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-41-

CATECHOLAMINERGIC RESPONSES TO STRESSFUL MOTION STIMULI, SCOPOLAMINE PLUS AMPHETAMINE, AND DEXAMETHASONE. R.L. Kohl* and W.E. Chelen*. National Research Council, NASA Johnson Space Center, Houston, Texas 77058.

INTRODUCTION. Peripheral levels of epinephrine (EPI) and norepinephrine (NE) generally rise following stressful motion stimuli. Effective anti-motion sickness drugs, scopolamine plus d-amphetamine (S/D) and dexamethasone (DEX), modulate release of EPI and NE. This modulation may be of etiological relevance. METHODS. Severe nausea was induced by exposure to Coriolis stimulation using a rotating chair (ASEM 54:994). Chronic administration of S/D (0.4 & 5 mg/da), DEX (3 mg/da), and placebo preceded Coriolis stimulation. EPI and NE were measured immediately before and after stimulation. A double-blind, crossover design was used. RESULTS. Nausea-induced elevations of EPI (2.5-fold, $p < .01$) and NE were not diminished upon repeated exposure and adaptation to the stressor. Subjects with more pronounced elevations of EPI following stimulation displayed higher resistance to stressful motion ($p < .05$). Alteration of peripheral catecholamine levels following drug suggested that motion sickness was not mediated by peripheral catecholamine receptor stimulation. EPI and NE levels were 2.8- & 3.6-fold higher ($p < .03$ & .01) after nausea without DEX treatment. DEX loading halved pre-stress levels of EPI and NE ($p < .05$). CONCLUSIONS. Marked differences were noted in individual responses to drug and systemic responses of EPI and NE. It is possible the responses of EPI to motion sickness may predict resistance to stressful motion and represent a peripheral manifestation of some as yet unknown central event of etiologic relevance. NASA grant NAS9-17267, RTOP 199-16-11-08.

-42-

PHYSIOLOGICAL RESPONSES TO HEAD MOVEMENT

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Motion sickness (MS) is commonly elicited by head movement (HM) made out of axis of whole-body rotation. Some investigators observe a relationship between MS and heart rate (HR) and blood pressure (BP) using this procedure. Reasoning that an exercise effect might confound these results, we studied the HR and BP response to HM per se.

9 stationary subjects made a series of 1500 paced HMs, while changes in HR and BP (from the baseline to HM period) were calculated. HM protocol and data analysis were according to prior studies involving rotation (Cowings, et al, 1977, 1986, 1990).

HR rose during the period of HM ($p=.0001$, $F= 11.4$, ANOVA), while BP did not (sys. and dias. bp: $p> 0.4$, $F< 1.0$). Based on figures derived from existing rotation studies, we determined that the HR increase we observed during our HM period was significantly greater than the pre-rotation baseline condition in those studies. T-tests on the increase in HR during the HM period in our stationary versus other's rotating subject populations were not significant (2 tailed $p>.05$).

HR changes during HM in our stationary subjects were not distinguishable from those reported elsewhere for rotating subjects making HMs. It is necessary to control for exercise effects when measuring HR responses to MS induced by active HM or inappropriate conclusions can be drawn.

-43-

MASS PROPERTIES MEASUREMENTS OF AIRCREW HELMETS. B.P. Self, E.K. Spittle, L.A. Obergefell, and I. Kaleps*. Vulnerability Assessment Branch, Crew Systems Directorate, Armstrong Laboratories, Wright Patterson Air Force Base, OH.

Human dynamic response depends on the inertial properties of the body and any encumbering equipment. Mass properties of head-mounted systems are of critical importance when determining the injury potential for aircrew members during sustained acceleration, impact, and ejection. A methodology has been developed for determining mass, location of the center of mass, and the mass moments of inertia for a variety of helmet systems, and the accuracy of these measurements has been examined. Properties have been measured for helmets such as the HGU-5/P, -26/P, and -55/P, Combat edge, Anvis, Merlin, and I-Nights. These measurements have been referenced to a head anatomical coordinate system enabling comparison of various helmets and added-equipment configurations. Mass and center of mass were found by using a balance and moment table, while mass moments of inertia were calculated using a torsional pendulum. The accuracy of this system was examined by measuring rectangular blocks of known inertial properties. The precision of helmet measurements was determined by repeated tests of a single setup. The repeatability of the experimental procedure was explored by performing the total test protocol a number of times, including the repositioning of the helmet on the manikin head for each test. The system accuracy assessment ensures reliable helmet system inertial property measurements for use in modeling and in future helmet design specifications.

-44-

HELMET MASS AND CENTER-OF-MASS CRITERIA FOR HELICOPTER PILOTS. J.L. Haley, Jr.*, N.A. Alem, B.J. McEntire. U.S. Army Aeromedical Research Laboratory, Fort Rucker, AL 36362-5292.

The military pilot's head now is being used as a "platform" for the mounting of myriad audio and visual devices to enhance target acquisition, communications, information transfer, and situation awareness. Discomfort and fatigue cause irritation when wearing a 3-kg helmet system, but the mass is accepted because of the operational enhancement. Analysis of the effect of helmet mass and center-of-mass (c.m.) leads to the conclusion that mass can be related to the vertical location of the c.m. Thus, to prevent injurious neck muscle strains in high G maneuvers, seat ejections, or crashes, the transverse inertial loading of the helmeted head mass should not exceed an acceptable moment about the lower neck joint at the C-7, T-1 level. The tolerance of the neck of the seated, helmeted pilot undergoing "eyeballs out and down" crash forces was reviewed, and showed that helmeted volunteers with heads bowed, sustained "eyeballs out" acceleration pulses of equal levels of onset rate, peak G, and pulse duration as in the tests applied to the Army's best "crashworthy" seats. Helmeted volunteers also have sustained "eyeballs out and down" pulses nearly equal to those applied to the best crashworthy seats. A "constant moment" criterion is suggested. The constant moment curve varies from 1.55 kg at a vertical level of 62 mm above the ear canals to 2.67 kg at 10 mm below the ear canals.

-45-

HUMAN AND MANIKIN HEAD/NECK RESPONSE TO +GZ ACCELERATION WHEN ENCUMBERED BY HELMETS OF VARIOUS WEIGHTS. J.R. Buhrman, C. Perry, and F.S. Knox III. USAF Armstrong Laboratory, Wright-Patterson AFB, Ohio 45433-6573.

INTRODUCTION. New night vision goggles and helmet mounted display systems are increasing the weight of pilot helmets, and could pose an increased risk of head/neck injury during aircraft ejections. Human and manikin impact tests were performed with various helmet mounted systems in order to determine the effects on human dynamic response of increasing the helmet weight. METHODS. Impact tests with ten human subjects and a large ADAM manikin were performed at levels up to 10 G for humans and 20 G for the manikin, with helmet mounted systems weighing from 3.5 to 7.0 lbs. RESULTS. Increasing the helmet weight resulted in increasing compression, shear, and bending forces on the human subjects' necks. The manikin could accurately simulate the compression force, but not the shear and bending forces, at impact of 10 G. At higher impact levels, the manikin generated neck compression forces which were higher than predicted by the human data. CONCLUSIONS. Increasing helmet weight generates significant linear increases in compression, shear, and bending forces on the neck during impact tests of 10 G. Manikin tests show the same trend for compression forces, although at levels higher than expected at impacts greater than 10 G.

