units may not have openly addressed sleep issues.

We attempted to quantify the implementation of fatigue interventions during operations by combining the responses to the four questions (shift-working, napping, rest areas designation, and sleep schedules enforcement) to arrive at an overall metric, "sleep hygiene rating." (For this study, we use this term to refer only to these 4 sleep-promoting factors that are specifically mentioned in the existing Army regulations.) This sleep hygiene rating indicates the overall attention or emphasis placed on sleep issues by any given unit. The point values for each participant's response were summed across the four questions in this group, giving each participant an overall score. These scores ranged from 4 (the minimum value when all answers were "never") to 20 (the maximum value when all answers were "all the time"). For example, a respondent answering "rarely" to all four items would have an overall sleep hygiene rating of 8, whereas a participant responding "occasionally" to all four items would have a sleep hygiene rating of 12. Similarly, a respondent indicating "sometimes" to all four items would have a score of 16. Higher sleep hygiene ratings indicate that the unit was more attentive to sleep hygiene, whereas lower scores indicate that less attention was paid to unit sleep hygiene.

The results showed that participants' sleep hygiene ratings were related to whether or not they were briefed on a sleep management plan during their most recent deployment (Van der Waerden nonparametric test, 1-way chi-square approximation): $\chi^2(1, N = 44) = 2.7936$, $p = .09$; briefed: $n = 9$ ($M = 11.56$, $SD = 5.20$); not briefed: $n = 35$ ($M = 9.26$, $SD = 3.83$). Simply stated, units that briefed its members on sleep plans also engaged in

