



Fatigue in Aviation Operations

Research on effective fatigue countermeasures will help to safely optimize effectiveness in today's battlespace.

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Aircrew fatigue is an insidious threat to the safety and effectiveness of Air Force operations. In addition to fatigue's subtle effect on performance, fatigue is also estimated to cost the Air Force over \$54 million in Class A accidents each year.¹ However, despite intense study and development of effective countermeasures for ground-based personnel, researchers have performed relatively little research at overcoming fatigue in the aviation environment. A comprehensive effort in the Human Effectiveness Directorate focuses on maximizing alertness and endurance in air operations.

The basic causes of aircrew fatigue are insufficient sleep, disruptions to the body's clock, and extended duty periods. Technological advances and a global reach strategy that make long-range, continuous operations a way of life for today's Air Force, exacerbate these problems.

Procurement and deployment of the B-2 bomber paved the way for nonstop, intercontinental flights in which a 2-person crew can remain in the cockpit for up to 44 continuous hours. Advances in night vision technology have overcome the problem of limited nighttime visibility and maximized the Air Force's capacity to own the night. The result is that the Air Force relies upon 24/7 operations to an unprecedented degree.

Since 1990, there has been an overall 37.7% reduction in military personnel, while contingency deployments have increased by as much as 400%.^{2,3} Unfortunately, while Air Force equipment is well suited to such continuous and sustained operations, the performance capabilities of military personnel are not. People lose approximately 25% of their higher-level cognitive capacity with each 24 hours of sleep loss.⁴ Just 18 to 21 continuous hours without sleep leads to performance impairments like those seen with blood alcohol concentrations

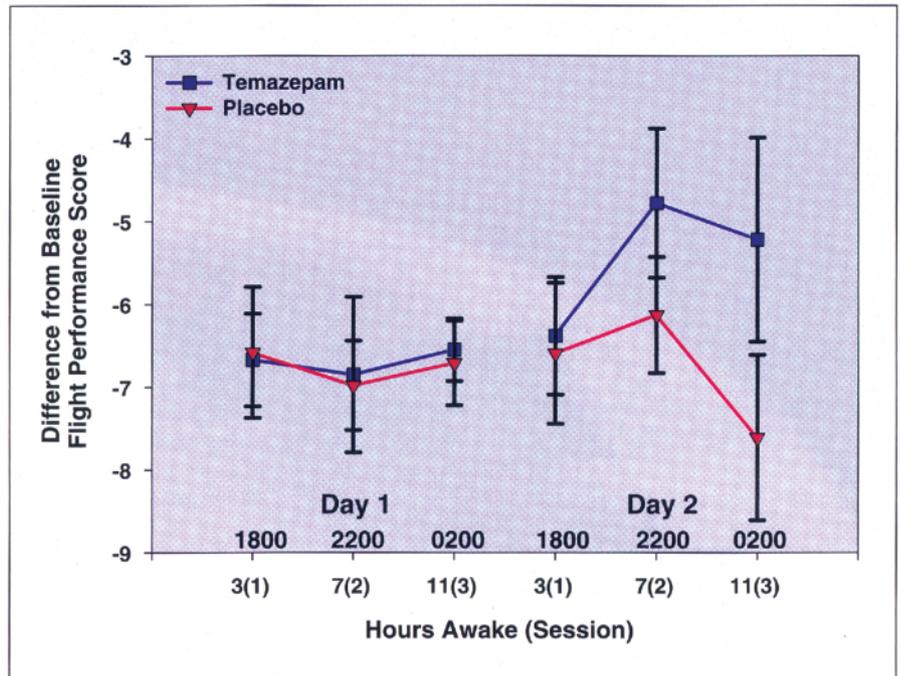


Figure 1. Temazepam improves nighttime performance compared to a placebo.

of 0.05 to 0.08%—beyond the legal limit of intoxication in every state in the US.^{5,6} Military capabilities are increasingly stressed as units strive to accomplish more work with fewer resources. This increases the dangers of aircrew fatigue in the tactical environment. Although fatigue is an ever-present problem throughout today's military, recent reports from Operation IRAQI FREEDOM indicate the need for effective, scientifically validated fatigue-management strategies, especially in combat operations.

Researchers with the Warfighter Fatigue Countermeasures program at Brooks City-Base, Texas, are helping pilots counter this fatigue-related threat by developing and validating effective alertness-enhancing strategies for use in the operational environment. Current efforts include tools to facilitate development of optimal crew work/rest schedules, techniques to enhance sleep quality and circadian adaptation, and

assessment and optimization of alertness-enhancing compounds.

Researchers developed a computer application called the Fatigue Avoidance Scheduling Tool (FAST™) to help mission planners devise the best possible duty schedules, given operational constraints. The application runs under Microsoft® Windows® and integrates information about circadian rhythms, performance decline associated with sleep loss, recovery rates associated with sleep, and temporary performance effects associated with post-sleep grogginess. FAST lets planners estimate the average effects of various schedules on crew performance and determine which schedules will maximize performance under specific operational circumstances. A Beta version of the software is available and in use at some Air Force units.