-46-

EJECTION RISK OF HELMET MOUNTED SYSTEMS. *F.S. Knox III, Chris Perry, and John Buhrman. Crew Systems Directorate, Armstrong Laboratory, Wright-Patterson AFB, OH 45433.

INTRODUCTION. Recent attempts to improve helmet mounted night vision devices and helmet mounted displays have raised questions about the safety of such systems during emergency escape in ejection seat equipped aircraft. On the one hand, "safe-to-fly" determinations must be made to allow some operational testing with prototypes. On the other, specifications must be written for full scale development. METHODS. A working group was convened to consider the problem. This group reviewed accident statistics, reports from the literature, and in-house laboratory data. Mass properties of standard flight helmets (HGU-55/P and HGU-26/P) and prototype night vision goggle (NVG) and helmet mounted display (HMD) equipped helmets were compared with biodynamic responses of humans at +10 Gz and instrumented manikins up to 20 +Gz. RESULTS. Severe neck injuries are relatively rare in the operational data, and these data contain so many variables that it is difficult to assign cause and effect related to helmet mass properties. Laboratory studies of head/neck biodynamic response relating compression force at the occipital condyles to head supported weight indicate that these forces exceed NBDL safe exposure guidelines (250 lbs) at weights greater than 5 lbs. Some subjects experienced calculated compression forces greater than 250 lbs without injury indicating that this guideline is conservative. CONCLUSIONS. Helmets, weighing less than 5.0 lbs and having a center-of-gravity centrally located and only slightly above the origin of the anatomical axis of the head, will not induce severe neck injury during the catapult phase of ejection more often than current operational helmets.

-35-

COMPARISON OF UPPER BODY STRENGTH IN A STANDARD EVA FOOT RESTRAINT WITH A RIGID EVA ENCLOSURE IN A NEUTRAL BUOYANCY SETTING. M. Barratt*. Department of Aerospace Medicine, Wright State University, Dayton, OH 45403

INTRODUCTION. A rigid EVA enclosure with full length anthropomorphic arms and mechanical restraint system offers several theoretical advantages over current EVA systems. To assess human factors aspects of such an enclosure, a mockup was constructed for neutral buoyancy testing. Upper body strength, an important contributor to EVA performance, was measured in subjects in the mockup and compared to that in a simulated EVA foot restraint. METHODS. Using an underwater load cell in a standardized position for force measurement, exertion profiles consisting of 16 separate configurations were assessed for 11 male subjects. Variables examined were environment (enclosure vs. foot restraint), restraint with the opposite hand (yes or no), direction of exertion (forward, backward, right, left), and hand used (right, left). RESULTS. ANOVA revealed a global enhancement of strength for exertions performed in the enclosure ($p<.001$). Use of the opposite hand for restraint enhanced strength ($p<.001$), and forward and backward exertions were significantly stronger than right or left exertions ($p<.001$). Hand used for a given exertion did not influence strength. Significant first order interactions ($p<.005$) were noted between environment and direction, environment and opposite hand use, and direction and opposite hand use . CONCLUSION. A rigid enclosure offers a strength advantage over a standard EVA foot restraint. Overall strength in the enclosure without opposite hand use was greater than overall strength in the foot restraint with opposite hand use. Thus, the enclosure allows a greater force exertion while sparing the opposite hand from fatigue induced by grasping.

-36-

FACTORS AFFECTING CREW MEMBER COMMUNICATION IN SPACE. A. Kelly, Hi-Tech Incorporated, San Francisco, CA 94107 and N. Kanas*, University of California, San Francisco, CA 94143.

INTRODUCTION. In order to maintain crew compatibility and performance during future long-duration space missions, it is important to understand how various factors related to the space environment may influence crew member interactions. METHODS. Fifty-four American, European, and Soviet astronauts and cosmonauts who had flown in space completed a questionnaire which assessed various aspects of crew communication in the space environment. RESULTS. Sensory activities (Watching and Listening) were judged to significantly increase, whereas complex communicative activities (Reading, Gesturing, and Writing) significantly decreased. Four factors were perceived to significantly help intra-crew communication: Shared Experience, Excitement of Space Flight, Close Quarters, and Isolation from Earth. Three factors significantly hindered communication: Facial Swelling, Spacecraft Ambient Noise, and Space Sickness. Two factors showed no effect: Weightlessness and Facial Redness. CONCLUSIONS. The space environment may increase sensory activities but decrease more complex communicative activities. Intra-crew communication may be helped by factors related to sharing a unique similar life experience or being brought closer together physically. It may be hindered by factors related to physical or physiological stress. Weightlessness per se appears to have no effect on crew member communication.

-37-

THE INFLUENCE OF AGE ON SUSCEPTIBILITY TO MOTION SICKNESS. B.S.K. Cheung, K.E. Money*. Defence and Civil Institute of Environmental Medicine, Toronto, Ontario, Canada, M3M 3B9.

INTRODUCTION. The influence of age on susceptibility to motion sickness has not been systematically studied. Most reports suggest a characteristic decline in susceptibility from a maximum in pubertal childhood to relative insensitivity by the sixth decade of life. However, Noble contends that susceptibility to swing sickness increases above the age of 40. In primates, older squirrel monkeys were reported to have longer latencies to vomiting in response to rotation than young ones. METHODS. A longitudinal study on the effects of age on the susceptibility to motion sickness in the squirrel monkey (typical life span 15 years) was carried out over a 10-year period (1982-91). Ten male, mature (3-5 years old) Bolivian-phenotype squirrel monkeys were found to be susceptible to motion sickness induced by a combination of vertical oscillation at 0.5 Hz and horizontal rotation at 25 rpm in a visually unrestricted environment. Signs of motion sickness were quantified by a rating scale modified from Graybiel's diagnostic criteria. Baseline susceptibility level was established from 5 trials (1 trial every 10 days) on each animal. Throughout the 10 year period various series of anti-motion sickness drugs were investigated. At the beginning and end of each series the monkeys were subjected to the same motion profile and the severity of sickness and latency to vomiting/retching were assessed and compared with the initial baseline score. RESULTS. Latency to vomiting and severity of sickness obtained from year 1 (baseline), 3, 5, 7 and 10 were subjected to repeated-measures design analysis. There were no significant changes in the susceptibility level in all the monkeys throughout the 10 year period. CONCLUSION. In squirrel monkeys there is no change in susceptibility to motion sickness with aging. Perhaps it is not age that has an effect on susceptibility, but rather the development of behavioural strategies for coping with different types of motion.

