

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

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# Aircrew Fatigue: Combating The Problem

Including modafinil,  
the new go-pill

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On a daily basis, the news stories from the Middle East remind us how continuous, sustained operations are stressing our personnel to the limits. The challenges can be particularly great for aircrew, who fly to distant destinations, put bombs on target, and then journey home, just to turn right around and do it again. The folks in charge of re-supply missions and troop transport are in the same boat. Our planes and equipment can handle this grueling non-stop pace with relative ease, but we humans just weren't designed to take continuous, around-the-clock operations—at least not for very long.

## Causes Of Fatigue-Related Problems

Modern warfare has become a long-range, 24/7 affair, and the physiological realities of sleep, fatigue, and circadian rhythms often get in the way of optimal performance. As they say, "The spirit is willing, but the flesh is weak." The truth is that humans simply weren't programmed to handle the continuous, sustained pace that has popped up over only the past 50-100 years.

The National Sleep Foundation says people slept an average of nine hours a night in the early 1900's, as compared to the under seven hours we get today. It has only been during the last 100 years that around-the-clock operations have become possible, and it has only been since the

1950's that night vision technology has allowed us to "own the night." These new capabilities have been unbelievably stressful from a human-endurance standpoint. The rapid changes in transportation technology has further complicated the mix. In the early 1900's, it took about 7-9 days to cross the Atlantic Ocean on an ocean liner; today it takes only seven hours on a plane. We can arrive before our internal clocks figure out we've even left the house!

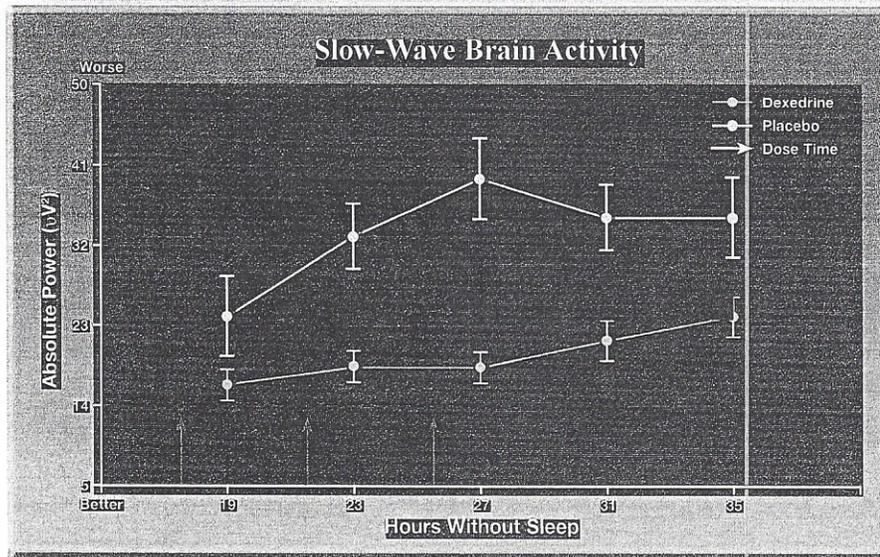
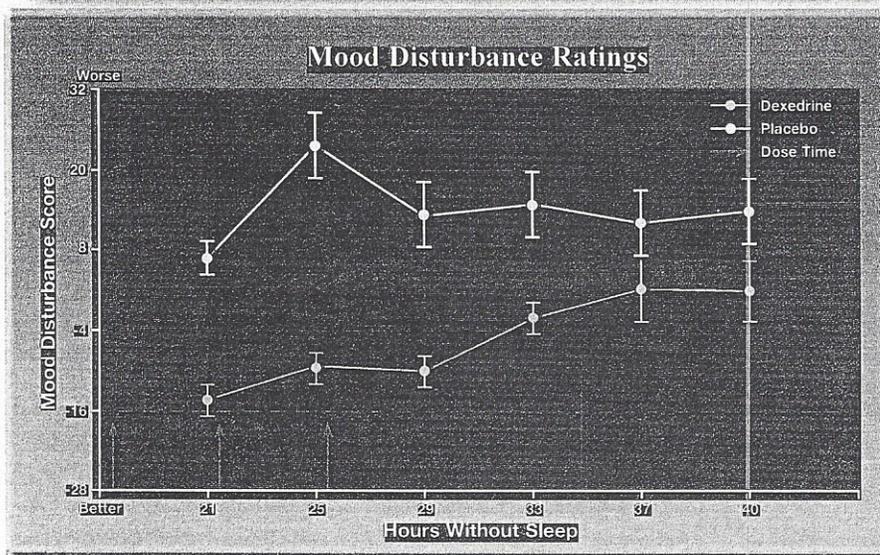
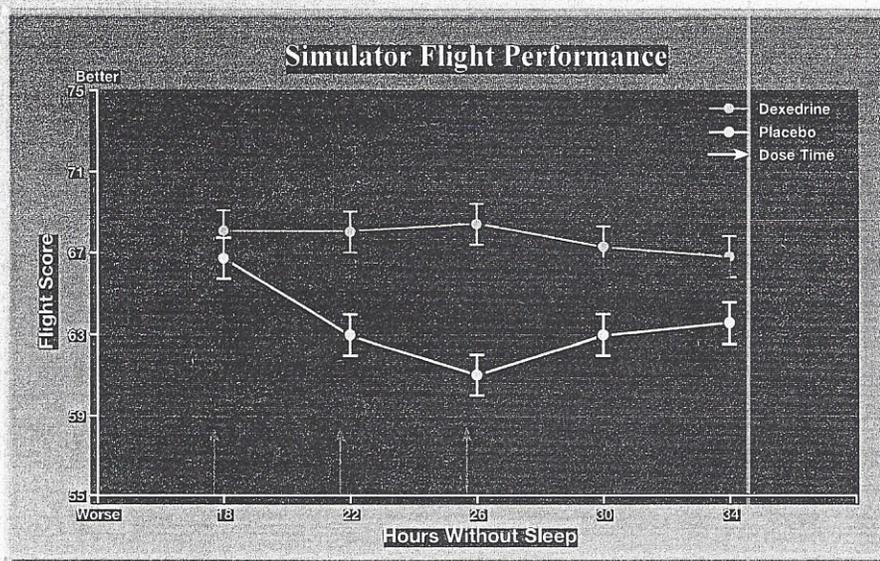
All of this rapid technological change has outstripped the human capacity to keep up. The result has been a dramatic increase in fatigue associated with shortened and/or disrupted sleep, and something called circadian desynchronization (disturbances to the body's internal clock). These problems add up to decreased alertness, impaired reaction time, inattention, disturbed mood, and fatigue-related physical discomfort, which threaten operational safety and effectiveness.

It would be great if we could modify our physiology to keep up with technological changes, but we can't. We are faced with adapting to the chronic sleep restriction and total sleep deprivation that often come with today's operations, and we must have help. We cannot train ourselves to get by on less than 7-9 hours of sleep, and adapting to new time zones or work/rest hours generally takes a lot longer than we would like to believe.

USAF Photo by TSgt Michael Featherston  
Photo Illustration by Dan Harman



22, 150, 10/18/2004, 2004



Flight surgeons and pilots have reported that dextroamphetamine has safely mitigated fatigue in continuous, sustained operations, and that it has been helpful for maintaining performance during those operations without producing unwanted side effects. Dextroamphetamine is authorized for certain situations today, when provided in accordance with carefully planned guidance and used in a well-controlled fashion.

**The New Go-Pill—Modafinil**

In December 2003, the Air Force authorized the use of modafinil to combat fatigue in certain types of aviation missions. Doses of 200 mg (not to exceed 400 mg within 24 hours) can be used to sustain pilot alertness in two-seater bomber missions greater than 12 hours in duration. Also, modafinil has been authorized for F-15C WSOs for missions longer than eight hours. To date, modafinil has not been approved for single-seat operations or for use by fighter pilots "pending further investigation," but approval for fighters is expected in the very near future.

Modafinil was only approved by the FDA in December 1998. Originally, it was approved for treating narcolepsy patients, but earlier this year it was also authorized for the treatment of severe alertness deficits in shift workers. Testing of modafinil in aviation-relevant (and other military) contexts is somewhat limited in comparison to what has been performed with dextroamphetamine, but a few well-controlled studies have been conducted. An investigation with Army helicopter pilots (using 600 mg modafinil given in three divided 200-mg doses) indicated modafinil was capable of sustaining simulator flight performance at near-rested levels despite over 30 hours of sleep loss. A more recent fighter-pilot study (with 300 mg modafinil

Figure 1. Pilot Performance Work with Dextroamphetamine

given in three divided 100-mg doses) indicated that modafinil sustained the flight control accuracy of sleep-deprived F-117 pilots to within about 27 percent of baseline levels, whereas performance under the no-treatment condition degraded by over 82 percent (see Figure 2). Modafinil also improved self-rated psychological status and reduced the types of slow-wave brain activity that are known to reflect physiological fatigue. Although the 300 mgs of modafinil used within a 24-hour period in this study was less than the amount prescribed by Air Force policy, other research with non-pilots has shown that the approved dosage of 200 mg every eight hours offers significant alertness enhancement without causing unwanted effects.

Some of the differences between modafinil and dextroamphetamine are:

- Modafinil does not significantly increase blood pressure and heart rate (a common side effect of amphetamines).
- Modafinil has a lower abuse potential than dextroamphetamine, and therefore creates fewer complications in terms of medical oversight or drug control.

Although not an issue for pilots, an overdose of modafinil is significantly less likely to result in a medical emergency than an overdose of dextroamphetamine. Thus, in general terms, modafinil is viewed to be somewhat safer than the more traditional go-pill. On the slightly negative side, modafinil's alertness-enhancing effects are sometimes not as self-noticeable as those produced by dextroamphetamine, and this could lead people to inappropriately increase the dose in an effort to "feel" modafinil's effects. However, this should not be a problem as long as personnel are informed not to expect the "buzz" that they may have come to associate with stimulants such as amphetamine or caffeine. Just because you don't