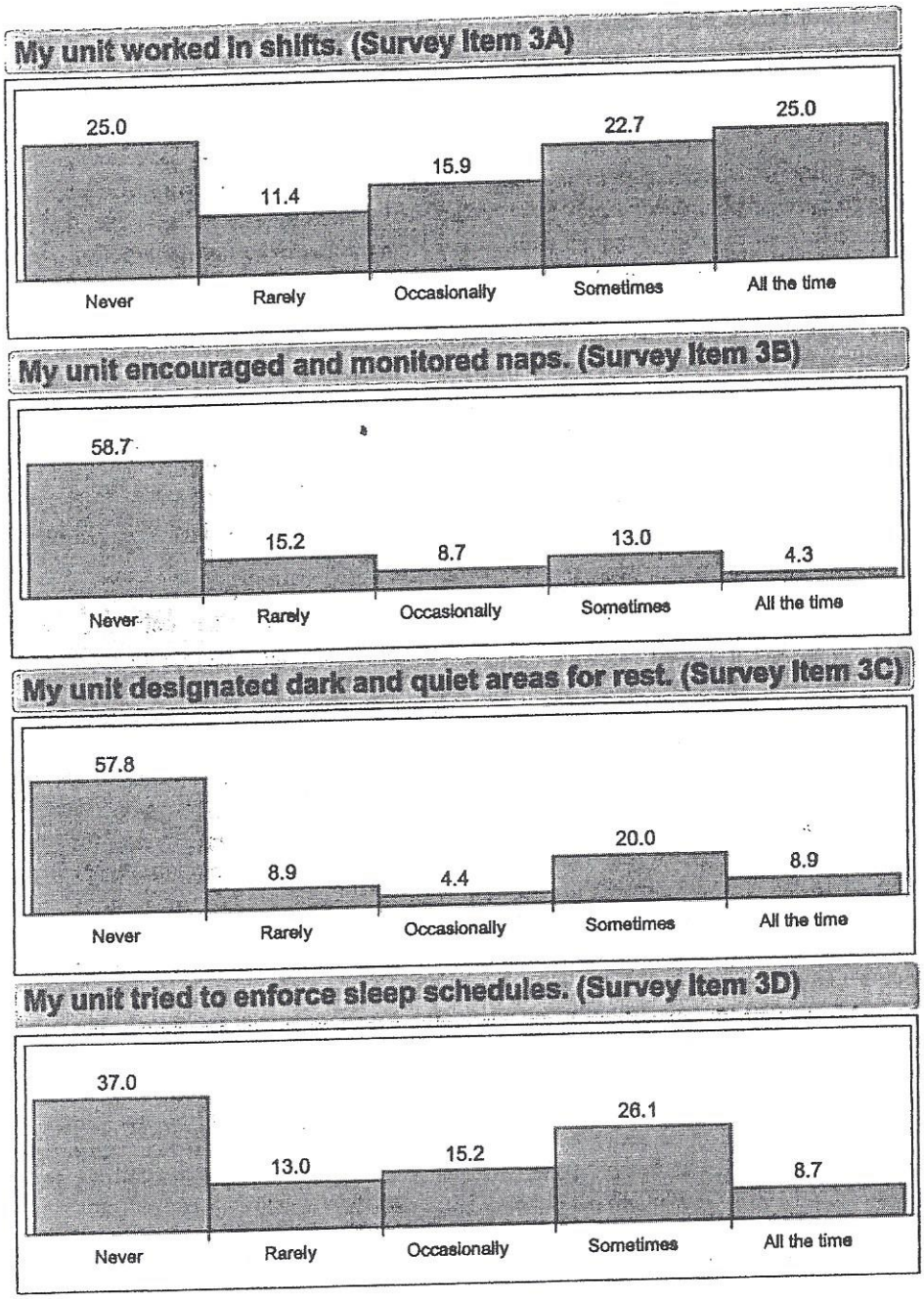

FIGURE 1 Frequency of answers regarding sleep hygiene and the use of fatigue countermeasures.

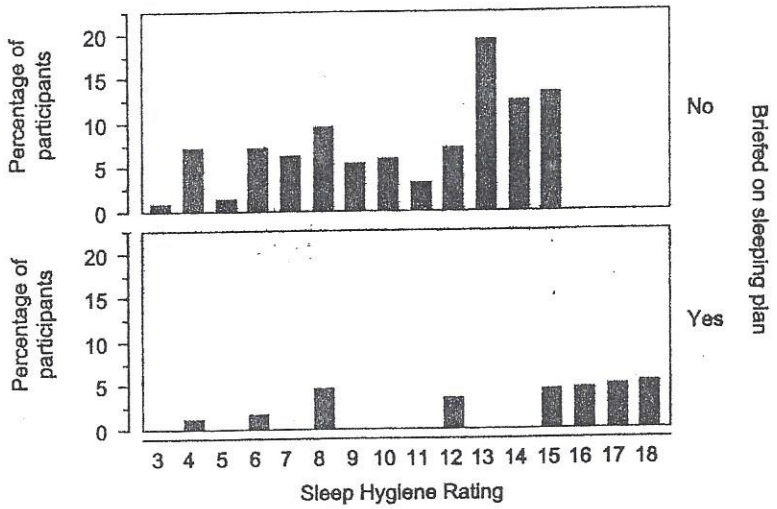

FIGURE 2 Frequency of overall sleep hygiene ratings as a function of sleep plan briefing status. *Note.* Higher ratings indicate better sleep hygiene.

other fatigue management practices. Figure 2 shows the frequency of the overall sleep hygiene rating, depending on whether or not the participants had been briefed on a sleep plan.

It is interesting to note that, although the participants who reported they had been briefed on a sleep plan generally had higher overall sleep hygiene ratings, 3 members of that group had very low overall sleep hygiene ratings. The specific type of units and the missions to which these individuals were assigned is unknown.

Overall Unit Fatigue and Sleep Management

The next section of the questionnaire asked respondents to rate their agreement with the statements that "fatigue was a problem" in their unit and that their unit "did a good job managing sleep routines." Although we were not able to collect objectively determined measures of sleep in these deployed units, these subjective answers represent individual assessments of fatigue severity and unit effectiveness with respect to sleep management. Figure 3 shows the responses to "Fatigue was a problem in my unit." A majority of respondents (over 55%) agreed or strongly agreed that fatigue was a problem in their unit.