-38-

AN EMPIRICAL EVALUATION OF THE RESONANCE HYPOTHESIS OF MOTION SICKNESS. C. R. Wilpizeski*, L. D. Lowry and G. Li. Jefferson Medical College, Philadelphia, PA

INTRODUCTION. Lychakov proposed that motion sickness develops in man and animals when rhythmic changes in body displacment centering around 12/sec synergize brain waves occurring within the same frequency band (0.17-0.25 Hz for zeta rhythm). The resonance hypothesis is based on some selected factors associated with MS but is inconsistent with other evidence. METHODS. Squirrel monkeys, cynomolgus monkeys and cats were exposed to continuous linear vertical sinusoidal displacement and to 30-rpm constant-velocity horizontal rotation. Neural centers for vomiting (CTZ) were surgically ablated in some subjects. RESULTS. Squirrel monkeys of Bolivian phenotype developed MS syndrome readily during rotation but never during vertical linear oscillation. A different phenotype was highly resistant to all motion. Neither vertical displacement nor horizontal rotation created signs of MS in cynomolgus monkeys or cats. Based on data from CTZ-ablated monkeys, the postulated link between zeta rhythm, poisoning and MS is questionable. CONCLUSION. Contradictory findings from experimental animals challenge the validity of the resonance hypothesis of MS as it is currently formulated.

-39-

MOTION SICKNESS IS ASSOCIATED WITH A GENETIC POLYMORPHISM OF THE ALPHA-2 ADRENERGIC RECEPTOR. W. Lockette*, N. Shepard, T. Boismier, S. MacKenzie, and P. Miles. Wayne State University School of Medicine, Detroit; VAMC, Allen Park; University of Michigan Medical School, Ann Arbor, MI; and Naval Health Research Center, San Diego.

We reported that hypertensive individuals are significantly more prone to develop motion sickness than normotensives. We also described an association between high blood pressure and a genetic polymorphism of a gene coding for the alpha-2 adrenergic receptor (A2AR). We now hypothesize that polymorphism of the A2AR gene may similarly be associated with a predisposition for motion sickness in healthy subjects. Coriolis stress susceptibility (CSSI) was measured on 23 volunteers with normal vestibular function. CSSI was measured by determining the number of head movements subjects could complete while being rotated at increasing velocity before they developed motion sickness. Genomic DNA was isolated from their leukocytes and digested with Dra I. Southern analysis using a 4.5 Bam HI probe complementary to the C-10 A2AR gene yielded a restriction fragment length polymorphism of 6.3 and 6.7 kB. Individuals heterozygous for the 6.7/6.3 alleles had significantly lower CSSI scores ($p<0.02$) compared to the 6.7 homozygotic individuals; no 6.3/6.3 homozygotes were found. A2AR modulate central catecholamine concentrations, and catecholamines decrease the susceptibility to motion sickness. Genetic differences in central catecholamine release may predispose an individual to motion sickness. A further search for other candidate genes that may contribute to the etiology of motion sickness and sib-pair analysis using anonymous markers is warranted.

-40-

VASOPRESSIN DOES NOT INCREASE SUSCEPTIBILITY TO CORIOLIS STRESS. G. Hodder, N. Shepard, T. Boismier, Y. Wang, S.Farrow* and W. Lockette.* Wayne State University School of Medicine, Detroit; VAMC, Allen Park; and University of Michigan Medical School, Ann Arbor.

We demonstrated that intranasal administration of 1-desamino-8-D-arginine vasopressin (DDAVP), a synthetic V_2 analogue of antidiuretic hormone inhibits the diuresis and natriuresis induced by prolonged water immersion in man. DDAVP can counter the relative volume depletion that can follow operational maneuvers at sea or during exposure to microgravity. However, since provocative motion increases plasma [AVP], it has been argued that DDAVP could increase the incidence of motion sickness in these environments. We tested an alternative hypothesis--the increase in [AVP] during motion sickness is a reflex, protective measure that serves to maintain plasma volume and decreases untoward responses to motion.

We measured the Coriolis stress susceptibility index (CSSI) in six subjects receiving placebo or 20 ug intranasal DDAVP. All subjects had normal vestibular function as demonstrated by responses to sinusoidal harmonic acceleration, suppression of post-rotatory nystagmus, and dynamic posturography. The CSSI was measured by determining the number of head movements subjects could complete while being rotated at increasing velocity before they developed motion sickness. DDAVP had no discernible effect on the number of head movements completed (placebo, 318 ± 38; vs. DDAVP, 316 ± 30, p = n.s.) or CSSI score (placebo, 16.3 ± 6.0; vs. DDAVP, 15.4 ± 6.0, p = n.s.) DDAVP can be a helpful, adjunct measure for individuals who must perform tasks in the microgravity of space or endure prolonged water immersion.

-47-

INVESTIGATION OF VISUAL DISPLAY CONFIGURED HELMETS DURING WINDBLAST EXPOSURE. J.A. Plaga, D. Bonetti, J. Tallarovic, L.J. Specker. Armstrong Laboratory, WPAFB, OH 45433.

INTRODUCTION. Advanced helmets incorporating visual display equipment, with greater size and weight than helmets currently in use, have the potential to increase crewmember's risk of head and neck injury during the emergency escape sequence. The increased risk of injury can arise from the helmets exerting large aerodynamic forces on the head, helmet structural failure, and the ejection seat improperly functioning due to its velocity sensors (pitot tubes) being interfered by the helmets. METHODS. An instrumented manikin seated in an ACES II ejection seat was exposed to windblast velocities of 375, 450, 550, and 600 Knots Equivalent Air Speed (KEAS)with six different helmets at two seat attitudes and two head positions. Standard ACES II pitot tubes as well as new deployable pitot tubes which extend farther into the airstream were tested. RESULTS. Four of the new configurations significantly interfered with the standard ACES II pitot pressure measurement; however, use of deployable pitots eliminated most of the interference. The helmets produced larger neck loads, and many helmets suffered some structural failure at the higher velocities (>450 KEAS) including one which produced large neck forces. CONCLUSIONS. Use of deployable pitot tubes would eliminate interference that could cause pre-mature deployment of the crewmember's main parachute during ejection resulting in potentially injurious riser loads for all the configurations. The aerodynamic loading on the helmets create an increased risk of neck injury during emergency egress, especially at velocities greater than 450 KEAS.

-48-

EXPERIENCES WITH USING THE HELMET AS A PLATFORM FOR VISUAL DISPLAYS IN HIGH-G ENVIRONMENTS. K. McCloskey* and R. L. Esken, USAF Armstrong Laboratory, Wright-Patterson AFB, Ohio 45433-6573.