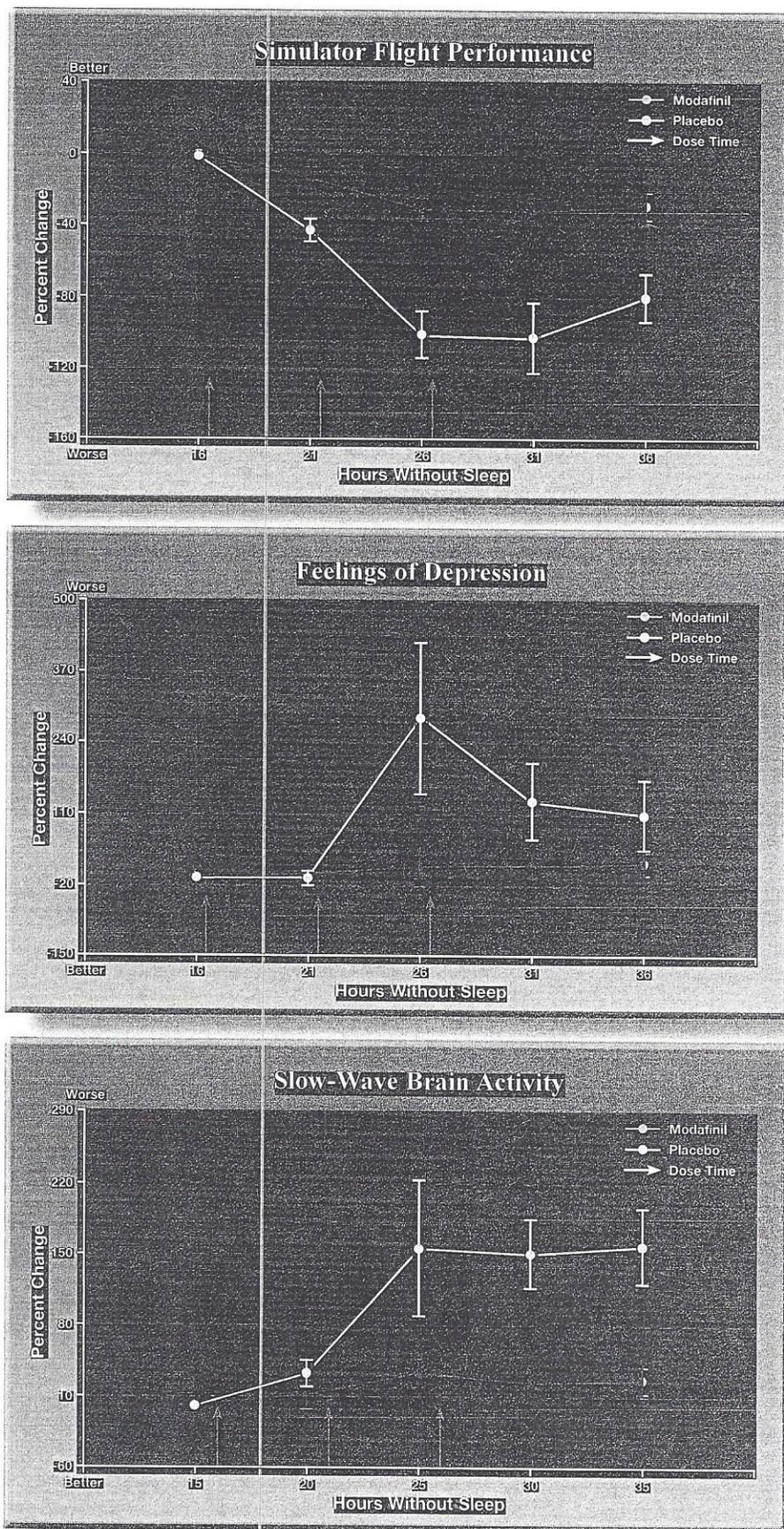
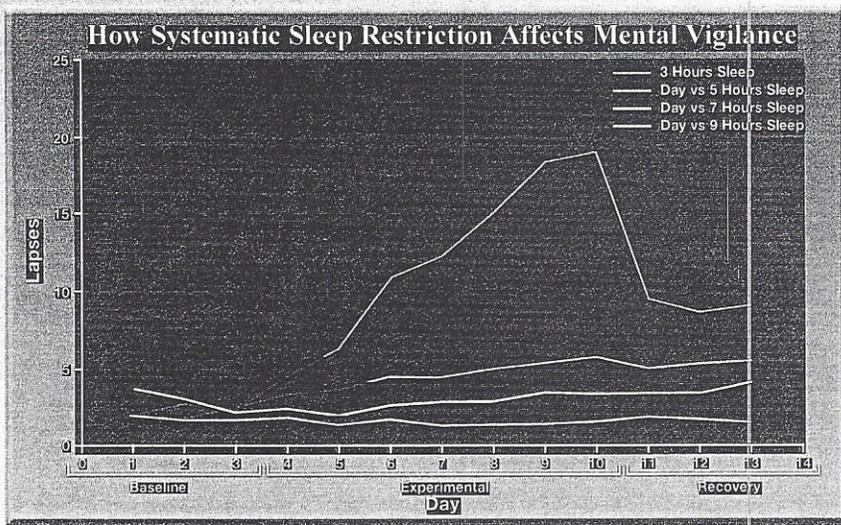


Figure 2. Pilot Performance Work with Modafinil

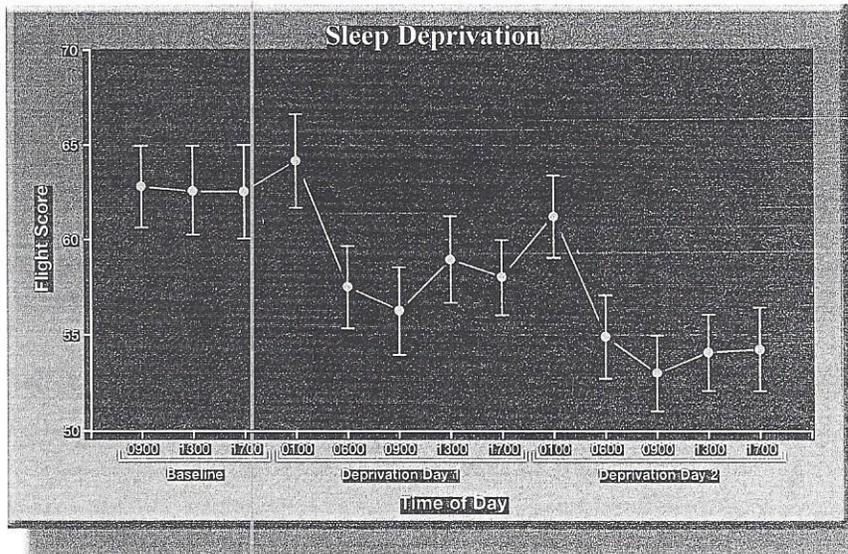
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so everyone should take advantage of ground testing opportunities as they become available. At present, bomber crews who have passed a successful ground test with both modafinil and dextroamphetamine can choose either drug for use on authorized flights. A similar choice will no doubt be available for other pilots when an expanded modafinil policy is issued. In the meantime, the Air Force Research Laboratory is continuing to examine the effects of different doses of modafinil in sleep-deprived pilots, as well as in other personnel. In addition, efforts are underway to augment simulator data and field reports with

feel it, doesn't mean it isn't working. From an effectiveness standpoint, there is some evidence from studies performed on patients with excessive daytime sleepiness that modafinil may be slightly less effective than dextroamphetamine. However, there are other studies that show modafinil produces alertness and performance benefits that are within the range of those associated with the more traditional go-pill.

How well modafinil will ultimately work out in the operational environment remains to be seen, but there is every reason to be optimistic. Preliminary data are already being collected from pilots and flight surgeons in the field, and this will be used by the Air Force Surgeon General to help make further determinations regarding the extent to which modafinil will be used throughout the remainder of Air Force aviation. The evidence we have now suggests that modafinil will be a useful addition to the Air Force's counter-fatigue tool box,



controlled in-flight assessments. As was (and still is) the case with dextroamphetamine, data from a variety of sources will continue to be combined and synthesized to ensure that Air Force guidance is state-of-the-art. Expect to hear more about this in the near future!

### Summary

The high tempo of Air Force flight operations will continue to challenge the adaptive capabilities and endurance levels of pilots and crews, but coordinated fatigue-management strategies will help to successfully meet these challenges now and in the future. While sleep deprivation and body-clock disruptions will remain unavoidable components of around-the-clock operations, concerted efforts to:

- (1) Educate personnel about the dangers of untreated fatigue.
- (2) Prioritize sufficient daily sleep.
- (3) Optimize work/rest scheduling.
- (4) Implement behavioral and administrative counter-fatigue strategies.
- (5) Employing both the new and the old go-pills, as appropriate, will ensure that Air Force pilots and crews remain the best and the safest in the world. ☛

# 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.

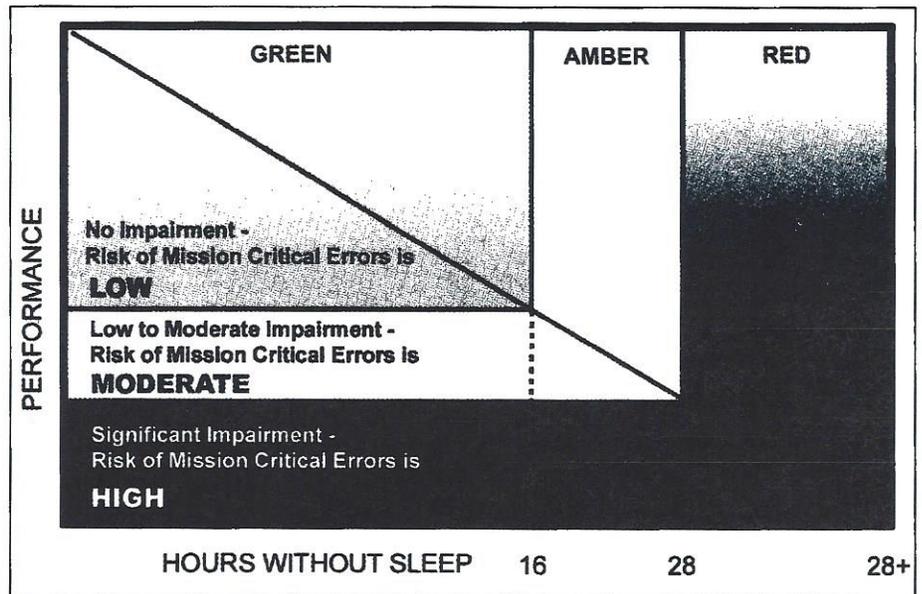
A sleep deprived Soldier may make bad tactical decisions. The bottom line is that sleep deprivation can get Soldiers killed!

### 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.

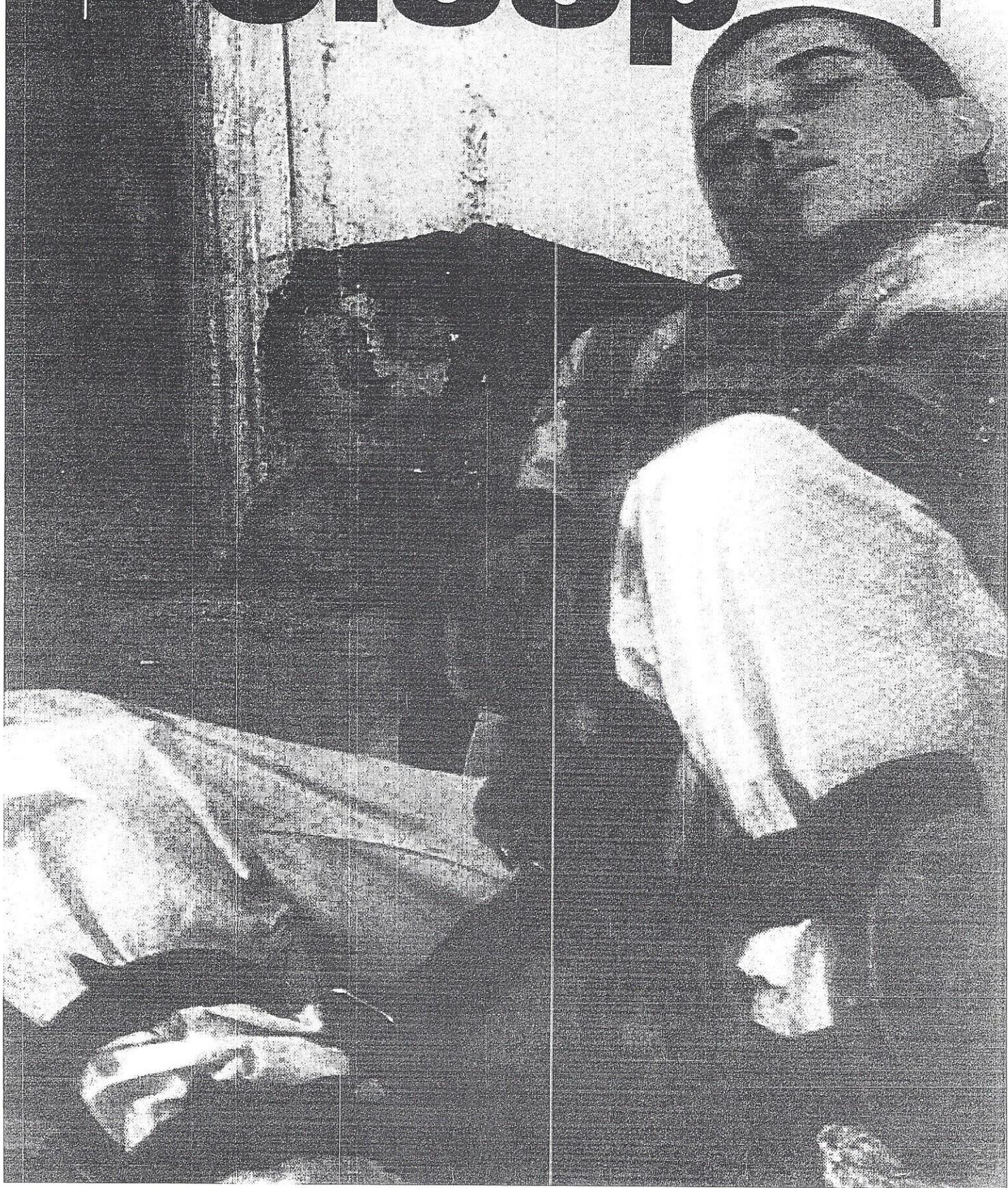
Arrange sleep schedules that give Soldiers opportunities to sleep at a consistent time.

