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EVALUATION OF LBNP AS COUNTERMEASURE TO CARDIAC DECONDITIONING.

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PURPOSE and METHOD: To evaluate the effects of LBNP as a countermeasure for cardiac deconditioning in space, seven youngmale volunteers were admitted to the hospital andexperienced 6-degree head-down tilt (HDT) for 3 days. Passive 60-degree head-up tilt (HUT) was performed before and after HDT. Four volunteers received 30 mmHg LBNP for 30 minutes to induce fluid shift to the lower body twice a day (every morning and afternoon)during HDT for 3 days, while 3 of 7 volunteers (the control group) did not receive LBNP. Continuous blood pressure monitoring, heart rate, and impedanceplethysmogram were measured during the HUT test before and after HDT. **RESULTS:** One volunteer became presyncope during the first LBNPand also became presyncope again during the HUT test after HDT. The other LBNP volunteers (3 out of 4) did not show undesirable conditions. One volunteer of control grouphas become presyncope during the HUT test before HDT. However he did not become presyncope during the HUT test after HDT for 3 days. **CONCLUSION:** 30 mmHg LBNP loading for 30 minutes twice a day didnot seem to prevent cardiac deconditioning induced by 3 days of 6-degree HDT.

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DISUSE OSTEOPOROSIS: CHANGES IN BIOCHEMICAL PARAMETERS DURING AND FOLLOWING SIMULATED MICROGRAVITY OF DIFFERENT DURATION.

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A limiting factor for prolonged human exposure to microgravity is the loss of bone mass. Immobilization and bed rest have proved to be useful models for earth based simulation of weightlessness effects. To further our understanding biochemical bone parameters were observed over a period of 120 days in 15 healthy male volunteers, divided into three groups. Group I (5 subjects) experienced 3 weeks, Group II (5 subjects) 1 week of horizontal bed rest. Group III (5 subjects) served as ambulatory control group All bed rest subjects received a Ca balanced individual diet and were kept under close supervision in a hospital. Blood and urine samples were collected throughout the bed rest periods and during follw up (15 weeks).
Results: Serum and 24h urine parameters of Group I showed changes that resembled the typical mineral and hormonal pattern of disuse osteoporosis (slight increase of Serum Ca, increase of osteocalcin, decrease of serum PTH, increase of urinary Ca and Hydroxyproline). Group II showed similar trends, however, changes were not significant compared to base line.
Conclusion: A bed rest period of more than 1 week appears to be necessary to show significant biochemical changes due to immobilization.

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ENHANCED GAMMA COMPUTED TOMOGRAPHY FOR BONE DENSITY MEASUREMENT IN SHORT TERM BED REST SUBJECTS.

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INTRODUCTION. Prolonged space flight may produce bone density loss of sufficient magnitude to adversely impact extended duration space travel. Trabecular bone density change which occurs early in space flight has not been adequately measured due to the limited accuracy of prior measuring devices. **METHODS**. The OsteoQuant gamma computed tomography device, with 0.5% change in trabecular bone density detection ability, was used to characterize changes in the bone density of healthy male bed rest subjects. Three groups of five subjects received periodic measurements of trabecular bone density of the distal radius and distal tibia: five had three weeks bed rest, five had one week bed rest, and five were controls. **RESULTS**. Trabecular bone density changes in the bed rest groups approached 1%. There was an unexpected rise in tibial trabecular bone density of both bed rest groups in the first week of bed rest, followed by a decline in bone density during the bed rest period. **CONCLUSION**. The initial rise in tibial trabecular bone density at the onset of bed rest may represent a new finding. The OsteoQuant could be used to measure changes in bone density in connection with current space shuttle missions.

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COMPUTER SIMULATION APPLICATIONS IN PLANNING STUDIES OF A NEW COUNTERMEASURE TO FLUID SHIFTS IN WEIGHTLESSNESS.

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Fluid shifts caused by the absence of gravity initiate a series of reflexes to reduce the blood volume (BV) to a new setpoint appropriate to the weightless environment. In addition, there are losses of other body fluids, and together these losses contribute to a reduction in postflight orthostatic tolerance. One possible way to counteract early fluid losses is to preadapt the circulation through a moderate BV reduction preflight. This concept has been validated in short-term water immersion experiments using human subjects, and in preliminary computer simulation studies using a mathematical model of circulation, fluid and electrolyte regulation. Results to date suggest that preflight adaptation of the BV to weightlessness could result in greater BV, extracellular volume, and total body water for 20 to 30 days of exposure. The optimum preflight BV reduction to apply appears to be the volume which would ultimately be lost in adapting to weightlessness; preadaptation by this volume results in the least deviation from fluid homeostasis following fluid shifts. Further modeling studies are planned prior to actual experimentation to test the countermeasure's effectiveness on enhancing postflight orthostatic tolerance by simulation of lower body negative pressure (LBNP), and to simulate fluid loading prior to reentry with and without the countermeasure. Computer simulation is being used to aid in the understanding of relevant mechanisms and in the planning of experimental studies by suggesting the selection and timing of variables to be measured. It is a highly cost-effective method to test interactions of current and planned countermeasures to determine the expected benefits and potential risks of their combined use.

