Abstracts of Current Aerospace Medical Literature

Acceleration Physiology

Bain B, Jacob I, Buick F : Effect of simulated air combat manoeuvering on muscle glycogen and lactate. Aviat Space Environ Med 1992; 63 : 505-509.

Muscle glycogen and Muscle and blood lactate were evaluated before and after a +4.0/7.0 Gz simulated air combat manoeuvering (SACM) protocol in the human centrifuge. The subjects were eight healthy males, ages 25-43 years. Muscle glycogen and lactate were determined from biopsies of m. vastus lateralis in six subjects and whole blood lactate was analysed in finger-tip blood samples from eight subjects. G-tolerance time was 256 ± 33 s (Mean ± SEM). The decrease in glycogen concentration averaged 81 ± 36 mmol: Kg^{-1} dry wt ($p=0.07$). The rate of glycogen utilization was low, averaging 0.4 ± 0.1 mmol Kg^{-1}. S^{-1}. Muscle lactate increased significantly from 28 ± 2 mmol. Kg^{-1} dry wt pre-SACM to 51 ± 4 mmol Kg^{-1} post-SACM. Post-SACM blood lactate was 4.2 ± 0.3 mmol. L^{-1}. Neither final blood nor muscle lactate values nor the difference between pre and post-SACM muscle lactate concentrations were related to G-tolerance time. It was concluded that glycogen availability in m vastus lateralis is not a limiting factor during exposure to headward acceleration of this type and duration. The lactate values, while high, cannot fully explain the muscular fatigue occurring during centrifuge exposures of the type used here. Therefore, the suggestion by others that anaerobic energy metabolism in skeletal muscles is the crucial factor limiting ability to resist fatigue during exposure SACM is not supported and likely an oversimplication of a much more complex problem.

Pecaric M, Buick F : Determination of a pressure breathing schedule for improving +Gz tolerance. Aviat Space Environ Med 1992; 63:572-578.

A base of empirical data for developing optimal pressure breathing during +Gz (PBG) schedules is lacking. Relaxed +Gz-intensity tolerance with PBG was measured during gradual +Gz-onset rate centrifuge profiles using standard lightbar criteria. Constant PBG levels ranging from 18-73 mm Hg were randomly assigned . G suit pressure followed the standard or an increased inflation schedule. Nine subjects wore a jerkin, CSU-15/P G-suit, and TLSS helmet and mask. With mean mask cavity pressures of 0.18, 38, 60 and 73 mm Hg, corresponding +Gz tolerances (mean ± SEM) were 5.3 ± 0.2, 5.8 ± 0.1, 6.6 ± 0.2, 7.3 ± 0.3, and 7.5 ± 0.3 Gz (Linear correlation, r=0.994). Increased G suit pressure did not change the +Gz tolerance improvement with PBG. The inverse of individual subject regression slopes ranged from 22.6 to 58.1 mmHg/+Gz. Considering additional factors and adequate +Gz protection for all subjects while relaxed, the proposed schedule would apply 42 mm Hg PBG/+Gz beginning at +3.3 Gz with a maximum pressure of at least 73 mm Hg.

Yacavone DW, Bason R : Cervical injuries during high G manoeuvers : A review of Naval Safety Centre Data 1980-1990.Aviat Space Environ Med 1992; 63 : 602-605.

As aircraft capable of sustaining high "G' manoeuvers enter the US Navy Fleet, the reported incidence of cervical injury to aircrew seems to have increased. To determine the extent of the problem, personal injury reports submitted to the Naval Safety Center were reviewed for the 10-year period from 1980 to 1990. In addition, confidential questionnaires were sent to flight surgeons supporting fighter/or fighter-attack units. The data collected were statistically analysed. The incidence of cervical injuries, defined as at least one day's absence from the flight schedule, was computed. Other subjective factors, such as the type helmet worn, the cockpit position flown and the type of mission profile completed, were examined. As might be expected, the most common offender was air combat manoeuvering. The most common aircraft was the F/A 18, but the radar intercept officer position in the F14B was also a significant contributor. The most common injury pattern reported was a simple muscle strain. Cervical pain after high "G" mission poses a potential threat to combat readiness. However, the use of the newer light-weight helmet seems to have reduced the severity. Muscle strengthening exercises appear to help in prevention. Treatment is successful in most cases with minimal or no

residuals noted. As yet, there exist little official data to support the notion of a major problem.