Sleep plan briefing status was a significant determinant for participants' evaluation of whether their unit managed sleep routines well, $F(1, 43) = 9.0378$, $p = .004$ (Van der Waerden nonparametric test, 1-way chi-square approximation): $\chi^2(1, N = 45) = 7.5404$, $p = .006$). Nearly two thirds of participants (66%) who were briefed on a sleep plan agreed or strongly agreed that their unit did a good job managing sleep routines. This finding is in stark contrast to the responses of participants who did not receive sleep plan briefings; of those not receiving a sleep plan briefing, only 24.3% agreed that their unit did a good job managing sleep routines. Those respondents who received a sleep plan briefing were much more likely to agree that their unit did a good job managing sleep routines.

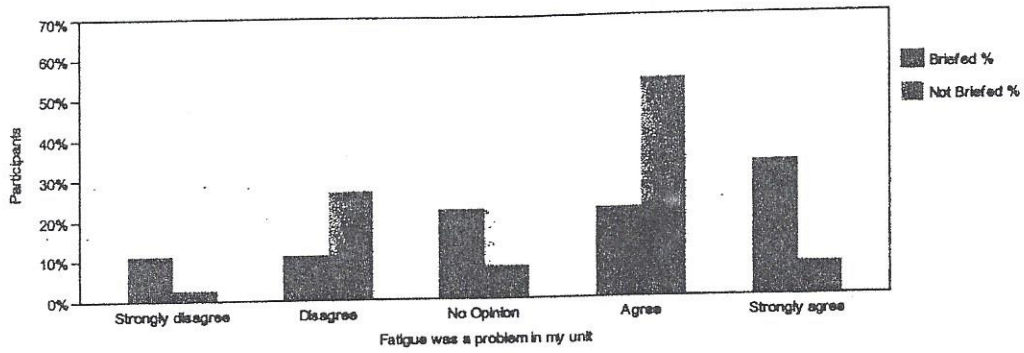

FIGURE 3 Frequency of responses to Survey Item 4A ("Fatigue was a problem in my unit") as a function of sleep plan briefing status.

Finally, participants indicating that their units did a good job at sleep routine management were those who placed an emphasis on sleep issues (as shown by increased sleep hygiene ratings: correlation, $r = .484$; $n = 43$; $p < .001$).

OPTEMPO

Participants were asked to estimate the percentage of time during their last deployment that they spent at high, moderate, or low OPTEMPO, based on their subjective assessments of OPTEMPO load. Nearly half (46.7%) of the time ($SD = 23.0\%$), participants reported that their units were at high OPTEMPO, contrasted with 36.3% of the time ($SD = 17.8\%$) at moderate OPTEMPO and 17.5% of the time ($SD = 17.2\%$) at low OPTEMPO.

For each OPTEMPO level, participants reported the average amount of daily sleep they received. Results showed that reported daily sleep varies with OPTEMPO: ANOVA, $F(2, 122) = 69.3067$, $p < .0001$; median test, $\chi^2_2 = 70.2601$, $p < .0001$—that is, the higher the OPTEMPO, the less sleep participants received (low: $M = 7.80$ hr, $SD = 1.52$ hr, $Mdn = 8.00$ hr; moderate: $M = 6.00$ hr, $SD = 1.33$ hr, $Mdn = 6$ hr; and high: $M = 3.90$ hr, $SD = 1.56$ hr, $Mdn = 4$ hr).

Reported daily sleep was also related to the overall sleep hygiene rating, which may reflect the extent to which participants were able to implement sleep hygiene practices while in the field. This association was significant only at high and moderate OPTEMPO levels: high, $F(1, 42) = 6.1292$, $p = .0174$; and moderate, $F(1, 41) = 6.5587$, $p = .0142$.