### 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.

# The Sleep



# actor

Story by Karen Fleming-Michael

**A**S 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.

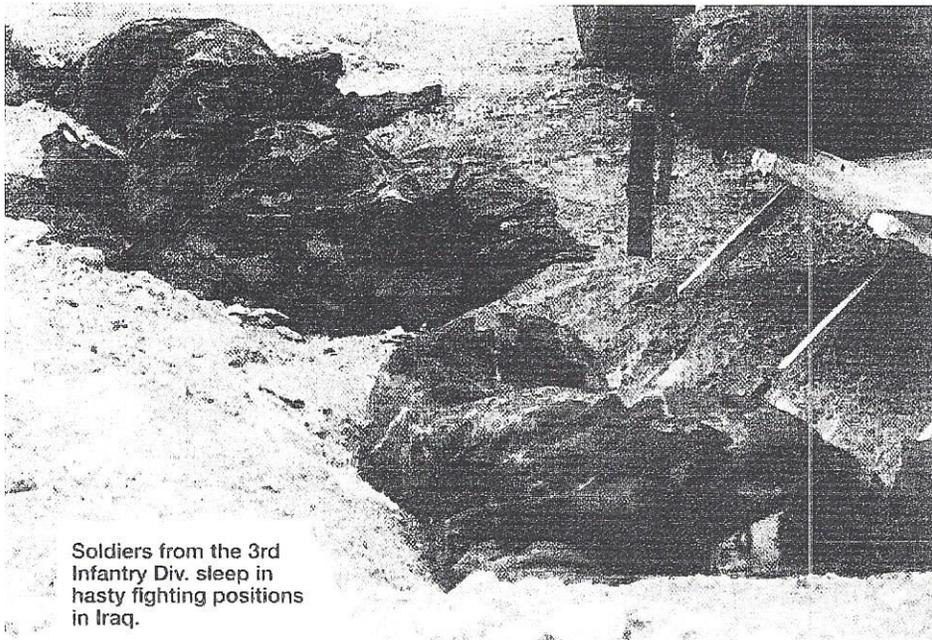
"There's nothing heroic about staying awake for long periods of time," said COL Gregory Belenky, lead sleep researcher at the Walter Reed Army Institute of Research outside Washington, D.C. In fact, combat soldiers who deprive themselves of sleep can cause missions to fail, he said.

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.

SP-4 David Blum/ICJ



SGT LUIS LAZAR

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

MAPPIN' 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.

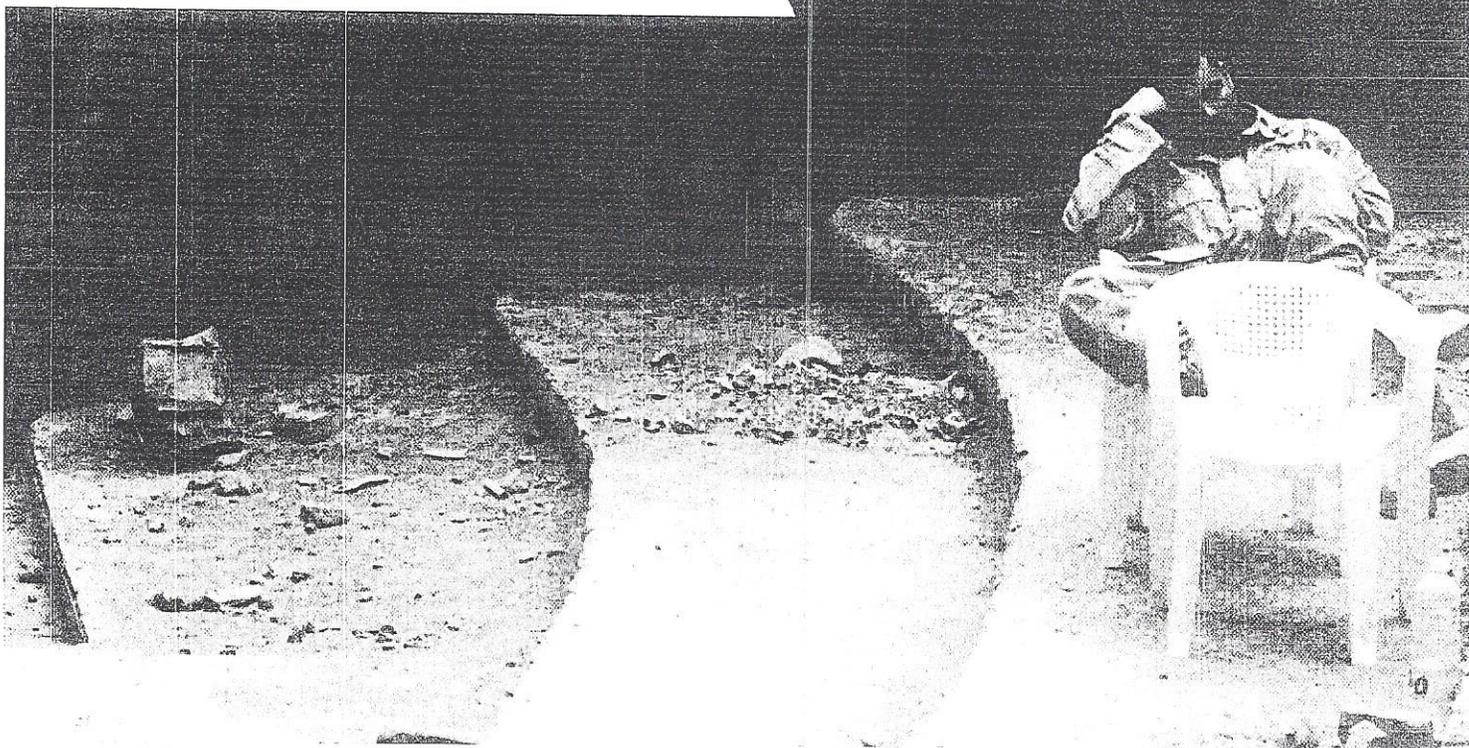
Le Duc and other researchers hope an upcoming eight-day, seven-night study of 12 aviators will provide answers as to whether a 10-milligram dose taken before an early bedtime will allow subjects to fall asleep faster and get better sleep. The team also hopes to learn if more sleep will increase alertness, 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. ☞

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.

SGT Bryan V. Adams



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# The Problem of Fatigue Among Student Pilots at the Naval Air Training Center, Pensacola, Florida

BY COMDR. ASHTON GRAYBIEL, MC-V (S) USNR, LT. ORVILLE HORWITZ,  
MC-V (S) USNR, LT. COMDR. DONALD GATES, MC-V (S) USNR

THE COMMAND at the Naval Air Training Center at Pensacola is responsible for certain phases of the instruction of aviation cadets, the majority of whom will eventually become combat pilots. This responsibility has both quantitative and qualitative aspects. With regard to the former it is obviously desirable to train as many aviators as possible. With regard to the qualitative aspects, three may be mentioned. First, the aviators must attain at least a minimum degree of professional skill. Second, a relatively high level of physical fitness should be maintained. And third, the psychological fitness of the aviator including such factors as emotional stability, the desire to fly, and the offensive spirit should not only be maintained but improved.

One of the important limiting factors in the carrying out of this program is that of human fatigue. That the fatigue experienced by aviators at Pensacola presents a problem worthy of serious consideration is shown by

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From the School of Aviation Medicine, Naval Air Training Center, Pensacola, Florida.

Presented in part at the Fifteenth Annual Meeting of the Aero-Medical Association of the U. S., October 26, 1943, at Cincinnati, Ohio.

FEBRUARY, 1944

information and intelligence which has come to us from several sources. Thus, an analysis<sup>4</sup> of the medical complaints of pilots over a six-month period revealed that fatigue and related symptoms are not infrequent complaints; medical officers receiving instruction in flying have observed and commented upon the excessive fatigue among students and instructors alike; officers of the line in charge of flight instruction have recognized the frequent occurrence of overfatigue among flying personnel; physicians living in intimate contact with aviators at Bachelor Officers Quarters have listened to numerous complaints of fatigue; and lastly investigation has shown that some pilots were over-fatigued at the time their planes crashed. Because of these facts, a general survey of the fatigue problem at this center was deemed advisable.

## TERMINOLOGY

Few words in medical parlance have a broader meaning than the word fatigue.<sup>2, 3, 5</sup> It is used in the physiological laboratory to describe the diminishing capacity of various tissues under working conditions to respond to stimulation. It is also used in describing

various subjective and objective phenomena in man.

Objectively, fatigue may be declared by alterations in appearance, by a decrease in the amount of work performed, and by the production of certain chemical substances and exhaustion of others. Subjectively the word fatigue is used in describing feelings of tiredness which range from boredom to exhaustion. These feelings of fatigue are difficult to describe but are known to everyone by experience. The lesser degrees are declared by weariness, a falling off of interest and pleasure in the activity undertaken, and a disinclination to continue. These feelings are readily abolished by rest or masked by the use of certain drugs, alcohol, or by the stimulation resulting from increased motivation. Greater degrees of fatigue are characterized by feelings of great weariness and exhaustion, a positive aversion to continuing a given activity, and listlessness. If a night's rest does not relieve the fatigue, or if the relief is short lived, i.e., if the fatigue comes on earlier in the day than usual, it indicates an accumulative process which we have referred to as "over-fatigue." Extreme degrees of fatigue may continue for many days in which case the term "fatigue syndrome" has been appropriately used.

Sometimes a clear distinction is made between physical and mental fatigue depending on whether it results principally from physical or mental activity. Although this distinction at times may be useful, it should be emphasized that whether the bodily activity be predominantly "mental" or "phys-

ical" the fatigue which follows may have a similar symptomatology.

Because the signs and symptoms of fatigue are prominent in anxiety states (psychoneurosis) and, conversely, because anxiety is often present in the fatigue state, confusion between the two has resulted especially in the minds of some of those who are not trained psychiatrists. This is even more readily understandable when it is realized that frequently those experiences which may precipitate an anxiety neurosis are also fatiguing or exhausting, and that among a group of persons undergoing the same stresses and strains, some may become very fatigued and a few may develop some form of psychological disorder.

The stress and strain incident to flying, and particularly combat flying, afford a good illustration because even strong stable men may break down with a variety of mental symptoms.<sup>1</sup> Such cases are usually regarded as having a common etiology and the terms, "pilot fatigue," "flying stress," "aviator's neurosis," "aeroneurosis," et cetera, have been used to designate what is believed to be a distinct clinical syndrome. It has become apparent, however, that these cases do not represent a single clinical entity but comprise a group of disorders including the fatigue syndrome, and various psychological illnesses, all of which fit into well recognized clinical categories. The recognition of these different disorders among flyers is of considerable importance as it will lead to logical treatment, disposition, and possibly prevention.

## FATIGUE—GRAYBIEL, HORWITZ AND GATES

### PLAN AND BACKGROUND OF STUDY

The present study consists essentially of a statistical analysis of the information obtained from interviewing a random sample of 172 student aviators during the various stages of primary and intermediate training. Additional information was also obtained from a small number of flight students referred from the dispensary because of symptoms of fatigue, but was not included in the general analysis.\*

Of the 172 students, fourteen were officers, 144 were aviation cadets and fourteen were enlisted personnel. Their ages ranged from nineteen to thirty and the average was twenty-two. Only a few were married. All but seven had finished high school and all but twenty-five had finished at least two years of college study. The subjects had been selected for flight training only after a careful examination designed to exclude those with physical defects or psychological handicaps. They represented, therefore, a group well above the average with respect to intelligence, learning, and freedom to physical and mental disorders.

