Naval Health Research Center *San Diego, CA*

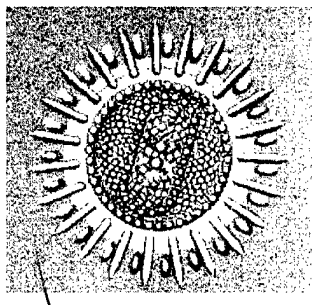
NHRC UPDATE

March 1996 Thru April 1997 **Issue No. 1** Thru No 5.

This update is being published periodically to highlight a few of the many contributions being made by your friends and colleagues at NHRC and to illustrate the importance of NHRC's work for the Navy and the broader scientific community.

NHRC Scientists First to Detect Diverse HIV-1 Genetic Subtypes in the USA

CAPT Stephanie Brodine and her colleagues, including Dr. Frank Garland and Stan Ito from NHRC, and researchers from Walter Reed Army Institute of Research Retrovirology Lab, identified the first cases of U.S. natives infected with the HIV-1 strains causing the African and Asian epidemics. This study, published in the November 5, 1995 issue of *Lancet*, used new state-of-the-art laboratory techniques to identify the specific strains or subtypes of HIV. In the U.S. and Europe, nearly all of the HIV viruses are subtype B, whereas the predominant subtypes in Africa are A, C, and D. Subtype E predominates in Thailand. Differentiating HIV subtypes may have important implications in vaccine development, HIV diagnosis, and the epidemiology of the epidemic. Given the wide dispersal of HIV-1 subtypes internationally and the routine occurrence of international travel, it seems inevitable that strains other than subtype B eventually will spread in the USA. NHRC is in a unique position to address the question of the introduction of these divergent HIV subtypes into the U.S. as our HIV Central Registry allows identification of recently acquired HIV infections and our powerful databases enable tracking of personnel and their ships' movements.



In this study, HIV subtype screening was performed on HIV-infected servicemen whom we identified as having deployed to countries such as Kenya, Uganda, and Thailand that have high rates of these other subtypes of HIV. In this procedure, 26 subjects were identified and tested. Of these, 21 individuals were found to be infected with subtype B, and 5 individuals were found to be infected with non-subtype B: 3 with subtype E, 1 with A, and 1 with D. All HIV-infected personnel receive a 2- to 3-week medical evaluation, which includes an intense educational program that emphasizes the essentials for preventing the transmission of HIV.

In another related research study being conducted in conjunction with the University of California, San Francisco, and co-funded by the NIH, a primary prevention program to decrease acquisition of sexually transmitted diseases in Marine Corps personnel on deployment has been developed and shown to have efficacy in reducing risky sexual behaviors in foreign ports. Current efforts are focused on the development of intervention programs to reduce unplanned pregnancies and STDs among women assigned to U.S. Navy ships. As one of our most senior and productive scientists, CAPT Brodine, who also works as a physician on the HIV ward at the Naval Medical Center, continues to set the standard for establishing critical partnerships and conducting world class science.

The Big Chill

Although Southern California does not immediately spring to mind as the region from which to conduct research on the effects of cold, NHRC is very well situated to execute this mission. Our laboratory at the Ma-

rine Corps Mountain Warfare Training Center in the Eastern Sierras is specially equipped to support both Navy and Army field research with the Marines as they train in the cold. Similarly, our close proximity with the Navy Sea, Air, Land (SEAL) special forces personnel provides access to operational research in the cold waters of the Pacific Ocean. Information gained from more controlled laboratory studies using our thermal chambers can be readily transitioned and evaluated with the operating forces.

In a recent article in the *New England Journal of Medicine*, Dr. Robert Pozos from NHRC, and his colleague Dr. DF Danzl from the University of Louisville, addressed the issue of accidental hypothermia, which is defined as an unintentional decline in a person's core temperature below 35°C. In this article, the authors presented an overview of the pertinent pathophysiology of hypothermia and guidelines for resuscitation and rewarming. In addition to this effort, Dr. Pozos co-authored a chapter titled, "Limits of Tolerance to Hypothermia," in the 1995 edition of the "Handbook of Physiology."

Dr. Don Roberts, who currently is leading our terrestrial cold weather research efforts, and Dr. Pozos recently met with Army experts in Washington to review and update cold weather policy for our troops in Bosnia.

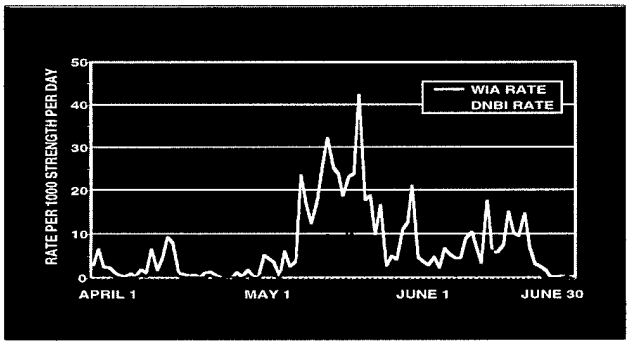
Last spring, four Army special forces personnel died of hypothermia as a result of cold water immersion during Ranger School training. Based on our extensive experience with laboratory and field studies of immersion cold in the SEAL community, NHRC was asked to consult with the Army on this issue. As a result of his "incisive and useful analysis" and "timely and helpful support," Dr. Keith Prusaczyk received a letter of appreciation and an Army coin from the Under Secretary of the Army.

Over the past few years, NHRC's program of cold research has demonstrated its effectiveness in laboratory studies of wet and dry cold, altitude exposure with the Marines in Alaska (CDR Steve Feith, CDR JT Coyne, Dr. Pozos), field exercises with the Norwegian army in the arctic (Dr. Jim Hodgdon, LT Robert Hesslink), SEALS in Alaska and in high-speed boats, and immersion cold with the SEALs in open water swims and SEAL delivery vehicles (Dr. Hal Goforth, Dr. Prusaczyk). Exposure to extremes

remains a professional obligation of our military forces. Understanding the physiological and biomedical effects of these extremes and developing appropriate countermeasures remains a professional obligation of the scientists at NHRC.

Contingency Medical Planning

Medical and manpower resource planning for military operations, such as Operation Desert Storm, requires that logisticians project the numbers of casualties likely to be sustained from disease or nonbattle injuries, as well as from battle injuries. These projections are central to the prepositioning of medical supplies and equipment, the deployment of appropriate medical personnel, and the distribution of evacuation assets. After compiling enormous files of archival data from World War II, Korea, Vietnam, and the Falkland Islands, Chris Blood and



his colleagues have developed sophisticated statistical models to predict the "pulse and pause" nature of theater-specific engagements that are sensitive to factors such as combat intensity, troop strength and type, and projected length of engagement. In a letter from the Office of the Secretary of Defense, NHRC's empirically based approach was referred to as "fundamental in shifting not only Navy but all-service and Departmental attitudes toward medical issues as the Department begins adjusting to the post-Cold War environment." Noting that this work was "far superior to that of the other services," the letter further recommended that "the robust approach taken within the Navy to apply operations research techniques to medical issues be adopted by the Department in general as well as the other services."

The methodology developed at NHRC has also been adopted by the Congressional Budget Office in its work on converting patient diagnoses to International Classification of Disease codes. Chris Blood, and his colleagues are frequent contributors to *Military Medicine, Military Operations Research Society Symposium,* and *Naval War College Review*. The recent development of a personal computer-based medical casualty forecasting system (FORECAS) will enable the forward migration of this capability to better serve medical planners and practitioners.

Retrospective...

Center for Prisoners of War Studies

Near the end of the Vietnam War, the Center for Prisoner of War studies was established at NHRC. This Center was largely responsible for planning and coordinating the repatriation and medical follow-up of all Army, Navy, and Marine Corps POWs, maintaining the classified debriefing material, and conducting medical and family reintegration research.

