Current Abstracts of Aeromedical Literature

Relation of the time course of venous gas bubbles to altitude decompression illness. Conkin J, Foster PP, Powell MR, Waligora JM. Undersea Hyperbaric Med 1996;23(3):141-149.-

The correlation is low between the occurrence of gas bubbles in the pulmonary artery, called Venous Gas Emboli (VGE), and subsequent Decompression Illness (DCI). The correlation improves when a "grade" of VGE is considered: a zero to four categorical classification based on the intensity and duration of the VGE signal from a Doppler bubble detector. Additional insight about DCI might come from an analysis of the time course of the VGE outcome between 322 subjects who exercised and 133 Doppler technicians who did not exercise to evaluate the role of physical activity on the VGE outcome and incidence of DCI. We also compared 61 subjects with VGE and DCI with 110 subjects with VGE but without DCI to identify unique characteristics about the time course of the VGE outcome to try to discriminate between DCI and no-DCI cases. The VGE outcome as a function of time showed a characteristic short lag, rapid response, and gradual recovery phase that was related to physical activity at altitude and the presence or absence of DCI. The average time for DCI symptoms in a limb occurred just before the time of the highest fraction of VGE in the pulmonary artery. It is likely, but not certain, that an individual will report a DCI symptom if VGE are detected early in the altitude exposure, the intensity or grade of VGE rapidly increases from a limb region and the intensity or grade of VGE remains high.

What does a backrest actually do to the lumbar spine? Tom Bendix, Vibeke Poulsen, Klaus Klausen, and Claus V. Jensen-Ergonomics, Vol 39, No.4, 533-542

It is generally believed that a backrest facilitates lumbar lordosis. To test this, the spontaneously adopted postures of 12 healthy subjects were measured by a statiometric method during 2-h sitting periods on three types of chairs in a stratified sequence. The only difference between the three workstations regarded backrest: "A" had no backrest; "B" had a vertical lumbar backrest; and "C" had an anteriorly curved backrest. In general, the most lordotic postures were assured with backrest C, whereas backrest B rather facilitated kyphosis as compared with sitting without a backrest. However, when specifically considering passive sitting, i.e., reading, both types of backrest facilitated kyphosis. Moreover, spinal shrinkage was evaluated by measuring exact height before and after each 2-h sitting period. This was done to assess spinal load. From this perspective, backrest C induced the greatest load on the spine. In conclusion, the traditional conception that a backrest facilitates lordosis is apparently not true. It seems rather that backrests actually facilitate the opportunity for the user to stabilize their lumbar spines by providing their lower backs with support, resulting in relative kyphotic increases. The practical ergonomic applications from this study are unclear. However, traditional

concepts in backrest ergonomy should be reconsidered.

Muscle Strain during aerial combat maneuvering exercise. Oksa J, Hamalainen O, Rissanen S, Mullyniemi J, Kuronen P. Aviat Space Environ Med 1996; 67:1138-43

Background : Little is known about the in-flight muscular strain of fighter pilots. *Hypothesis*: The purpose of this study was to measure fighter pilots' mean and peak muscular strain during aerial combat maneuvering exercises. The results obtained were compared against existing ergonomic recommendations.

Methods : Six pilots volunteered to serve as test subjects. Their mean age (± SD) was 28.5 ±5 yr, height 181 ± 7 cm, and weight 75 ± 10 kg. They performed one-to-one dog-fight exercises in the morning and in the afternoon. During the flights, the pilot's electromyographic activity (EMG) was measured from the thigh, abdomen, back, and lateral neck. The mean and peak muscular strain for each muscle was calculated as the percentage of maximal voluntary contraction (%MVC).

Results : The results showed that the mean muscular strain was 5.2-19.8% MVC, the strain in the lateral neck being the highest. Peak muscular strain (over 50% MVC) occurred almost only during the encounters and usually in the lateral neck. Other muscles were subjected to fewer peak train episodes; most of these occurred in the back. At least one peak strain episode exceeding 100% MVC was recorded for every muscle studied. The highest peak strain 257% MVC, was measured in the lateral neck area, and the flight mission was discontinued.

Conclusion : The mean muscular strain measured in this study was rather low. However, the strain occurring in the lateral neck and the back exceeds the ergonomic recommendations for static work. Especially in the lateral neck, and to some extent in the back, peak strain occurs frequently, in a magnitude that is well above the maximal voluntary contraction; in these areas, the peak strain presents a potential risk of injury and negative health effects. The level and frequent occurrence of peak strain episodes means that fighter pilots' muscular strength and muscular endurance, especially in the neck and shoulder area, are subjected to demands clearly higher than those of the average population.

