Acceleration Research News

Submissions from the International Acceleration Research Workshop Community

Volume 2, Issue 1 May 2001

INSIDE THIS ISSUE

The 2001 International Acceleration Research Workshop is proudly sponsored by

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wyle laboratories

Where and When

This is the 15th anniversary of the International Acceleration Research Workshop conceived by Dr. Russell R. Burton. This year's workshop will be held again during the Aerospace Medical Association Annual Scientific Meeting in Reno, Nevada.

The workshop will take place at:

Room: Genoa Room
John Ascuaga's Nugget Hotel
Thursday, 10 May 2001
12:30 – 2:00 PM

Chairman's Message

Welcome to the 2001 International Acceleration Research Workshop. This year's program is a blend of both oral laboratory reports, as well as a number of special presentations on "works-in-progress." In keeping with last year's workshop, I have chosen a discussion topic that will (hopefully) form the basis of spirited discussion during the workshop. I am grateful to Barry Shender for submitting this topic.

Thanks also to all those people who responded to my many pleading emails and especially to those who provided the enclosed reports for this newsletter. Many thanks also to this year's sponsors of the Workshop, AMST Systemtechnik and Wyle Laboratories. Special thanks to Dennis Kiefer for his help in getting the newsletter printed.

I hope you all find the Workshop to be enjoyable, stimulating and productive.

David G. Newman, DAvMed, PhD

Chairman, IARW 2001

Aerospace Physiology Laboratory, RMIT University

Thursday May 10, 2001;
12:30 – 2:00 PM

Room: Genoa Room
John Ascuaga's Nugget Hotel
Reno, Nevada, USA

International Acceleration Research Workshop

Agenda

- Welcome
- Introductions
- Laboratory Reports
- Special Presentations
  - The Swedish DFS Project – Dennis Kiefer, Wyle
  - "Libelle" Anti-G suit update – Dr Welsch, GAF
  - IARW Website
- Discussion Topic:

"Head/neck injury during high performance flight in both fast jets and attack helicopters"

- General Discussion Forum
- Selection of Chair for IARW 2002
- Concluding Remarks

RMIT Aerospace Physiology Laboratory

David G. Newman, DAvMed, PhD

RMIT Aerospace Physiology Laboratory, RMIT University, Victoria Australia

March 2001 saw the first anniversary of the Gravitational Physiology Laboratory (GPL) in the Department of Human Biology and Movement Science of the Faculty of Biomedical and Health Sciences at RMIT University in Melbourne, Australia.

In light of this historic event, several changes have been made to both the lab and its over-riding university structure. The Faculty has been re-named the Faculty of Life Sciences, and the previous department has amalgamated with some others to form the School of Medical Sciences. In keeping with these changes, the laboratory has been renamed the Aerospace Physiology Laboratory. This name change reflects our expanding interests in the field of aerospace physiology research.

While we plan to continue our main interest in gravitational physiology, we also plan to move into all other areas of aerospace physiology research, including altitude physiology and spatial disorientation The main emphasis of the laboratory will, however, continue to be on biodynamics. The expansion of activity allows more scope for postgraduate students to participate in the field of aerospace physiology research. As always, we welcome contact from any like-minded innovative aerospace physiology research facility or centre wishing to pursue any joint scientific project.

During its first year of operation, the laboratory completed a number of research projects, and successfully graduated its first postgraduate Honours student, Caroline Rickards.

Caroline, who is also a member of AsMA, will be presenting her research work in poster form on Tuesday May 8 during the Acceleration Physiology poster session at 2:30 pm. This work involved and investigation into the effect of low-level normobaric hypoxia on orthostatic tolerance, as well as a comparison of the +75^0 head-up tilt and the squat-stand test. Caroline also received an Australian Postgraduate Award Scholarship which has enabled her to continue her research interests as the Laboratory's first PhD student.

The laboratory also made a number of scientific presentations during the year, at meetings such as the Annual Scientific Meetings of the Aerospace Medical Association, the Aviation Medical Society of Australia and New Zealand, and the Australian Physiological and Pharmacological Society.

During 2001 the Laboratory has also taken on another postgraduate student, who will spend her Honours year research programme investigating the effect of caffeine on +Gz tolerance. Efforts are still being made towards establishing an airborne flight research programme. It is anticipated that initial flight testing of the +Gz protocol will be concluded by the end of the calendar year. In addition, we are developing a website to promote our aerospace physiology activities.