Deep Freeze

Just prior to the International Geophysical Year (1957-1958), one of the Antarctic winter-over personnel became overtly psychotic and caused a great deal of difficulty for other station members. This event, coupled with intense interpersonal conflicts occurring at one station, prompted a research requirement for screening, adjustment, and performance studies for Antarctic personnel. In response to this requirement, Dr. Eric Gunderson and his colleagues at NHRC conducted studies that greatly improved the selection of candidates for the 6-month wintering over assignment in Operation Deep Freeze. Antarctica was long regarded as a natural laboratory for the social and behavioral sciences and is regarded by NASA as a unique analogue for future space station operations and extraterrestrial exploration. Dr. Gunderson served as a consultant to NASA for more than 25 years, and his many contributions were recognized when he was asked to write a preface for the volume, "From Antarctica to Outer Space: Life in Isolation and Confinement."

Recent Publications

HIV Program

Brodine SK, Hyams KC, Molgaard CA, Ito SI, Thomas RJ, Roberts CR, Golbeck AL, Oldfield EC, Blattner WA. The risk of human T-cell leukemia virus and viral hepatitis infection among US Marines stationed in Okinawa, Japan. *J Infect Dis.* 1995;171:693-696.

Malone JL, Wallace MR, LaRocco Jr A, Hendrick BB, Tonon E, Brodine SK, Bowler WA, Lavin BS, Hawkins RE, Oldfield EC. Syphilis and neurosyphilis in a human immunodeficiency virus Type-1 seropositive population: evidence for frequent serologic relapse after therapy. *Am J Med.* 1995;99:55-63.

Brodine SK, Mascola JR, Weiss PJ, Ito SI, Porter KR, Artenstein AW, Garland FC, McCutchan FE, Burke DS. Detection of diverse HIV-1 genetic subtypes in the USA. *Lancet.* 1995;346:1198-1199.

Cold Research

Hackney AC, Coyne JT, Pozos RS, Feith S, Seale J. Validity of urine-blood hydrational measures to assess total body water changes during mountaineering in the Subarctic. *Arctic Medical Research.* 1995; 54:69-77.

Shaw E, Feith S, Coyne JT, Bales B, Pozos RS, Hackney AC. Effects of high altitude exposure in the Subarctic on weight loss and anthropometric measures of body composition. *Israel Journal of Sports Medicine.* 1995;2:173-178.

Danzl DF, Pozos RS. Accidental Hypothermia. *N Engl J Med.* December 29,1994;331:1756-1760.

Pozos, RS, Danzl DF, Iaizzo PA, Mills WT Jr. Limits of tolerance to hypothermia. In Fregley MJ, Blatteis, CM, eds. Handbook of Physiology. New York, NY: Oxford University Press; 1996;1(4).

Medical Contingency Planning

Blood CG, Jolly RT, Odowick MS. Casualty i n - cidence during naval combat operations: a matter of medical readiness. *Naval War College Review.* 1996.

Blood CG, O'Donnell ER. A system to project injury and illness incidence during military operations. *J Med Systems.* 1995;19(6): 457-464.

Blood CG, Jolly RT. Comparisons of disease and nonbattle injury incidence across various military operations. *Mil Med.* 1995;160(5):258-263.

Gauker ED, Blood CG. Friendly fire incidents during World War II naval operations. *Naval War College Review.* Winter 1995;48 (1;349):115-22.

Blood CG. Blue on blue: a history of friendly fire [book review]. *Naval War College Review.* 1995.

Blood CG. Filling a lexical void. Phalanx: *The Bulletin of Military Operations Research.* 1995;28(4),22-23.

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Naval Health Research Center *San Diego, CA*

NHRC UPDATE

July 1996 **Issue No. 2**

This update is being published quarterly to highlight NHRC contributions to the Navy and the broader scientific community.

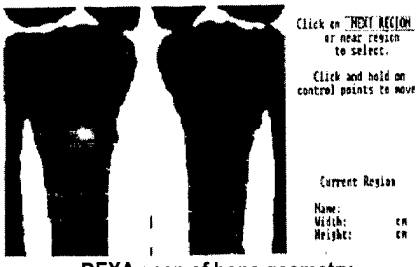
NHRC Research Reduces Recruit Training Injuries and Costs

Although the benefits of physical activity and exercise are well documented, these activities are also known to incur certain risks. Musculoskeletal injury, for example, is the most common morbidity in civilian and military populations who participate in sports and exercise. These injuries are a leading cause of patient visits, lost training time, and reduced operational readiness in U.S. military forces. In recent studies at NHRC, LCDR Rick Shaffer and his colleagues have documented that approximately one half of the women and one third of the men are injured during recruit training in the Marine Corps. At the Marine Corps Recruit Depot, San Diego, previous NHRC research demonstrated an annual loss of 53,600 injury-related training days at a cost in excess of $16 million.

Recruit physical training at MCRD

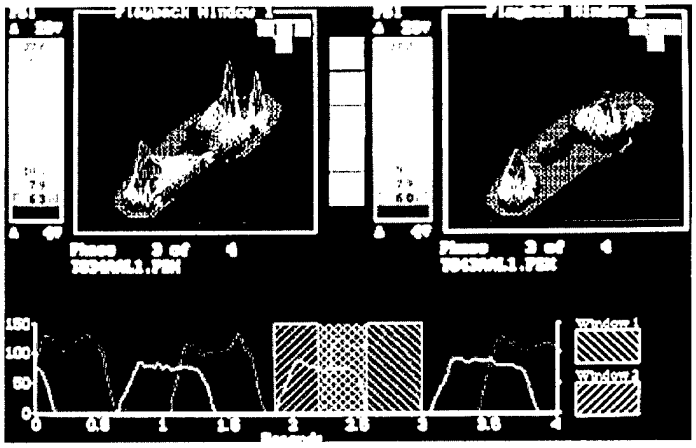
Working closely with Marine Corps, Navy, and Special Operations personnel, LCDR Shaffer, CAPT Brodine, Dr. Almeida, and their colleagues have fielded an aggressive research program to reduce the incidence of musculoskeletal injuries. This approach involves the development and deployment of data collection systems at major training facilities to document the incidence and nature of the injuries, the development of risk factor profiles for injury susceptibility, and the development and evaluation of interventions to reduce injuries. To accomplish these objectives, the NHRC researchers have assembled a sophisticated, multidisciplinary team of Navy sports medicine and operational experts and research partners from Johns Hopkins University, University of California, and Children's Hospital, San Diego.

In a recent article in the *Journal of Bone and Mineral Research*, Dr. Beck and his Johns Hopkins' colleagues, in concert with LCDR Shaffer, Karen Maxwell-Williams, and CAPT Brodine of NHRC, used dual-energy x-ray absorptiometry(DEXA) to derive structural bone geometry as a potential predictor of stress fractures among Marine Corps recruits. These authors concluded that both small body weight and small dimensions of the long bone shaft (diaphyseal) relative to body weight are factors predisposing to the development of stress fractures in this population. Poor physical fitness at time of entry into recruit training also has been identified by LCDR Shaffer and his colleagues as a strong predictor of injury. This and other information derived from the injury monitoring program has led to the development of a scientifically based intervention to reduce injuries at the Marine Corp Recruit Depot. An evaluation of this intervention demonstrated an overall reduction in overuse injuries and a 50% reduction in stress fractures, with no decrement in physical fitness at graduation. Current efforts are focused on the development of improved footwear and the development of interventions to reduce injuries at the Naval Recruit Training Center, Great



DEXA scan of bone geometry

Lakes, at the Marine Corps Recruit Depot, Parris Island, and at various operational commands.



Force plate measures of biomechanical stress

NHRC Physiologists Assess Body Composition Links to Physical Performance and Health

NHRC's research on health and physical performance has played a crucial role in setting Navy fitness standards. Previous NHRC studies on body composition measurement techniques established the Center's prediction equations for body fat percentage as the standard used by the Navy and the Air Force. Recently, in an attempt to identify effective predictors of physical performance, Dr. James Hodgdon and his team of researchers performed a study using bioelectrical impedance to measure body composition.