Anthropometric measurements and ejection injuries. Edwards M. Aviat Space Environ Med 1996; 67 : 1144-7

Background : A previous study examined anthropometric variables to determine possible ejection seat risk factors. It concluded that individuals who weighed below the average body weight or who met the criteria of having a tall, thin physique as measured by body mass index (BMI – $kg.m^{-2}$) were significantly more at risk for acceleration induced back injuries. *Hypothesis:* Because of the increased number of female pilots and the potential need to modify ejection seats for lighter aviators, this retrospective analysis of Naval Safety Centre data attempted to reproduce and confirm the same results with more current data, covering a 5-yr period from Jan 1989-Dec 1993.

Methods : In this study, the same criteria were used to define back injury, including weight, height BMI, and below average

weight. Additional categories of injury were examined, including all spinal fractures alone without soft tissue back injuries, all injuries combined, and severity of injury. Sitting height and trunk height were added to the variables.

Results : Out of 810 aircrew involved in mishaps, 199 ejected. Of all the ejections, 111 (56%) had some type of injury as a result of the ejection. Severe injuries occurred in 8 (4%) including 4 (2%) fatalities. Back injuries occurred in 44 (22%) and 8 (4%) involved spinal fractures. Although there were no significant risk factors for ejection back injury, weight and height were statistically significant risk factors for severe injury and spinal fracture, respectively.

Conclusions : Aircrew with severe injury were heavier (average weight 88 kg. vs. 79 kg). In addition, taller aircrew (185 vs. 180 cm) were at increased risk for any spinal fracture.

+Gz acceleration affects the trace minerals zinc, copper, and chromium in serum and urine of humans. Kikukawa A, Miyamoto Y, Akamatsu T. Aviat Space Environ Med 1996;67:1166-9.

Background : Research investigating the relationship between physical training and trace mineral concentrations has primarily focused on athletes. Few investigations, however, have specifically examined the alterations of trace mineral concentrations occurring in humans exposed to +Gz acceleration. Exercise alters mineral content; G-exposure is a form of exercise; therefore, G-exposure may elicit changes in mineral content.

Hypothesis : Exposure to +Gz acceleration may affect the concentrations of the trace minerals zinc, copper, and chromium in human serum and urine.

Methods : Blood samples were obtained from 7 men and 3 women, before and immediately after +Gz accelerations, decreasing from 7 men and 3 women, before and immediately after +Gz acceleration. Urine samples were obtained before, 30 min after, and 2 h after +Gz acceleration.

Results : The serum zinc concentration was significantly different after +Gz acceleration, decreasing from 90.6 ± 21.00μg.dl^{-1} to 80.8 ± 14.4μg.dl^{-1}. The serum zinc concentration was also significantly altered immediately after +Gz acceleration, decreasing from 111.7 ± 27.5μg.dl^{-1} to 98.5 ± 35.2μg.dl^{-1}. The urinary zinc and copper concentrations, and the serum chromium concentration were not significantly affected by +Gz acceleration.

Conclusion: The circulating levels of these minerals presumably change as they are transported to the tissues requiring greater amounts to the increased physiological work associated with +Gz acceleration.

The effect of positive pressure breathing for altitude protection of intra-ocular pressure. Ryles MT, Perez - Becerra JL. Aviat Space Environ Med 1996; 67:1179 - 84.

Background : The effect of positive pressure breathing for altitude protection (PBA) on intra-ocular pressure was studied; the behaviour of intra ocular pressure both during and after PBA exposure was of particular interest.

Methods : Seven subjects were exposed to PBA of up to 60 mmHg at ground level. The subjects were seated, and wore an aircrew helmet (HGU-55/P), oro-facial mask (MBU-20P), thoracic counterpressure garment (CSU-17/P) and an extended coverage G-

suit (ATAGS). Before, during and after each exposure, intra-ocular pressure was measured using a Tono Pen XL ™ applanation tonometer. Results : All 7 subjects completed 10 min of PBA at breathing pressures of 30 and 40 mmHg, and 6 subjects completed 10 min at 50 and 60 mmHg. Mean and SEM increases in intra-ocular pressure, as compared to pre-exposure baseline measurements, were 7.7 ± 0.6mmHg at a breathing pressure of 30 mmHg, 12.0 ± 0.9 mmHg at 40 mmHg, 18.4 ± 1.3 mmHg at 50 mmHg and 20.0 ± 0.6 mmHg at 60 mmHg. The difference between each of these increases was significant ($p < 0.05$), with the exception of that between 50 and 60 mmHg PBA.