In primary training, the completion of which requires at least three months, the students' time is about equally divided between Ground School and flying. Ground School presents short intensive courses in the theory of flight, navigation, ordnance, et cetera. Flying was done in small training planes and two one-hour flights were planned daily.

Intermediate training requires a min-

\*We wish to express our thanks to Ensign Howard West for his help in the statistical treatment of the data.

imum of three and one-half months. Each student receives a short course of instruction in formation and instrument flying, using planes which are heavier than the types used in primary training. Following this the students specialize in one of three types of aircraft, namely, large patrol seaplanes, carrier type (land based) planes (OS2U) or small seaplanes (VO-VS).

The questionnaire used in the interview consisted of two main parts. The first portion was of the free-response type in which only general indirect questions were asked. By this means it was hoped to obtain "new" information which was not prompted or colored by the direct-question method. The second portion consisted of a long series of specific questions requiring an exact answer or definite opinion. Both portions of the questionnaire were designed to yield information concerning (1) the incidence and degree of overfatigue; (2) the predisposing factors; (3) the precipitating factors; (4) the symptomatology of overfatigue and (5) certain other aspects of the problem.

### THE INCIDENCE AND DEGREE OF FATIGUE

Nearly all of the students complained of feeling tired at the end of a day's duty and over half (ninety-one of 172) stated that they had experienced periods of overfatigue as defined above. Hereafter they will be referred to as the "fatigue group" while the remaining eighty-one will be referred to as the "non-fatigue group." It should be emphasized, however, that most members of the latter group experi-

enced symptoms of fatigue often to a significant degree, but the symptoms were abolished by a night's rest. The duration of fatigue in the fatigue group ranged from one to forty-five days, the average period being ten days. The severity of the fatigue was judged by the amount of time necessary for recuperation and this information was obtained in eighty-nine cases. In twenty-seven instances the additional rest obtained in a single day was all that was required for the relief of symptoms; in forty-eight instances two nights and a day (restful week end) were necessary; and in the remaining sixteen instances a longer period was required.

#### PREDISPOSING FACTORS

An attempt was made to determine the predisposing factors to fatigue by inquiring into the student's past and family history. The questions were weighted according to their importance and scored arbitrarily. Negative values were given to unfavorable attributes such as nervousness and emotional overreaction and positive values to favorable attributes such as calmness and the ability to work hard without undue fatigue. The same questions were asked of all students and the scores ranged from -39 to +61. A comparison of scores of the fatigue and nonfatigue groups is shown in Graph 1. Points on the curves were obtained by grouping the scores by increments of 5. The curves are similar and no significant difference between the two groups is demonstrated.

Because of the possibility that the method of composite scoring led to error the answers to two direct questions were analyzed separately. These questions dealt with the ease with

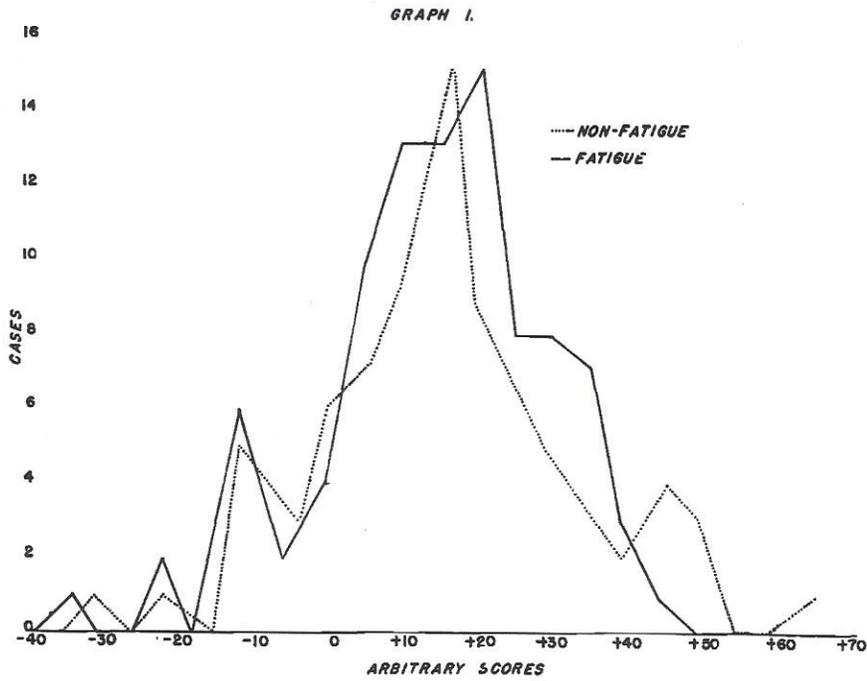
which the subject developed (1) physical and (2) mental fatigue in the past. Five choices were open in answering, i.e., whether fatigue came on very slowly, slowly, average, rapidly or very rapidly. The results are shown graphically in Graphs 2 and 3. It is apparent that there is little difference between the two groups.

Our failure to demonstrate the importance of any predisposing factors with respect to the development of overfatigue requires explanation. One possibility is that the entire student group is homogeneous with respect to the predisposition to fatigue. If this were true then it should be possible to show that the precipitating factors were greater for the fatigue than for the nonfatigue group. This, however, was usually not the case as will be shown later. A more likely explanation is that the method of direct questioning and scoring used was inadequate. Many of the direct questions called for a comparison with an "average" subject. This is difficult at best and sometimes impossible. Furthermore, there was a tendency on the part of many students to answer personal questions in accordance with what they wished or hoped to be true. Before concluding, therefore, that the entire group was homogeneous with respect to the predisposing factors, or that they were unimportant, a further attempt should be made to evaluate them more accurately.

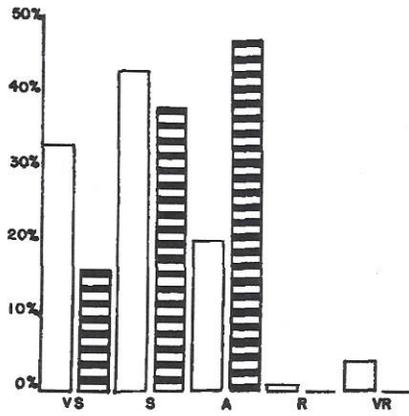
#### PRECIPITATING FACTORS

Each student in the fatigue group was asked, in the first part of the questionnaire, to discuss the factors which he thought were immediately re-

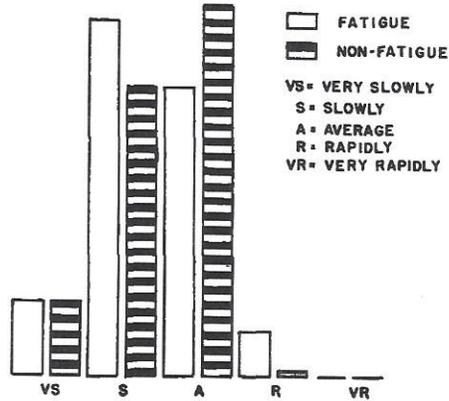
FATIGUE—GRAYBIEL, HORWITZ AND GATES



GRAPH 2



GRAPH 3.



sponsible for the overfatigue. In addition the students in both the fatigue and nonfatigue groups were asked to give their opinion regarding the im-

portance of various factors which contributed to their fatigue or overfatigue and these data were analyzed separately for both groups.

*Physical Illness*

On direct questioning twenty-two of the fatigue group and twelve of the nonfatigue group stated that they either felt ill on entering, or developed some illness during the flight training course. Eight of the twenty-two in the fatigue group were of the opinion that illness was a chief factor in bringing on the fatigue. Sometimes the illness had a favorable effect, i.e., it afforded the student an opportunity to rest. It is of interest in this connection that twelve students in the fatigue group went to the dispensary complaining of some physical ailment, when feeling tired and exhausted were their true symptoms. This was done because of the fact that "fatigue" was not always accepted by the squadron leader as a valid reason for "excuse from flying."

*Factors Closely Related To Flying*

1. *Stage of Flying at which Fatigue Occurred*—The absolute incidence of fatigue was greatest in the primary squadrons, but the relative incidence was approximately the same in all except the final squadrons. Many students complained of fatigue on first joining a new squadron. The change in environment, the necessity of quickly mastering new skills and the fear of failure were among the contributing factors. After they became oriented in their new surroundings and began to acquire the new skills, the strain was lessened and with it, the likelihood of overfatigue. This is shown in Graphs 4, 5, 6 and 7. The only exception is the occurrence of fatigue in the advanced squadrons (Graph 7) which

had its highest incidence in the middle of the course. This may be explained in part by the small numbers involved but also by the fact that assumption of responsibility in the advanced squadrons may proceed rather slowly.

2. *Number of Hours Flown*—The actual number of hours flown only occasionally contributed to fatigue. Only thirty of the ninety-one students in the fatigue group flew more than fourteen hours per week, during the period immediately preceding the onset of fatigue and only nine flew more than twenty hours. Thirteen stated that long hours of flying were partly or chiefly responsible for their overfatigue. This was usually the result of special circumstances in which they flew as many as four and one half hours in the day and an additional two hours at night for two or three consecutive days. There is no doubt that night flying, coming as an additional duty after a long day's work, may cause an extreme degree of acute fatigue and is illustrated by the following actual experience: E. D., a student pilot when asked to "describe any special circumstances which you believe may have been responsible for the overfatigue" answered by tabulating his flying time as follows:

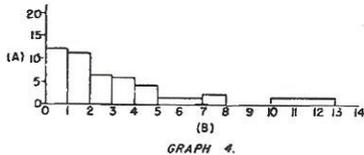
Sunday afternoon	— 3	hours flying
Sunday night	— 2	hours flying
Monday morning	— 4½	hours flying
Monday night	— 2	hours flying
Tuesday morning	— 3	hours flying
Tuesday night	— 2	hours flying

Recovery from the effects of night flying was speeded, in not a few instances, by the pilot going to the dispensary the next morning with some

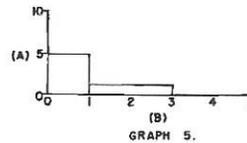
FATIGUE—GRAYBIEL, HORWITZ AND GATES

FATIGUE IN RELATION TO TIME SPENT IN EACH SQUADRON

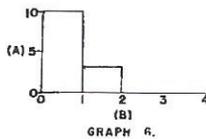
PRIMARY



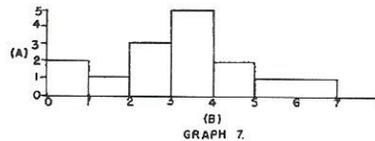
SQUADRON 2



SQUADRON 3



ADVANCED SQUADRON



(A) = NUMBER OF COMPLAINTS OF FATIGUE AT TIME DURING THE COURSE  
(B) = WEEKS SPENT IN SQUADRON

complaint which would excuse him from flying for a day.

3. *Fear of Flying*—The question was asked whether fear or anxiety about flying contributed to fatigue. Twelve out of eighty-six (16 per cent) in the fatigue group and nine out of seventy-three (14 per cent) in non-fatigue group admitted it did. One-quarter in each group also stated that they felt tense while waiting to fly. In nearly every instance the student went on to explain that his anxiety was not great save in special circumstances and not a single student stated that he felt "very tense" while waiting to fly. Furthermore none of the students in the fatigue group gave fear of flying as a chief cause of their over-fatigue. However, it must be remem-

bered that students hesitate to admit of their anxiety with regard to flying even to themselves. It is probable that an undercurrent of anxiety plays a more important role than the above figures would indicate.