Frequency of Naps

Respondents were asked to rate the frequency with which they used naps to augment their major sleep period when they were at high, moderate, or low OPTEMPO. Figure 4 shows the frequency of these answers. Not surprisingly, increased OPTEMPO is associated with less napping (i.e., napping frequency drops off as the time available to do anything, other than operations, becomes more limited). This finding could account, in part, for the reduction in average daily sleep during high OPTEMPO. If one combines the two napping categories,

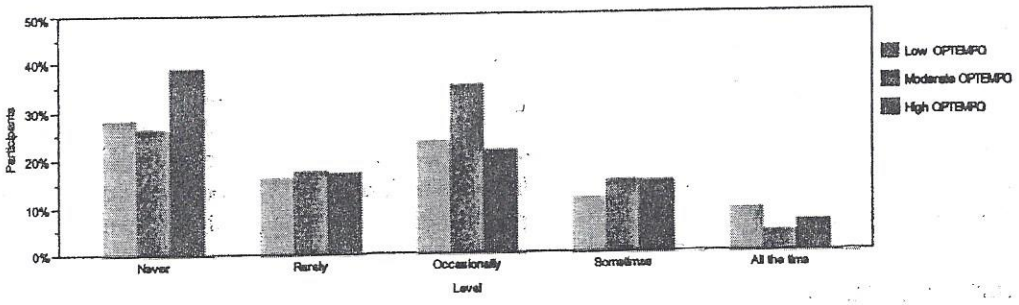

FIGURE 4 Frequency of answers to Survey Item 7 ("In addition to one major sleep period, I took naps to get more sleep") versus operational tempo (OPTEMPO).

"never" and "rarely," 45% of the participants reported that during low and moderate OPTEMPO, they never or rarely napped. During high OPTEMPO, this percentage reached nearly 60%.

Sleep Deprivation

Participants were asked to rate the frequency of sleep deprivation symptoms when they were at high, moderate, or low OPTEMPO. Results showed that increasing OPTEMPO levels lead to greater severity of sleep deprivation symptoms: likelihood ratio test, $\chi^2(1, N = 46) = 44.502$, $p = .0001$. Consequently, 53.5% of the participants reported that they rarely or never felt sleep deprivation symptoms during low OPTEMPO, whereas this percentage decreased to 37.8% during moderate OPTEMPO, and it was only 17.4% during high OPTEMPO. Clearly, an overwhelming number of respondents (82.6%) reported they felt sleep-deprived occasionally, sometimes, or all the time while at high OPTEMPO.

Sleep Deprivation and Stress Levels

Given that the questions so far captured a subjective evaluation of daily sleep, napping, and sleep deprivation, the next group of questions assessed the severity of sleep deprivation, the level of stress experienced during the deployment, and the use of caffeinated drinks.

Participants indicated that sleep deprivation was occasionally regarded as a serious problem in their unit ($M = 2.67$, $SD = 0.96$, $Mdn = 3.00$). During deployments, they were "sometimes" exposed to significant sources of stress ($M = 3.91$, $SD = 1.05$, $Mdn = 4.00$). The more strenuous the deployment (higher OPTEMPO), the more they experienced significant stress (Spearman's $\rho = 0.42$, $p = .003$). Participants who indicated more exposure to stress also indicated that they got more naps during high OPTEMPO (Spearman's $\rho = 0.31$, $p = .038$), possibly because the efficacy of napping becomes more evident during such missions.

Stress level on the most recent deployment was reported as occasionally very high ($M = 3.37$, $SD = 1.06$, $Mdn = 3.00$). In general, the frequency of very high stress levels was related to the frequency of sleep deprivation symptoms during high OPTEMPO missions (Spearman's $\rho = 0.32$, $p = .033$), whereas there is negative relationship between reported daily sleep during such operations (Spearman's $\rho = 0.37$, $p = .014$; i.e., personnel sleeping more felt

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less extreme stress). It was not all that surprising that the deployed personnel reported that they "sometimes" consume more caffeinated drinks (coffee, soft drinks, or tea) compared to their normal life ($M = 3.44$, $SD = 1.55$, $Mdn = 4.00$), with the percentage of participants reporting increased consumption "all the time" reaching 40% ($n = 18$). The frequency of caffeine consumption increase was related to the frequency of sleep deprivation symptoms during moderate (Spearman's $\rho = 0.46$, $p = .001$) and high OPTEMPO (Spearman's $\rho = 0.39$, $p = .008$).