As part of the Department of Defense's weight control policy, DoD Directive 1308.1 indicated that "the determining factor in deciding whether a service member is overweight is the member's percent of body fat." The Bureau of Naval Personnel updated its physical fitness and weight control programs to follow this Directive, and tasked NHRC with developing field techniques for estimating body fat content. The current tables used to estimate body fat from circumferences and height were developed by NHRC and incorporated into the Physical Readiness Instruction. Also, NHRC developed techniques for estimating body fat content. In the process, NHRC concluded that body fat is not strongly related to the performance of physical job tasks, and that the primary rationale for setting body composition standards is the relationship of body fat to health. The National Institutes of Health determined health risks associated with excess body fat are elevated when individuals exceed the optimum weight for height on the Metropolitan Life Insurance Co. tables by 20%, and it defines obesity as 20% above the life insurance table values. NHRC has determined that these weights are equivalent to a single percent body fat value for each gender, and these values, 22% fat for men and 33% fat for women, provide the basis for the Navy body fat standards.

Physical strength remains a critical component of many tasks required of sailors. However, job selection standards based on strength tests are difficult to apply because of the specificity of individual strength tests, injury risks, and poor portability of testing equipment. An alternative approach that may overcome all three of these limitations is to predict strength performance through one of its primary determinants, fat-free mass (i.e., muscle and bone mass). Dr. Hodgdon and his colleague, Marcie Beckett, previously have shown fat-free mass, estimated from circumferences and height, to be strongly associated with performance on lifting tasks. Fat-free mass is effectively predicted by expedient methods, using analyses based on skinfold thickness and body density.

In the most recent study, Hodgdon and Beckett, and researchers at the U.S. Army Research Institute of Environmental Medicine, have examined the effectiveness of bioelectrical impedance analysis (BIA) measurements as predictors of physical performance. Through its association with fat-free mass, BIA offers the possibility of a noninvasive and reproducible technique that may be associated with strength performance. The study examined the relationship between BIA measures, fat-free mass, and muscular strength. The relationships in this triad were tested in Navy men and women in a cross sectional study: Army women before and after eight

weeks of basic combat training, and Army Ranger students before and after eight weeks of Ranger training. The research study, to be published in October 1996 as a supplement to the *American Journal of Clinical Nutrition*, reports that BIA is valid as an indicator of fat-free mass and changes in fat-free mass only in situations wherein water and nutritional balance are maintained. In short, BIA does not appear to be particularly useful for performance prediction despite its moderate relationship to fat-free mass. NHRC is continuing research in alternative approaches to physical performance prediction.

NHRC Scientists Strive to Reduce Navy Occupational Injuries and Cut Costs

Each year, the Department of the Navy is responsible for approximately one seventh of the federal government's total workers' compensation bill, which in 1993 cost the Navy more than $250 million. In 1990 alone, 20,364 civilians working in Navy facilities were injured on the job, and these injuries are projected to cost $382 million in lost wages, medical costs, and workers' compensation payments over the duration of the claims. With a work force of more than a quarter of a million civilian employees serving in over 2,000 facilities, the Navy faces a complex task in reducing the occurrence and costs of occupational injuries.

In response to this challenge, researchers at NHRC have been developing powerful database tools and software systems to assist the Navy Occupational Safety and Health Program Manager in analyzing workplace injuries and illnesses, pinpointing risk factors to guide the development of better intervention and control measures, and evaluating the effectiveness of worksite changes. These database tools draw from complex, diverse sources, such as the U.S. Department of Labor's Office of Worker's Compensation Program and the Department of the Navy Civilian Personnel Data System Center, to compile comprehensive information on injury incidence, injury costs, and demographic, occupational, and career data on the civilian work force employed at each facility over the past seven years. The analytic and display software provides statistical adjustment procedures to enable comparisons across diverse worksites and populations, develops models for estimating costs, generates information for developing intervention strategies, and provides critical outcome measures for evaluation.

In a recent article published in the *Journal of Occupational and Environmental Medicine*, July 1996, NHRC researchers Steve Shepherd and Bonnie LaFleur used this approach to demonstrate excessive Monday workplace injuries among Department of the Navy civilian employees. After examining more than 55,802 injury claims from 1989 to 1994, these researchers found that the rate of Monday sprains and strains, particularly of the back or trunk, significantly exceeded the expected rate and that such claims were more likely to be made by supervisors who were craftsmen and mechanics without college degrees. They estimated that 22% of claims for Monday-occurring sprains and strains are possibly fraudulent, and suggested that about 1,500 of these claims are unrelated to safety conditions at Navy facilities. The fact remains, however, that these claims for the six years studied have generated costs and future liabilities for the Navy in excess of $38 million. The cost to private industry insurers for fraudulent sprains and strains alleged to have occurred on Mondays has been estimated at between $175 and $185 million annually.

Currently, this powerful technology, developed by NHRC and referred to as the Occupational Safety and Health System (OSHSYS), is being placed on CD-ROM so it can be migrated closer to the worksite. Karen Freeman, Jennifer Jaeger, Hoa Ly, and Dr. Ivan Show are continuing this NHRC effort to help policy-makers and safety managers track and assess, manage, and control the occurrence of workplace illnesses and injuries and their attendant costs in medical care and compensation.

Technology Transfer...

NHRC Assists Investigators of ValuJet Crash

The Naval Health Research Center (NHRC) is providing technical assistance to the National Transportation and Safety Board (NTSB) as the crash site investigation of ValuJet Flight 592 continues in the Florida Everglades.

Crash site investigation team

In coordination with the Naval Science Assistance Program (NSAP), researchers from NHRC are sharing information and technology used to protect Navy and Marine Corps personnel who frequently operate for extended periods in adverse environments and in protective clothing ensembles that increase body temperature.

At the request of the NTSB and Susan Bales, Director of NSAP, Jay Heaney, a research physiologist at NHRC, has flown to the crash site with 14 Steele Ice Vests™. Heaney has briefed the divers and ground-based personnel on the proper use of the ice vests to reduce thermal stress and extend stay times.

NHRC has proved these ice vests are effective in military situations such as the Persian Gulf, firefighting, and damage control operations, and are now in the inventories of most Navy ships.

As in many military operations, the investigators at the crash site are operating at the upper limits of human endurance and environmental extremes. The assistance of Navy Medicine will contribute measurably to the accomplishment of this enormous and difficult task.

NTSB worker with ice vest before donning biohazard suit

NHRC Launches Home Page on the World Wide Web

The NHRC home page was developed to further enhance the transfer of research and development information. Through this window to the world, NHRC organizational information is available at the department, division, work unit, and individual level. The home page also provides access to the latest scientific information through abstracts of NHRC publications and links to other relevant resources. Last month this home page was accessed by nearly 16,000 individuals from more than 30 countries around the world. For further information about NHRC and a copy of this and other "updates," you are invited to visit our home page @ http://www.nhrc.navy.mil.

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Naval Health Research Center *San Diego, CA*

NHRC UPDATE

October 1996 **Issue No. 3**

This update is published quarterly to highlight NHRC contributions to the Navy and Marine Corps as well as the scientific community.

NHRC Researchers Identify Health Outcomes of Navy POWs From Vietnam

At the close of the Vietnam War, the Center for Prisoner of War Studies was established at the Naval Health Research Center (NHRC) to coordinate the medical aspects of the POWs repatriation,

identify short-term medical effects, and document the process of social reintegration. Having successfully completed this mission, the Center for Prisoner of War Studies was disestablished in 1978; however, the annual medical follow-up program established in collaboration with the Naval Aerospace and Operational Medical Institute (NAOMI), Pensacola, Florida, continued. In this program, the POWs and a matched comparison group receive an extensive medical and psychological examination in Pensacola each year.

In 1993, 20 years after the POW repatriation, researchers at NHRC worked in partnership with medical and computer specialists at NAOMI to convert the thousands of pages of medical examination records into an electronic database for computer analysis. In a recent article published in the *Journal of the American Medical Association*, Dr. Nice and his colleagues, Ms. Sue Hilton and Dr. Cedric Garland from NHRC, and Dr. Baggett and Dr. Mitchell from NAOMI, reported their findings on the long-term health outcomes of the U.S. Navy prisoners of war in Vietnam.