4. *Difficulty in Learning to Fly*—This statement was not put in the form of a question but eight students in the fatigue group indicated that difficulty at a particular stage of flying was an important factor contributing to their fatigue.

5. *Relations with Instructors*—Each student was asked if the instructor-student relationship was a factor in causing fatigue. Twenty-seven of eighty students in the fatigue group and twenty-five of seventy-eight

students in the nonfatigue group answered in the affirmative. They were further asked to indicate which of the following list of attributes or mannerisms on the part of the instructor were most important in this regard: (1) indistinctness of speech; (2) rough handling of the stick; (3) lack of interest; (4) silence; (5) impatience; (6) shouting; (7) profanity, and (8) "incessant" criticism. The first four of the above were underscored with equal frequency by the students in both groups but the last four were underscored twice as frequently by the students in the fatigue as in the nonfatigue group. This difference may be significant and, if so, would indicate that students in the fatigue group either received more criticism or were more sensitive to criticism. In discussing this problem with the students there was no doubt in the minds of some that an unhappy relationship with certain instructors quickly led to a state of fatigue.

6. *Airsickness*—This was not an important factor in causing fatigue save in rare instances. Only two of 167 students stated that they were much troubled with airsickness and only twenty-eight were occasionally troubled. There was no difference in the incidence of airsickness in the fatigue and nonfatigue groups.

7. *Effects of Acceleration*—Of 152 students questioned, fourteen had "blacked out" many times, twenty had "blacked out" from two to five times, twenty-one had "blacked out" once, and the remaining ninety-seven had never "blacked out." There was no

significant difference between the fatigue and nonfatigue groups with respect to the incidence of blackout. There are two possible relationships between the blackout and fatigue, first, that blacking out may result in fatigue and second, that fatigue of sufficient degree may predispose to the blackout. The history in occasional cases proves the truth of both of the above relationships but the blackout is not experienced sufficiently during the primary and intermediate training periods for it to be an important factor.

#### *The General Program*

1. *Length of Working Day*—Each student was asked if the day's work in the various squadrons was "much too short," "slightly too short," "satisfactory," "slightly too long," or "much too long." Only a few were of the opinion that the day's work was too long or too short in the final squadrons. Twelve per cent were of the opinion that it was too long and 17 per cent that it was too short in squadron III. Twenty per cent were of the opinion that the day's work was too long and 10 per cent that it was too short in squadron II. Thirty-five per cent believed the working day was too long and only 4 per cent that it was too short in the primary squadron. Although more members of the fatigue group than the nonfatigue group stated that the working day was too long, the differences were not great and were considered not to be significant.

The chief reason why the day's work was so long in the primary squadron was because of the large number of hours devoted to various

studies in ground school. This not only required attendance at class but "home work" as well. The amount of time spent in various studies decreased progressively as more advanced squadrons were reached.

2. *Intensity of the Work*—Data were also obtained with regard to the intensity of the program as distinct from the length of the working day. An expression frequently heard was that the student was "taught too much, too soon, in too many subjects."

This difficulty was experienced by approximately 15 per cent in the primary squadron and during instrument flying (squadron III), and by only a small percentage of students in the other squadrons. Here again, more complaints were made by students in the fatigue than in the nonfatigue group but the difference was not great.

3. *"Hanging Around"*—It would appear, at first glance, that "hanging around" the ready rooms while waiting to fly would come under the heading of relaxation. This is true if the period of waiting is short. But hanging around for long periods was found to be an important contributing cause of fatigue. Seventy-four per cent in the nonfatigue group and 80 per cent in the fatigue group believed this factor was important and 30 per cent of the latter group were of the opinion that it contributed greatly to fatigue. There are a number of factors which make waiting around a fatiguing experience including (1) uncomfortable lounging rooms; (2) sense of expectancy; (3) tenseness; and (4) irritation at lack of freedom. It was the

opinion of a large number that more comfortable ready rooms, some sort of organized diversion and instruction, and greater freedom would improve this situation.

4. *Recreation*—Too little time for play and relaxation during the day, and too many consecutive working days without a pause were also important factors contributing to fatigue. At certain squadrons where a regular day of rest every eight days was obtained\* it was the opinion of many students that this was not only desirable but necessary in order to prevent fatigue and loss of efficiency.

Approximately 20 per cent of the students were of the opinion that the time and energy spent in various pleasures and sports outside of their regular work contributed to fatigue. However, the great majority of students spent much less time than usual on entertainment.

5. *Physical Work*—The actual amount of physical work performed by the flight students is small except at certain centers where primary instruction is given. About 10 per cent of the students considered it was a significant factor contributing to fatigue but about twice as many considered it was helpful in preventing fatigue.

6. *Athletic Program*—There was great variation in the opinions expressed with respect to the athletic program. Approximately thirty per cent considered it contributed to fatigue and

\*This is now true for all squadrons.

a like percentage that it prevented fatigue. This is what might be expected in a rigid program which, for obvious reasons, cannot be suited to the individual. There is no doubt that men who are working hard for many hours a day often reach a state of fatigue where exercise is harmful rather than helpful. It was equally evident from our discussions with the students that nearly all wished to take exercise provided they felt able to do so and if the exercise was of the kind which they enjoyed. The experience of the students who took the pre-flight course might be mentioned in this connection. They found that even when a high degree of physical fitness was reached it afforded little protection from the fatiguing experience of flight instruction.

*Lack of Sleep*

In the first part of the questionnaire each student in the fatigue group was asked to state the causes of over-fatigue which he thought were most important. Forty-four of the ninety-one students spontaneously mentioned lack of sleep as an important cause and this was three times the frequency with which any other single cause was spontaneously mentioned. In another part of the questionnaire each student was asked how many hours on the average he slept at night and the results are shown in Table I.

It is obvious that there is little difference between the two groups with respect to the average number of hours of sleep at night. Students in both groups complained of getting too little sleep.

TABLE I

Average Number Hours Slept	Number in Non-Fatigue Group	Number in Fatigue Group	Number in Both Groups
5	1	1	2
6	11	10	21
7	38	54	92
8	18	18	36
9	2	2	4

The reasons why so little sleep was obtained are the following: (1) Reveille at 0500 (usually) and taps at 2200. Although it is possible to retire before 2200, it is practically impossible to sleep because of the light, bells, and other disturbances. (2) During the day sleeping is forbidden while on duty even during periods of waiting in the ready room. (3) Sleeping on the bunks is forbidden during the day even during "time off." The way in which extra sleep is usually obtained is by "sneaking it in" at the risk of being put on report.

The majority of young healthy persons require more than 7 hours sleep when engaged in strenuous mental activity. Lack of sleep hastens the onset of fatigue, is a cause of inefficiency, and "doping off" leads to obvious dangers and the neglect of important duties.

*Miscellaneous Factors*

1. *Worry*—Worry over conditions at home was a contributing factor to fatigue in about 10 per cent of the cases. It was a chief cause in only a few instances.

2. *Poor Food*.—This was mentioned by seven students in the fatigue group as an important factor in causing fa-

tigue. This opinion was given by students who had been sent to new Primary Training Bases which were still under construction and where the food was cooked and handled in temporary messes.

3. *Heat and Humidity.*—Only two students in the fatigue group spontaneously offered the opinion that the heat of summer was a chief cause of their overfatigue. However, when the question was put directly to the students (165) in both groups eighty-five were of the opinion that hot weather was an important factor; fifty of the eighty-five thought it was slightly and thirty-five thought it was very important.

#### *Comment*

A consideration of the precipitating factors of overfatigue must begin with the simple fact that the flight training program both in the primary and intermediate stages is very strenuous indeed. The amount of physical work is small but the mental and emotional strains are great. This results from long hours of work with insufficient time for relaxation and sleep. Although the number of hours spent in the air is not large, yet, there is an element of excitement and strain associated with flying because of its hazardous nature. Because the overfatigue usually occurred during the initial part of the various stages of training, it must be assumed that the difficulty in adjusting to new circumstances played an important role.

Although each student is subjected to much the same rigorous schedule,

fortuitous circumstances of various kinds act to aggravate or alleviate the strain. These are sufficiently great in borderline cases, to prevent or precipitate overfatigue. Thus it is that a wide variety of minor factors acquire significance in individual cases. In appraising these occasional precipitating factors it is important not to ascribe too much importance to them but to regard them as "last straws" added to an already heavy load.

With respect to remedial measures it is important to distinguish between the factors contributing to fatigue which are common to most or all of the students, and the factors which play a role in only a few instances. It is clearly not advantageous to spend too much effort on the latter but rather to focus attention on the common precipitating factors which offer promise of being changed for the better. By making such changes the "reserve" may be increased to the extent where other factors, not easily remediable, will not cause overfatigue.

The analysis of the precipitating factors in the present study indicates that long hours of duty, too few hours of sleep, the initial period of adjustment, the anxiety associated with a hazardous occupation, and hanging around the ready rooms are the important factors common to all. By favorably altering one or more of these factors the onset of overfatigue may be lessened. Arranging for more hours of sleep, insuring periods of rest, and organizing a program for periods of waiting in the ready rooms would undoubtedly result in a lessening of fatigue. This favorable effect might

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TABLE II

Symptoms	GROUP COMPLAINING OF OVER-FATIGUE						GROUP NOT COMPLAINING OF OVER-FATIGUE	
	1. Symptoms in Period of Over-Fatigue as Elicited by Free Response		2. Symptoms in Period of Over-Fatigue as Elicited by Direct Questions		3. Symptoms in Period When not Over-Fatigued as Elicited by Direct Questions		4. Symptoms Elicited by Direct Questions	
	No.	%	No.	%	No.	%	No.	%
Increased restlessness	5	5.5	66	72.5	7	7.7	5	6.2
Changed sleeping habits	6	6.6	51	56.0	7	7.7	7	8.6
Increased irritability	22	24.2	70	76.9	2	2.2	5	6.2
Increased effort necessary to carry on work	7	7.7	72	79.1	5	5.5	9	11.1
Feeling of weakness	9	9.9	63	69.1	2	2.2	4	4.9
Troubled with inability to forget about flying	2	2.2	25	27.4	3	3.3	10	12.3
Inattention to duty	21	23.1	52	57.1	9	9.9	13	16.1
Tendency to carelessness	12	13.2	62	68.1	3	3.3	15	18.5
Tendency to dope off	4	4.4	69	75.8	11	12.1	12	14.8
Excess excuses	1	1.1	19	20.8	1	1.1	0	0.0
Palpitation	0	0.0	8	8.8	1	1.1	1	1.2
Anorexia	8	8.8	57	62.5	5	5.5	12	14.8
Dizzy spells	1	1.1	12	13.2	0	0.0	3	3.7
Abdominal distress	1	1.1	16	17.6	1	1.1	3	3.7
Loss efficiency	10	11.0	80	87.9	1	1.1	0	0.0
Loss weight	0	0.0	19	20.8	6	6.6	8	9.9
Increased smoking	0	0.0	32	35.2	7	7.7	12	14.8

protect the student from other precipitating factors which are present from time to time such as excessive heat and humidity, minor ailments, difficulty in ground school or in learning to fly, and worry over home affairs.