For further information, please contact the laboratory's Director, Dr David G. Newman via email at david.newman@rmit.edu.au ❖

Air Force Research Laboratory – RIMIC Project

Ted Knox, PhD

Deputy Chief,Biodynamics and Acceleration Branch (HEPA), Air Force Research Lab (AFRL), Wright-Patterson AFB, OH

RIMIC (Real Impact Injury Criteria): Dr. Knox of AFRL/HEPA and Mr. Doug Hill, of TRICE_Motorsports Research, are conducting a cooperative research program (CRADA) to collect data from race drivers relating their head motion during crashes for correlation with any resulting injury. These data will form the basis for Real Impact Injury Criteria (RIMIC) that can then be applied to new helmet mounted displays and advanced pilot and driver protection concepts. Dr. Knox and Mr. Hill have initiated arrangements to have 9 drivers, representing many major race series (CART, IRL, NHRA, BDPS, NASCAR and USAC), act as test drivers to evaluate the performance of the instrumentation system under real race conditions. This month was highlighted by the transfer of two data recorders and one instrumented earplug to TRICE for installation on one CART (Championship Auto Racing Teams) car owned by PacWest and one for use by the chief engineer of the Barber Dodge Pro Series (BDPS). Mr. Hill will be running the crash data program for the Barber Dodge Pro Series this season and is negotiating funding from various sources to cover the costs of all on track equipment and operations. The small data recorders (Advanced Crash Data Recorder Modules) were recently developed under an SBIR with SPEC Inc. of Austin, Texas. As part of SPEC's efforts to commercialize their product, Mr. Joe Priest, SPEC principal engineer, participated in the installation and check out of the recorder on the CART car at the Phoenix Race Track. The first use in the BDPS this season will be at the American Le Mans Series, March 13-17, at the Sebring International Raceway. Endevco designed and manufactured a new miniature triaxial accelerometer (model 7269) with partial funding from AFRL/HEPA for use in the driver's earplugs. Endevco recently advertised this accelerometer as the world's smallest triaxial accelerometer for sale to the open market and referenced its use in racecars. ❖

US Navy Acceleration Research Programs

Barry Shender, PhD

Naval Air Warfare Center Patuxent River MD, USA

1. Centrifuge training: The LeMoore centrifuge is up and running at full capability since January 2001, training up to 24 individuals a week, including four hours of classroom briefing as well as the actual centrifuge exposures.

2. Head/neck injury during maneuvering acceleration: As part of the US Naval Air Systems program "Human Tolerance To Acceleration-Induced Spinal Injury", the Naval Air Warfare Center Aircraft Division Patuxent River has three studies completed or in-progress. The centerpiece of this program is the development of a model that will be used to determine the probability of neck injury resulting from exposures to the entire acceleration envelope.

The first, to be presented at 1030 hours on May 7 at the Impact, Injury and Escape session, was a manikin study in which the effects of added head weight and change in center of gravity on loads and moments developed in the head and neck were determined during exposures to +Gz loads experienced during maneuvering acceleration in fast jets and attack helicopters.

The second study involves determining both isometric and dynamic peak neck strength and endurance in a large and diverse subject pool. Along with these measurements, anthropometrics and EMG data is collected from three sets of muscle groups. Some of the subjects are also participating in a subset of this study in which they return to repeat their efforts with a varying amount of rest (ranging from a few hours to a week) to gauge the effects of work/rest cycle on strength.

The third study involves determining the effects of work/rest cycle on the strength and EMG activity of the neck when subjects perform simulated flight maneuvers, while realistically moving their heads, while their necks are exposed to loading associated with +Gz stress. POC: Barry S. Shender, Ph.D., 301-342-8881; shenderbs@navair.navy.mil

3. SAILSS: The USN will evaluate the Smart Aircrew Integrated Life Support System (SAILSS) this year at the Brooks AFB centrifuge. SAILSS synergistic approach includes: 1) assessing pilot status (real-time) based on input from a) physiologic microsensors embedded in the helmet, mask, and a sensor vest, b) the aircraft, and c) the cockpit; 2) optimizing said status via the control of life support equipment; and 3) communicating such status to the pilot and the remainder of the weapon system including its emergency components such as recovery, avoidance, and escape systems.

The current components of SAILSS are: 1) host computer, 2) physiologic sensors, 3) signal conditioning system, and 4) a data acquisition and control computer system (VME). SAILSS is currently focusing on the acceleration environment and is integrated with the USN Combat Edge ensemble. Two approaches to +Gz protection will be evaluated: a) Breathing Regulation Anti-G (BRAG) Electronic Control and b) the CRU-103 regulator slaved to an electronically controlled g-valve. The SAILSS will also be evaluated as to its interface with Missile Avoidance (MA) and Ground Collision Avoidance (GCAS) systems. POC: Estrella Forster, Ph.D., 301-342-9278; forsterem@navair.navy.mil ❖

Update on the Zhukovsky Human Centrifuge Project

Richard Schlüsselberger

President & Owner, AMST-Systemtechnik Ges.m.b.H., Austria.