BACKGROUND. Techniques designed to measure the effects of acceleration on helmet-mounted devices such as night vision goggles (NVGs) and helmet-mounted displays (HMDs) have been developed on the Dynamic Environment Simulator (DES) centrifuge. These techniques include manikin tests, human measures of "image migration," three-dimensional representations of human head movement, fit assessments, and subjective measures of helmet comfort. These types of measurement techniques have been correlated with each system's weight, outer helmet profile, helmet center-of-gravity (COG), and with each subject's neck strength. RELEVANT VARIABLES. One basic issue was the degree of image migration (the amount of movement away from the eye the display apperture exhibited under acceleration). This movement was strongly affected by helmet weight, helmet COG, and the shape of the helmet profile (which determined the amount of physical interference the headrest had on helmet stability). Other variables with a surprisingly weaker impact on image migration during acceleration included fit assessment (only one system tested was adversely affected by poor fit) and neck strength. A related issue was that, overall, the systems which exhibited the least amount of image migration were rated the least comfortable (increased incidence of "hotspots" and uncomfortable tightness). Another issue was head stability. As the weight of the helmet-mounted systems increased, head stability under acceleration decreased; again, neck strength as a mediating variable in this relationship proved weaker than originally hypothesized. RECOMMENDATIONS. Relevant test and evaluation efforts should be conducted before deploying helmet-mounted systems in operations. The most important design recommendations may prove to be that helmet weight be minimal and the helmet COG be as close to the natural human head COG as possible. In addition, the trade-off between helmet stability and comfort may become a major factor concerning pilot acceptance of helmet-mounted systems. Finally, neck strength needs to be evaluated further in a more realistic flight regime, where subjects are rapidly moving their heads during target location under varying g-onsets and levels, before any definitive recommendations can be made.

-49-

PREPARING FOR THE STORM: AEROMEDICAL TRAINING WITHIN THE THEATER OF OPERATION. P. F. Pierce* 69th Aeromedical Evacuation Squadron, McGuire AFB, NJ 08641.

INTRODUCTION Throughout Desert Shield deployed aircrew members lived under conditions of great uncertainty concerning the nature and magnitude of their mission should efforts for a peaceful solution fail. As the United Nations deadline passed and hostilities were imminent, it became clear that large numbers of additional medical personnel would be required and they would have to be prepared for war in a very short period of time. This presentation will fully describe the training program developed to address this emergent need. METHODS. The intent of the program was to provide: (1) a rapid orientation to a combat environment, (2) instruction on conventional, chemical and biological warfare, (3) aeromedical operations training, and (4) psychological preparation for further deployment and the reality of combat. RESULTS. Within 6 weeks, a total of 946 medical, operations, MASF personnel and aeromedical crew members completed the training and were deployed to numerous sites within the theater of operation. Anecdotal evidence suggests that such intensive on-site training provides focused instruction, enhances cohesion among crewmembers, and sharpens real world performance. CONCLUSION. This on-site program provided intensive training in a hostile and threatening environment under extreme and adverse conditions. Despite these circumstances, personnel were committed to learning because of the immediate implications of their ability to perform in a wartime environment. The implications of this type of real-world training program for the structure and context of peacetime readiness training are numerous.

-50-

INSIGHT INTO THE MANPOWER, MANAGEMENT, AND MORALE OF A MASF DURING OPERATION DESERT STORM. M.J. MADER* 32nd AEROMEDICAL EVACUATION GROUP, KELLY AFB, TX 78241-6001.

INTRODUCTION. The 32nd Aeromedical Evacuation Group (AEG) was activated in January, 1991, and four Mobile Aeromedical Staging Facilities (MASFs) were deployed to Saudi Arabia and a fifth MASF to Incirlik AB, Turkey. The overall mission was to establish an operational MASF for aeromedical evacuation of casualities from the war. This presentation will focus on the specific factors which created problems for the MASF deployed to Turkey, part of the Area of Responsibility (AOR). These factors included three "M's" (manpower, management, and morale) as well as logistics and training. Guidelines to assist medical units in problem identification and resolution will also be discussed.

METHODS. Slide/transparency presentation and handout material. 1) 32nd AEG members deployed to Turkey. 2) Problem identification list related to deployment. 3) Problem resolution plan. 4) A checklist for developing a unit-specific plan.

RESULTS. This study will identify the responsibility of the Aeromedical Evacuation Unit to establish a more specific operational plan to prevent and/or solve problems resulting from actual wartime deployment.

CONCLUSIONS. The presentation will recognize the vulnerability of MASF personnel to identified problems related to manpower, management, morale, logistics, and training during wartime deployment. The need for a specific plan will be emphasized to ensure that the highest level of medical readiness can be achieved during wartime.

-51-

EXPERIENCES OF AIR EVACUATION IN SAUDI ARABIA. C.A. KRAMER. 32ND AIR EVACUATION GROUP, KELLY AFB, TX 78241-6001.

INTRODUCTION. The 32nd Air Evacuation Group was called to active duty in January 1991, assigned to the 1611th Air Evacuation Squadron (Provisional) to set up mobile air staging facilities and assist with airlift of casualties out of Saudi Arabia (January to May 1991). This presentation will provide the experiences learned in aeromedical evacuation patient care, give an explanation of the aeromedical airlift system, along with a description of the lifestyle of medical crew members during this period. METHODS. A slide presentation showing: (1) The MASF at and HUB. (2) A MASF on it's own on classified site. (3) Scences from receiving patients to the MASF. (4) Scenes loading the plane for a mission. RESULTS. The study will contrast the wartime and peacetime aeromedical evacuation system and lifestyle required of medical aircrew members. CONCLUSIONS. The presentation will recognize the accomplishments of the reserve medical personnel during this period and provide insight into their wartime roles.

-52-

TREATMENT OF ENEMY PRISIONERS OF WAR DURING DESERT STORM. R.D. ROBERTS. 32ND AEROMEDICAL EVACUATION GROUP, KELLY AFB, TX 78241-6001.

INTRODUCTION. The care of our own troops has always been a priority. During Operation Desert Shield/Storm enemy prisioners of war, because of the great number, became our primary mission. METHODS. A slide presentation will accompany the discussion. RESULTS. The presentation will show: (1) The difficulties in treating E.P.W.s (2) The many cultural problems associated with even communications (3) The E.P.W.s views on what was happening to them past, present and future (4) The effect treating E.P.W.s had on our immediate MASF family. CONCLUSIONS. The presentation will recognize the many problems and solutions in treating enemy prisioners of war.

-53-

THE HUMAN ANIMAL BOND IN A WARTIME SCENERIO;A PERSONAL PERSPECTIVE OF DESERT STORM. C. J. Stegall,* 63rd Aeromedical Evacuation Squadron O'Hare ARFF, IL. 60666

Of major importance to personnel serving in Desert Storm were support systems. One mechanism for providing support for troops that has had little recognition within the military is human-animal bonding. From the time troops arrived in the AOR, warnings were given by the military not to touch, feed, or pet the animals in the area; but warnings are seldom obeyed under stress and duress. Animals were a positive diversion for many soldiers, lifted their spirits and made them smile. Petting a cat or dog often relieved loneliness and homesickness, reminded the soldiers of their pets at home, and helped them to take their minds off of where they were and what they were doing. Specific examples of how human-animal bonding provided the mechanisms of support for selected personnel in Desert Storm will be presented.

