



The Effects of Dextroamphetamine and Modafinil in Sleep-Deprived Aviators

Fatigue has been identified as an important operational problem in both military and civilian aviation. Requirements for extended duty periods, inconsistent work/rest schedules, multiple-time-zone operations, and night flights combine to potentially degrade performance and alertness in the cockpit. Duty-time limitations traditionally have been relied upon to manage aircrew fatigue: but problems persist, as evidenced by the fact that significant fatigue-related mishaps continue to occur. Because of this, it may be worthwhile to consider the limited use of alternative strategies such as stimulants. The data from five placebo-controlled studies (four with dextroamphetamine and one with Modafinil) were combined to examine the overall efficacy of stimulants for preserving flight performance, physiological alertness, and subjective vigilance in sleep-deprived pilots. Statistically-significant drug main effects and drug-by-time interactions revealed that both compounds maintained flight performance across six maneuvers, attenuated deprivation-related increases in slow-wave electroencephalogram (EEG) activity, and preserved subjective ratings of psychological vigor throughout 34-39 hours of continuous wakefulness, whereas substantial difficulties were observed under placebo. Furthermore, the drug-related effects were remarkably consistent across all of the five studies that were examined. Dextroamphetamine and Modafinil are effective for sustaining aviator alertness and performance (although, some potentially dose-related adverse effects were observed with Modafinil). While it may be ill advised to rely upon the long-term use of these or other pharmacological strategies as the sole remedy for fatigue in aviation, stimulants can be counted upon to temporarily mitigate the deleterious effects of fatigue during operations in which no other countermeasures are feasible. If you would like a copy of the Technical Report, please contact Dr. John Caldwell at John.Caldwell@brooks.af.mil or 2Lt Jennifer Smith at Jennifer.Smith@brooks.af.mil.

-- John Caldwell, Ph.D.,
AFRL/HEPM

Critical Knowledge Gaps Concerning Pharmacological Fatigue Countermeasures For Sustained and Continuous Aviation Operations

A literature search was compiled to identify knowledge gaps concerning the potential uses of pharmacological fatigue countermeasures in aviation. This type of review is a necessary step in developing an operationally based, safe-to-fly pharmacological doctrine that extends mission performance without introducing unwanted side effects. The review was conducted with respect to seven potential pharmacological countermeasures to fatigue: dextroamphetamine, modafinil, caffeine, temazepam, zolpidem, zaleplon, and melatonin. Thirty-four operationally relevant terms and phrases, such as acceleration, memory, computational performance, and predisposition to heat injury, were used. The searches were conducted in ten different on-line, scientific and medical databases on literature published in or after 1980. Of the hundreds of returned citations, 117 were relevant and were categorized, and the obvious knowledge gaps discussed. Aggressive research is indicated for

both non-pharmacological and pharmacological countermeasures to fatigue. If you would like a copy of this TR, please email Dr. James Miller (jcmiller@brooks.af.mil) or 2Lt Christina Schroeder at Christina.Schroeder@brooks.af.mil.

-- Lee G. Saltzgaber, M.D., USAFSAM, Brooks City Base TX,
James C. Miller, Ph.D., AFRL/HEPM

Fatigue in Aviation Operations

Summary of an article written by Dr. John Caldwell of the Air Force Research Laboratory, Warfighter Fatigue Countermeasures and published in the AFRL Technology Horizons Magazine, June 2003

Aircrew fatigue is a dangerous threat to safety and effectiveness of Air Force operations. Researchers have performed some research at overcoming fatigue in the aviation environment. However, 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. Since 1990, there has been an overall 37.7% reduction in military personnel, while contingency deployments have increased by as much as 400%. People lose approximately 25% of their higher-level cognitive capacity with each 24 hours of sleep loss. With military capabilities increasingly stressed, units strive to accomplish more work with fewer resources. The Warfighter Fatigue Countermeasures program at Brooks City-Base, Texas is 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. For the article, please go to www.afrihorizons.com. The article goes into some detail about several of the pharmacological research studies we have completed. If you would like more information about our services and program, please contact Major Brandon Doan at Brandon.doan@brooks.af.mil.

-- 2Lt Christina Schroeder, AFRL/HEPM

The Fatigue Avoidance Scheduling Tool (FAST™)

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. Please contact Dr. James C. Miller at jcmiller@brooks.af.mil for more information or Lt Dan Wheeler at Daniel.Wheeler@brooks.af.mil for a sample copy.

The research protocol, "Observing cognitive performance during Air Force deployments," has been approved by the Human Use Committee. This study will allow us to collect real-world cognition and affect data to quantify the impact of AF Ops on cognition and fatigue and for comparison to the FAST™ predictions in an attempt to validate certain aspects of the model. The intent is to quantify the impact of AF Ops on the cognitive performance and subjective sleepiness of aircrews. It is relevant because military operations often involve periods where sleep is minimized or disrupted due to Ops Tempo or deployment factors (e.g., transmeridian travel). A tool that could effectively predict human

We bridge the gap between operational demands and physiological realities

performance in such situations would be useful for managing operational risk and maximizing operational efficiency. FAST™ will predict performance to some moderately successful extent. Data from this effort will allow further refinement of FAST™.

Current Studies

Sleep Aids, Sudden Awakening and Performance Study funded by the Army will be completed by the end of Sept 2003. Principal Investigator - Douglas R. Eddy, Ph.D., NTI, Inc, douglas.eddy@brooks.af.mil

The hypnotic zolpidem and the hormone melatonin will be compared systematically for effects on sleep, cognitive performance and mood in operationally-relevant and sudden-awakening paradigms. Data will also be used to develop parameters for FAST™.