SYMPTOMATOLOGY

In the first part of the questionnaire each student in the fatigue group was asked to describe in his own words the feelings and reactions which appeared during the periods of overfatigue and

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TABLE II (Continued)

Symptoms	GROUP COMPLAINING OF OVER-FATIGUE						GROUP NOT COMPLAINING OF OVER-FATIGUE	
	1. Symptoms in Period of Over-Fatigue as Elicited by Free Response		2. Symptoms in Period of Over-Fatigue as Elicited by Direct Questions		3. Symptoms in Period When not Over-Fatigued as Elicited by Direct Questions		4. Symptoms Elicited by Direct Questions	
	No.	%	No.	%	No.	%	No.	%
Increased coffee and coca-cola	0	0.0	26	28.6	6	6.6	17	21.0
Decreased alcoholic consumption	0	0.0	20	22.0	14	15.4	18	22.2
Increased alcoholic consumption	0	0.0	8	8.8	6	6.6	5	6.2
Decreased extracurricular activity	3	3.3	41	45.0	15	16.5	19	23.2
Tendency to sigh more frequently	0	0.0	32	35.2	1	1.1	4	4.9
Decreased love of aircraft	10	11.0						
Depressed	8	8.8						
Decreased reaction time	5	5.5						
Headache	3	3.3						
Burning eyes	2	2.2						
Homesick	2	2.2						
Loss of insight	1	1.1						
Felt "going crazy"	1	1.1						
Muscle aches	1	1.1						
Ears ringing	1	1.1						

which indicated a departure from his usual state of well-being. In the second part of the questionnaire each student in the fatigue group was asked to answer two sets of the same specific questions on symptomatology; the first

set compared the period before flight instruction began with the period of overfatigue during flight training, and the second set compared the period before flight instruction with the period during training when the student

was not overfatigued. Students in the nonfatigue group answered only one set of questions which compared the period before, with the period during flight instruction.

The information obtained is summarized in the accompanying table which is largely self-explanatory and only a few comments will be made.

The first column in Table II shows the incidence of the various symptoms occurring during the period of overfatigue which were mentioned spontaneously. The commonest complaints, in addition to a feeling of tiredness, are inattention to various duties, and increased irritability. The more objective aspects of the symptomatology such as weight loss, increased use of tobacco, coffee, et cetera were omitted but a wide variety of symptoms were mentioned.

The second column in Table II shows the incidence of the various symptoms occurring during the period of overfatigue as obtained by direct questioning. It is apparent from a comparison of the percentages in columns one and two that the true frequency of the various symptoms can only be determined by asking direct questions. It is also evident that the subjective phenomena of fatigue occurred with greater frequency than the objective phenomena.

In addition to feeling tired the symptoms which occurred in more than half of the students in the fatigue group were: (1) increase in effort necessary to carry on with work, (2) increase in irritability; (3) tendency to fall asleep or "dope off"; (4) tendency to carelessness; (5) loss

of appetite and (6) change in sleeping habits. The only common objective phenomenon was a loss in efficiency in the work being done. Other important signs were: (1) a tendency to sigh more frequently; (2) loss of weight; (3) increased consumption of tobacco and coffee and a change in the amount of alcohol used and (4) a lack of desire for outside activities.

Column three in Table II shows the incidence of the various symptoms which occurred in members of the fatigue group at a time when they were not overfatigued. With the exception of dizzy spells all of the symptoms were noted but much less frequently than during periods of overfatigue.

It is of interest that all of the symptoms listed in Table II were occasionally noted by students who never complained of overfatigue (Column 4). Too much emphasis, therefore, cannot be placed on the mere occurrence of a single symptom. Unless a complaint is extraordinarily prominent or unless several symptoms occur simultaneously the significance may be in doubt. For example, an increase in the number of cigarettes smoked may be an important part of the symptomatology of the fatigue syndrome or it may be an isolated and relatively unimportant occurrence.

#### ACCIDENTS AND FATIGUE

A number of specific instances have come to our attention suggesting a direct relationship between accidents and fatigue. Although this relationship is usually impossible to prove in particular instances the general truth has been established by surveys conducted in various industries.<sup>2</sup> A review of

the symptomatology of fatigue emphasizes the fact that fatigued aviators are certainly less efficient in their work, and, in some instances at least, are unfit to fly. Approximately two-thirds of those in the fatigue group stated that during the period of overfatigue they were aware of carelessness and inattention to duty. It was further found that thirty-five out of eighty-six in the fatigue group had been involved in an accident or near-accident and that in eight of these instances, fatigue was thought to be a factor. Even in the nonfatigue group thirty out of eighty-one students were involved in an accident or near-accident and four out of the thirty considered that fatigue was a significant factor.

#### FATIGUE AND THE PSYCHONEUROSES

It is apparent that the symptoms complained of during periods of overfatigue are similar to symptoms occurring in some of the psychoneuroses. There seems no reason to doubt the fact that experiences which may precipitate an anxiety neurosis are often fatiguing and that among a group of persons undergoing the same stresses and strains some simply become very fatigued, while a few may develop some type of minor psychological disorder. However, the significance of fatigue in the development of anxiety neurosis, for example, is not always clear. We have observed cases of anxiety neurosis which appeared to develop at a time when the individual was not fatigued. However, it is impossible to say that the background may not have been laid during periods of overfatigue. In some instances at least there seems to be a very close

relationship between the overfatigue and the development of psychoneurosis. It would appear either that the presence of fatigue increased the susceptibility or that both developed at the same time and were due essentially to the same precipitating factors. The following illustrative cases are mentioned.

*Case 1.*—R. R., Lt. (jg), with 530 hours flying to his credit was referred to us because of difficulty in flying. Save for unimportant illnesses, he was always well and strong until ten months previously when he was assigned to a patrol squadron. He often made two four-hour flights daily, and, in addition, had to perform various other duties. He grew extremely tired and anxious, lost weight, and began to be troubled with nightmares. After six weeks of such intensive duty he took off early one morning and quickly ran into an overcast. He was ordered to dump his depth charges and fly inland for a landing. In a little over an hour he landed without injury to himself or plane. Next morning after flying over water for about twenty minutes he became very anxious and returned to his base. After another unsuccessful attempt at flying he was sent away for a month's rest. He returned, apparently in good physical condition but still anxious. He lacked confidence for flying, was awkward at the controls, and was sent away for an additional period of three months. Following this he flew short distances under favorable circumstances but continued to have difficulty because of the fear and anxiety which persisted. A diagnosis was made of anxiety neurosis. An important question is—to what degree was fatigue responsible for this anxiety state? Although impossible to prove, it seems reasonable to assume that overfatigue increased the susceptibility to anxiety thus aiding in the development of the neurosis.

*Case 2.*—R. B., Lt. (jg), aged twenty-three, with 1,500 hours of flying to his credit, was referred for examination because of anxiety and fatigue. His father suffered from chronic alcoholism, his mother from nervousness, scleroderma and Raynaud's disease, and one of his three sisters had had a severe "nervous breakdown." He had always enjoyed robust health, lived a strenuous life, and "worked on his nerve." During the period of flight training he grew extremely tired and at times became anxious about flying. Later on, while act-

ing as an instructor, he gradually lost all pleasure in flying. He felt tired even in the morning after a long night's rest and was usually exhausted at night. A short vacation resulted in only a little temporary improvement and shortly thereafter, at a time when he was beset with various family troubles, he no longer wished to continue flying. There is an apparent causal relationship, in this case, between fatigue and anxiety. Anxiety did not develop as the result of any single incident insofar as could be determined but gradually became a more prominent symptom over a relatively long period of time during which he complained of much overfatigue. The waxing and waning of the anxiety was definitely related to the degree of fatigue which would indicate a lowered resistance to the anxiety at times of severe fatigue.

*Case 3.*—P. N., a Lt. AV(P), aged forty-one, with many hours of flying to his credit, was referred for examination because of symptoms of anxiety and fatigue. This officer was thoroughly studied both in and out of the hospital, and no adequate cause for the anxiety neurosis was discovered. His past history revealed that he had enjoyed unusually good health. He began flying in 1925 and his activities ranged from barnstorming to piloting commercial aircraft. He had been in three crashes but was never seriously injured. In the summer of 1941 he obtained a job as flight instructor in Alaska. He worked hard and flew many hours because of the long daylight period. He enjoyed the work even though it was fatiguing. In the winter he flew commercial aircraft. In the summer of 1942 he returned to his job of instructing but within a period of two to three weeks he became jittery, tired and sought all manner of excuses to avoid flying. After six weeks of instructing he decided to take a vacation. After three months he felt quite well physically but, on attempting to fly his fears returned. He still believed it was a passing and temporary ailment and after another period of rest entered the Navy as an AV (P). However, he became so anxious and fearful on attempting to fly a plane that it was clearly impossible for him to go on with his training. In this case the relationship between fatigue and the anxiety neurosis is less clear as the latter developed at a time when the degree of fatigue was not extreme. Whether the background was laid during periods of hard work and fatigue in the past is a question.

*Comment.*—From the information gained by interviewing many pilots who had experienced overfatigue and

a smaller number who had developed an anxiety neurosis, a direct relationship between the two has been apparent. It has been observed that certain pilots during periods of overfatigue may develop anxiety about flying. Insofar as student pilots are concerned the degree of anxiety usually is not great and ordinarily disappears, along with the other symptoms, when the fatigue is relieved. However, in certain instances anxiety remains even after the abolition of many of the symptoms of fatigue. It may wax and wane somewhat in accordance with the state of bodily rest and fatigue but in some cases may grow steadily worse even under favorable conditions.

The hazards and strain associated with flying are probably an actual or potential cause of anxiety to every pilot. Fatigue lowers the threshold for such stresses and the immediate result depends on the degree and duration of fatigue on the one hand, and the degree of individual susceptibility on the other. The reversibility of this relationship is complicated by the phenomenon of conditioning. The conditioning stimulus is fatigue and the conditioned stimulus although often unknown is presumably connected with some aspect of flying. Relief from the factors responsible for overfatigue causes the anxiety to disappear in cases where the conditioned response has been weakly established. Exceptions to this are those cases in which the weakly conditioned stimulus may be strengthened by the individual's conscious or subconscious recollections of past events which are linked to anxiety or fear. Lastly, there are those cases

in which the conditioned stimulus is so well established during the period of overfatigue that the anxiety remains and may properly be termed a neurosis.

COMMENTS AND CONCLUSIONS

Nearly all of the flight students complained of fatigue and more than half became overfatigued at some stage of primary or intermediate training. Overfatigue usually occurred during the initial or indoctrinational period in the various training stages. The period of overfatigue averaged 10 days.

Although an attempt to demonstrate a correlation between predisposing factors and overfatigue was unsuccessful more definitive data might reveal such a correlation.

The factors precipitating fatigue and overfatigue may or may not be directly related to flying. The commonest factors are the anxiety associated with a hazardous occupation, long hours of duty, too little sleep and insufficient time for rest and relaxation. Many other significant factors are discussed as well.

Pilots who are overfatigued are inefficient as students and may be unfit to fly. Some of the accidents in training are attributable to fatigue.

There is a close relationship in

certain cases between overfatigue and anxiety neurosis.

The desire to train as many men in as short a time as possible is understandable under the circumstances of war. Our strategy demands a certain number of trained aviators, and, if they are not forthcoming, the success of this or that campaign may be jeopardized. It is neither the duty nor the prerogative of the Medical Department to interfere in matters of strategy. But it is the duty of the medical officers to determine as accurately as possible the price which must be paid when men are subjected to the stresses and strains of an intensive training program.

The opinions and assertions contained herein are the private ones of the writers and are not to be construed as official or reflecting the views of the Navy Department.

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**Executive Council**

The Executive Council of the Aero Medical Association will meet in Washington, D. C., on Sunday, March 12, 1944.