-54-

CRITICAL INCIDENT STRESS DEBRIEF: A POST DESERT STORM READJUSTMENT TOOL. P.J. MANN*, C. KRAMPITZ. 32nd AEROMEDICAL EVACUATION GROUP, KELLY AFB, TX 78241-6001.
INDRODUCTION. As personnel began to return to the 32nd AEG from Operation Desert Storm, obvious signs and symptoms of stress and readjustment difficulties were observed. This presentation will review the unique pre-deployment factors that influenced the stress levels of personnel, give guidelines to assist units in indentifying/developing a plan to provide support during the readjustment phase. In addition, Critical Incident Stress Debriefing concepts/practice and design will be discussed. METHODS. Transparency/slide presentation 1) members of the 32nd AEG during deployment and upon return 2) Critical Incident Stress Debriefing concept/practice 3) checklist for developing a unit specific plan for CISD implementation. RESULTS. Identification of the responsibility of each Reserve unit to develop an ongoing plan for prevention and management of stress through education, training, and facilitation through the practice of CISD. CONCLUSIONS. This presentation will acknowledge the susceptibility of all personnel to stress and the need for development of a unit specific plan to ensure the mental health, performance and safety at the highest possible level, particularly during wartime.

-55-

A REVIEW OF CIVIL AVIATION PROPELLER-TO-PERSON ACCIDENTS: 1983-1989. W. E. COLLINS*. FAA CIVIL AEROMEDICAL INSTITUTE, OKLAHOMA CITY, OK 73125-5060.

INTRODUCTION. Various types of paint schemes on aircraft propeller and rotor blades are used to improve the visual conspicuity and attention-getting value of those blades when they are rotating. The improved conspicuity resulting from the paint schemes has the purpose of reducing the number of injuries and fatalities that might occur due to accidental contact with a rotating blade by pilots, passengers, or ground crew. The present study was undertaken to provide information regarding the circumstances surrounding such accidents in recent years and to compare those findings with the frequency and circumstances of propeller accidents during a pre-1980 period. METHODS. Computer retrievals of brief reports of all propeller accidents during the period from 1983 through 1989 were provided by the National Transportation Safety Board. Those reports were examined and analyzed in terms of type of accident, degree of injury, actions of pilots, actions of passengers and ground crew, night or day, and other conditions. RESULTS. The computer search yielded a total of 88 reports of propeller accidents for the 7-year period. Twenty of these involved operation of the aircraft. The remaining 68 cases were "propeller-to-person" accidents. Each involved harm or death to a single individual with one exception: in that case, 2 persons were injured in a unique sequential accident. Causes and circumstances associated with the 68 accidents were analyzed and categorized. CONCLUSIONS. "Prop-to-person" accident frequency for the 1983-1989 period was notably lower than that previously reported for the 1960's and 1970's. Differences in the causes and circumstances of such accidents for the two time periods suggest the focal points for safety improvements.

-56-

POSTMORTEM PRODUCTION OF ETHANOL IN LIVER SPECIMENS. D. Levine. K. Moser, and M. Smith. Division of Toxicology, Armed Forces Institute of Pathology, Washington, DC 20306-6000.

INTRODUCTION. One of the most frequently encountered problems in the interpretation of toxicologic results in aircraft fatalities is the source of ethanol often measured in these cases. Did the ethanol result from antemortem consumption of alcoholic beverages or from postmortem formation due to tissue decomposition? In many of these cases, fluids such as blood and urine are unavailable and the only collected specimens are solid tissues. METHODS. Twenty liver specimens not containing ethanol were divided into 1 g portions, stored in an aqueous environment at room temperature and analyzed for ethanol and other volatiles after 5 days. Volatile analysis was performed using head space gas chromatography. RESULTS. Variable concentrations of ethanol were produced over this time, ranging from 0 to 470 mg/dL. Acetaldehyde was the most frequently identified other volatile produced, but n-propanol and isobutanol were also produced. CONCLUSION. Large concentrations of ethanol can be produced in liver specimens, but no general statement as to the amount of ethanol produced can be made. The interpretation of postmortem liver ethanol concentrations must be made cautiously, especially when the specimens are decomposed.

-57-

INFLUENCE OF SAFETY CONCERNS ON DESIRE TO CHANGE AIRCRAFT TYPE. *T.J. Ungs. U.S. Coast Guard, Kodiak, Alaska
INTRODUCTION. The USCG is known for conducting flight operations sometimes in the most hazardous of conditions. USCG pilots have the potential to request and change aircraft (a/c) type, ie, change from the fixed wing (fx) to helicopters and visa versa. The purpose of this study was to determine pilots perception of a/c and mission safety and the influence this has on pilot desire to change a/c type. METHODS. A voluntary questionnaire was sent to all operational USCG pilots, 461 (72%) participated. RESULTS. Two thirds (204) of helicopter and 19% (29) of fx pilots stated a desire to change a/c type. Only 1 (4%) of the 29 fx pilots while 81 (40%) of helicopter pilots stated that their desire for a/c change was influenced, in part, by mission and a/c safety concerns. Over 90% of all pilots thought that compared to fx aircraft, helicopters had more dangerous missions and were otherwise less safe. Pilots whose desire for transition was influenced by safety concerns were found; to be more senior, have more flight experience, and feel that they were engaging in dangerous flight operations. Other descriptive statistics and associations are given. CONCLUSION. Helicopters are considered to have more dangerous missions and be less safe. Many helicopter but few fx pilots would change a/c type due, in part, to safety concerns.

-58-

COMPARISON OF SINGLE LOCUS AND MULTILOCUS GENE PROBES IN DNA FINGERPRINTING. S. Baker, S. Mackenzie, P. Miles, P. Tranchida, and W. Lockette.* Wayne State University School of Medicine, Detroit; VAMC, Allen Park; the University of Michigan Medical School, Ann Arbor, MI; Naval Health Research Center, San Diego, CA.

In our attempt to identify the gene(s) associated with certain traits in the population, such as hypertension or a predisposition for motion sickness, we perform DNA fingerprinting. This technique can be used to identify victims of aviation mishaps. DNA fingerprinting can be done with single- and multilocus gene probes; we compared the advantages of each. The human genome has repetitive DNA sequences arranged in tandem repeat units known as variable number of tandem repeats (VNTR). Discrimination between individuals is based on the number of repeat units present; VNTRs are length, rather than sequence, polymorphisms. VNTRs found in a single locus can be amplified with polymerase chain reaction. This technique is rapidly performed, and analysis can be performed on minimal tissue from an accident site (i.e. a few cells). The human genome also contains multi-locus, dispersed tandem-repetitive 'minisatellite' regions which are highly polymorphic due to allelic variation in the repeat copy number in the minisatellites. DNA fingerprints specific for an individual can be detected with a probe based on a tandem-repeat sequence of many variable loci simultaneously. This technique is more lengthy, and it requires a larger tissue sample. However, the accuracy of multi-locus probes is much greater than techniques with single locus probes. We advocate the use of both of these techniques over traditional forensics methods in the identification of victims of aircraft mishaps.

