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INTRAMUSCULAR PRESSURE: A BETTER TOOL THAN EMG TO OPTIMIZE EXERCISE FOR LONG-DURATION SPACE FLIGHT.

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INTRODUCTION. A serious problem experienced by astronauts during long-duration spaceflight is muscle atrophy. In order to develop countermeasures for this problem, a simple method for monitoring *in vivo* function of specific muscles is needed. Previous studies document that both intramuscular pressure (IMP) and electromyography (EMG) provide quantitative indices of muscle contraction force during isometric exercise. However, at present there are no data available concerning the usefulness of IMP versus EMG during dynamic exercise. METHODS. IMP (Myopress catheter) and surface EMG activity (Cadwell, Inc.) were measured continuously and simultaneously in the tibialis anterior (TA) and soleus (SOL) muscles of 9 normal male volunteers (28-54 years). These parameters were recorded during both concentric and eccentric exercises which consisted of plantarflexion and dorsiflexion of the ankle joint . A Lido Active Isokinetic Dynamometer concurrently recorded ankle joint torque and position. RESULTS. Intramuscular pressure correlated linearly with contraction force for both SOL (r^2=0.937) and TA (r^2=0.948) during concentric exercise. SOL and TA EMG did not correlate as well with force during concentric exercise (r^2=0.716 and r^2=0.802, respectively). During eccentric exercise, SOL and TA IMP also correlated linearly with contraction force (r^2=0.883 and r^2=0.904, respectively), but SOL and TA EMG correlated poorly with force (r^2=0.489 and r^2=0.702, respectively). CONCLUSIONS. IMP measurement provides a better index of muscle contraction force than EMG during concentric and eccentric exercise. IMP reflects intrinsic mechanical properties of individual muscles, such as length-tension relationships. Although invasive, IMP provides a more powerful tool than EMG for developing exercise hardware and protocols for astronauts exposed to long-duration flight. (Supported by NASA)

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GROUND REACTION FORCES DURING RUNNING ON ACTIVE AND PASSIVE TREADMILLS IN SIMULATED ZERO-GRAVITY. B.L. Davis, P. R. Cavanagh*. Center for Locomotion Studies, Penn State University, University Park, PA 16802. INTRODUCTION. A number of studies have shown that bone mineral loss in the lower extremities may continue for many months in space. In order to reduce the severity of this process, in-flight treadmill exercise has been suggested as a possible countermeasure. The aims of the present study were first, to conduct a detailed investigation into the design of a zero-gravity locomotion simulator, and second, to investigate which factors affected the loads experienced by the legs during tethered treadmill exercise in simulated hypogravity. METHODS. Twelve subjects were recruited for the study that compared jogging in 1G to running on a treadmill that formed part of a 0G locomotion simulator (ZLS). This device required subjects to be suspended horizontally from multiple latex cords - each cord negating the weight of a different limb segment. Once subjects were "weightless", a set of springs was attached to the waist region to act as a tether to the treadmill. RESULTS. The results showed that running on active and passive treadmills in the simulator produced similar magnitudes for the maximum ground reaction force (maxGRF). It was also found that these maximum forces were significantly lower than those obtained during overground trials, even when the speeds of locomotion in the simulator were 66% greater than those in 1G. With regard to the rate of force application at footstrike, it was found that the maximum rate of change of force (maxDFDT) was similar for overground running and exercise in simulated 0G, provided the "weightless" subjects ran on a motorized treadmill. Running on a passive treadmill in the simulator however, produced significantly lower magnitudes for maxDFDT (21584 N/s versus 42952 N/s) when compared to overground running. CONCLUSION. These results are considered important in light of work showing that low strain magnitudes do not prevent bone deterioration *except at high strain rates*. It is thus possible that the high maxDFDT responses for active treadmill running could compensate for lower maxGRF values and produce an adequate osteogenic stimulus during space missions.

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Effects of Seating Configuration and Number of Type III Exits on Simulated Emergency Egress from a Narrow Body Transport Category Aircraft. G A McLean* & C B Chittum, FAA Civil Aeromedical Institute (CAMI), Oklahoma City, OK, 73125-5066.

INTRODUCTION. An increase in the required pathway width from aircraft center aisles to Type III overwing exits is being weighed by the FAA. To augment the analysis, an examination of seat/exit configuration effects on simulated emergency egress was conducted in the CAMI Evacuation Research Facility. METHODS. Four subject groups traversed four different seat/exit configurations in a counter-balanced, repeated-measures design. Pathway width was modified by altering seat pitch. RESULTS. In single-exit trials the fastest times and highest flow-rates occurred with a 20" pathway between triple seats or a 10" pathway between double seats. Double exits produced 36% shorter egress times ($p<.007$), although flow-rates declined 11% and exit plug removal times increased 32%, compared to single exits. CONCLUSION. Efficient egress requires optimization of the space around the exit. Generally, wider pathways and fewer obstructions enhance this process; however; when pathway size is too great, conflicts among passengers may be produced which inhibit egress.