Unit Sleep Patterns

To address unit sleep patterns, respondents were asked to report on their own sleep patterns and those of subordinates, peers, and superiors. Overall, participants reported that the sleep they received during deployment was not enough ($Mdn = 2$: "less than needed"). They reported that subordinates' and peers' sleep was "about right" (median response), whereas they reported that sleep for "self" and "superiors" was "less than needed" (median response). Of the four sleep categories (self, subordinates, peers, and superiors), an overwhelming majority of respondents reported that their superiors slept significantly less than needed (Kruskal–Wallis rank sum test), $\chi^2(1, N =) = 6.1655$, $p = .013$). Nearly 70% of respondents reported that their superiors receive less or much less than the amount of sleep they needed. Nearly one half of the respondents (47.0%) reported that subordinates receive less or much less sleep than needed. When looking at their own sleep patterns, over one half (55.1%) of respondents reported receiving less or much less sleep than they need.

Interventions to Address Sleep Issues

An open-ended question asked respondents to report things that positively affected the sleep of their unit. Twelve participants noted the following factors: (a) shift work and rotation of individuals or squads; (b) monitoring personnel performance and motivation by unit leaders; (c) enforcing a work schedule, mandatory sleep periods, or days off; and (d) employing operational risk-management policies when conducting operations.

Negative Factors Affecting Unit Rest

Participants were also asked to report any factors that adversely affected their unit. These comments from 16 respondents are summarized in the following categories: (a) heat stress, (b) working long duty hours or non-optimized rotations, (c) lack of soldiers' refit opportunities, (d) increased workload due to reduced manning, (e) commitments other than conducting operations, (f) high OPTEMPO, (g) difficulty in scheduling activities, and (h) poor management of personnel.

DISCUSSION

This study afforded an opportunity to address sleep deprivation issues during military operations from the viewpoint of Army officers newly returned from combat. The way respondents were

determined poses both a strength and a threat to the validity of our findings. The survey respondents are not a random sample of all Army officers, but represent a "convenience" sample of deployed Army officers taking part in the operations currently conducted in Iraq and Afghanistan. These officers were drawn from the larger population of Army officers who conduct their duties as junior leaders for the deployment period. We attempted to minimize possible bias of the sample by coordinating with the school's leadership to recruit respondents, since course attendants represent a typical group of returning Army officers. One strength of this study is the use of these "real-world" respondents, since they lend external validity to the results.

This study identifies several disturbing findings. The results indicate that a very high percentage (80%) of participants did not receive a briefing on sleep management planning, although such briefings are mandatory under U.S. Army policy. The majority of participants in this survey were junior leaders (i.e., platoon leaders, company commanders, or staff officers at the company or battalion level). If they did not receive briefings on sleep management planning, it is likely they did not give such briefings to the soldiers for whom they were responsible. The findings from this survey indicate that this figure has dropped even lower than that reported by Doheney (2004), pointing to the possibility that commanders address sleep management issues even less now than at the beginning of the Global War on Terror. In many units, even the most basic sleep and fatigue management practices (e.g., encouraging napping or designating dark and quiet places to sleep) were not implemented. Fortunately, the study also revealed that briefing soldiers on (and implementing) sleep plan management had a positive effect on the sleep hygiene of a unit.

Another notable finding in the study relates to the sleep reported for each level of OPTEMPO. Respondents reported spending nearly half their time at high OPTEMPO—as much as 7 months of a 15-month deployment—during which time they averaged approximately 4 hr of sleep per night. Unquestionably, 4 hr of sleep is insufficient for young men and women whose survival is dependent upon their ability to remain vigilant.