Aviation ENT

Kinnedy RS, Fowlkes JE, Berbaum KS et al : Use of motion sickness history questionnaire for prediction of simulator sickness. Aviat Space Environ Med 1992; 63 : 588-93.

This research assessed the usefulness of the Motion History Questionnaire (MHQ) for the prediction of simulator sickness, a form of motion sickness experienced by the pilots training in ground based flight simulators. Four MHQ scoring keys were compared : (1) the original MHQ key which had been validated on a sample of US. Navy student pilots exposed to Coriolis forces, (2 and 3) two keys which had been validated on a sample of civilian college students exposed to simulated ship motions, and (4) a simulator sickness key empirically derived in the present research and cross-validated. Navy and Marine Corps (n=456) filled out the MHQ prior to their regularly scheduled flight simulator training and were divided into validation and cross-validation samples. All scoring keys were predictive of reported symptoms of sickness, but highest correlations were obtained with the empirically-derived simulator sickness (SS) Key. It is suggested that the SS key be used for self-testing so that pilots may be made aware of their risk for developing simulator sickness.

Ashton DH, Watson LA : Inner Ear Barotrauma : A case for exploratory tympanotomy. Aviat Space Environ Med 1992; 63 : 612-615

A case of inner ear barotrauma (IEBT) due to a hypobaric chamber experience in presented. IEBT is an exceedingly rare condition in aviation. In the case described, the diagosis was initially unsuspected due to accompanying middle ear barotrauma. The underlying etiology, the diagnosis, and management of IEBT are discussed.

Aviation Ophthalmology

Moorman DL, Green RP Jr: Cataract surgery and intraocular lenses in military aviators. Aviat Space Environ Med 1992; 63 : 302-307.

We reviewed the medical records of 23 military aviators who were evaluated by the United States Air Force School of Aerospace Medicine (USAFSAM) after cataract extraction with intraocular lens implantation between 1979 and 1990. The 23 subjects were male Caucasians, with a mean age of 43 years. Of the subjects, 21 were pilots, and of these, 8 were qualified in high performance aircraft. There were a total of 28 operated eyes, 24 of which had received extracapsular cataract extractions (ECCE) with posterior chamber lenses. The best-corrected, postoperative vision was 20/20 or better in all eyes. Posterior capsule opacification occurred in 14 (60%) of the ECCE eyes, with five requiring Nd:YAG (Yttrium-Aluminium-Garnet) laser capsulotomies. One aviator was disqualified from flying duties because of ocular deficiencies, for a visually-qualified-to-fly rate of 96%. Eight aviators have actually flown since surgery. Although follow-up was short, the initial results are encouraging.

Provines WF, Rahe AJ, Block MG et al : Yellow lens effects upon acquisition performance. Aviat Space Environ Med 1992; 63 : 561-564

Twenty subjects made a total of 400 threshold visual acquisition of T-38 aircraft approaching from 9 miles out. Half of the acquisitions were made with the subjects wearing yellow ophthalmic filters and the other half without filters. No over all statistically significant difference in acquisition performance due to the use of yellow filters was found.

Civil Aviation Medicine

Bennett CT, Schwirzke M : Analysis of accident during instrument approaches. Aviat Space Environ Med 1992; 63:253-61.

General aviation and air taxi approach phase accidents, which occurred during Visual and Instrument Flight Rules (VFR and IFR, respectively) over the last 25 years, were analysed. The data suggest that there is a 204% higher risk during the approach and landing phase of VFR flights, than during similar IFR operations (14.82 vs 7.27 accidents/100,000 approaches). Alarmingly the night single pilot IFR (SPIFR) accident rate is almost 8 times the rate of day IFR, 35.43 vs 4.47 accidents/100,000 approaches, and two and a half times that of day

VFR approaches, 35.43 vs 14.82 accidents/ 100,000 approaches. Surprisingly the overall SPIFR accident rates are not much higher than dual-pilot IFR (DPIFR), 7.27 vs 6.48 accidents/100,000 approaches. The generally static ratio of the statistics for SPIFR/DPIFR accident rates may be accounted for by little or no change in general aviation cockpit technology during the last 25 years, and because IFR operational flight task management training has not kept pace.