-59-

LOSS OF SITUATIONAL AWARENESS (LSA) AND SPATIAL DISORIENTATION (SDO) RELATED MISHAPS IN THE US AIR FORCE 1980-89. D.A. HOLLAND.* University of Virginia School of Medicine, Charlottesville, VA 22908.

INTRODUCTION. Operationally-related mishaps involving LSA/SDO continue to be a major contributor to aircraft Class A accidents in the USAF. METHODS. Data from Class A mishaps from the Air Force Safety Agency were reviewed over a 10-year period to determine how many of the mishaps had LSA/SDO contributing components. LSA/SDO-related mishaps are those accidents where the investigating flight surgeon found channelization of attention, distraction, task over-saturation, or spatial disorientation as suspected or definite contributors to the mishap. RESULTS. Out of 356 operationally-related mishaps, 270 were found to have LSA/SDO components. A breakdown of the LSA/SDO mishaps by aircraft category reveals that 70% were Fighter-Attack-Recon (FAR), 10%-Training, 10%-Cargo, 5%-Helicopter, and 5%-other. Evaluation of the database showed that LSA/-SDO was a contributing factor to 85% (437) of the fatalities and 80% (1.5 billion dollars) of the costs associated with the mishaps. The The highest number of accidents relatable to LSA/SDO in the FAR community were 54 in the F/RF-4, 47 in the F-16, and 33 for the A-10. There were 15 LSA/SDO T-38 mishaps in the training community. The C-130 and KC-135's had 10 and 8 LSA/SDO accidents, respectively. Air Force helicopter accidents involved the H-3 with 7 LSA/SDO mishaps and the H-53 with 6 LSA/SDO occurrences. CONCLUSIONS. USAF Class A mishaps often have a high level of association with LSA/SDO. Continued safety-awareness measures and research are needed to aid in the mitigation of these factors.

-60-

DRUG AND ALCOHOL USE FOUND IN FATAL AVIATION ACCIDENTS. D.V. Canfield and J.R. Hordinsky*. FAA Civil Aeromedical Institute, Oklahoma City, OK 73125.

INTRODUCTION: Post aviation-accident toxicology assessment is directly provided by the Civil Aeromedical Institute (CAMI) as part of an FAA-NTSB agreement. Specimens are received from nearly all fatal aviation accidents through a system directly coordinated from Oklahoma City. METHODS: Specimens are subjected to a complete forensic toxicology screen for drugs, alcohol, carbon monoxide, and cyanide. Drugs are screened at therapeutic and sub-therapeutic levels. RESULTS: CAMI received biological specimens from 367 pilots in fatal aircraft accidents in 1990. During 1990, eight percent (29) of the pilots were found to have an ethanol reading at or above the .04% limit allowed by FAA regulations. It was determined that 12 (41%) of the positive cases were from the ingestion of ethanol, 9 (31%) were from putrefaction, and 8 (28%) could not be determined. Controlled Dangerous Substances (Schedules I & II) were found in 15 (4%) of the cases tested. Controlled Dangerous Substances (Schedules III, IV, and V) were found in 6 (2%) of the cases. Fifty percent of these cases were benzodiazepines. Therapeutic prescription drugs were found in 24 (7%) of the cases analyzed. Legal non-prescription therapeutics, such as acetaminophen, were found in 61 (16%) of the cases. CONCLUSIONS: The number of detected abused drugs exceeds the percent found in the random drug testing program by more than a factor of eight. Benzodiazepines are being found more often than some of the required NIDA test drugs. Postmortem ethanol continues to be a problem in the interpretation of toxicology results.

-61-

5-YEAR STUDY OF AEROMEDICAL EVACUATION FOR INVALID PASSENGERS IN KOREA (1986-1990). Y.H.LEE*, I.H.Kwak, R.Keum. Civil Aeromedical Center, Kimpo Airport, Seoul, Korea.

INTRODUCTION. During a 5-year period, total of 6,139 invalid passengers were transported through civil airlines. A retrospective study was done to analyze such invalid passengers with respect to airline medical practices. METHODS. The study was conducted using data filed in the medical department of a civil airline for invalid passengers. RESULTS. During the 5 years, a total of 6,139 cases were transported with their rates decreasing despite their annual increase. Among the total, 3,267 invalid passengers were on international flights and the rest on domestic flights. The use of aerostretcher was twice as high on domestic compared to international flights. With the use of aerostretcher(1,366), the inflight medical care rate was higher in international flights(75.6%) than in domestic flights(56.4%). Before going on-board, the give up rate per 100 invalid passengers flights was 5.7 slightly higher in domestic route than 4.0 in international route. The oxygen using rate per 100 invalid passengers in domestic flights was 9.1 compared to 6.0 in international flights. Flight irregularities occurred in 242 cases : also, there were 3 inflight deaths, 238 off-loadings, and 1 diversion. CONCLUSION. With respect to the increasing number of invalid passengers utilizing air travel as their means of transportation, the necessary provisions and adequate services must be met and maintained with the coordination of the medical department of the airlines, the invalid passenger, and the personal physician of the passenger.

-62-

MEDICAL CONTINGENCY OPERATIONS DURING A PEACETIME FOODBORNE ILLNESS MASS CASUALTY SITUATION. Q.C. Snyder*. USAF School of Aerospace Medicine, Brooks AFB, TX 78250.

INTRODUCTION. From 13-15 July 88, approximately 750 cadets from the US Air Force Academy sought treatment for an acute gastrointestinal illness. Over 400 cadets required intravenous therapy and 106 were hospitalized. Demands for care overwhelmed the capacity of the local clinic and hospital. Key decisions by senior military medical officials resulted in rapid and effective treatment of all casualties. DESCRIPTION. Existing mass casualty contingency plans were deemed inappropriate due to construction at the main hospital and the designated hospital expansion site. Rapid re-evaluation of available space to set up an Alternate Medical Facility allowed personnel seeking care to be treated expeditiously on scene. A staged selective recall of assigned hospital personnel augmented by local military medical facilities assured prompt triage and treatment. Medical leadership recruited military line commanders, civil engineers, public affairs officers and the USAF Epidemiology team to support the mass casualty situation. A problem identified was obtaining real-time information of available bedspace and personnel tasking requirements. Also recognized was that available personnel and resources would have been severely strained if required to support a similar level of surge operations for an extended time period. CONCLUSIONS. Effective medical leadership resulted in impromptu revisions of existing mass casualty contingency plans. These revisions allowed prompt and effective treatment of all affected casualties.