The amount of daily sleep reported by respondents to our survey is significantly lower than the recommended requirement of 8 hr of sleep per day. Yet, this result is in keeping with results from other studies conducted in Southwest Asia, which reported sleep issues in U.S. Army and Marine Aviation units (Doheney, 2004; Miller, Shattuck, & Matsangas, 2006). (For a review of fatigue in military operational environments, refer to Miller, Matsangas, & Shattuck, 2008.) OPTEMPO also appeared to be related to napping behavior: When soldiers were getting the least amount of sleep (i.e., during high OPTEMPO), they were also least likely to take naps.

Soldiers who deploy to a Combat Training Center and are at high OPTEMPO for a few weeks may be able to sustain an acceptable level of performance. However, placing soldiers in dangerous environments for up to 15 months and restricting their sleep will inevitably take its toll. The effects of acute and chronic sleep deprivation, coupled with other stressors of combat, could quite possibly impact soldiers long after they have returned home. Recovery from trauma and stress, whether physical or psychological, requires a sufficient amount of quality sleep (Dolan, Adler, Thomas, & Castro, 2005). Chronic sleep restriction may exacerbate underlying health issues and prevent the body from healing and fending off stress-related illnesses (Naitoh, Kelly, & Englund, 1990).

Responses evaluating self, peers', subordinates', and superiors' sleep suggest worrisome trends as well. Respondents acknowledged that the amount of sleep received by the participants

and others with whom they served was inadequate. In fact, they reported that those in more senior leadership positions (and, therefore, those who had more responsibility) were 20% more likely to get inadequate sleep. This finding is consistent with earlier studies (Belenky, 1997). The very people who are making decisions that will affect the greatest number of soldiers are getting the least amount of sleep, and are likely to be the most impaired as a result of their sleep deprivation.

There are two final concerns raised by the survey results. First is the continuous push "to do more with less." Survey responses regarding management of work and rest schedules while deployed suggest that units are undermanned with respect to the missions they are given. Units compensate for lack of personnel in various ways. For example, the number of patrols a soldier must perform may increase, the number of soldiers sent out on a patrol may be decreased, or the length of a soldier's shift may increase. Any of these compensatory strategies could have negative consequences. Second is the inference that soldiers are not being managed properly. This may suggest a lack of good leadership or, perhaps, an inadequate understanding of Army doctrine with respect to sustained operations. Although there is Army doctrine that addresses issues such as sleep hygiene, it is either not adequate or not widely known.

We conclude this article with an excerpt from Shay (1998):

> Pretending to be superhuman is very dangerous. In a well-led military, the self-maintenance of the commander, the interests of his or her country, and the good of the troops are incommensurable only when the enemy succeeds in making them so. It is time to critically reexamine our love affair with stoic self-denial, starting with the service academies. If an adversary can turn our commanders into sleepwalking zombies, from a moral point of view the adversary has done nothing fundamentally different than destroying supplies of food, water, or ammunition. Such could be the outcome, despite our best efforts to counter it. But we must stop doing it to ourselves and handing the enemy a dangerous and unearned advantage. (p. 104)

To Shay (1998), we add this: Although military leaders often must rely on other units to resupply them with food, water, or ammunition, well-rested soldiers are a resource almost entirely under the leaders' control. As leaders put a great deal of effort into managing the logistical resources of combat, they must also expend time and effort into managing the alertness of their soldiers. Failure to attend to either logistical or human resources can lead to the same dire consequences.