During the past month impressive progress was made in the installation of the process. The installation of the main power supply, consisting of a 110/10 kV substation, included the connection of the 10 kV power cables to the AMST substation for the main drive. This process was finished by the end of May 2000. The installation of the containers for the power supply for the 36 Megawatt main drive system, and the corresponding control system, were also installed and tested by the same date.

The installation of the main drive in its foundation was a major event for the whole team on site. The rotor of this drive, with a total weight of 158 tons, had to be placed very precisely into the stator, using the 180 ton, crane. This task was completed within half a day.

Over a period of 4 weeks, the whole drive system, including the huge ventilation system for the cooling air of the main drive, was tested and put into operation. On 29th of May, 2000 AMST successfully carried out the pre-acceptance for the main drive system (together with the supplier – Siemens, Erlangen, Germany).

The installation of the 750 kW hydraulic substation for the roll and pitch drives was successfully finished, as was the complete installation of the control room equipment.

At the beginning of June, the installation of the mechanical parts of the centrifuge within the centrifuge hall began with the compressed air system, the shaft for the centrifuge arm (including the disk for the already installed mechanical brake), and a small auxiliary drive (which enables the centrifuge to be positioned to 3 different, pre-selectable positions). On the 10th of June, the pre-assembled main arm was installed on its shaft.

In parallel with the installation process, our specialists began systems checks for putting into operation sub-systems such as the main controller for the centrifuge itself, and for the interfaces to the control systems for the main roll and pitch drives.

Completion of the installation process occurred in mid July 2000, far AHEAD of SCHEDULE! After a holiday period AMST continued with system checks and fine tuning of the single systems. By November 2000, the centrifuge was successfully rotating for the first time. Until mid-December the computer Hard- and Software were checked, as well as the safety systems.

Further performance tests could not be performed from Christmas until mid-April 2001 because of existing problems related to the short supply of electrical power during the cold period in Russia.

Therefore, AMST continued work in April 01 with the integration of the DFS systems being completed by the end of April 01.

At the moment, further tests for increasing the performance of the Centrifuge are being performed and will be finished by end of May.

Beginning in June 01, AMST plans to run internally the whole program for the acceptance of the Centrifuge and to complete the fine tuning.

Acceptance of the whole system is planned (at the latest) for the end of August 01.

USAF Annual Report

William Albery, PhD

Wright Patterson Air Force Base, USA

The US Air Force has three human centrifuges. The centrifuge at Holloman Air Force Base NM is owned by the Air Combat Command and is used for pilot training. They recently celebrated the training of their 20,000th pilot. The other two centrifuges are in the Air Force Research Laboratory and are used principally for research. Below is a summary of research on-going at both facilities:

G-Induced Loss of Consciousness Research: Begun in Oct 2000, this effort, sponsored by the DoD Live Fire Test Office and the Navy (NAWCTSD/Orlando), has Veridian as the prime contractor investigating techniques for reducing the total incapacitation period associated with a GLOC. Techniques being investigated include repeated GLOCs (typically 4 over a 4 week period) to see if the subject recognizes the GLOC, recovery after GLOC to less than 1 G, GLOC in a modified G suit (one that deflates slower than usual), and recovery with bells and whistles. The work is shared between the two facilities (Brooks AFB and Wright-Patterson AFB).

Libelle G-suit evaluation: This past summer, the AFRL participated in centrifuge training at Brooks AFB of aircrew protected with the Libelle. The results of this evaluation and subsequent flying evaluations were presented at the SAFE meeting in Reno in Oct 00. Tom Morgan is presenting on this topic during this AsMA. The training at Brooks did not include any objective measures or scientific evaluations of the Libelle, but did afford researchers the opportunity to see how the Libelle performs up to 9G. The USAF is currently pursuing a Foreign Comparative Test Program for the Libelle.

Thermal Burden of COMBAT EDGE: At the request of Air Combat Command, Brooks performed a thermal burden study of the COMBAT EDGE system. The study was related to aircrew concerns that wear of the COMBAT EDGE counter-pressure vest increased their heat load and subsequent dehydration. Each of twelve subjects completed two trials, consisting of wear of COMBAT EDGE with and without the vest. There were no significant differences in core or skin temperature, or dehydration level between the two conditions. A final report was submitted to ACC in June 2000.