## 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 management 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 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 quiet 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

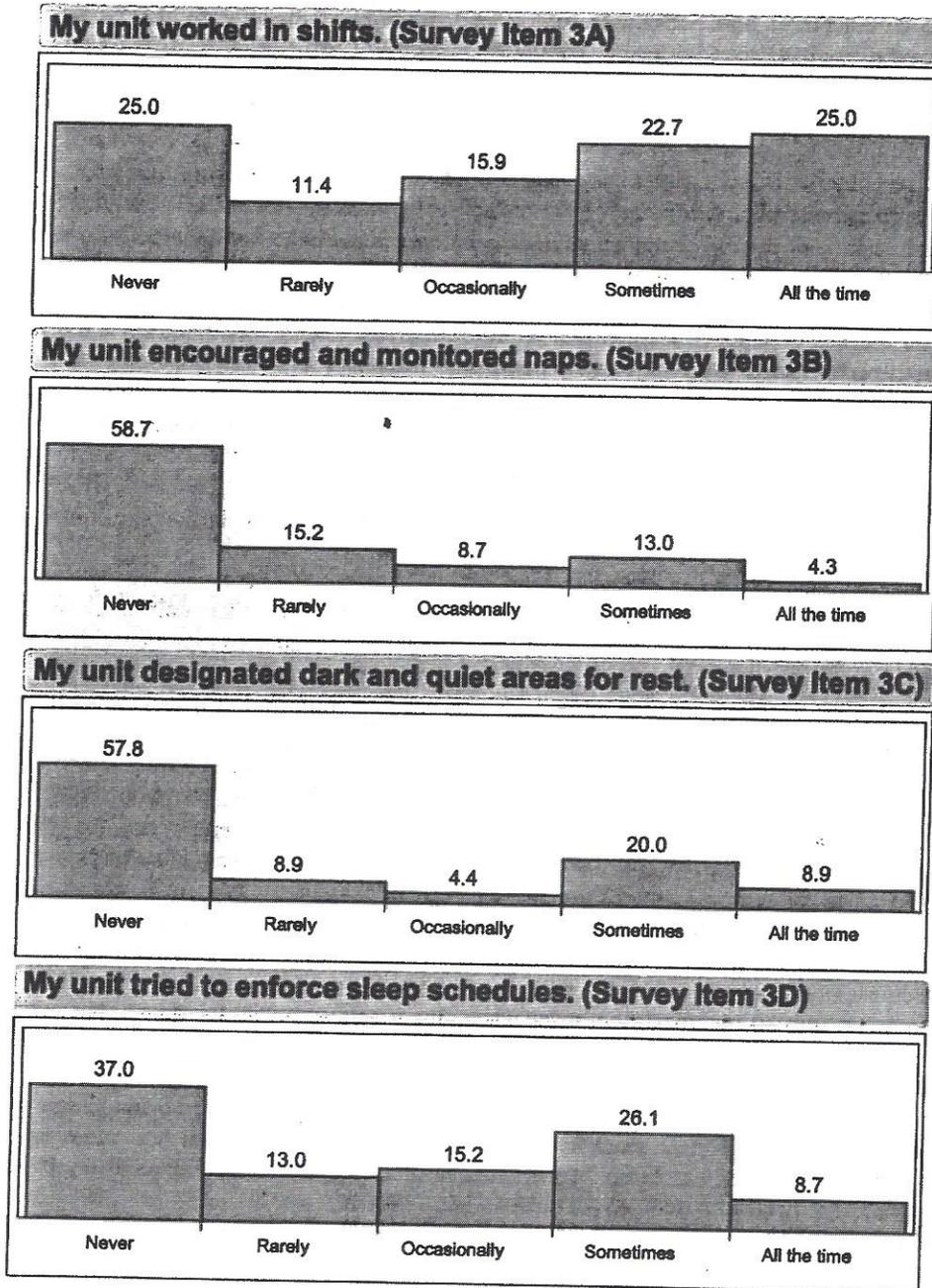


FIGURE 1 Frequency of answers regarding sleep hygiene and the use of fatigue countermeasures.

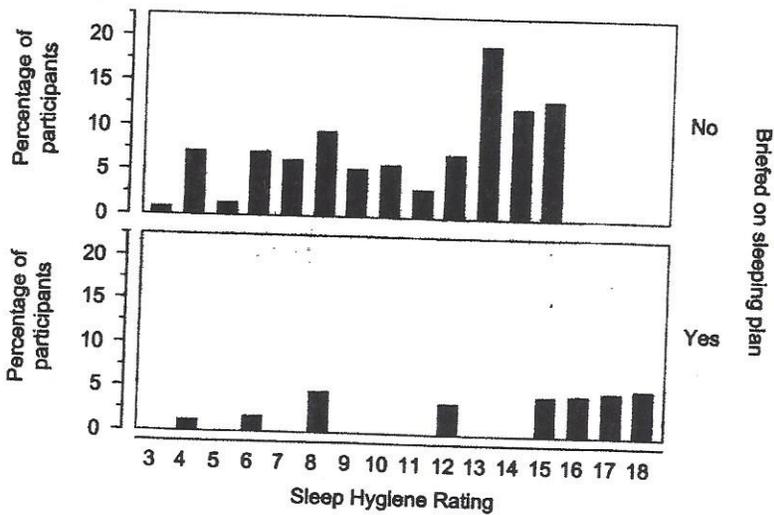


FIGURE 2 Frequency of overall sleep hygiene ratings as a function of sleep plan briefing status. *Note.* Higher ratings indicate better sleep hygiene.

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.

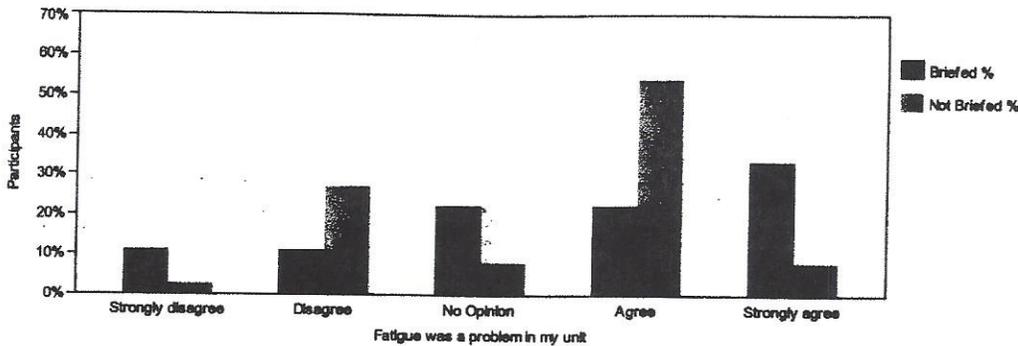


FIGURE 3 Frequency of responses to Survey Item 4A ("Fatigue was a problem in my unit") as a function of sleep plan briefing status.

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,

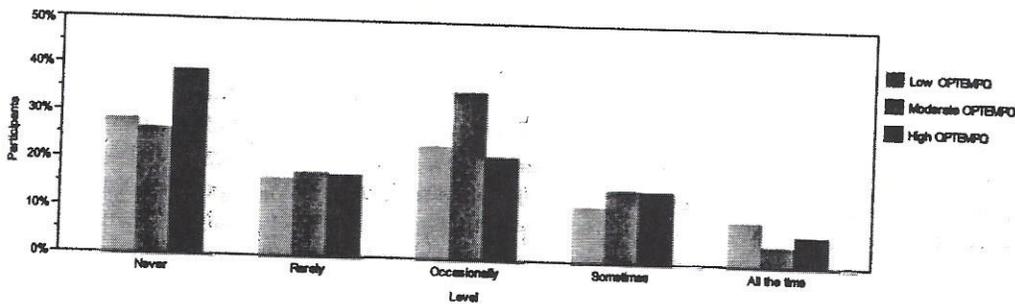


FIGURE 4 Frequency of answers to Survey Item 7 ("In addition to one major sleep period, I took naps to get more sleep") versus operational tempo (OPTEMPO).

"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

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 Dohoney (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 (Dohoney, 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 re-supply 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.**

# 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.

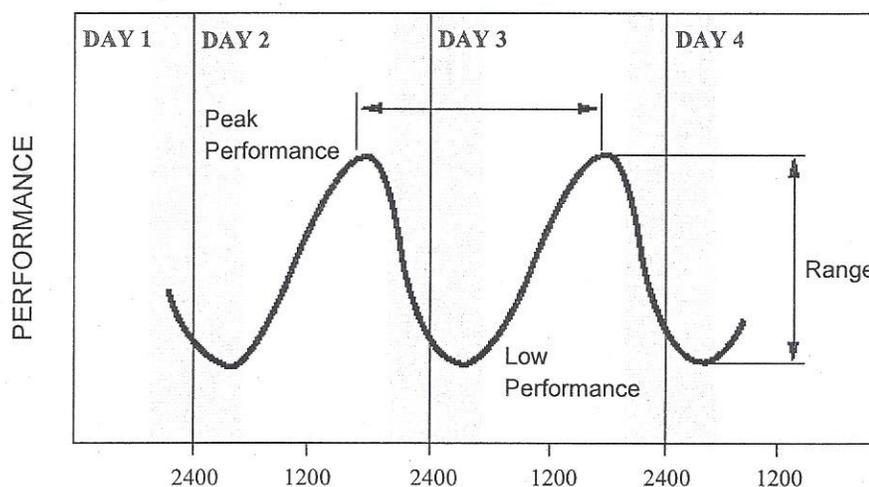
Experiments carried out in isolation (where all environmental cues have been removed) place humans on a free-wheeling cycle resulting in a spontaneous period commonly close to 25 hours. Entraining agents, however, reset the biological clock daily. These include light and darkness (the most powerful cues),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

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.**

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



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."

# Fatigue

EASY TO UNDERSTAND BUT DIFFICULT TO DEFINE

Fatigue is something we all have experienced in varying degrees. Unfortunately, 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

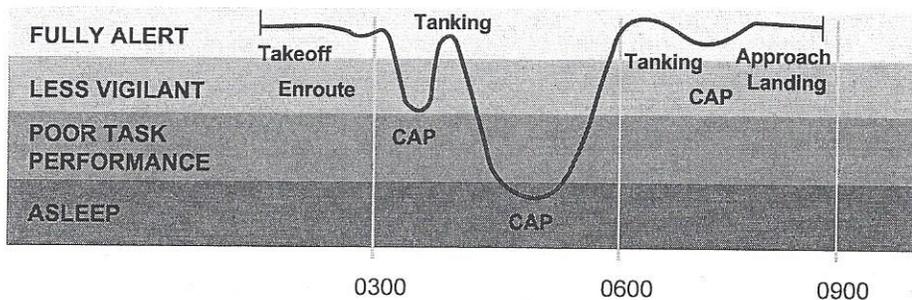
- depression or “chronic fatigue syndrome”
- a medical or psychological problem

### OPERATIONAL

- attributed to physiological as well as psychological factors
- sleep loss and circadian desynchronization are prime culprits
- the type of fatigue produced 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)



# Performance

FOR THE MILITARY AVIATOR PERFORMANCE IS THE BOTTOM LINE

Poor performance is the cost of fatigue. At the extreme is disorientation, overwhelming sleepiness and inability to give and receive orders as described during the Normandy operation of WWII. It would be unusual for the tactical aviator to ever get to this point. More likely is that some intermediate level of fatigue and compromised performance will occur.

It is not possible to give a single value or quantity to describe how performance degrades as a result of fatigue. There is no physiologic equivalent to a fuel state or energy on an airframe. The many things that must be considered include: the type of task, preload of fatigue, time of day (circadian effects) and state of arousal.

Fatigue affects different capabilities at different rates. From most to least sensitive these would generally include: (1) subjective sense of well being, (2) vigilance and attention, (3) judgement and decision making, (4) complex intellectual or physical tasks, and finally, (5) well learned/simple intellectual or physical tasks. Staying awake is sometimes the most important job occurring in an airplane. **Sleeping is the ultimate failure of performance.**

The basic skills of flying an airplane are extremely fatigue resistant. Several studies illustrate this point. Carrier landing during Vietnam actually improved at night after 22 days of combat flying and only slightly worsened during the day (9,10). Likewise LSO scores in Desert Shield/Storm aboard the USS AMERICA remained the same or improved as operations progressed (11). The Army studied three two-man crews who flew a helicopter simulator for 14 hours a day for 4 days and 10 hours on the 5th day while sleeping four hours each night. Cognitive and judgmental errors were made, but pilots flew well into the 5th day (12). Interestingly, flight surgeons deemed the aviators unsafe to fly after the third night. Copilots were noted to increasingly fall asleep due to the boring nature of their duties.

## FOUR DETERMINANTS OF PERFORMANCE

- TYPE OF TASK** – Takeoff and landing skills are more fatigue resistant than maintaining vigilance
- PRELOAD** – How tired you were when you started
- TIME OF DAY** – Performance is best 1200 to 2100 and at a low 0300 to 0600
- AROUSAL** – What is happening during the flight.