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COMPARISON OF SALINE AND FLUDROCORTISONE AS FLUID-LOADING COUNTERMEASURES FOLLOWING EXPOSURE TO SIMULATED MICROGRAVITY.

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INTRODUCTION. Saline loading (SL) within hours of reentry is currently used as a countermeasure against postflight orthostatic hypotension in astronauts. However, its effects on blood volume expansion is not quantified and its effectiveness has proven marginal at best. The purposes of the present study were: 1) to quantify the effects of SL on plasma volume and orthostatic tolerance following exposure to simulated microgravity and 2) to compare these effects with the use of a pharmacological fluid expander, fludrocortisone (F). METHODS. eleven men (30-45 yr) underwent a 15-min stand test before and immediately after 7 days of head-down bedrest (BR). Five of the subjects ingested SL (8 g salt tablets with 1 liter of water) 2 hr before standing at the end of bedrest while the other 6 subjects received 0.2 mg oral doses of F at 0800 and 2000 hours the day before and 0800 hours the day the subject got out of bed (i.e., 2 hr before standing). Plasma volume (PV) was measured before BR, on day 7 of BR, and after the final SL and F treatments just before the post-BR stand test. Blood pressure and heart rate was measured continuously during the stand tests. RESULTS. BR decreased PV from 40.7±1.9 ml/kg to 35.9±1.1 ml/kg (-11.8%, $P<0.05$). Following SL, PV remained at 36.4±1.5 ml/kg while F returned PV to 39.1±1.8 ml/kg. The post-BR stand test was completed without syncopal symptoms by 5 of 6 F subjects but only 2 of 5 SL subjects. CONCLUSIONS. SL may be ineffective in restoring PV to preflight levels and may provide inadequate protection against postflight orthostatic hypotension. In contrast, F may provide a promising countermeasure since it restored PV and reduced the incidence of syncope following exposure to simulated microgravity in the present study.

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THE SPATIAL DISORIENTATION TRAINING SYSTEM BIULT IN AIR FORCE CHINA

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INTRODUCTION. To reduce the incidence of the Spatial Disorientation (SD) accidents a SD training System was built in AF of China. METHODS. This System consist of a). Education, through which the pilots should acquire adequate knowledge about the SD, its etiology, manifaction and the methods for coping with it ; b). Ground-Based training, through which allow the pilots to safely experience the SD , simulated by Barany chair and Optokinetic stimulator and to acquire adequate skill necessary to copy with SD by Visuo-Instrument Orientation ; c). In-Flight Training, trough which allows the pilots to acquire the factual ability of identifing SD (special for I type SD), induced by a series of flight maneuvers on the training aircraft and to acquire the skill of maitaining correct spatial orientation to solve disorientational conflict and the skill of developing optimum control strategies for recovery from unusual attitudes. More then ten thousands pilots are trained for overall training programm. RESULTS. After training, the SD incedence is reduced from 84.696 to 23.896; the person-time of SD per every 100 h.flight is reduced from 0.95 to 0.6 ; the person-time of SD per every 100 h.night flight is reduced from 9.9 to 2.6; the averaged frequence of SD fatal accident per one year is reduced from 1.6 case (1980-1984, befor training) to 0.4 case (1985-1989, after training). CONCLUSION. This SD training System is realizable and effective for avoiding SD fatal accident.

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COMPARISON OF SIMULATOR SICKNESS SYMPTOMATOLOGY IN TWO FIXED-WING AND TWO ROTARY-WING SIMULATORS. Michael G. Lilienthal, Ph.D.,* Naval Air Systems Command; Robert S. Kennedy, Ph.D.*, Essex Corporation; Sherrie A. Jones, M.S., Naval Training Systems Center.