Helmet Biodynamics: The Wright-Patterson AFB centrifuge group has completed an extensive study on the effect of helmet mass and center-of-gravity on head tracking performance up to 6.5 G for the Joint Strike Fighter program office. The purpose of the research was to determine the effect of helmet mounted displays on pilot performance during dynamic head tracking tasks. The study was completed in early 2001 and will be reported at the 2002 AsMA meeting.

New anti-G suit materials, techniques: Lt Col Tom Morgan has been investigating future materials for G suit development. These advances include "active" textiles for life support ensembles and medical applications as well as Nitinol, a shape memory alloy that may have application to helmet and G suit tensioning.

G Modeling: Several Small Business Innovative Research (SBIR)contracts have been awarded by AFRL for the development of a performance under sustained acceleration model. NTI Inc has won three SBIRs over the past 5 years for the development of the model that will predict the effect of Gz on pilot performance. The model will eventually go into larger scale models used for Battlespace Management and other applications.

Plans: Both facilities are staying very busy. Brooks and Wright-Patterson AFB centrifuges will complete the GLOC research in mid-2001. Brooks will then begin an Almost Loss of Consciousness (ALOC) study with DoD LFT funding through the Navy and with Wyle Labs as the prime contractor. They will also continue with their support of the Navy SAILSS (Smart Aircrew Integrated Life Support System) program. Brooks also has plans to evaluate the effect of pharmacological agents on Gz tolerance. The WPAFB centrifuge will begin a G layoff study with the NAMRL (Pensacola) which will run this summer and fall. In addition, the W-P group has been involved with two Cooperative Research and Development Agreements (CRADA) with ETC over this past year. Color perception and Push-Pull research will also resume. We are looking forward to seeing everyone at the International Acceleration meeting on 10 May. ❖

Holloman AFB Centrifuge Trains 20,000th Pilot

Sandi Busch
Aircrew Training Systems, ETC

Holloman AFB has completed the training of the 20,000th pilot on its G-Lab® Human Centrifuge. Celebration activities took place at the Holloman Air Force Base Physiology Training Unit (PTU), to acknowledge this milestone accomplishment.

The G-Lab was selected by the U.S. Air Force in 1988 and has become the most utilized centrifuge in existence. During these 13 years, the G-Lab has been the primary centrifuge for the United States Air Force High-G training program. It has been responsible for reducing the number of G-induced Loss of Consciousness (G-LOC) mishaps (both Class A and C) by more than fifty percent.

The United States Air Force Centrifuge Training Program is one of the most aggressive training programs in the world. In addition to training U.S. pilots on the G-Lab, the Air Force Physiology Training unit has trained pilots from Canada, Japan, Korea, Israel, Jordan, Bahrain, Pakistan, Australia, Poland, Italy, Taiwan, Singapore, Chile, United Kingdom, Sweden, Switzerland, Czechoslovakia, Egypt, Finland, Germany, Turkey, Kuwait, Saudi Arabia, and others.

G-LOC and High-G unusual attitude conditions are a constant threat to the aircrew of high performance fighter and attack aircraft. These dangers will become even greater in the future, as high airspeeds, low altitude, and super maneuverability of modern aircraft will place even greater demands on the physical capabilities of pilots. G-tolerance training and dynamic flight simulation, using High G-onset centrifuges, are the most effective ways to increase aircrew G-tolerance and train aircrews in new recovery techniques and High-G spatial orientation. Through ongoing centrifuge-based training and research, a centrifuge-based program can continue to improve the performance and effectiveness of aircraft and protect the lives and well-being of aircrew.

ETC, the world leader in human centrifuge design and manufacture, has provided Aircrew Training Systems and Flight Trainers to military and civil agencies worldwide for nearly 32 years.

William F. Mitchell, ETC's President & CEO, who attended the Holloman AFB celebration, noted that "We are extremely proud of the G-Lab. It has been a workhorse for the Air Force for over ten years, and continues to reflect the high level of quality that ETC puts into the design, manufacture and long-term maintenance of its products. I would also like to mention that Steve Arnold, our on-site manager, has received several awards from the Air Force over the past ten years in recognition of his professionalism and technical prowess. We are also very proud of him.” ❖

Swedish Acceleration Research Report

Ola Eiken, MD, PhD

Gravitational Physiology Research Group, Defence Research Agency, Karolinska Institute, Sweden

During the past year the Gravitational Physiology Research Group at the Defence Research Agency* has undertaken several experimental projects in the centrifuge at the Karolinska Institute. The projects can be summarized as follows:

G-tolerance and G-protection.