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Sleep

MORE IS BETTER ... UP TO A POINT

- CO's, XO's, department heads and strike leaders will sleep far less than normal the week prior to the first strike because of the multiple demands of running the squadron, planning and flying.
- Sleep cannot be stored or built up but the preload of sleep loss can be reduced (2).
- Prior experience with sleep loss does not provide training to maintain performance.
- The minimum amount of sleep to maintain performance during sustained operations is 4-5 hours per day. Fragmented sleep is less effective (2).
- Many studies indicate the important factor is the total amount of sleep, not the amount in a specific sleep cycle. The body tends to adjust for the stage of sleep if given enough time for sleep (2).
- Resting on a bed is not the same as sleep. For some unknown reasons, the regenerative properties associated with sleep cannot be accomplished by just rest (2).
- Combat naps of 10 minutes or more will help maintain alertness and job performance. There is some risk from "sleep inertia" lasting about 5 minutes after awakening characterized by confusion, sluggishness and uncoordination (3).
- "Non-habitual nappers" experience sleep inertia more frequently. Taking more naps (practicing) appears to reduce this problem (4).
- It is easiest to initiate sleep twice a day; in the early afternoon and just before the normal sleep time.
- Alcohol, while initially relaxing, significantly worsens the duration and quality of sleep.
- Sleeping more than 10 hours may cause "sleep drunkenness" and should be discouraged, even after a period of sleep deprivation (2).
- Caffeine interferes with sleep. During Desert Storm aviators who drank less caffeine on non-flying days took longer naps (5).

THE COMBAT NAP

Conventional wisdom suggests that the combat nap is sought by junior officers as a means of avoiding the executive officer. From the standpoint of performance maintenance, however, it is probably the most useful tool we have during continuous and sustained operations. Unlike other interventions, sleep reduces fatigue itself. In other words, it treats the problem not the symptom. Research suggests that a period of sleep as short as 10 minutes improves objective functioning. The only drawback to the nap is that some individuals awaken disoriented and lethargic which lasts from 5 to 20 minutes. "Practice" naps may reduce this period of sleep inertia.

It is strongly recommended that commands encourage, and at times mandate, combat naps.

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Circadian Rhythms

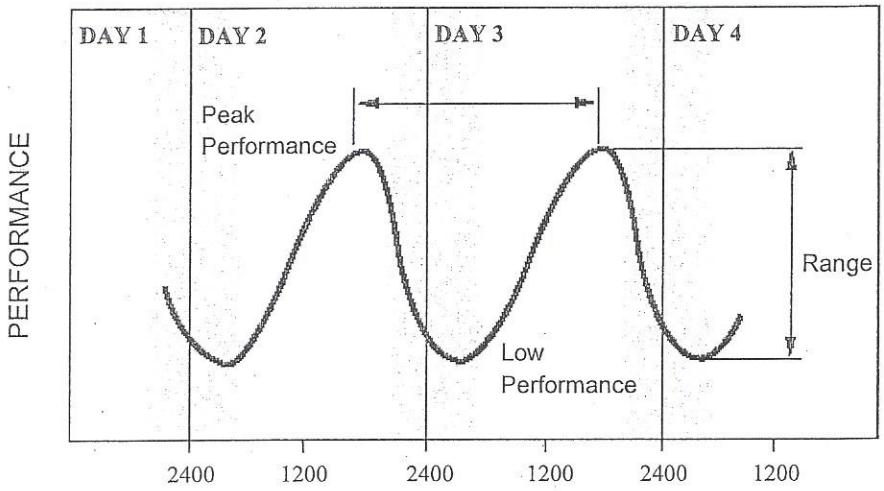
EARLY MORNING IS THE HARDEST TIME

There are numerous cyclic body rhythms in man that collectively are described as circadian rhythms. The influence of the circadian rhythm on aviator performance during continuous operations can be dramatic and warrants both appreciation and understanding.

Experiments carried out in isolation (where all environmental cues have been removed) place humans on a free-wheeling cycle resulting in a spontaneous period commonly close to 25 hours. Entraining agents, however, reset the biological clock daily. These include light and darkness (the most powerful cues), sleep, meals, social activities and clocks.

A general rule is that your body will adapt 1.5 hours/day when traveling east and 1.0 hours/day when traveling west (6). This does not mean that a person cannot perform before all his/her systems are locked on; just that the performance will not be maximized.

THE CIRCADIAN CYCLE



Desynchronization occurs when internal rhythms are no longer in tune with external cues or each other. Continuous operations, transmeridian travel (jet lag) and sleep deprivation (as found in SUSOPS) all force the rhythmic systems of the body to re-adapt.