INTRODUCTION. Studies have found that moving-base simulators of rotary-wing aircraft with CRT displays produced the highest incidence of simulator sickness, as measured by self-report, postural, and visual tests. A standardized scoring technique was developed which facilitates comparison between simulators and a factor analysis revealed three distinct factor clusters corresponding to oculomotor, visual-vestibular, and neurovegetative systems. METHOD. Four simulators were examined in the present experiment. Two "sister" moving-base simulators (2F121) for the H53E helicopter and two fixed-wing simulators (2F114 and 2F143) for the A6E and EA6B aircraft. The helicopter simulator employ CRT infinity optics and the other two were dome projection systems. The 2F114 was a fixed base. Approximately 100 aircrew were observed in each simulator. RESULTS. Simulator sickness was found in all simulators when total scores were taken into account, with the highest incidence in the helicopter simulators. When the symptomatology was scored according to the three factor clusters, it was found that the CRT-based helicopter simulators had the highest reports of eyestrain and the fixed-base simulator had the highest reports of disorientation. Nausea was reported about equally in all three of the motion-base simulators. CONCLUSION. Different symptom clusters which occur in specific simulators with sufficient regularity suggest using this method of analysis in an attempt to identify specfic equipment features that relate to simulator sickness.

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NUTRITION AND ACCELERATION TOLERANCE: CURRENT UNDERSTANDING. G. H. Evans and L. P. Krock,* Valparaiso University, Valparaiso, IN 46383 and Armstrong Laboratories, Brooks AFB, TX 78235-5000.

INTRODUCTION: Nutritional status and the influence of diet on individual ability to perform in the increased acceleration environment is an important aeromedical concern. Although relatively more information has been generated regarding the nutritional needs of the infantry soldier, little data is available for the special case of the high performance pilot (HPP). METHODS: Approximately 5 decades of nutrition research and current sources of nutrition information for HPP under operational conditions were reviewed. Interviews, computer data base searches, and manual searches of earlier aeromedical literature provided sources for this review. RESULTS: Limited data are available from intervention studies addressing the effect of pre-flight meals and long-term nutritional status on acceleration and the nutritional requirements of HPP. Data showed an increased G-duration tolerance in the fed vs. fasted and induced hyper- vs. hypoglycemic states. Combined sodium and fluid restrictions are known to decrease G tolerance. No recent studies evaluate the energy cost of the high G environment. Although limited to one study, dietary recall data indicate nutrient intake was primarily similar to U.S. military standards. However, carbohydrate quantities consumed in two studies did not meet recommendations to HPP pilots, and types of carbohydrate were not differentiated. Surveys indicate pilots frequently miss meals, but the pre-flight food habits of U.S. pilots are unknown. CONCLUSIONS: More research is needed to determine optimum composition, size and timing of pre-flight meals, suitable composition of meal substitutes during operational conditions when time is short, and the effect of longer-term dietary intake on acceleration tolerance.

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THE INCIDENCE OF ACUTE ADVERSE HEALTH EFFECTS IN PILOTS USING A POSITIVE-PRESSURE BREATHING ANTI-G SYSTEM (PBG).
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INTRODUCTION. Modern fighter aircraft subject pilots to acceleration forces that can cause G-induced loss of consciousness (GLOC). Over 300 such cases have been documented since 1982; 15 have resulted in fatalities, all of these in fighters. The Air Force has thus sought to improve acceleration protection under a program called COMBAT EDGE. This system retains the conventional G-suit and valve, but additionally provides positive-pressure breathing during G (PBG) assisted by a counter-pressure vest. Pressure begins at +4 Gz, increasing 12 mmHg per G to a maximum of 60 mmHg at +9 Gz. PBG has been shown to more than double G-time tolerance in centrifuge tests. It has recently undergone operational test and evaluation (OT&E) in the F-15 and F-16, and is scheduled to be widely fielded in the near future. This study was undertaken to initially assess potential aeromedical issues. METHODS. All F-15 and F-16 pilots exposed to PBG during the test were anonymously surveyed at intervals over the course of the OT&E. As controls, non-PBG exposed F-15 and F-16 pilots were also surveyed during the same period. RESULTS. Dependent variables sought included neck pain, back pain, arm pain, gray-out, black-out, G-LOC, dyspnea, and cough during high-G flight. Early analysis reveals no significant increase in any of these acute adverse health events in pilots flying with PBG. CONCLUSIONS. Thus far, PBG appears to be safe with regard to the dependent variables tested. Long-term surveillance of pilots using PBG technology will continue.

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ACCELERATION PROTECTION AFFORDED BY POSITIVE PRESSURE BREATHING: THE INFLUENCE OF F-15 AND F-16 SEAT-BACK ANGLES. T. R. Morgan*, C. L. Brown*, J. W. Burns* and J. B. Bomar*. Human Systems Program Office, Brooks AFB TX 78235-5000.