• The effect of physical training regimens on G-tolerance

• G-protection afforded by the hydrostatic anti-G suit Libelle®

• The effect of different AGSM on G-tolerance and cardiovascular responses while using the Swedish anti-G ensemble 39 (extended coverage anti-G suit in combination with PBG)

G-induced arm pain

• Counter measures against G-induced arm pain

• Habituation effects due to repeated exposures

• Mechanisms underlying G-induced arm pain

Spatial disorientation/motion illness

• Effects of motion sickness on temperature regulation

• Inter-individual variability in roll-plane disorientation during centrifugation

*As from Jan 1, 2001 the former Defence Research Establishment (Swedish abbreviation: FOA) has changed name to the Defence Research Agency (FOI).

<u>Publications from above projects</u>:

Eiken, O., R. Kölegård, B. Lindborg, H. Örnhagen, W. Johansson and G. Danbolt. (2000). Locally applied counter pressure and support as counter measures against G-induced arm pain. FOA-report: FOA-R—00-01503-720—SE. (Only abstract in English).

Eiken, O., R. Kölegård, B. Lindborg, M. Aldman, K-E. Karlmar and J. Linder*. (2001). Protection against increased gravitational (G) forces afforded by the hydrostatic anti-G suit Libelle® is not adequate for use in a 9 G aircraft. FOI-report: FOI-R—0085—SE. (Full report in English)

Mekjavic IB., MJ. Tipton, M. Gennser and O. Eiken. (2001). Motion illness attenuates cold-induced peripheral vasoconstriction. J. Physiol. 531P: 51P.

Eiken, O. and R. Kölegård. (2001). Pressure habituation of arm vessels alleviates G-induced arm pain. Aviat. Space Environ. Med. 72: 281. ❖

Swedish Dynamic Flight Simulator Update

Dennis Kiefer

Wyle Laboratories

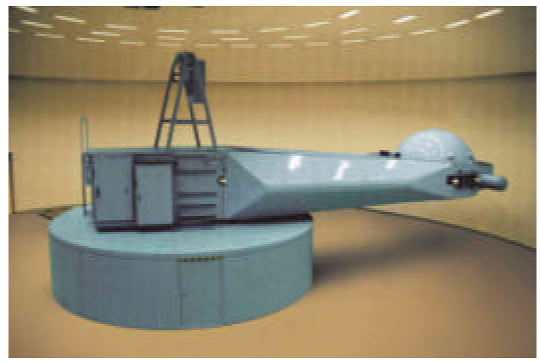
During March 2001, the Swedish Dynamic Flight Simulator (DFS) facility installation has progressed to the point of beginning the human demonstrations of its usability as a flight simulator. Tests so far have shown the device to be controllable without pilot induced oscillations throughout the full range of acceleration permitted in the initial manned testing phase. Other recent test achievements of the device are reaching the design maximum of 15 Gz and creating measured Gz onset rates up to 14 G/s. This is beyond the 10G/s requirement! Efforts will continue throughout the next few months to complete the remaining acceptance tests on the facility.

System Overview

The Wyle DFS is a flight simulator using a 30-foot radius centrifuge equipped with a controllable dual gimbaled gondola as its motion base. The sensation of free flight is created by an elaborate combination of out-the-window visual system with proprioceptive inputs generated by means of perceptual control algorithms recently acquired by Wyle Laboratories from Veridian Inc. (formerly Veda).

System Applications

The Wyle Dynamic Flight Simulator, created for Sweden, is a key component of any modern, state-of-the-art Aerospace Medical Training Center. For training pilots to fly modern high performance aircraft, the centrifuge will be used for G-tolerance training of the aircrew, acceleration physiology research and development and medical evaluations of flight personnel.



System performance characteristics include:

- Maximum G (design) – 15 G
- Onset/Offset - 0 to 10(15) G/sec
- 2 Gimbals (roll and pitch)
- Control - Selectable open and closed loop
- Payload - 1,000 lb.

The Dynamic Flight Simulator is a turnkey system and includes all operating controls, safety interlock systems, emergency stop system, intercommunication and color closed circuit television systems, biomedical monitoring and data acquisition systems, and peripheral vision light bar system.