-63-

THE ASSOCIATION OF AVIATION ACCIDENTS FOR APHAKIC VERSUS NON-APHAKIC CIVIL AIRMEN. V.B. Nakagawara* and K.J. Wood. Federal Aviation Administration, Civil Aeromedical Institute, Oklahoma City, Oklahoma 73125

INTRODUCTION. Airmen with aphakia and intraocular lens (IOL) who, on a case-by-case basis, may obtain a waiver for a medical certificate, have been previously associated with higher aviation accident rates when compared to the total civil airman population. This study analyzes the accident frequencies of these civil airmen for a 4-year period (1982-85). METHODS. Medical records were evaluated for all certified airmen during the study period who were carrying FAA-specific pathology codes for aphakia and artificial lens implants. Aviation accident and active airman population frequencies were obtained from FAA databases. RESULTS. Aphakic and IOL airmen were found to have significantly higher ($p < .05$) accident rates than the total non-aphakic airman population. CONCLUSIONS. The significant association between aviation accidents and airmen with aphakia and IOL, even with improved ophthalmic surgical procedures and therapeutic devices, does not justify any relaxation in FAA's specialized aeromedical certification or in the clinical research review of these conditions.

-64-

EMPIRICAL PREDICTION OF PHYSIOLOGICAL RESPONSE TO PROLONGED WORK IN THE CHEMICAL DEFENSE ENSEMBLE. P. Bishop, G. Smith, P. Ray, J. Beaird, and J. Smith. Human Performance Laboratory and Department of Industrial Engineering, University of Alabama, Tuscaloosa, AL 35487-0312.

INTRODUCTION. Personnel required to work in moderate or hotter environments while wearing the US Chemical Defense Ensemble (CDE) experience heat storage, substantial diminution of work productivity, and health risks. Predicting responses of these workers would be very useful. METHODS. Work times at 21°C of 15 subjects performing hard work (450W) while wearing CDE were predicted based upon prior brief measures of bench-step in the CDE, and heart rate responses. RESULTS. A model was derived which shows good potential for predicting work time for repeated work bouts in moderate temperatures in the CDE: (total time= 7.2*bench step duration-34*bench comfort+4*height; R^2=.83, C.V.=13). Unexpectedly, models which incorporated recovery heart rate as an independent variable were not as effective. CONCLUSION. With further refinement, the prediction approach tested in this study would be immediately useful for managing personnel working in CDE, and also useful to civilian industry. Also, it could be utilized at minimal cost during routine training.

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-65-

EVALUATION OF THREE METHODS FOR TESTING COLD WEATHER COMBAT BOOT SYSTEMS. D. A. DiRaimo, W. R. Santee, and R. R. Gonzalez*. U.S. Army Research Institute of Environmental Medicine, Natick, MA 01760-5007.

INTRODUCTION. Studies were conducted on a static copper model of the foot, which is sectioned into twenty-nine heat transfer regions. This foot model is used to determine the dry insulation properties of commercial and prototype cold weather combat boot systems (CWCBS). Heat flux through the boot sole is an important criterion in selecting CWCBS. The insulation of air (I_a) between the foot and the boot sole is the key variable in the amount of heat flux through the sole. I_a, which incorporates both the radiative heat transfer (h_r) and the convective heat transfer (h_c) coefficients, is reduced as the boot sole is compressed, thus increasing the heat flux through the sole. The heat flux is further augmented with the addition of a cold substance, such as mud, water, or snow in an actual cold/wet field environment. Methods were developed for comparing the amount of heat flux through the boot sole of CWCBS using a dry compression test method (to simulate standing in cold/dry environmental conditions) and a wet compression test method (to simulate standing in cold/wet environmental conditions). METHODS. Eight CWCBS were evaluated on the foot model according to three test methods: a free suspension (FS) control test, a cold/dry environmental compression (CDC) test, and a cold/wet environmental compression (CWC) test. Across all test conditions, the chamber temperature was kept at 20°C and the model surface temperature was kept at 30°C. For the CWC test, 5 cm of lead shot were interposed between the boot sole and a metal compression plate to simulate mud, water, or snow. Lead shot was used to ensure uniformity throughout the test and to maintain a replicable test material. RESULTS. The insulation values between the different test methods did not vary significantly ($p > 0.05$). The CWC test provided no better basis for distinguishing between boot systems than either the CDC test or the FS test. CONCLUSION. It was expected that the CWC test method would be more responsive than either the FS or the CDC test method, but it was not. Further studies are needed to develop more quantitative methods for evaluation of I_a as a means of discriminating between CWCBS.

-66-

Test and Evaluation of Two Personal Cooling Systems in Simulated Helicopter Flight Operations. L. Meyer*, D. Horrigan*, D. Siniff, and W. Lotz*. Naval Aerospace Medical Research Laboratory, Pensacola, FL 32508-5700.

INTRODUCTION. Helicopter operations conducted in high ambient temperatures expose aircrews to potentially dangerous physiological conditions. We tested two personal cooling systems to evaluate their effectiveness in reducing heat strain on aircrews. METHODS. One of the systems was a long-sleeved shirt, while the other was a vest with an attached head unit. Both were cooled with cold liquid pumped continuously through tubing in the garment. Ten student aviators wearing standard USN helicopter aircrew flight equipment were exposed to both 35 °C/55% RH and 50 °C/25% RH with and without cooling for 90 min. Heart rate, blood pressure, and mean skin and rectal temperatures were monitored before and during heat exposure. Additionally, sweat rate and subjective thermal sensations were recorded in the heat. Subjects performed 30 min of continuous submaximal work on a bicycle ergometer (50 W for 10 min, 100 W for 10 min, 150 W for 10 min). Oxygen consumption, metabolic rate, and rating of perceived exertion were determined during exercise in the heat. Venous blood samples were drawn before and after each test. RESULTS. Both systems effectively improved the physiological response to heat stress at rest and during exercise in both environmental conditions. The shirt-type system proved better at controlling all dependent variables during exercise. Thermal sensation ratings were also cooler with the shirt. The decrease in serum osmolality from pre- to post-heat exposure was greater with the vest. CONCLUSION. Both systems effectively reduced heat strain with the shirt-type system providing the greater benefit in physiological and subjective response both at rest and during exercise.

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-67-

HEAT STRESS AND A COUNTERMEASURE IN THE SHUTTLE RESCUEMAN'S SUIT. D.F. Doerr*, H. Reed, and V.A. Convertino*. NASA, Kennedy Space Center, FL 32899

INTRODUCTION: Rescue of the astronaut flight crew from a contigency landing may risk exposure of the rescue crew to toxic propellants spilling from potentially ruptured tanks in the crew module area. An Aquala dry diver's suit has been in service by the rescue team to preclude exposure, especially in the water rescue scenario. Heat stress has become a factor of concern in recent years when older and less physically-fit team members work in this suit. **METHODS:** Field testing was initiated using fully instrumented rescuemen in a simulated scenario to determine the extent of heat stress. Two tests were accomplished, one in the normal (N) configuration and one with a proposed cooling countermeasure, the Steele vest (S). **RESULTS:** Heat stress was high as indicated by average rectal temperatures (Tre) of 38.28°C (100.9°F) after the 45 min protocol. Slopes of the regression equations describing the increase in Tre with time were greater ($P < 0.05$) with N (0.073 ± .008) compared to S (0.060 ± .007). Projection of time to the 38.89°C (102°F) limit for Tre was increased by 15.3 % with the vest. Mean skin temperature (Tsk) was higher ($P < 0.05$) in N (38.33 ± .11°C) compared to S (34.33 ± .67°C) even when the two skin temperatures recorded from the sensors located on the torso, under the vest, were eliminated from the calculation of Tsk (38.22 ± .17°C vs. 37.33 ± .39°C). Average heart rate was higher ($P < 0.05$) in N than S. Sweat loss, as measured by weight loss, was more ($P < 0.05$) for N (1.09 ± .09 kg vs 0.77 ± .06 kg). Air usage, while slightly less for S, was not statistically different. **CONCLUSION:** The use of the cool vest provided significant relief from thermal stress inspite of the addition of 3.4 kg (7.5 pounds) weight and some loss in mobility.