Of the 47 diagnostic groupings that were analyzed, 4 demonstrated significant differences between POWs and the comparison group. Although there were no significant differences in life-threatening disorders such as cardiovascular disease or cancer, the POWs had significantly higher rates of disorders of the peripheral nervous system (particularly upper limbs), arthropathy (joint disorders), dorsopathy (back disorders), and peptic ulcer. Many of these effects were believed to be associated with the torture incurred during their long years of imprisonment. During captivity, which lasted an average of 5 years, ropes, ratchet handcuffs, leg irons, or stocks were used to put tightly constrictive pressure around an extremity, most often the upper arm, and were left in place for several minutes to a few hours. The resulting ischemia was extremely painful, and it produced swelling and persisting neuropathies (nerve damage). Often, POWs were unable to write, shave, or even properly feed themselves for as long as 3 months after such treatment. Paresthesias accompanied the motor impairment and generally persisted in the form of numbness or decreased vibratory sense through the time of repatriation. The increased incidence of peripheral nerve damage and arthritis at the time of this study indicates that many of these effects may be permanent.

Although many of the POWs from World War II and Korea experienced psychiatric symptoms, such as Posttraumatic Stress Disorder, these effects were not found in the Navy POWs from Vietnam. Because all but one of the Navy POWs were officers in naval

aviation, Dr. Nice and his colleagues attribute this resilience to a combination of factors, including selection, training, and the long-term medical follow-up. As this cohort of POWs and comparison group members continues to age, NHRC researchers may gain additional insights into the psychosocial and physiological associations with chronic disease and the medical management of former POWs.

NHRC Scientists Lead Navy Health Promotion Efforts

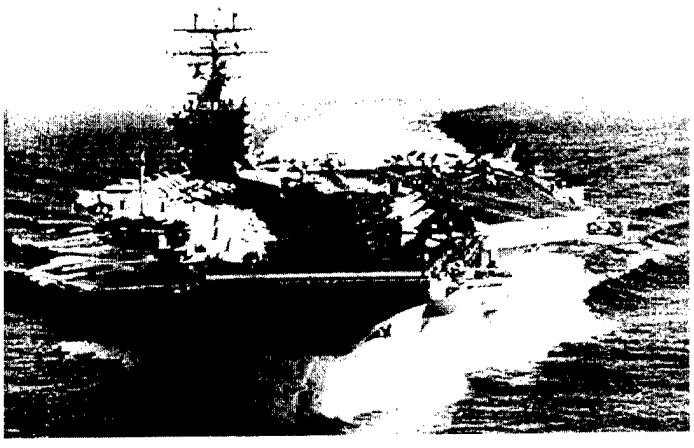
For more than a decade, the Naval Health Research Center has been a leader in health promotion research in the Navy, and much of this effort has focused on the use of tobacco. It has been estimated that more than 400,000 Americans die each year as a result of cigarette smoking, accounting for 1 in every 5 deaths in the United States. Tobacco use is a particular concern of the Department of Defense (DoD) because the military overall has higher and heavier rates of tobacco use than does the civilian sector. For many years, the Department of the Navy has been concerned about the adverse effects of smoking on health and performance of military personnel, since cigarette use can influence military effectiveness and readiness.

Consistent with national policies restricting or totally banning smoking in large organizations, such as health care and educational settings, as well as in smaller environments, such as restaurants and airplanes, the U.S. Navy's primary health promotion goal is to create a healthy, smoke-free work environment. As the nation's largest employer, the DoD took a major step toward achieving this goal when it banned workplace smoking in April 1994, affecting some 3 million employees. However, establishing a healthy workplace means not only discouraging and restricting tobacco use among smokers but also preventing secondhand, environmental tobacco smoke exposure to nonsmokers. But, given the large number of smokers and the addictiveness of nicotine, this is no easy task.

In recent years, NHRC's health promotion program has focused on the reduction of tobacco products among active-duty personnel. In a forthcoming *Military Medicine* article, Ms. Suzanne Hurtado reports the results of a study on changes in smoking prevalence among Navy recruits. This study examined more than 400 Navy recruits who were smokers upon entering Navy recruit training. Recruits were prohibited from using tobacco for the duration of the 8 weeks of basic training. At the end of recruit training, 40% of the smokers had changed their classification to former smokers, and at the one-year follow-up, 19% of the initial smokers had classified themselves as former smokers, thus suggesting that the Navy's no-smoking policy during recruit training contributes to reducing smoking prevalence.

In another recent *Military Medicine* article, Dr. Terry Conway and Ms. Hurtado discussed Navy health care providers' attitudes and practices concerning their patients' tobacco use. Results from this study, which surveyed nearly 2,300 Navy health care providers, showed that of 11 cessation-oriented practices recommended by the Secretary of the Navy and the National Cancer Institute, most Navy health care providers (67-78%) engaged in only four behaviors with most or all of their tobacco-using patients. These behaviors were: advise to stop using tobacco, advise pregnant tobacco users of health risks to the fetus, inform patients of the benefits of quitting, and explain the dangers of using tobacco. Given that physician-delivered cessation counseling has been estimated to be more cost-effective than other common preventive medicine practices, Dr. Conway and Ms. Hurtado recommended that all Navy health care providers be trained to use the National Cancer Institute's team approach for tobacco cessation, and that strong organizational support to implement these procedures be provided.

The Navy's concern for a smoke-free work space, of course, is not limited to its shore-based worksites. Aboard all ships under the cognizance of the



Commander, Naval Air Forces, U.S. Atlantic Fleet, the use of smoking tobacco in any form is prohibited in all spaces unless a space meets strict specifications. In a recent article in *Aviation, Space, and Environmental Medicine*, Ms. Hurtado and her AIRLANT colleagues focused on crew members aboard 6 U.S. Atlantic Fleet aircraft carriers. This study documented crew members' reports of exposure to environmental tobacco smoke, smoking behavior and history, and attitudes regarding "no-smoking environment" policy. While the increased smoking restrictions significantly reduced environmental tobacco smoke exposure, there was very little change in smoking rate among crew members during this time, and, among some ships, smokeless tobacco use increased. Ms. Hurtado and colleagues recommended continued enforcement of the smoking restrictions, and command support and emphasis on all tobacco use prevention and cessation programs and activities.

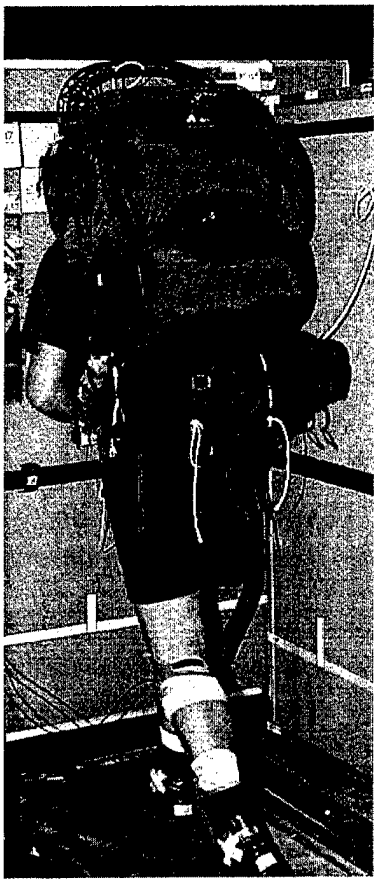
Based on these important studies and recommendations, NHRC researchers plan to expand their focus from tracking and program evaluation to include smoking cessation and prevention program development and implementation. An example of this is Operation Stay Quit, a study currently under way with young Navy women graduating from recruit training. The goal of this study, which is testing the effectiveness of telephone-based counseling and of mailed educational and motivational information packets, is to help these women quit the smoking habit, and more importantly, to stay quit. This two-and-a-half-year study, funded by the Defense Women's Health Research Program, is a collaborative effort between San Diego State University and NHRC. Designed to address the everyday situations Navy women face, Operation Stay Quit interventions focus on issues particularly relevant to female smokers, such as fear of weight gain after smoking cessation, the need for social support, and the inevitable stress associated with breaking an addictive habit. Through these, and other health promotion and preventive medicine efforts, the Naval Health Research Center will continue to assist Navy medicine in meeting its commitment to ensure that Navy and Marine Corps personnel are fit to fight.