Recently, researchers conducted a study of the sleep-enhancing medication

Temazepam to determine if it could aid personnel in rapidly transitioning from daytime duty to nighttime duty. The study evaluated the performance, mood, alertness, and sleep of military pilots and showed that Temazepam increased the amount of daytime sleep and improved its quality as compared to a placebo. As a result, researchers saw enhancements in early-morning alertness, reduced fatigue, and improved performance (see Figure 1).

A related investigation is comparing melatonin to the sleep aid Zolpidem to determine if these compounds will

enhance nighttime mood and performance by improving daytime sleep. Although the project is not complete, measures of cognitive task performance, vigilance, subjective self-reports, salivary melatonin and cortisol, polysomnography, and vital signs will help determine the conditions under which melatonin or Zolpidem may be useful in the operational environment.

Several investigations looked at the effects of the hypnotic Zaleplon to aid sleep. One study investigated Zaleplon's

ability to effectively promote sleep during the daytime in well-rested individuals. Drug administration occurred during the day and participants were given a 3.5-hour opportunity to nap. Upon awakening, researchers collected performance and subjective data for the next 3.5 hours. The results indicated an increase in total sleep time and sleep efficiency compared to a placebo. Thus, Zaleplon may be useful for enhancing sleep in uncomfortable operational settings.

For situations where the operations tempo makes sleep temporarily impossible, research shows Dextroamphetamine is effective in countering fatigue. A recent Air Force technical report details the results of a series of four aviation studies where researchers compared Dextroamphetamine to a placebo. They examined flight performance, psychological mood evaluations, electroencephalograms, and sleep assessments from 28 pilots in a 2-day, 1-night period of continuous wakefulness. Results showed Dextroamphetamine maintained flight skills at well-rested levels despite lengthy periods of sleep deprivation (see Figure 2). In addition, the pilots sustained psychological mood and physiological activation, and these positive effects were not offset by deleterious side effects. These data validate current Air Force reliance on Dextroamphetamine as a viable countermeasure for fatigue in aviation-sustained operations.

Researchers are considering new alternatives for countering aviator fatigue. The Warfighter Fatigue program recently completed data collection in a study designed to determine whether Modafinil could maintain performance of personnel for 3.5 straight days without sleep. Researchers evaluated two doses of Modafinil: 100 mg every 8 hours or 200 mg every 8 hours. Researchers are currently examining the results of this investigation based on a variety of cognitive, mood, and physiological assessments. Preliminary indications suggest Modafinil effectively attenuated many of the cognitive deficits associated with untreated fatigue. These findings agree with previous laboratory studies supporting the effectiveness of Modafinil for sustaining flight performance, psychological mood, and physiological alertness for long periods without sleep. Researchers will soon validate these findings in B-2 pilots performing simulated missions. If the results are positive, the addition of Modafinil to existing fatigue

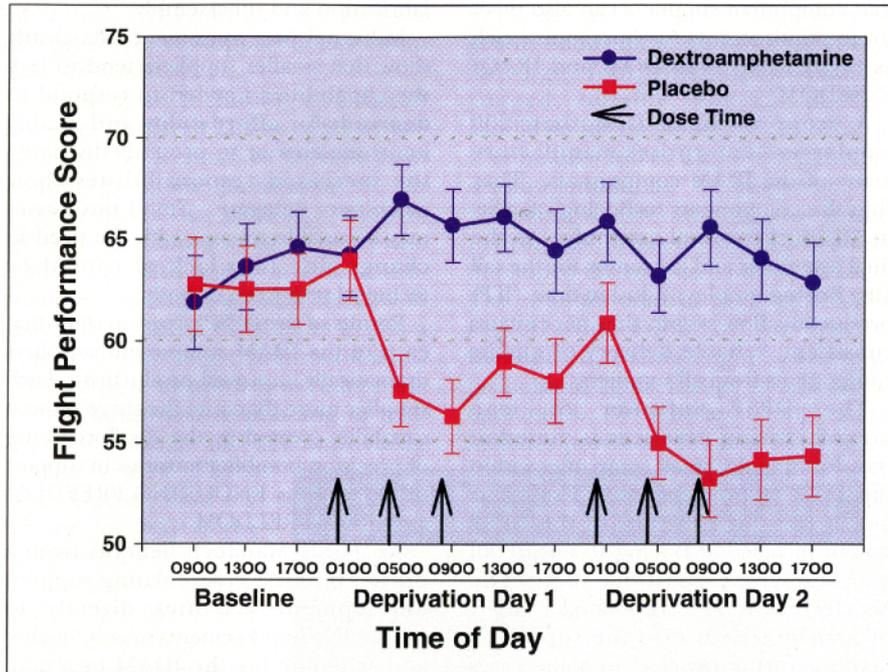


Figure 2. Dextroamphetamine is effective in maintaining performance over 58 hours without sleep.

countermeasures will enhance mission performance and increase safety.

No substitute exists for adequate sleep. However, the directorate's focused program of research will mitigate the risks associated with sleep loss by delivering operationally feasible ways to

sustain alertness in the cockpit. Implementation of proper work/rest scheduling, effective use of sleep-promoting strategies, and employment of proven alertness-enhancing compounds will go a long way towards maximizing warfighter performance.

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