Clinical Aviation Medicine

Canaveris G, Halpern MS, Elizari MV : Intraventricular conduction disturbances in civilian flying personnel : Left Anterior Hemibloc. Aviat Space Environ Med 1992; 63: 292-298.

We undertook a retrospective study of the natural history, clinical significance, prognosis, associated conduction disturbances and pathology, as well as flying fitness qualification of 247 cases of left anterior hemiblock (LAH), detected in a presumably healthy population of 8,915 male individuals engaged in civilian flying activities (prevalence : 2.77%). The cases were divided into three groups according to the electrical axis value of the first electrocardiogram (ECG). The group with the slow mode of appearance of LAH was the most common. If associated with right bundle branch block, LAH usually evolves first. LAH could not be ascribed to any definite pathology; neither was it a fore-runner of left bundle branch block nor complete atrioventricular block. Not one episode of syncope nor of sudden incapacitation was reported. As a mere ECG finding, LAH does not modify an aviator's fitness qualification. If another conduction disturbance develops, qualification will depend on the results of complementary studies, non-invasive or invasive, according to any associated conduction disturbance.

Clinical Medicine

Perkins, Kenneth A : Metabolic effects of cigarette smoking. J Appl Physiol 1992; 72(2) : 401-409.

The inverse relationship between cigarette smoking and body weight, a potent obstacle to stopping smoking, may be due in part to effects of smoking on increasing whole body metabolism. Studies examining chronic and acute metabolic effects of smoking, as well as its constituent nicotine, are reviewed. Evidence suggests the absence of a chronic effect; most studies indicate that smokers and nonsmokers have similar resting metabolic rates (RMR) and that RMR declines very little after smoking cessation. Although an acute effect due to smoking is apparent, its magnitude is inconsistent across studies, possibly because of variability in smoke exposure or nicotine intake. In smokers at rest, the acute effect of smoking (and nicotine intake) appears to be significant but small (% of RMR) and transient (less than or equal to 30 min). However, the specific situations in which smokers tend to smoke may mediate the magnitude of this effect, in as much as smoking during casual physical activity may enhance it while smoking after eating may reduce it. Sympathoadrenal activation by nicotine appears to be primarily responsible for the metabolic effect of smoking, but possible contributions from nonnicotine constituents of tobacco smoke and behavioral effects of inhaling may also be important. Improved understanding of these metabolic effects may lead to better prediction and control of weight gain after smoking cessation, thus increasing the likelihood of maintaining abstinence.

Environmental Physiology

Razmjou S, Kjellberg A : Sustained attention and serial responding in heat : mental effort in the control of performance. Aviat Space Environ Med 1992; 63 : 594-601.

The effects of heat (40° C) on sustained attention and serial responding were studied in a simple reaction time test and a serial four choice reaction time task, respectively. Core temperature (Tc), heart rate variability (HV) and subjective reaction were monitored during the 80 min of exposure time. Simple reaction time performance and accuracy in the serial choice reation time task deteriorated significantly in heat. In the serial choice reaction time task, the effects of heat on response times and on HV were correlated. Performance and level of Tc were not correlated, but a relationship was found between performance and rate of Tc change. Results are

discussed in relation to the thermophysiological status of the subjects and the compensatory mechanism of effort allocation. It is proposed that task characteristics regulate the degree of activity of this compensatory mechanism.

High Altitude Physiology

Goldberg SV, RB Schoene D, Haynor B et al : Brain tissue pH and ventilatory acclimatization to high altitude. J Appl Physiol 1992; 72(1) : 58-63.