NHRC Experts Evaluate Equipment for the Marines

As outlined in the *Operational Maneuver From the Sea*, dominant maneuver and sustainment are principal capabilities for the U.S. Marine Corps in the 21st century. These capabilities will require skillful operations executed at a high tempo to accomplish decisive objectives. The success of these high tempo operations will depend on highly trained personnel using advanced technology and equipment. In continuing efforts to support Marine Corps personnel, the Naval Health Research Center conducts laboratory and field studies to evaluate equipment and procedures. The most recent efforts in this program have addressed backpack design and tent safety. As part of the Marine Enhancement Program, a replacement for the All-Purpose Lightweight Individual Carrying Equipment (ALICE) pack is being considered to reduce the risk of

injury caused by carrying heavy loads on the shoulders. An NHRC team led by Dr. Don Roberts conducted a sophisticated laboratory study to compare 13 commercial backpacks with the ALICE pack. This comparison was based on biomechanical, physiological, and subjective measurements of active-duty Marines carrying 100 lbs for 4 hours. While none of these backpacks is the ideal replacement for the ALICE (due to limitations with carrying war-fighting supplies), the study concluded that certain aspects of several backpacks can be incorporated into a new backpack

design. The new backpack should include a waist belt that carries the load (shoulder straps are used only to prevent forward or backward rotation of the load) and prevents the hand-numbing effect of the ALICE. The load should be carried as close to the center-of-mass as possible, so the pack frame should be as close to the back as possible (internal backpack design). The frame needs to be strong but flexible, and the vertical frame stays should attach to the waist belt on the sides of the hip rather than on the lower back (minimize lower back injury). The most important consideration is the fit, and the key measurement is the torso length (from top of shoulders to the top of hips). Any new backpack design must incorporate carriage of war-fighting supplies (ammunition and water) as part of the backpack while maintaining the ability to detach the two components. The development of a new backpack will reduce injury associated with carrying heavy loads on the shoulders and enhance maneuver and sustainment on the battlefield.



In an effort to reduce the weight of equipment and increase mobility of assault troops, the Marine Corps has incorporated a NorthFace® 4-man tent as the primary tent for field use. The tent has two components: (1) a tent with a floor and a single door, and (2) a rainfly with a door. Ventilation is achieved by opening the doors. Because cold weather operations involve the use of a stove, the Marine Corps was concerned about the quality of air in this tent when occupied and requested assistance from the NHRC. In response to this request, Dr. Roberts and Ms. Katie Canine tested 20 tents for carbon dioxide, oxygen, and carbon monoxide during winter training at the Marine Corps Mountain Warfare Training Center (MCMWTC). The tent fabric restricts

the movement of gases across the fabric, and results of the study showed increases in carbon dioxide and decreases in oxygen when the tents were not ventilated. The only source of heat (also for cooking or melting snow for drinking water) for this tent is the Peak1® stove. The MCMWTC policy is to ignite the stove outside the tent and move it inside the tent. When a stove is ignited inside the tent, the carbon monoxide level is three times the acceptable limit (25 parts per million). As the stove warms, the production of carbon monoxide decreases, but prolonged use of the stove inside the tent creates unacceptable levels of carbon monoxide. Carbon monoxide combines with hemoglobin to form carboxyhemoglobin (COHb), which displaces the oxygen needed for cellular function. As the concentration of COHb increases, individuals will display various symptoms of carbon monoxide poisoning, including nausea, dizziness, and headache, and, if exposure is long enough, death can result. Based on these findings, researchers at the Naval Health Research Center are working with the Marine Corps to develop new guidelines to ensure high levels of air quality inside the NorthFace® 4-man tent during cold weather operations.

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Naval Health Research Center *San Diego, CA*

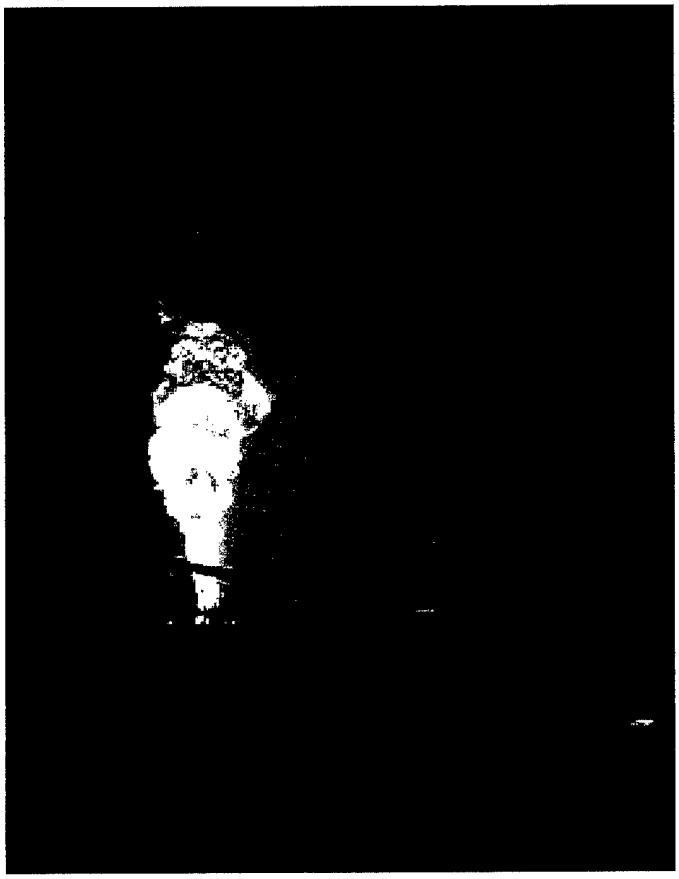
NHRC UPDATE

January 1997 **Issue No. 4**

This update is published quarterly to highlight NHRC contributions to the Navy and Marine Corps as well as the scientific community.

NHRC Scientists Lead Epidemiological Research on Gulf War Veterans

The health of the veterans who served in the Gulf War has been a matter of intense public interest and of great concern to health care providers and planners at the Department of Defense and the



Department of Veterans Affairs. In the Spring of 1994, the Assistant Secretary of Defense for Health Affairs tasked the Naval Health Research Center to develop comprehensive epidemiologic studies among Gulf War veterans. In response to this tasking, Captain (select) Greg Gray, a Navy physician and epidemiologist, assembled a strong multi-disciplinary team at NHRC and established effective research partnerships with eminent scientists at the University of California, San Diego; the Walter Reed Army Institute of Research; the Centers for Disease Control and the Department of Veterans Affairs.

In a study recently published in the *New England Journal of Medicine*, Dr. Gray and his colleagues examined the hospitalizations of 1.1 million veterans. The researchers looked at a broad spectrum of diagnosis from August 1991 until September 1993. Screening the 487,549 hospitalizations which occurred during this 2-year period, the team found that the 547,076 Gulf War veterans had the same postwar overall hospitalization experience as their 618,333 nondeployed peers of the same era.

Differences in hospitalization experience for specific diagnostic categories were found between the two populations, but these differences were consistent with research findings from other wars and attributed to other reasons. The results of the study suggested that after the war, there was no increased risk of "any cause" hospitalization among Gulf War veterans compared with nondeployed veterans. Gulf War veterans had a different risk of hospitalization than did nondeployed veterans in 16 of 42 diagnostic category comparisons. In four of these 16 different comparisons, Gulf War veterans were at increased risk: neoplasms during 1991 (largely benign), diseases of the genitourinary system during 1992, diseases of the blood and blood-forming organs during 1992 (mostly anemias), and mental disorders during 1992 and 1993. These differences were not consistent over time and could be explained by deferred care, postwar pregnancies, and postwar stress.