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EVALUATION OF A MAN-MACHINE INTERFACE FOR CREW-AIDED, TARGET AQUISITION SYSTEMS. A. Sobel,* Wright State University, Dayton, OH, G. Kuperman, Armstrong Laboratory, Wright-Patterson AFB, OH.

INTRODUCTION. Automatic target recognizers (ATRs) have failed to achieve the level of robustness required for autonomous application in military systems. Man is still required to reduce the large number of false alarms generated by ATRs. Developing man-machine interfaces, capable of supporting the operator in the conduct of cued target confirmation, is a current challenge to the crew station design community. METHODS. A man-in-the-loop crew system simulator was modified to include a target acquisition sensor and ATR capability. A structured rating scale debriefing instrument was developed to capture Subject Matter Expert (SME) judgments and opinions regarding the importances and criticality of ATR-related information elements. Sixteen radar navigators participated in this MMI concept demonstration and assessment study. RESULTS. Descriptive statistics revealed strong and consistent SME reports regarding non-intrusive cues to target location and a mechanism for "decluttering" ATR symbology and alphanumerics. CONCLUSIONS. These results will apply directly to crew station concepts for the future Multi-Role Fighter and Offensive Counter Force Theater Missile Defense attack aircraft.

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HUMAN FACTORS CONSIDERATIONS FOR NIGHT VISION SYSTEM DESIGN: RESULTS OF USAF NVG USERS' CONCERNS SURVEY. M.M. Donohue-Perry, J.T. Riegler, and L.J. Hettinger. Human Engineering Division, Crew Systems Directorate, Armstrong Laboratory, Wright-Patterson AFB OH 45433-6573.

INTRODUCTION. Due to lack of field data regarding user concerns with night vision devices, a survey of all Air Force commands who use the Aviator's Night Vision Imaging System (ANVIS) was initiated by our laboratory. The purpose of the survey was to document user concerns about fielded ANVIS systems, provide user input on design of future night vision devices, and identify human factors problems for future study. METHODS. The survey consisted of onsite questionnaire administration and individual interviews. Users included crewmembers from all USAF commands who currently use the ANVIS system. RESULTS. Users indicated that current ANVIS design causes significant muscular fatigue due to forward moment and weight of the helmet mounted system. Helmet-goggle integration problems were also widely noted as users reported difficulties achieving proper system fit. This resulted in decrements in ANVIS system performance. CONCLUSIONS. Results indicated that design considerations for future helmet-mounted night vision systems must take better account of the demands imposed by individual missions, and the requirements of individual crewmembers. Specific recommendations relate to helmet weight and center of gravity, helmet-goggle integration, and cockpit lighting.

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SENSORY ILLUSIONS REPORTED WHILE USING NIGHT VISION DEVICES IN SOUTHWEST ASIA. D. T. FITZPATRICK*. U.S. ARMY SAFETY CENTER, FT. RUCKER, AL 36362.

INTRODUCTION. Degraded visual cues associated with the use of night vision devices (NVDs) combined with the adverse environmental conditions of Southwest (SW) Asia often produced unexpected visual effects and illusions. This study identified the variety of sensory illusions experienced by U.S. Army aircrew in SW Asia while using NVDs. METHODS. An open-ended questionnaire was distributed to aviation units while deployed. Aircrew were asked to report any episodes of disorientation, sensory problems, or illusions noted while flying with NVDs. Information on NVD hardware, flight parameters, and environmental conditions at the time of the event was also obtained. RESULTS. Of the 87 returned questionnaires, 98% reported using the AN/AVS-6 Night Vision System. Most of the sensory events occurred during good weather, over open desert terrain, during low levels of illumination, in all phases of flight. Degraded visual cues accounted for over half of all reports, with loss of visual horizon and degraded resolution most frequently mentioned. Over one-third reported a negative outcome ranging from fatigue or aborting the mission to ground impacts or hard landings. CONCLUSIONS. Familiarity with sensory illusions is critical for safe NVD flight. These findings can be used to better prepare aviators to fly at night in a desert environment.

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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.

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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.

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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.

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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.

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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.

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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 anti-diuretic 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 $\pm$ 38; vs. DDAVP, 316 $\pm$ 30, p = n.s.) or CSSI score (placebo, 16.3 $\pm$ 6.0; vs. DDAVP, 15.4 $\pm$ 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.