INTRODUCTION. COMBAT EDGE (CE) is a new anti-G system permitting the optional selection of positive pressure breathing for G (PBG). Initially developed for use in F-16 aircraft, it was later selected for retrofit to the F-15 fleet. Evaluation of the prototype system thus included assessment of its effectiveness at the different seat-back angles used in each aircraft. METHOD. Conditions were structured to permit the comparative evaluation of traditional gear, CE without PBG, and CE with PBG, each at seat-back angles of 17 and 34 degrees, as in the F-15 and F-16 respectively. Each was scored on the endurance attained by experienced subjects riding a standardized centrifuge test profile to exhaustion. RESULTS. In comparisons with traditional gear the combined influences of introducing CE and PBG increased the endurances attainable from both seats (ANOVA $p<.05$ for F-15, $<.001$ for F-16). Incremental increases in endurance appeared to accompany the introduction of CE and PBG respectively, but were much larger, and statistically significant (paired-t test), in the F-16 case only. CONCLUSION. The endurance advantage conferred by PBG is thus demonstrable in both F-15 and F-16 seat configurations, but is more marked, and displays statistically definable increments, only in the F-16 case. How slight postural differences between the seats may cause this is unclear. Whether or not it will influence aircrew acceptance in either aircraft should emerge from ongoing operational tests.

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AEROBIC AND STRENGTH TRAINING EFFECTS DURING HINDLIMB SUSPENSION. JJ Hartley, MJ Plyley, NH McKee, RD Forsyth and W Rhodes. Departments of Physiology and Surgery, School of Physical and Health Education, University of Toronto, Toronto, Ontario, Canada, M5S 1A8.

INTRODUCTION. The hindlimb suspension model has been used to study the response of skeletal muscle to a simulated "microgravity" environment. The purpose of this study was to determine the influence of strength training (electrical stimulation) and aerobic exercise (treadmill running) on the response of the slow twitch soleus and the fast twitch plantaris skeletal muscles to six weeks of hindlimb suspension. METHODS. Female Wistar rats (275g) were randomly assigned to suspended (S, n=30) and non-suspended (NS, n=30) groups. Both groups were subdivided into sedentary, aerobic and strength-trained groups. Trained rats were removed from a harness during the training sessions (3 days/week). Muscle contractile function and morphometry were assessed at the end of six weeks. RESULTS. In S rats, soleus peak twitch tension (Pt, N/g), tetanic tension (Po, N/g) and mean cross-sectional areas (CSA, um2) of typesI and IIa fibers were reduced, respectively to 82, 78, 47 and 68% of NS values ($p<.05$). In group S, plantaris fiber CSA was reduced to 82 (typeI) and 81% (typeIIb) of NS values ($p<.01$). Within S and NS groups respectively, sedentary values (mean$\pm$sd) for soleus Pt (2.4$\pm$0.79, 2.8$\pm$0.82 N/g), Po (10.8$\pm$3.90, 13.8$\pm$4.08 N/g), typeI CSA (1696$\pm$240, 3552$\pm$457 um2) and typeIIa CSA (1715$\pm$256, 2234$\pm$841 um2) were not significantly changed by either strength or aerobic training.Compared to sedentary activity, strength training increased plantaris Pt by 23% in S and 29% in NS groups($p<.05$). CONCLUSION Intermittent aerobic or strength training intervention during prolonged hindlimb suspension may be ineffective in reducing the amount of muscle wasting due to simulated "microgravity" exposure.

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SKELETAL MUSCLE RESPONSES TO UNLOADING IN HUMANS. G Dudley, P Tesch, B Hather, G Adams & P Buchanan*. NASA & Bionetics Corp, Kennedy Space Center, FL 32899; Karolinska Institute, S10401, Stockholm, Sweden.

INTRODUCTION. This study examined the effects of unloading on skeletal muscle structure. **METHODS**. Eight subjects walked on crutches for six weeks with a 10 cm elevated sole on the right shoe. This removed weight bearing by the left lower limb. Magnetic resonance imaging of both lower limbs and biopsies of the left m. vastus lateralis (VL) were used to study muscle structure. **RESULTS**. Unloading decreased ($P<0.05$) muscle cross-sectional area (CSA) of the knee extensors 16%. The knee flexors showed about 1/2 this response (-7%, $P<0.05$). The three vasti muscles each showed decreases ($P<0.05$) of ~ 15%. M. rectus femoris did not change. Mean fiber CSA in VL decreased ($P<0.05$) 14% with type II and type I fibers showing reductions of 15 and 11%, respectively. The ankle extensors showed a 20% decrease ($P<0.05$) in CSA. The reduction for the "fast" m. gastrocnemius was 27% compared to the 18% decrease for the "slow" m. soleus. **SUMMARY**. The results suggest that decreases in muscle CSA are determined by the relative change in impact loading history because atrophy was 1) greater in extensor than flexor muscles, 2) at least as great in fast as compared to slow muscles or fibers, and 3) not dependent on single or multi-joint function. They also suggest that the atrophic responses to unloading reported for lower mammals are quantitatively but not qualitatively similar to those of humans.

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