-68-

PHYSIOLOGICAL RESPONSES DURING SHIPBOARD FIRE FIGHTING. B.L. Bennett*, R.D. Hagan, G.R. Banta* and F.W. Williams. Naval Health Research Center, San Diego, CA, 92186-5122 and Naval Research Laboratory, Wash., D.C. 20375-5000

INTRODUCTION. Fire fighters dressed in full protective ensemble and combating shipboard fires are subjected to extreme heat strain. However, physiological responses have not been well documented. Environmental chamber simulations to date have not been true representations. Therefore, the purpose for this study was to document the physiological responses of U.S. Navy Damage Control personnel while combating fires aboard a fire fighting demonstration ship. **METHODS.** Nine male volunteers (36.7 yrs, 181 cm, and 81 kg) experienced in fire fighting were monitored for heart rate (HR), four skin temperatures (Twsk) and rectal temperature (Tre) during three days of fire fighting (n=4 per day). Each subject wore the standard Navy fire fighting ensemble (fire retardant suit, gloves, boots, flash hood, helmet and breathing apparatus). Peak fire temperatures reached 600°C, while temperatures in the adjoining fire fighting compartment ranged from 40-100°C. **RESULTS.** As expected, significant ($p<0.05$) heat strain occurred during approximately 25 mins of fire fighting. However, the magnitude and rate of change of Tre, Twsk, and HR were greater than expected. Mean responses were: peak Tre = 39.1± 0.8°C; Tre slope = .04°C/min; peak Twsk = 39.5 ± 0.7 °C; Twsk slope = .1°C/min; peak HR = 186 ± 13; and % of predicted maximum HR = 103 ± 8%. **CONCLUSION.** Actual shipboard fire fighting wearing protective ensembles can lead to extreme heat strain and potential heat injury. These data have implications for operational training, generation of exposure guidelines, and development of protective ensembles and heat strain countermeasures.

-69-

ACCLIMATION AND MICROCLIMATE COOLING CONSERVE PLASMA VOLUME DURING EXERCISE IN THE HEAT. J.H. Heaney, K.M. Wilmore, M.J. Buono, G.J. Noffal, M.D. Hurst, N.A. Pimental, G.R. Banta*. Naval Health Research Center, San Diego State University, San Diego, CA and Navy Clothing and Textile Facility, Natick, MA.

INTRODUCTION. Effective thermoregulation during heat exposure is partially dependent on maintenance of plasma volume (PV). Navy engineroom personnel, who typically work 4-6 hour shifts in thermal environments exceeding 32°C, are constantly subjected to heat strain. This study investigated the effects of microclimate cooling on PV conservation during exercise in the heat following a baseline acclimation (AC) protocol. **METHODS.** Eight engineroom personnel underwent an 8-day acclimation process (35°C, 70% RH) followed by 6 simulated engineroom watches (EW) in an environmental chamber. Two duplicate EW tests, with and without a passive ice vest (IV), were performed in three thermal conditions: EW1=43.3°C, 48%RH; EW2=50.6°C, 33%RH; EW3=57.2°C, 24%RH. During AC, a 2-hr exercise protocol (exercise 25-min, rest 5-min) alternated treadmill walking with stationary cycling. The EW protocol consisted of a 20-min treadmill walk (3mph, 3%grade) and 40-min of seated rest each hour to a maximum duration of 6-hrs or volitional withdrawal. PV changes were determined from seated (20-min) blood samples obtained prior to entering and exiting the heat chamber. **RESULTS.** PV changes (%) across day-1, day-3, day-5 and day-8 (-5, -1.3, -1.7 and +.6 respectively) of AC showed a trend towards conservation but were not statistically significant ($p>.05$). End of test PV changes during IV EW showed a similar conservation trend except for EW3: EW1=-7.1,-.1 ($p<.05$); EW2=-8.5, -4.2 ($p>.05$); EW3=-6.3, -9.7 ($p>.05$) for non-IV and IV conditions respectively. **CONCLUSION.** PV loss decreased over time during AC and was less in the IV conditions for EW1 and EW2. EW3 PV findings may be the result of a considerably longer IV test duration in combination with the high heat. When expressed relative to test duration non-IV PV losses were twice those in the IV exposures. These results suggest that heat acclimation will conserve PV and microclimate cooling can provide continued support of PV conservation during exposure to high heat.

-70-

COMPARISON OF ICE-BASED PERSONAL COOLING SYSTEMS. S.D. Hart,* J. Zarinczuk,* T.E. Bernard. College of Public Health, University of South Florida, Tampa, FL 33612-3899.

INTRODUCTION. Heat stress becomes a notable problem when there is a need to wear impermeable clothing for protection against biological, chemical and radioactive contaminants. The purpose of this project was to evaluate the cooling performance of five commercially available personal cooling systems having ice as the heat sink. The five systems included one ice vest, two liquid cooling vests (one with a hood), and a whole-body liquid cooling suit with hood configured two ways (as a portable system and as a tethered system). Elapsed time was used as the performance measure. METHODS. Overall, there were seven subjects (3 men and 4 women). The subjects walked on a treadmill at about 260 W in a controlled environment (Tdb=38°C and Twb=30°C) while wearing polycoated Tyvek coveralls and hood, rubber gloves and full-face respirator. For each cooling system, three men and two women were assigned to a trial. For the no-cooling control, the three men completed two trials and each women one (10 control trials). Melted ice was replenished as needed. Heart rate and rectal temperature were recorded. Elapsed time was the time until a volitional or physiological limit was reached. RESULTS. For the control, ice vest and both liquid cooling vests, trials were terminated for high rectal temperature (38.5°C). The average elapsed times (± SD) in minutes were control: 30±8; liquid-cooling vests: 39±15 and 43±8; and ice vest: 62±20. Trials for the two configurations of the liquid cooling suit were arbitrarily stopped at 120 min, and there was no important increase in heart rate or rectal temperature during that time. CONCLUSION. The superior performance of the liquid cooling suit is attributed to the large surface area covered by the suit. When long work times are required and there is a method to replenish the ice, the liquid cooling suit can provide sustained protection from heat strain.