The high performance aircraft of the 1990s and the 21st Century demand that attention be given to G-induced loss of consciousness (G-LOC) phenomena and to the need for training to increase aircrew tolerance to G forces in the prevention of G-LOC. Key in this training is the man-rated centrifuge equipment that generates the G-profiles representative of aircraft performance. The Wyle design for a man-rated centrifuge that serves these objectives is a proven design tailored to particular customer needs. Experienced, innovative design specialists are available at Wyle to develop state-of-the-art hardware and software systems. ❖

Canadian Annual Report

Len Goodman, PhD

DCIEM, Defence Research & Development Canada

DCIEM's human centrifuge is back on-line. After a lengthy down-time, a control system and mechanical system upgrade has been completed. Human rating was completed in January/March 2001, and two successful G-training courses were conducted in February and March 2001. Regular CF Squadron G-training courses (conducted by DCIEM CF military acceleration training officers) is scheduled for May 2001.

Essentially, the DCIEM centrifuge retains it's past performance specifications: operation from +1.4Gz baseline start, with ROR capability of nominal 2.6 Gz/s onset-rate from +1.4 Gz baseline, up to +15 Gz. However, the centrifuge has been human rated to a maximum of +9 Gz. Full PBG and G-valve functionality remains as before. A new computer-controlled light bar has been designed for research and training purposes. New to the centrifuge is a man-in-the-loop and target tracking system. During normal runs, in addition to the usual light bar, the rider is presented with a dynamic color image (vista with sky, mountains & ground with superimposed image of a leading F-18) using a flat plasma screen which updates the scene's horizon tilt and background topography according to +Gz imputs. Or, in man-in-the-loop mode, the rider (using the centre stick control) can track any +Gz/time profile presented on the screen, and the centrifuge will respond with the correct +Gz outputs. A new Marquette Case 8000 ECG system was also purchased and installed. It will be shared between training and research functions.

Two new data acquisition and display systems are available: 1. A system running National Instruments BIOBENCH™ v. 1.0 on a Pentium III PC. for CF training activities. Display plots from this system may be ported to the gondola screen for teaching purposes. For example, immediately after a AGSM training run, the student can view the force plate output and G-suit pressure plotted against +Gz, and discuss the quality of the strain with the instructor.

The second data acquisition system is dedicated to research activities. It is custom data display and acquisition software, designed and installed under contract to Engineering Services Inc. (Toronto), and runs on a Pentium IV processor. It allows a wide variety of real-time data display, analysis, plotting and archiving functions.

Research activities will re-commence in approximately the late May/early June time frame, as the full suite of physiological instrumentation equipment is re-installed in the gondola (ECG, Portapres™, impedance cardiography, ear pulse plethysmography). Dr. Fred Buick, Dr. Len Goodman (Head, Aircrew Performance and Protection Group), Dr. Bob Cheung (vestibular physiology) and Mr. Bill Fraser (Head, SAILSS) are the main research users of the DCIEM centrifuge. Dr. Bill Bateman (recently retired CF Cdr and former Head, Aerospace Life Support Sector)is now Advisor in Aerospace Medicine to our Aerospace Life Support Sector, and is our first-line Acceleration Medical Officer, overseeing medical/safety aspects of acceleration training and research. Capt Daan Beijer is DCIEM's Acceleration Training Officer, and coordinates CF High-G Training courses. Dr. Len Goodman functions as Centrifuge Plans and Programs officer, oversees facility research operations and scheduling, and reports to Director General DCIEM (Dr. Manny Radomski), and Deputy Director DCIEM Col. David Salisbury. Dr. Brian Sabiston head of DCIEM's Business Development Office may be contacted directly by parties interested in contracting the services of our acceleration facility for research or test/evaluation use.

As our re-emergence into full acceleration training and research activities continues, we will soon begin the next significant upgrade program to DCIEM's acceleration facility. New arm and gondola components have recently arrived at DCIEM, and will be installed late 2001/early 2002. The 18 ft. arm is a monocoque construction. The gondola will be capable of +/-180° rotation at a rate of 1Gz/s, making it Canada's first "push-pull"-capable centrifuge. The ejection seat can also be electronically tilted to 90° in the pitch orientation. The existing motor, motor pit and building infrastructure will be retained, but new control software will be developed under the supervision of Mr. Bill Fraser. ❖

Key Personnel Contact List:

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Discussion Topic

"Head/neck injury during high performance flight in both fast jets and attack helicopters"

The discussion topic for this year's Workshop was submitted by Dr Barry Shender. His initial thoughts on this topic are reproduced below.