Systems shift their phases at different rates and therefore may not only be out of phase with local time (external desynchronization) but also out of phase with each other (internal desynchronization). Some phases will be phase delayed and others phase advanced. Finally, there are substantial individual differences. For example, extroverts tend to readjust faster than introverts and individuals over age 40 take more time to readjust than the same person would at age 20. People who live on a more regimented schedule appear to have an easier time adjusting than a person who eats, sleeps, etc. when he or she feels like it. **Fortunately, the military aviator is normally younger and tends toward regimentation and extroversion.**

On an average circadian cycle, performance peaks between 1200 and 2100 hours (normally around 1600) and falls to a minimum between 0300 and 0600 hours. Many body rhythms are tied to sleep rather than the temperature cycle and by disrupting sleep these other cycles are also affected.

About seven consecutive days of shift work are required to adjust the body temperature cycle (and the associated performance peaks and valleys). A single period of night work is more easily tolerated than three or four consecutive nights (which starts the process of circadian desynchronization) (7).

Continuous and sustained operations are prime culprits in causing circadian desynchronization. The resultant fatigue can be more difficult to manage as the body is now challenged both internally and externally. This is known as "operational fatigue."

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Fatigue

EASY TO UNDERSTAND BUT DIFFICULT TO DEFINE

Fatigue is something we all have experienced in varying degrees. Unfortunatley, given its multi-faceted nature, a clear and concise definition remains elusive. We will therefore discuss some of the qualities of fatigue as described by Krueger (8) and offer three working definitions applicable in the military setting.

Physical fatigue is the temporary loss of the power of muscles (or sensors) to respond. Mental fatigue includes the subjective feeling of weariness followed by worsening performance of cognitive tasks.

One characteristic of mental fatigue is "an aversion to effort." During prolonged difficult tasks Krueger describes how "...we often see fatigued workers suddenly stop their work, be it physical or cognitive, and vigorously participate in sporting activities, or computer games during 'break'."

Also seen are occasional periods of no response to stimulation but with normal functioning between. This has been described as the "lapse hypothesis" and while not fully understood, explains why vigilance and attention are early casualties of fatigue.

The subjective sense of fatigue is the first indicator that people are getting tired. **In a normally close knit squadron interpersonal dynamics, in particular everyone's sense of humor, may be the first thing to change.** As a management tool this can be a useful hint for the commanding officer.

TYPES OF FATIGUE

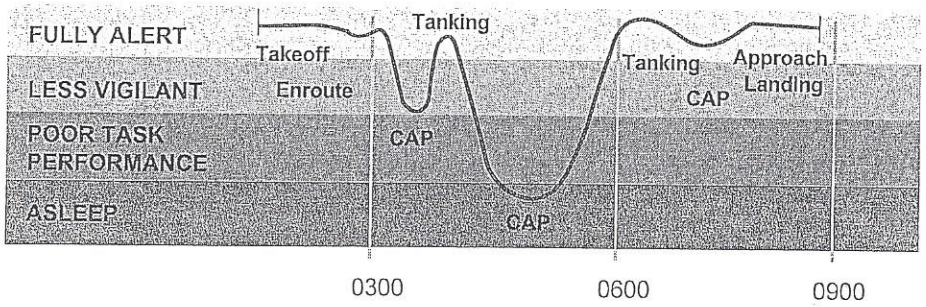
Working definitions which provide a starting point in the operational setting:

ACUTE
- produced by physical exertion or sleep loss
- alleviated by a single rest or sleep period

CHRONIC
- depression or "chronic fatigue syndrome"
- a medical or psychological problem

OPERATIONAL
- attributed to physiological as well as psychological factors
- sleep loss and circadian desynchronization are prime culprits
- the type of fatigue produce by continuous operations
- most commonly seen after 3-4 days of heavy tasking
- not relieved by a single sleep period

FIGURE 1 – PERFORMANCE EFFECTS OF FATIGUE
An Already Tired Aviator Flying an Uneventful Seven Hour Combat Air Patrol (CAP)



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