Conclusions : Intra-ocular pressure increases as breathing pressure increases. It is likely that this change in intra-ocular pressure would provide some protection to the retinal vasculature during PBA. In addition, it is unlikely that the temporary elevation of intra-ocular pressure following pressure breathing is of medical concern.

Instrument flying performance after G - induced loss of consciousness. Paul MA. Aviat Space Environ Med 1996; 67 : 1028-33.

While both the USAF and the USN have characterized the immediate sequelae of G-induced loss of consciousness (G-LOC) as resulting in approximately 24seconds of incapacitation, very little is known about the effect of a G-LOC immediately after this incapacitation period. This study is attempt to determine the effect of G-LOC on instrument flying performance immediately after G-LOC.

Method : In order to establish their flying performance baselines, 29 Canadian Forces (CF) pilots attending the high sustained G (HSG) course flew 3 iterations of a 15-min instrument flying risk on the day prior to their HSG course. All 29 pilots performed this same task the next day within 5 min of completing the centrifuge training. In addition, the pilots who experienced G-LOC flew the task again 45 min after G-LOC. Flying performance was assessed by calculating Root Mean Square (RMS) error mon 11 flight parameters. These RMS values were submitted to a multivariate analysis of variance.

Results : Of the 29 pilots, 12 experienced G-LOC during the centrifuge training. The flying performance of the 17 non G-LOC pilots, 11 had no measurable performance decrement while 1 pilot, after a severe G-LOC stalled and "spun-in" on take - off and then (after being re-established on the outbound radial) could not complete the task. This same pilot flew the task very well 15 min later. This study did not identify a degradation in flying performance after HSG nor after G-LOC except in the 1 pilot.

Conclusion : Whether or not a pilot's flying performance is affected after G-LOC may be related to the severity of the G-LOC. Some pilots may experience seizure activity relating to the G-LOC with a resulting sustained performance decrement that appears to resolve by 45 min. It is possible that some of the other G-LOC pilots in the study might have had measurable performance decrements if we had been able to have them fly the task while they were still in the gondola (i.e., immediately after the G-LOC).

Lipid lowering therapy and military aviators. Khan MA, Amroliwalla FK,

Aviat Space Environ Med 1996; 67:867-71

This article discusses the role of the newer lipid lowering agents (stations and fibrates) for the treatment of hyperlipidaemia in military aviators. Special emphasis will be on long-term safety and the effects of these drugs on CNS functions pertinent to aviators. We propose that these new lipid lowering agents, such as hydrophilic statins and newer fibrates are reasonably safe in aviators with restricted flying duties, subject to long-term surveillance by a specialist.

A "Smart" molecular sieve oxygen concentrator. With continuous cycle time adjustment. Safe Journal 1996; Vol 26, No. 2, 25-34

A "smart" Molecular Sieve Oxygen Concentrator (MSOC) is controlled by a set of computer algorithms. The "smart" system automatically adjusts concentrator operating parameters to accurately control product oxygen concentration while minimising bled air consumption. The purpose of this effort was to determine if concentrator performance could be controlled by computer algorithms which continuously adjust concentrator cycle time.

A two-bed laboratory molecular sieve oxygen concentrator was constructed and instrumented. The concentrator was operated at ground level and ambient temperature. Computer algorithms or decision processes were developed to control concentrator cycle time. Step changes in product flow from 5 to 40 standard litres/ minute were induced by a flow controller. A signal representing the product oxygen concentration was produced by a medical gas analyser and inputted into the computer algorithms.

Using continuous cycle time adjustment over a range of 14 to 36 seconds, the "smart" concentrator maintained the product oxygen concentration within + 2.5% of a desired oxygen concentration. The highest observed overshoot in oxygen concentration which occurred during the step changes in product flow was about 12%. Inlet air consumption was reduced by approximately 40% which compared to operation at a constant cycle time.

"Smart" MSOC techniques, such a continuous cycle time adjustment, can significantly improve our ability to control oxygen concentrator performance. An added benefit is reduced bleed air consumption which results in increased aircraft thrust and fuel economy.

Centrifuge man-rating of a conceptual internal abdominal bladder. Restraint in an extended coverage anti-G suit.Safe Journal 1996: Vol 26, No. 2, 42-46