This work is one of the first large-scale studies to compare health outcomes among Gulf War veterans with appropriate comparison groups of other active duty personnel. According to Dr. Gray, additional NHRC

studies which have been strongly endorsed by the Institute of Medicine, will focus upon symptoms, reproductive health, and hospitalizations among various groups of Gulf War veterans. One such study will compare hospitalizations among Gulf War veterans who may have been exposed to the destruction of Iraq's Khamisiyah ammunition dump in March 1991.

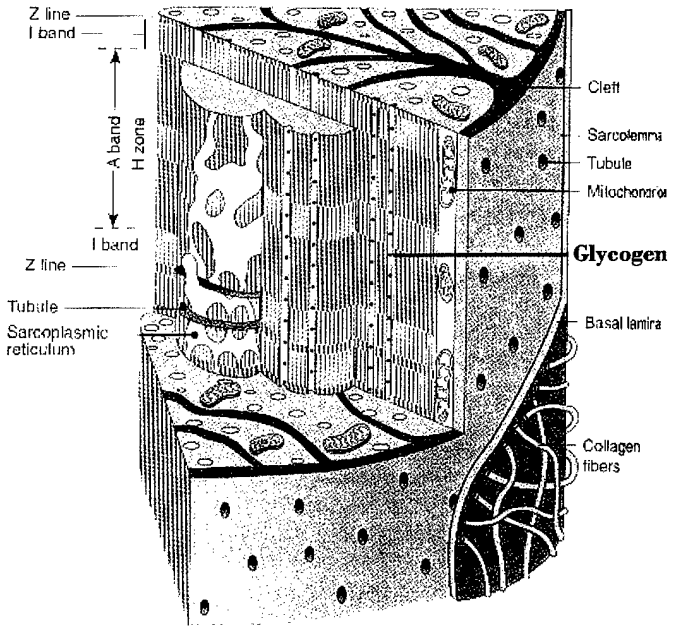
NHRC Physiologists Develop Methods to Sustain Physical Performance of Special Operations Personnel

Special forces operators (SEALs, Force Recons, SANGLICO, etc.) often perform physically demanding tasks at the limits of human endurance to achieve mission success. Their primary

missions, which are candlestine and performed by small units, include 1) beach surveys in support of amphibious operations, 2) reconnaissance and intelligence gathering, 3) rescue of downed pilots and extraction of personnel from denied territory, 4) limpet (ordinance) attacks against enemy ships and piers, and 5) direct actions against military targets on shore or at sea. NHRC researchers have been studying special operations mission requirements for several years and have identified a number of methods and techniques to enhance or sustain physical performance under extreme environmental conditions.

The NHRC Special Operations Division, composed of exercise physiologists, exercise biochemists, nutritionists, and statisticians, works with the special forces community on a daily basis to study the efficacy of physical training, nutritional and ergogenic interventions. Nutritional strategies include carbohydrate loading and supplementation, creatine supplementation, and hyperhydration. Guidelines for applying these interventions have been published and distributed to special operations commanders and medical officers.

Carbohydrate loading, a method used to increase muscle glycogen to abnormally high levels



Source: *Exercise Physiology*. Mcardle, Katch & Katch (Eds.) Williams & Wilkins, 1996

Glycogen storage within the muscle fiber

(supercompensation), is a common practice among endurance athletes. This increases the time that an athlete can maintain a given power output and thus extends his/her exercise endurance time. Carbohydrate loading also has potential to sustain physical performance during special operations missions; however, unlike athletic events military operations may

be delayed for several days, and the glycogen levels may return to normal before the mission. In a recent study published in the *Journal of Applied Physiology*, Dr. Goforth and his colleagues found that supercompensated muscle glycogen can persist in special forces personnel for at least 3 days if physical activity is limited. This indicates that carbohydrate loading has sufficient flexibility for use by special operations personnel in an operational setting even if the mission is delayed. Armed with this information, the NHRC team is now working with colleagues at the Yale University Medical Center using Nuclear Magnetic Spectroscopy to test two modified carbohydrate loading procedures. In contrast to the previous study, these protocols include daily exercise and are designed to achieve and maintain muscle glycogen supercompensation and fitness for 3-6 days.

The NHRC researchers are also working with special operations personnel to evaluate physical training techniques, which involve eccentric training (downhill running) to toughen muscles and reduce muscle soreness, and short-term, high intensity cycle exercise to simultaneously increase aerobic and anaerobic capacities. These studies are being conducted in collaboration with researchers from the Canadian Defense and Civil Institute of Environmental Medicine; Northern Arizona University; University of California at Los Angeles, and Yale University. Our close proximity to the Navy and Marine Corps special forces provides NHRC researchers the ability to fully understand mission requirements, execute high tempo field research activities, and effectively transition biomedical technologies and interventions to these highly specialized communities.

NHRC Researchers Explore the Cycle of Domestic Violence

Violence directed toward an intimate partner or a child is an issue of great national concern and is an area of special interest within the Bureau of Naval Personnel (BuPers). As part of a broad set of initiatives to prevent and treat domestic violence in the Navy, BuPers has tasked NHRC researchers to identify factors associated with domestic violence, including the view that childhood experiences in the family of origin may contribute to the risk of child abuse during adulthood. In a study recently published in the journal of *Child Abuse & Neglect*, Dr. Lex Merrill and his colleagues, including Ms. Linda Hervig at NHRC and Dr. Joel Milner at Northern Illinois University surveyed 3,776 female and male recruits to determine their histories of physical abuse, alcohol misuse, and their potential for child abuse.

The results of the study showed that 31% of the female and 20% of the male recruits witnessed parental violence and about 40% of all recruits experienced at least one instance of childhood physical abuse. The study also found that a pattern of violence in women, such as receiving physical abuse as a child or inflicting physical violence on an intimate partner, increased the risk of child physical abuse. Being a victim of child abuse also increased the potential for child abuse among men. A history of alcohol misuse was also a predictor of intimate partner abuse and injury, as well as the potential for child abuse.

Navy recruits at RTC, Great Lakes

NHRC researchers are currently extending these findings through a 4-year longitudinal study in conjunction with Northern Illinois University and in collaboration with researchers at the University of Southern California, University of Arizona, and the University of North Carolina. This study, which is being supported by the Navy Family Advocacy Program in the Bureau of Naval Personnel, will determine the impact of premilitary maltreatment histories on the careers of Navy personnel, long-term health care consequences, and the risk for revictimization and recidivism. Results from this research will assist the Bureau of Naval Personnel in its proactive approach to the prevention and management of domestic violence.

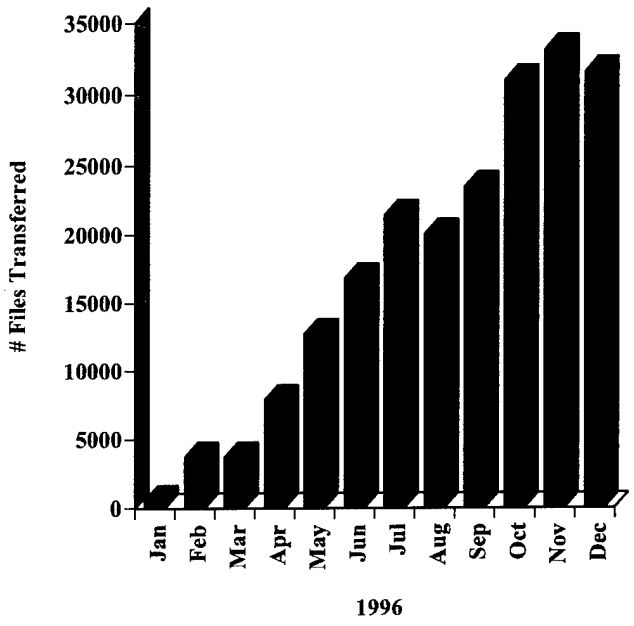
N091 and ONR Essential to Biomedical Fleet Support

About one-half of the research programs at the Naval Health Research Center are supported by the Director of Navy Test & Evaluation & Technology Requirements (N091) and are executed through the Office of Naval Research. With input from the Navy and Marine Corps operational commanders, N091 establishes our research requirements and provides fiscal support. As the execution sponsor, the Office of Naval Research manages the resources, maintains high standards of quality, and ensures the development and integration of research findings and technologies from both the private and public sectors.