*All things being equal you will be more awake flying through AAA than flying circles in the tanker pattern.*

Preload of fatigue is a concept not commonly studied in the laboratory but is extremely valuable when trying to predict how well an aviator will do on a given mission. It is all too easy to focus entirely on what the aviator is about to do and not consider what his schedule was for the past week.

Circadian effects are also important as we previously discussed. The most fatigue sensitive skills (vigilance/attention) are particularly vulnerable to circadian effects.

Different phases of flight have widely varying levels of arousal. Boring aspects might include flying a tanker, helicopter or E-2 on station for several hours, an uneventful combat air patrol, the transit back from a long range strike or holding in the marshal pattern prior to landing. Tasks with high arousal would include bombing a target with the enemy shooting back, engaging a fighter or simply taking-off or landing. **We can predict that performance in situations with inherent arousal will be much better than those that are boring.**

The most likely scenario to produce significant compromise in performance includes an already tired aviator flying between 0300-0600 on an uneventful mission that involves low tasking (no arousal). An example is a seven hour CAP (Combat Air Patrol) mission as shown in figure 1.

# Strategies and Ideas

SUGGESTIONS FOR THE AIR WING, SQUADRON, INDIVIDUAL AND FLIGHT SURGEON

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## ***AIR WING LEVEL:***

- Fatigue is a commodity to be managed. This policy/attitude must be established by the air wing commander.
- Everyone else's resistance to fatigue will rarely be the same as the air wing commander's.
- Recognize that planning/ground duties fatigue CO's/XO's and department heads prior to the first strike.
- Minimize unnecessary changes in tasking (weaponeering, rules of engagement, etc.). The cost is lost sleep.
- Task squadrons/units so they can minimize circadian disruption (allow day or night specialization).
- Expand facilities support when needed. Examples include longer food service hours, an additional sickcall or augmented base transportation.
- Optimize sleeping quarters for sleeping (sometimes hard to do). A noisy room is bad, a hot one is worse (make the base or ship fix the A/C).

## ***SQUADRON LEVEL:***

- Fatigue is a commodity to be managed. This policy/attitude must be established by the commanding officer.
- Preparation/planning for a strike may be harder than the strike itself; don't make it harder than it needs to be.
- Four to five hours of sleep per night is the minimum required for indefinite sustained operations.
- A change in squadron dynamics, such as losing a sense of humor, is an early and reliable indicator of fatigue.
- Kick people out of the ready room and send them to bed; encourage combat naps.
- It is harder to sleep at mid-day than at 0300; schedule a longer block of time for rest during the day.
- It takes about seven days to adjust to working nights. Working only three to four nights in a row starts the process of circadian desynchronization but doesn't complete the shift. Therefore, working a single night or seven in a row is better tolerated.
- Bright lights not only maintain alertness but are a strong factor in accelerating circadian adaptation.
- Establish "grounding" guidelines for both overly fatigued aircrew and ground support personnel.
- Let the senior enlisted do the paperwork.
- Use your flight surgeon.

***INDIVIDUAL LEVEL:***

- Decide early to “manage” yourself.
- Be honest about your limitations; no one can sprint 26 miles.
- Pay attention to nutrition, hydration and physical conditioning.
- Exercise sleep discipline; unless it is really important go to bed.
- Combat naps work (even as short as 10 minutes).
- Many people are sluggish and confused for five to twenty minutes after taking a nap. This could be a problem when manning an alert aircraft.
- Ten hours is the maximum effective sleep period (even when sleep deprived).
- During the day it is easiest to get to sleep just after lunchtime (whether you ate or not).
- Caffeine works well to keep you awake – so remember to stop drinking coffee several hours before you want to sleep.
- Consider raising the B.S. flag if you need too.

***FLIGHT SURGEON UTILIZATION:***

- The squadron flight surgeon (FS) can be of great value during Continuous Operations and SUSOPS. The FS’s familiarity with squadron members and knowledge of the signs and symptoms of fatigue place him in a unique position to assist the squadron.
- Consider the FS in planning/scheduling/briefing; he may think of things you didn’t and can be a good conscience.
- The FS can be a problem solver by improving the sleep and work areas and general facilities support.
- The FS can provide the aircrew an “out.” An aviator can save face by having his FS ground him verses having to go to the OPSO and admitting that he is too fatigued to fly.
- Anti-fatigue medications are an additional augment that the FS can provide should operational necessity demand it.

### 8.3 HUMAN PERFORMANCE AND AEROMEDICAL QUALIFICATIONS FOR FLIGHT AND FLIGHT SUPPORT

#### 8.3.1 General

Operational readiness and aviation safety are enhanced by assuring that flight crew and flight support personnel achieve and maintain an optimal state of physical and emotional health. It is important that personnel are adequately rested and that conditions which contribute to fatigue, impair health, decrease performance and increase mishap potential are reduced or eliminated. This section outlines basic guidelines that individuals and all levels of supervision and command can use to attain and monitor personnel performance.

#### Note

The senior aviation commander responsible for conduct of air operations may exceed these guidelines, should operational necessity dictate. Exceeding the guidelines increases the probability of crew fatigue, causing impaired judgment and reduced performance. When exceeding the guidelines, commanders shall manage the increased risk created by crew fatigue. Consultation with the flight surgeon (FS) or aeromedical safety officer (AMSO) is strongly recommended in the development and implementation of appropriate risk controls.

Landing signal officers (LSOs) shall meet the physiological standards required for aircrew in a flight status to perform the duties of a controlling or backup LSO. Maladies or injuries that do not impair mental acuity (such as minor sprains, etc.), but that preclude normal flight status may be waived by the FS on a case-by-case basis.

Commanding officers and FSSs shall comply with applicable directives pertaining to mental health evaluation of Service members. (See reference (bf) that is implemented by reference (bg). Individuals who fall under "Military Whistleblower Protection" guidelines per reference (bh) may require additional administrative procedures in conjunction with evaluation. Commanding officers are encouraged to consult with local FSSs and legal officers.

UAS flightcrews should comply with all sections of 8.3.

#### 8.3.2 Factors Affecting Aircrew Performance

Numerous complex factors affect the performance of flight and support personnel. Commanders and mission planners must assess the impact of factors that contribute to operational fatigue and reduce aircrew performance. The

principle factors include: weather, extremes of temperature, nighttime operations, use of vision imaging systems, mission delays, personal equipment and ALSS, duration of the duty period, quality and duration of sleep (prior to duty), number of hours flown during the previous several duty periods, time of day relative to the body's internal circadian clock, degree of circadian desynchrony (jet lag), physical health, additional duties, misuse of alcohol, caffeine, tobacco, or dietary supplements and adequacy of crew rest facilities. These factors must be understood by all concerned and appropriate countermeasures established to assure they do not reduce personnel readiness. FSS and AMSOs shall proactively establish an aeromedical adjunctive training program appropriate to their unit's human factors risks. Appendix E provides minimum requirements for aeromedical adjunctive training. Flight personnel should report any physical indisposition to superiors and assume flight duty only when fit to do so. Since an individual may frequently be the poorest judge of personal fitness, commanding officers shall ensure that flight personnel are adequately observed and appropriate temporary grounding action is taken when necessary. The following guidelines and requirements should be considered for all aspects of naval aviation.

#### 8.3.2.1 Crew Rest and Sleep

##### 8.3.2.1.1 Crew Rest for Flight Crew and Flight Support Personnel

Crew rest is the non-duty time before a flight duty period begins. Crew rest includes free time for meals, transportation and rest and must include an opportunity for 8 hours of uninterrupted sleep time for every 24-hour period. Crew rest does not begin until after termination of official duties and is required prior to reporting for preflight preparations. Flight crew should not be scheduled for continuous alert and/or flight duty (required awake) in excess of 18 hours. If it becomes necessary to exceed the 18-hour rule, 15 hours of continuous off-duty time shall be provided prior to scheduling the member for any flight duties. Flight and ground support personnel schedules shall be made with due consideration for watch standing, collateral duties, training, and off-duty activities. Crew rest can be reduced to less than 12 hours in order to maintain a 24-hour work/rest schedule, but a shortened crew rest period (for example to maintain circadian rhythm) must always include an opportunity for 8-hours of uninterrupted sleep.

#### Note

As the time continuously awake duty time exceeds 16 hours, performance efficiency begins to drop. After 18 hours, performance efficiency rapidly declines to 75 percent of effectiveness or less. The loss of effectiveness is manifested by lapses in attention, increased reaction time, slowed information processing, decreased vigilance, and increased error frequency. Accident rates for just about every type of human activity increase after 18 hours of wakefulness, particularly during the night "circadian trough" when sleep would normally occur.

#### 8.3.2.1.2 Circadian Rhythm

Circadian rhythms are cyclic fluctuations of numerous body functions that are set like a "radiological clock" by daylight exposure and sleep/awake periods. Changing local sleep/awake periods or rapidly crossing more than three time zones disrupts circadian rhythms and can cause a marked decrease in performance. This condition, called "jet lag," is compounded by illness, fatigue, dehydration, alcohol use, poor nutrition, or drugs, and is resolved only by accommodation to the new local time or sleep/awake period. The accommodation period can be estimated by allowing 1 day for every time zone crossed in excess of 3. Accommodation begins when a new daily routine is established. During that period, aircrew are not grounded but can be expected to perform at a less than optimal level. Less intense flight profiles and close observation by the FS during the accommodation period may be desirable. Shift work, where individuals are required to work during the night for extended periods, requires even longer times for adaptation (up to 4 weeks). Individuals may never fully adapt to night shift work unless completely isolated from daylight exposure, and additional controls may be necessary for safe operations. Specific fatigue countermeasures to adapt to and minimize disruption of circadian desynchrony can be found in reference (bi).

#### 8.3.2.2 Flight Time

Precise delineation of flight time limitations is impractical in view of the varied conditions encountered in flight operations. Required preflight/postflight crew duty time must be given due consideration. The following guidelines are provided to assist commanding officers:

- a. Daily flight time should not normally exceed three flights or 6.5 total hours flight time for flight personnel of single-piloted aircraft. Individual flight time for flight personnel of other aircraft should not normally exceed 12 hours. The limitations assume an average requirement of 4 hours ground time for briefing and debriefing.
- b. Weekly maximum flight time for flight personnel of single-piloted aircraft should not normally exceed 30 hours. Total individual flight time for flight personnel of other aircraft should not exceed 50 hours. When practicable, flight personnel should not be assigned flight duties on more than 6 consecutive days.
- c. Accumulated individual flight time should not exceed the number of hours indicated in figure 8-8.
- d. When the tempo of operations requires individual flight time to exceed the guidelines in figure 8-6 or paragraphs 8.3.2.2 a and 8.3.2.2 b, flight personnel shall be closely monitored and specifically cleared by the commanding officer on the advice of the FS. Aviation-capable ships that do not have access to FSs for recommendations to exceed flight time limitations should follow procedures outlined in reference (bj). Commanding officers should assure equitable distribution of flight time commitments among assigned flight personnel, commensurate with additional ground duties that each may be assigned.

PERIOD (DAYS)	SINGLE PILOTED AIRCRAFT	MULTI-PILOTED (PRESSURIZED) EJECTION SEAT AIRCRAFT	MULTI-PILOTED NON-PRESSURIZED AIRCRAFT	MULTI-PILOTED PRESSURIZED AIRCRAFT
1	6.5	12	12	12
7	30	50	50	50
30	65	80	100	120
90	165	200	265	320
365	595	720	960	1120

Figure 8-8. Maximum Recommended Flight Time

**Note**

Flight operations involving contour, NOE, chemical defense gear, night and NVDS, and adverse environmental factors (dust, cloud cover, precipitation, etc.) are inherently more stressful and demanding than flying day VFR. The resultant fatigue may have a profound physiological effect upon mission capability. Mission planners should take this physiological threat into account in making modifications to normal crew rest/crew day guidelines.