Historically, research into head/neck injury tolerance has focused on the response to impact acceleration, crash, parachute opening shock, etc. Designs for protective systems have similarly stressed these areas and have, for the most part, relied on automotive data. With the expansion of the anthropometric range of pilots, male and female, and the increased use of helmet-mounted devices (HMD), the occurrence of soft and hard tissue injury during every day flight has become a greater and greater operational problem.

There have been a several reports by Australia, Belgium, China, Finland, Sweden, and USA over the past ten years or so which have documented the increased incidence of injury, typically associated with exposures of +4 Gz and above. So, the problem exists - but the data to correct the problem does not.

There are a variety of unanswered questions of interest to our Workshop, including:

- What are the overall head/neck supported weight limits?
- What is the relationship between weight and location of the center of gravity of HMDs and potential for injury?
- What are the characteristics of dynamic neck muscle strength and endurance?
- What are the effects of work/rest cycle on the ability to tolerate increased head/neck loading?
- What are the effects of age and accumulated flight hours on neck injury tolerance?
- What are the gender-based differences in neck injury tolerance?
- Is there an effective regimen of strength and flexibility exercises that will increase injury tolerance? If so, which muscle groups should be targeted in such a regimen?
- Given that helicopter helmets are typically heavier than tactical and that high performance helicopters can generate +4 Gz or better, what is the magnitude of the injury potential for helicopter aircrew?

Given these, and I'm sure a host of other questions, I would propose that we:

- Discuss the current research programs our various organizations have;
- Determine if there are areas in which our members can coordinate their efforts.

Chairman's Note: This is an important topic for us as a research community to address. It goes to the very heart of issues surrounding the protection and long-term health and safety of pilots flying high performance aircraft. I would like to thank Barry for submitting this topic, and urge all participants to carefully consider the issues involved and the questions that Barry has raised. I hope that this topic provokes a lively and constructive debate, and provides the impetus for many ongoing collaborative research efforts. ❖

Imaging of the Internal Jugular Vein during PPB and Postural Changes

S. Cirovic, C. Walsh, W.D. Fraser

Defence and Civil Institute of Environmental Medicine, Canada

Introduction

The mathematical models that we developed over the past several years lead us to believe that the increase of the venous resistance associated with the collapse of the veins in the neck may be a significant factor that limits cerebral blood flow during exposure to +Gz [1]. The models also indicate that G-protection measures, and PPB in particular, help maintain consciousness by keeping the veins open. These concepts have been already verified experimentally by means of a mechanical model, in which surgical drain tubing was used to represent the highly compliant jugular veins [2]. Currently we are interested in obtaining an evaluation of theoretical results directly from human experiments. At this stage the experiments are limited to zero to +1Gz range. However, this will be sufficient to demonstrate whether venous collapse occurs in reality. The main objective of this study is to answer two specific questions:

Does transition from zero to +1Gz (supine to sitting) leads to narrowing of the jugular veins?

Can this trend be reversed by means of the PPB?

Methods

The right internal jugular vein was screened with vascular Doppler ultrasound (Hewlett Packard HP SONOS 5500) in eight healthy human subject (six male, two female) in supine and sitting position, and with PPB pressure varied in 10 mmHg increments from zero to 50 mmHg. The subjects were wearing G-suits and chest counter-pressure garments, with the G-suit pressure always equaling twice the PPB pressure. PPB and G-suit pressures were regulated by means of a manually operated control unit developed at DCIEM and previously used for training purposes. The jugular lumen was imaged at four locations along the length of the vessel: at the level of the inferior jugular bulb just above the jugular valve (lower-most, Point 1), at the base of the skull (upper-most, Point 4), and at two additional points place approximately equidistally between the lower and upper-most points (Point 2 and Point 3). The vertical locations of the measurement points was determined using the fourth intercostal space as a zero reference point. Images were always taken at the passive stage of the respiration: at the end of expiration for zero PPB and at the end of inspiration for PPB > 0. All the experimental sessions were recorded on videotape, and the lumen images were saved on optical disk. The lumen areas were determined from the digitized images using a built-in function of the ultrasound unit. The estimate of the jugular vascular resistance was obtained using Poiseuille's formula for viscous laminar flow where the resistance is inversely proportional to the square of the lumen area and directly proportional to the vessel length.