The remaining one-half of our research programs are supported directly by our operational customers, which include the Navy, Marine Corps, Army, and Department of Defense. Each of our research programs is managed through the Naval Medical Research and Development Command, our parent command, which provides administrative support, and program guidance and oversight. We are deeply indebted to each of these organizations for their critical roles in helping NHRC support our operational forces through biomedical research and development.

NHRC World Wide Web Site

The NHRC home page was developed to provide on-line access to information about the Naval Health Research Center. A cyberstroll through this website provides hyperlink access to organizational overviews, current research programs, publication abstracts, administrative information, copies of the NHRC "Update", links to other important websites, and even the 5-day weather forecast and visitor information for San Diego. Over 1,000 people per day from 50 different countries are currently visiting our site to learn more about our Navy and Marine Corps research in operational epidemiology, medical operations research, medical and performance modeling, operational performance assessment and enhancement, medical informatics, health promotion, and readiness standards. We hope to see you soon.



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Naval Health Research Center *San Diego, CA*

NHRC UPDATE

April 1997 **Issue No. 5**

This update is published quarterly to highlight NHRC contributions to the Navy and Marine Corps as well as the scientific community.

NHRC Scientists Develop Breakthrough Alertness Monitoring Technology

The Office of Naval Research is supporting an exciting, high tech research program at NHRC to develop a capability to monitor alertness among Navy personnel in critical positions or situations. At least five trends make alertness an increasingly important issue for the future of the Navy and Marine Corps. First, the number of workers, both military and civilian, whose positions are staffed around the clock is steadily increasing. The Office of Management and Budget recently pointed out that the U.S. Navy is the world's largest employer of shift work personnel and urged the Navy to increase its attention to alertness and fatigue issues. Second, there is increasing pressure to radically reduce staffing in all positions, including ship crews. The current Navy Smart Ship project is attempting to reduce crew staffing by at least half through increased automation and system integration.

This may leave many key work stations under the watchful eyes of solitary operators without close supervision or an available relief.

Ever-increasing automation poses a third challenge to maintaining vigilance and alertness. While computerized information systems can collect and display more and more detailed information, these systems may frequently leave their operators with little to do but monitor the streams of information they provide. Meanwhile, the ability of operators to maintain alertness and vigilance under such conditions has not increased and is bound by definite psychophysiological limits.

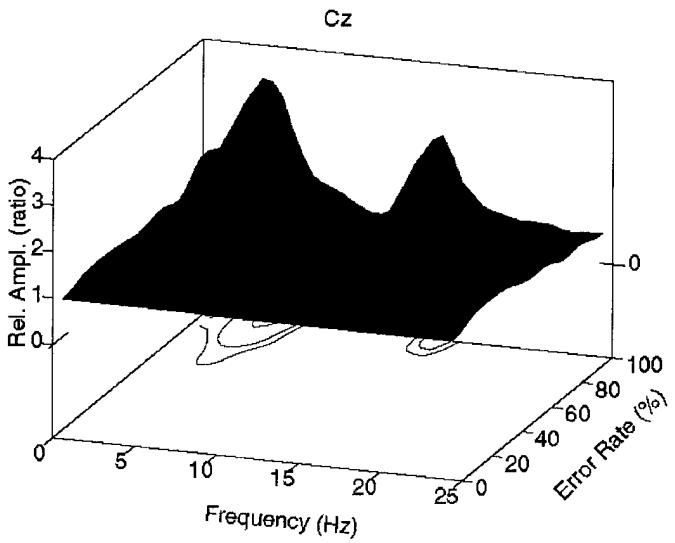
A fourth trend contributing to the growing importance of alertness in overall military performance is the increasing need for and frequency of global travel, often leading to jet lag or "desynchronosis" in which body rhythms and work schedule become out of sync with one another. Alertness problems occur most often under "contra-circadian" conditions, when our natural body clocks make us inclined to sleep while our work schedule, new time zone, or unforeseen events require us to work. Finally, modern warfare doctrine relies heavily on night operations, further increasing the "circadian stress" on front line fighters and their commanders during training and combat missions.

Research at NHRC has shown that precise information about an operator's current state of alertness is available in the small fluctuating electrical currents produced by the brain. These "electroencephalographic" or EEG signals, can be noninvasively recorded from the scalp, and change in size, location, and frequency as alertness diminishes. In the early phases of this work, Dr. Scott Makeig and colleagues at NHRC began studying the EEG of subjects who were attempting to press a response button whenever they heard a weak target sound during boring half-hour sessions conducted in a small, dark, sound-attenuated chamber.

Under these conditions, it was particularly difficult for subjects to stay alert and a wide range of performance changes resulted. Very few of the subjects were able to respond to every target. Instead, in many sessions the subject experienced "waves" of

drowsiness lasting four minutes or longer in which they could respond only intermittently or not at all. After such a session, the subject would typically remember struggling to stay awake but would often severely underestimate the number of targets they had missed. Further research by Dr. Makeig and his colleagues, published last year in the journal *Cognitive Brain Research*, showed that the periods of intermittent responding during drowsiness have a definite time pattern which in most subjects consists of a series of 15-20 second dips into unawareness, much like listeners who find themselves "nodding off' during a boring lecture in a dark room or while reading an article such as this.

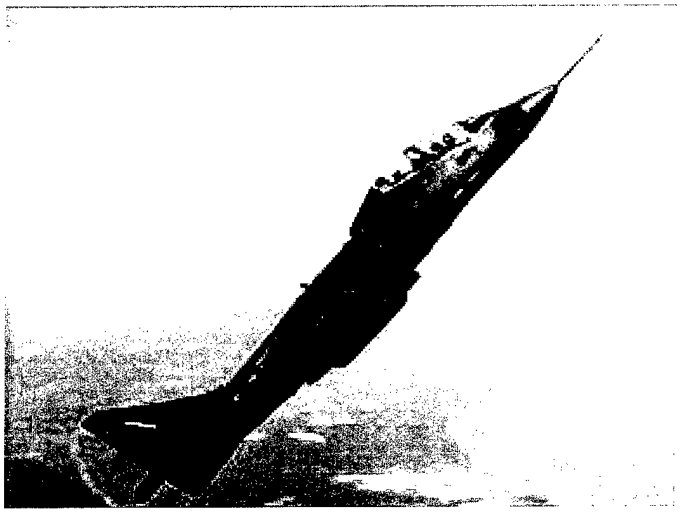
In 1993, Dr. Makeig and Mark Inlow published a paper in a leading EEG journal showing that these waves of drowsiness are accompanied by very specific changes in EEG patterns, and that these changes can be used to estimate changes in a subject's vigilance



3-D EEG plot to predict vigilance performance

performance. Further research established that while these changes vary somewhat from subject to subject, within subjects they are invariant and can be detected on-line in near real time. Working with Drs. Terrence Sejnowski and Tzyy-Ping Jung at Salk Institute, Dr. Makeig has developed a neural network algorithm for real-time alertness monitoring based on EEG data collected from four to five points on the scalp. This original algorithm provided a capability to monitor an individual's alertness and thereby predict his or her errors in a vigilance task. The still-greater accuracy of an advanced version of this algorithm has recently been demonstrated in a paper published by Dr. Makeig and colleagues in the *IEEE Transactions on Biomedical Signal Processing*. Results of this and related research are available on the world wide web (http://labhsp.nhrc.navy.mil/).

Dr. Makeig's research advances work done first at NHRC in the 1960's by former NHRC Scientific Director Dr. Laverne Johnson and associates, who noted the potential for real-time alertness monitoring based on EEG, but lacked the modern computer and neural network technology necessary to create a working system. Currently, Dr. Makeig is collaborating with LCDR Karl Van Orden of NHRC and researchers at Salk Institute, the University of California, San Diego, and NRaD on parallel streams of applied and basic research in operator state assessment based on EEG and eye tracking information. They are hoping to soon test a portable version of an EEG-based system to demonstrate its feasibility in monitoring alertness in an advanced command and control work station and gravity-induced loss of consciousness (GLOC) in Navy



and Marine Corps jet pilots. This operator status technology will provide the capability to more efficiently distribute the workload between the operator and the machine and marks a significant advance in human-system interface.