^{31}P nuclear magnetic resonance spectroscopy (^{31}P-NMRS) was performed on brain cross sections of four human subjects before and after 7 days in a hypobaric chamber at 447 Torr to test the hypothesis that brain intracellular acidosis develops during acclimatization to high altitude and accouts for the progressively increasing ventilation that develops (ventilatory acclimatization). Arterial blood gas measurements confirmed increased ventilation. At the end of 1 wk of hypobaria, brain intracelluar pH was 7.023 ± 0.046 (SD), unchanged from preexposure pH of 6.998 ± 0.029. After return to sea level, however, it decreased to 6.918 ± 0.032 at 15 min ($p<0.01$) and 6.920 ± 0.046 at 12 h ($p<0.01$). The ventilatory response to hypoxia increased (from 0.35 ± 0.11 l/min -%O_2 saturation) before exposure to 0.69 ± 0.19 after, $p=0.06$). Brain intracellular acidosis is probably not a supplemental stimulus to ventilatory acclimatization to high altitude. However, brain intracellular acidosis develops on return to normoxia from chronic hypoxia, suggesting that brain pH may follow changes in blood and cerebrospinal fluid pH as they are altered by changes in ventilation.

Human Engineering

Yacavone DW, Bason R, Borowsky MS : Through the canopy glass : A comparison of injuries in naval aviation ejections through the canopy and after canopy jettison, 1977 to 1990; Aviat Space Environ Med 1992; 63 : 262-266.

Two methods of ejection from tactical aircraft are commonly used : jettisoning the canopy prior to seat travel, and ejecting through a closed canopy. The report compares the ejection injury experience of Naval Aviation in each mode during January 1977-August 1990. During that period, 336 through-canopy and 580 canopy-jettison ejections were accomplished. The former group sustained 10.7% fatal injuries, and only 17.0% egressed injury-free. By comparison, the later cohort incurred only 4.7% fatalites and fully 31.9% egressed without injury. Analysis of pattern of injuries confirms higher G-forces in through-canopy ejections, resulting in not only more injuries, but more severe injuries. In spite of these findings, we discuss the compelling tactical and financial reasons to consider through-canopy systems.

Hyperbaric Oxygen Therapy

Jacobson Jane M, John R, Michael et al : Hyperbaric oxygen toxicity, role of thromboxane, J Appl Physiol 1992; 72(2) : 416-422.

Exposing rabbits for 1 h to 100% O_2 at 4 atm barometric pressure markedly increases the concentration of thromboxane B_2 in alveolar lavage fluid (1809 ± 92 vs 99 ± 24(SE) pg/ml, ($p<0.001$), pulmonary arterial pressure (110 ± 17 vs 10 ± 1 mmHg ($p<0.001$), lung weight gain (14.6 ± 3.7 vs 0.6 ± 0.4 g/20 min, ($p<0.01$), and transfer rates for aerosolized 99m/ Tc-labeled diethylenetriamine pentaacetate (500 mol wt; 40 ± 14 vs 3 ± 1 x 10^{-3}/min, P) and fluorescein isothiocyanate-labeled dextran (7000 mol wt; 10 ± 3 vs 1 ± 1 x 10^{-4}/min, $p<0.01$). Pretreatment with the antioxidant butylated hydroxyanisole (BHA) entirely prevents the pulmonary hypertension and lung injury. In addition, BHA blocks the increase in alveolar thrombaxane B_2 caused by hyperbaric O_2 (10 and 45 pg/ml lavage fluid, n=2). Combined therapy with polyethylene glycol-(PEG) conjugated superoxide dismutase (SOD) and PEG-catalase also completely eliminates the pulmonary hypertension, pulmonary edema, and increase in transfer rate for the aerosolized compounds. In contrast, combined treatment with unconjugated SOD and catalase does not reduce the pulmonary damage. Because of the striking increase in pulmonary arterial pressure to 100 mmHg, we tested the hypothesis that thrombaxane causes the hypertension and thus contributes to the lung injury. Indomethacine and UK 37248-01 (4-2-1H-imidazole-1-yl-ethoxy) benzoic acid hydrochlorlide, an inhibitor of thrombaxane synthase, completely eliminate the

pulmonary hypertension and edema. These results suggest that a major machanism by which hyperbaric O_2 produces lung injury in rabbits is by stimulating thromboxane synthesis.

Space Medicine

Polese A, Sandler H, Montgomery LD : Hemodynamic responses to seated and supine lower body negative pressure. Aviat Space Environ Med 1992; 63 : 467-475.