An extended coverage anti-G suit, has been demonstrated to improve +Gz tolerance substantially. In some pilots/subjects however, the abdominal bladder of the anti-G suit may expand excessively upward and inward causing discomfort and pain. This man-rating was performed to evaluate the effects on +Gz protection of an internal abdominal bladder restriant in the Swedish Tactical Flight Combat Suit (TFCS) used in conjunction with Pressure Breathing during G (PBG). The tests were executed in the Armstrong Laboratory Centrifuge at Brooks AFB with four Swedish test fighter pilots. The centrifuge profiles included gradual onset runs (GOR, relaxed) and rapid onset runs (ROR, with straining), as well as simulated aerial combat manoeuvre (SACM)

runs up to +9 Gz until subjects experienced light loss or fatigue or surpassed 228 s. All subjects withstood 60 s at + 9 Gz during GOR and ROR runs with and without abdominal bladder restriant. There was no difference in SACM duration times. In three of four subjects, abdominal pain or discomfort experienced without abdominal bladder restraint disappeared with the addition of a bladder restraint. Ratings of perceived exertion (after 5 peaks at + 9 Gz) in the SACM), subjective +Gz tolerance, overall comfort fatigue, and heat stress demonstrated no relevant differences with and without abdominal bladder restriant. Therefore, to enhance comfort, it seems possible to modify the TFCS by adding an abdominal bladder internal restraint without compromising its operation.

Differences between syncope resulting from rapid onset acceleration and orthostatic stress. Self DA, White CD, Shaffstall RM, Mtinangi BL Croft JS, Hainsworth R. Aviat Space Environ Med 1996; 67:547-54

Background and hypothesis: Orthostatically - induced syncope is accompanied by venous pooling and vasodilatation. Loss of consciouness during head-to-foot acceleration (G-LOC) in aviators may be caused by a different mechanism, as venous pooling should be prevented through the use of an anti - G suit. This research was conducted to test the hypothesis that in individuals wearing a well-fitted anti-G garment, no important changes occur in the volume of dependent regions during loss of consciousness resulting from rapid onset acceleration stress. Further, this work compares venous pooling patterns in G-LOC subjects to patterns seen during syncope in volunteers and patients subjected to orthostatic stress. We conducted the tilt/ LBNP tests to establish what level of venous pooling was required to induce syncope in the absence of a hydrostatic component (other than 1 G) and to confirm that our equipment was sensitive enough to detect volume changes large enough to cause syncope.

Methods : Shifts in blood volume to the calf, thigh and abdominal segments were compared in subjects with G-LOC to those in subjects taken to presyncope with orthostatic stress created by upright tilt and lower body negative pressure (LBNP). Centrifuge subjects were exposed to a 15 s rapid onset (6G s -1) + 5 Gz exposure on the centrifuge while remaining relaxed and wearing a well-fitting anti G-suit, but with the anti G suit pressure inactivated.

Results : Blood volume decreased an average of 14.09 ± 22.1 ml in the calf segment; increased an average of 64.1 ± 7.9 ml in the thigh segment, and decreased an average of 80.1 ± 29.7 ml in the abdominal segment. The mean net change in volume of the three combined regions was not significantly different from zero. Presyncope was induced in subjects by a progressive exposure to upright tilt, and then additional of LBNP at -20 mm Hg and -40 mm Hg. In the tilt/ LBNP group, there was a net increase of 1022 ± 269.8 ml for the combined segments. Changes in all three segments were significantly different than the mean segmental volume changes seen in centrifuge subjects at G-LOC end points. Significant changes from baseline mean arterial pressure, but not heart rate were also seen within but not between the 2 groups, with mean eye level blood pressures (ELBP

falling an average of 45.6 ± 7.7 mm Hg in the tilt / LBNP group at syncope and 105.1 ±15.5 mm Hg in the centrifuge subjects at G-LOC.

Conclusion : These differences suggest that G-LOC may be due entirely to hydrostatic effects, with venous pooling being prevented by the wearing of an anti-G garment, even when it remains uninflated.

Is there a hypercoagulable state in military fighter pilots? Biondi G, Farrace S, Maameli G, Marongiu F. Aviat Space Environ Med 1996; 67:568-71.

Background : A hypercoagulable state is associated with an increased incidence of cardiovascular disease, the most important cause of permanent grounding of flying personnel.

Hypothesis : The aim of our study was to investigate whether a hypercoagulable state is present in jet pilots, and whether it can be due to flight activity.

Method : To this purpose we studied Fibrinopeptide A (FPA), Thrombin-Antrithrombin complexes (TAT) and D - Dimer (DD), sensitive biochemical markers of blood coagulation and fibrinolysis aviation, in 10 jet pilots after a standardized training flight mission, and in a control group. Also evaluated before flight were 6 jet pilots.

Results : We were able to show increased thrombin and plasmin activity both in jet pilots compared to the control group, and after flight in the 6 pilots who were evaluated twice.

Conclusion : We conclude that a hypercoagulable state due to flight activity is present in jet pilots after flight. Possible mechanisms involve an effect of psycho-physical stress mediated by a neuroendocrine response to flight activity, for an effect of chronic +Gz exposure on cardiovascular structure and function.