Results

In all subjects the jugular vein was opened when they were supine, regardless of the PPB pressure. Without PPB the transition from supine to sitting position caused a significant decrease in the vessel area which in some cases dropped to less than 10% of its original value. Due to narrowing of the vessel lumen, the estimated resistance increased more than 50 times with transition from zero to +1Gz. It should be noted, however, that even then the jugular resistance remained a small component of the cerebral flow loop. Thus, for an estimated maximal flow rate of approximately 500 cm^3/min the total viscous pressure loss in the jugular veins should not exceed 2-3 mmHg. The effect of PPB on the jugular vein of a sitting subject was to gradually reopen the vessel, moving the point of collapse further up with increasing PPB. When the PPB pressure was delivered, an initially collapsed vessel of irregular cross-sectional shape was easily inflated to become fully opened by increasing PPB pressure from zero to 30 mmHg; at 30 mmHg of PPB the lumen shape was circular, and the area was greater than in the case when the subject was supine and PPB was zero; a further increase in PPB pressure had little effect on the area since the vessel was already completely stretched. Figure 1, which illustrates the effect of PPB on the jugular resistance, shows that the resistance can be brought down by applying PPB.

Discussion and Conclusions

The results show that change in posture has a significant effect on the geometry of the internal jugular vein. With transition form zero to +1Gz the local cross-sectional area decreases significantly which results in a dramatic increase of vascular resistance. Although the veins will not necessarily contribute significantly to the total vascular resistance at +1Gz, the trend of the venous collapse associated with hydrostatic effect indicate that at Gz > 1 the venous resistance may become dominant. For +1Gz the PPB of approximately 30 mmHg is sufficient to completely overcome the gravitational effects on the jugular resistance. At higher levels of +Gz PPB should have the same effect, but the pressure required to completely open the vessels should be substantially higher.

References

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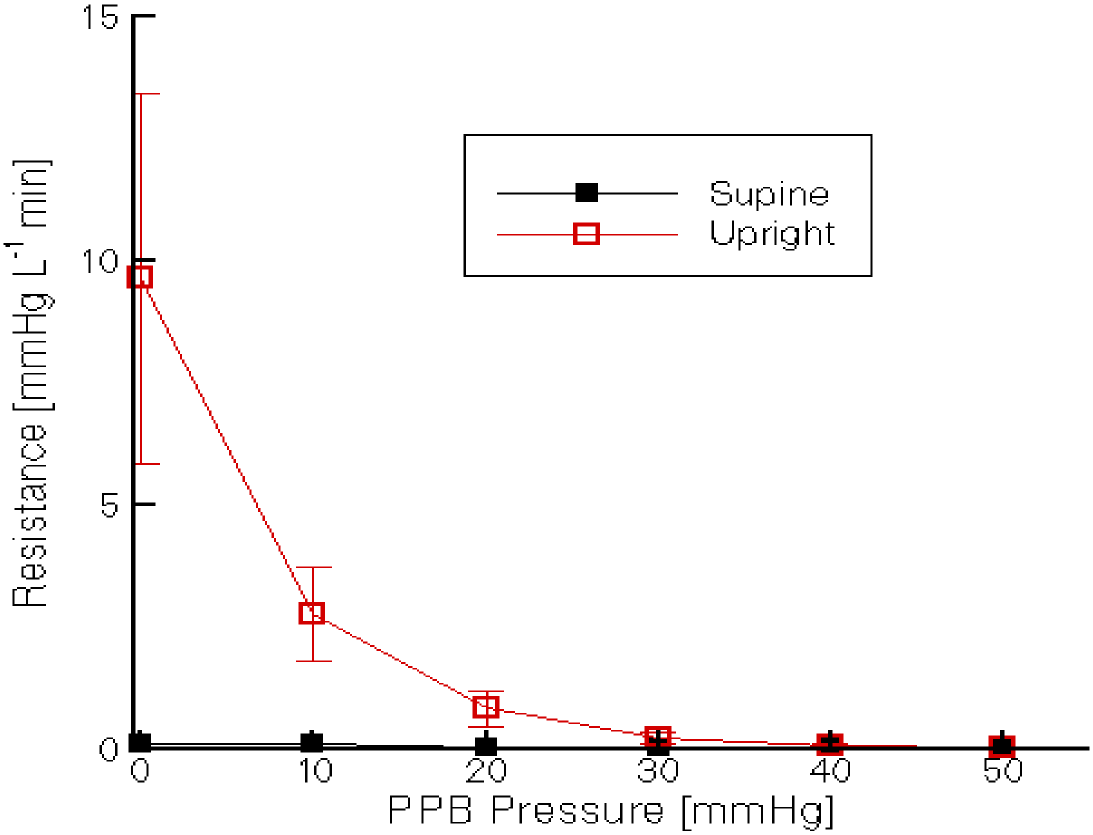

Figure 1: Population mean of the jugular resistance in supine and sitting (upright) position with PPB pressure increasing from zero to 50 mmHg