Hemodynamic changes between upright and supine lower body negative pressure (LBNP) to levels of -70 mmHg were compared in 8 subjects (5 males, 3 females) and correlated with their findings during simulated Shuttle reentry acceleration with a slow onset rate of 0.002 G/s (1.020 s to peak +2Gz) and during gradual onset exposures (0.03 G/s) to +3 Gz and 4 Gz. Six of the 8 subjects were able to tolerate 2 min at peak +2 Gz, 2-5 min at +3 Gz and 1-2 min at +4 Gz. Heart rate (HR) at any given level of upright LBNP regularly exceeded supine levels. HR change at -50 mm Hg in upright subjects (+47.7 bpm from 74.1 ± 1.9 (M ± SE) bpm, control) was 2.6 times greater than in supine subjects (+18.3 bpm from 64.8 ± 2.8 bpm, control). HR values at -40 mm Hg supine (73.7 ± 2.6) matched seated upright pre-LBNP control levels (74.1 ± 1.9 bpm), while values at -70 mm Hg supine (102.5 ± 4.4 bpm) were not significantly different from those at -40 mm Hg upright (103.1 ± 4.0 bpm). Peak HR during +3 Gz (145.8 ± 7.7 bpm) and +4 Gz (152.3 ± 6.5 bpm) significantly exceeded recorded supine and upright LBNP levels, whereas values at +2 Gz (104.8 ± 5.5 bpm) closely matched those at -40 mmHg upright (103.1 ± 4.0 bpm) and -70 mmHg supine (102.5 ± 4.4 bpm). Supine LBNP HR changes in this relatively small group of subjects closely matched those previously reported in the literature. Overall LBNP HR changes could be closely related by second-order polynomial equations. Diastolic (DBP) and mean arterial blood pressures (MAP) showed a nonsignificant tendency to decline during progressive LBNP exposure, while acceleration induced significant elevations. However, MAP (90.6 ± 2.6 mmHg) and DBP (75.8 ± 2 mm Hg) at -40 mmHg upright were similar to those at peak +2 Gz (93.2 Gz ± 4.5 mm Hg and 80.7 ± 5.5 mm Hg, respectively). The magnitude of seated LBNP-induced leg pooling, measured by impedance plethysmography was 65% of that found with +3 Gz (3.6 ± 0.2% Δ DVE) and +4 Gz (3.6 ± 0.1% Δ DVE) and 64% of that with +2 Gz (3.7 ± 0.3% Δ DVE). Pooling during seated LBNP (-70 mm Hz, 2.38 ± 0.4% Δ DVE) was a significant 22% greater than supine LBNP (1.85 ± 0.1% Δ DVE. Results provide evidence that seated LBNP at a level of -40 mm Hg can serve as static simulator for heart rate and mean blood pressure changes induced by the gradual onset acceleration stress occurring during Shuttle reentry. Findings also provide a rationale for use of LBNP during weightlessness as a means of imposing G-loading on the circulation prior to reentry.

Burton RR, Meeker LJ : Physiologic Validation of a short-arm Centrifuge for space application. Aviat Space Environ Med 1992; 63 : 476-81.

A short-arm centrifuge (SAC) of 5-6 ft (1.5-1.8 m) radius may be useful in space to measure tolerances to acceleration (G) and to stimulate the cardiovascular system, thereby reducing cardiovascular decompensation that occurs in weightlessness. Relaxed rapid (1 G/s onset rate, ROR) and gradual (0.1 G/s onset rate, GOR) G tolerances were measured on seven men using a 5-ft (1.5 m) radius centrifuge and compared with their G tolerances obtained on the 20-ft (6.1 m) radius human-use centrifuge at the Armstrong laboratory, Brooks AFB, TX. Since the subjects were required to flex their legs to assume a squatting position on the SAC, a similar position was used on the 20 ft (6.1m) centrifuge called feet up (FU), and compared with normal-seated +Gz tolerances (controls). The subjects tolerated the SAC exposures without any problems. ROR and GOR tolerances were as follows : control, 3.6 G and 4.2 G; FU, 4.5 G and 5.6 G; and SAC, 4.6 G and 6.4 G. We concluded that a 5-ft radius centrifuge can be used to measure G tolerances. The increases in the SAC GOR tolerances over ROR tolerances indicate that the baroceptors were stimulated by the G, and the SAC exposure would be useful in preventing cardiovascular decompensation in microgravity.