The Effect of Caffeinated Tube Food on Cognitive and Simulated Pilot Performance During Fatigue/Circadian Desynchronization. Principal Investigator - Brandon K. Doan, Maj, USAF, Ph.D., AFRL/HEPM, Brandon.Doan@brooks.af.mil

The objective of this study is to determine whether moderate doses of caffeine formulated in tube foods can enhance cognitive performance in a laboratory study designed to simulate the cognitive demands of a U-2 mission. It's intent is to validate and more effectively employ performance enhancing foods in military operations. Performance sustaining tools are desperately needed to meet demanding mission requirements safely and effectively during sustained and surge operations that superimpose circadian rhythm shifting on fatigue in aircrews. The expected outcome is an objective assessment of the efficacy of caffeinated - pudding for sustaining cognitive, vigilance, and basic pilot performance during extended nighttime operations

Impact Of Fatigue/Circadian Desynchronization On Acceleration Tolerance and Piloting Performance With and Without Use Of Pharmacological Stimulant Countermeasures. Principle Investigator - Col Carol S. Ramsey, D.O., M.P.H., AFRL/HEP, Carol.Ramsey@brooks.af.mil

To determine the comparative effects of currently utilized and proposed performance enhancing/fatigue countermeasure stimulant pharmacological agents on +Gz tolerance and performance of basic flight skills. The impact of these agents on performance and +Gz tolerance will be compared against that of the same individual in a daytime rested state, and in state of a circadian desynchronization with fatigue not countered by the use of pharmacological agents. This research protocol supports five of six United States Air Force Core Competencies, and MAJCOM deficiencies addressed in the Air Combat Command FY02 Global Attack MAP, Sustained Operations, AFSOC-91, Limited Ability to Deal with Fatigue in Special Operations, and AF/SG01, Sustained Operations Issues, FY00.

Modafinil: Alerting Efficacy in a Sustained Activity Field Environment. Principal Investigator - Jeffrey N. Whitmore, M.S., AFRL/HEPM, Jeff.Whitmore@brooks.af.mil.

The objective is to evaluate the effectiveness of modafinil for maintaining performance during a 4-day period of reduced sleep in a field environment. Collection of performance data during a field-based event in which some of the participants use modafinil to maintain alertness will occur. Enhanced alertness during field-based operations (e.g., escape and evasion) may improve the safety, survival, and efficiency of military personnel. The principal expected outcome is that modafinil will improve the participants' cognitive, subjective and physiological ability to complete the route and tests compared to placebo.

Future Studies

- ❑ Efficacy of Modafinil for Maintaining the Combat Performance of Rifle Battalion Personnel during Sustained Operations -- *Dr. J. Caldwell*
- ❑ The Efficacy of Modafinil for Sustaining the Alertness and Simulator Flight Performance of F-117 Pilots During 40 Hours of Continuous Wakefulness -- *Dr. J Caldwell*
- ❑ Sleep Aids, Sudden Awakening and Performance -- *Dr. D Eddy & Dr. W Storm*
- ❑ Combined Use of Selected Hypnotic and Alerting Medications to Counteract Aircrew Fatigue Due to Disrupted Sleep During Sustained Operations -- *Dr. W. Storm & Dr. D Eddy*
- ❑ Human research protocol "Sleep deprivation in humans, transient immuno-depression and provision of amino acids, Study III" -- *Dr. Castell & Dr. J Miller*
- ❑ An Examination of Circasemidian Rhythms in Human Body Temperature, Sleepiness and Response Time -- *Dr. J. Miller*
- ❑ The Effects of Fatigue on Sustained C4ISR Team Performance -- *Dr. D. Harville*
- ❑ The Relative Efficacy of Single Operational Doses of Caffeine, Dextroamphetamine, and Modafinil on Measures of Sleepiness and Performance in Sleep Deprived Volunteers -- *Dr. J Caldwell*

Events - September/November 2003

Phoenix Challenge, Sept 8-12, Nellis AFB, NV – Dr. J Miller spoke on Sept 11 and HEP presented a booth. <http://www.pc2003.org/>

Human Performance Conference 2003 – Oct 28-29 Houston, TX.
<http://advtech.jsc.nasa.gov/humanPerf.asp>

MILITARY AVIATION FATIGUE COUNTERMEASURES COURSE, November 13 –14, 2003, Brooks City-Base (formerly Brooks Air Force Base) in San Antonio, Texas, USA

John Caldwell, Ph.D.

Lynn Caldwell, Ph.D.

James C. Miller, Ph.D., CPE

This course will outline the dangers of fatigue in military aviation and related operations, the basic mechanisms underlying fatigue, the most common causes of overly-tired personnel, and the best techniques for optimizing alertness in military environments. Participants will receive instruction on the effective design of crew work/rest schedules and the use of a computerized scheduling tool. A short overview of research topics will be included as well. No prior education in fatigue management, sleep, or circadian rhythms is required. The cost of this course will be \$120.00 to cover the expense of two continental breakfasts and the take-home books containing course-related materials. Additional information and advanced course registration (required) is available through charlie.dean@brooks.af.mil.

For over 30 years the WFC R&D Program has delivered counter fatigue products that enhance warfighter combat effectiveness in global mission extremes demanding night, sustained and 24/7 mental and physiological supremacy. We give American warfighters the "edge" to overcome physiological realities and win.