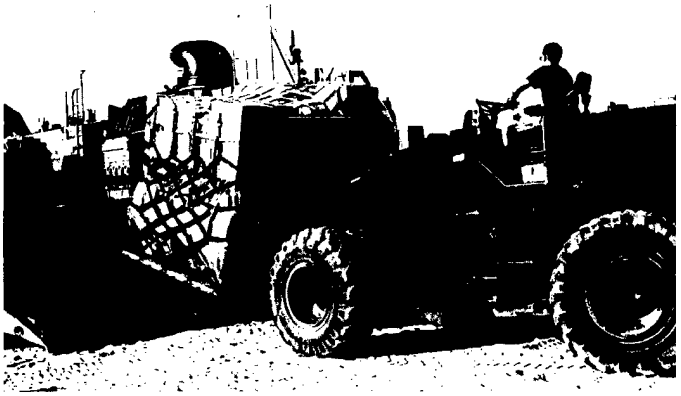
The NHRC research team, in collaboration with researchers at the University of Pennsylvania, is also assisting the National Highway Traffic Safety Administration in monitoring the alertness of truck drivers and developing appropriate drowsiness countermeasures during night driving. These tests are expected to involve prototypes of new "dry" electrode chips that can be worn comfortably by operators under a baseball cap or earphone head band without special

skin preparation.

In the future, related psychophysiological monitoring methods could be used to detect when an operator fails to show a brain response to an important warning signal, and could increase the efficiency of computer-based training. With LCDR Neri of the NASA Ames fatigue research program, Dr. Makeig has proposed that future Navy and Marine Corps commanders have available an integrated alertness and fatigue management system to help them maintain the readiness-for-duty of their personnel under high circadian-stress conditions. Such a system might combine noninvasive crew rest monitoring and intelligent work/rest scheduling software with on-line cognitive assessment of operators at key work stations.

NHRC's Operations Research Division Streamlines Forward Medical Supplies for the Marine Corps

Having the right amount and type of medical supplies and equipment is essential for medical readiness. While insufficient medical materiel may result in manpower losses, attempts to move excessive quantities of supplies must be avoided



because scarce fiscal resources and transportation assets are diverted. The Commandant of the Marine Corps requested that NHRC review the Authorized Medical and Dental Allowance Lists (AMAL/ADALs) so that they accurately reflect changes in Marine Corps doctrine and policy as well as the anticipated reduction in casualty rates. Mike Galarneau and his colleagues Dr. Paula Konoske, Kevin Mahoney, and Kristee Emens-Hesslink are currently reviewing the medical supply and equipment lists for the Marine Corps' far forward medical treatment facilities.

Working closely with Marine Corps medical professionals, Mr. Galarneau linked the Echelon I and II medical tasks required to treat patients with specific patient condition codes established by the defense medical standardization board and compiled lists of the supplies and equipment required to perform each task. More than 85 subject matter experts from the 1st, 2nd, and 4th Medical Battalions, the 1st and 2nd Force Service Support Groups (FSSG), and the Naval Hospitals Camp Pendleton and Camp Lejeune reviewed treatment briefs, tasks, supplies, and equipment and determined their usefulness for Marine Corps Echelons I and II. The result of this work is a model of Echelon I and II supply stream that establishes a clinical requirement for each item used to support forward medical care.

AMALs containing the Echelon II lab and x-ray supplies and equipment were evaluated first. Studies showed that substantial reductions could be made in the number of items required, weight, and cube of the proposed AMALs when compared to the current Marine Corps AMALs. For example, 34 items in the proposed laboratory equipment AMAL could be eliminated with a corresponding 28% reduction in weight and 10% reduction in space, while in the proposed x-ray equipment AMAL there was a 14% weight savings and a net space savings of 4%. By establishing the clinical requirement for each item pushed forward, the NHRC model was able to reduce the logistical burden carried by Marine Corps units. This approach also produces an audit trail for each item because only items that can be clinically related to a treatment task conducted in theater are considered for inclusion in the AMALs. The Marine Corps Combat Development Center has endorsed NHRC's review process and has recommended that the process be used for the evaluation of the remaining AMALs.

Currently, Battalion Aid Station and Echelon II Operating Room AMALs are being revised. A computer program that estimates supplies and equipment requirements based on a given patient stream distribution has been designed and is under development. This will allow the current configuration to be revised using information such as the type of conflict anticipated, the expected duration, and changes in medical doctrine. Additional efforts are underway to use this methodology to evaluate the AMAL/ADALs of shipboard medical departments.

NHRC's Environmental Physiologists Evaluate Anti-Exposure Suits for Use During Shipboard Flooding Operations

Shipboard flooding as a result of mechanical failures, mismanagement of ballast, or breaches of the ship's hull often requires damage control personnel to work in cold ocean water. One of the most serious hazards of cold-water exposure is hypothermia caused by loss of body heat. Because the thermal conductivity of water is 20 to 25 times that of air, cold water quickly absorbs most of the heat which reaches the skin and poses a serious hazard for damage control personnel.

Naval personnel normally perform damage control for shipboard flooding operations dressed in dungarees or engineering coveralls. However, these garments have a minimal insulation capacity and do not provide adequate protection for cold-water exposure. Therefore, Dr. Don Hagan and Lt. Barry Cohen are working with the Personal Protection Division of the Naval Sea Systems Command to identify and evaluate a number of anti-exposure suit concept-designs for possible use by damage control personnel.

There are two basic types of anti-exposure suit designs which prolong staytime in cold air or ocean waters. These are called "wet" suits and "dry" suits. "Wet" suits usually cover the whole body and allow cold water to seep up the legs and down the arms to eventually cover the entire body surface. Protection from the cold is provided when this water layer between the skin and the inside of the suit is warmed sufficiently to reduce convection heat loss from the skin. On the other hand, "dry" suits prevent water from making direct contact with the skin, thus protection is greater because the air layer between the skin and suit serves as another barrier to heat loss.

In an initial set of studies supported by the Office of Naval Research, NHRC researchers evaluated two "wet" suits and one "dry" suit which were already in the Navy supply system but were not designed for damage control operations. These studies indicated that the "dry" suit, which was the CWU-62P anti-exposure coverall worn by Navy pilots, afforded the best protection, but was difficult to don and costly to manufacture. Subsequent tests evaluated three "dry" suits in a realistic flooding problem in which subjects performed

a pipe patching task while they were progressively immersed in cold water. In these tests, a British-made whole-body suit manufactured by MultiFabs Survival, Inc. provided the best overall protection against decreases in body temperature; however, a suit developed by the Naval Clothing and Textile Research Facility was nearly as effective and proved to be more durable under simulated operational conditions. Additional findings from laboratory and field studies also revealed a need to identify pliable waterproof work gloves to keep the fingers and hands dry and warm to maintain dexterity and patching effectiveness. These preliminary findings will aid in the future development of a cost effective, easily donned, anti-exposure "dry" suit designed specifically for shipboard flooding repair operations.

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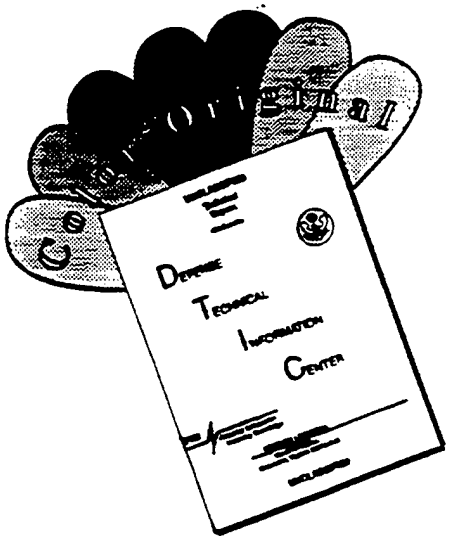

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